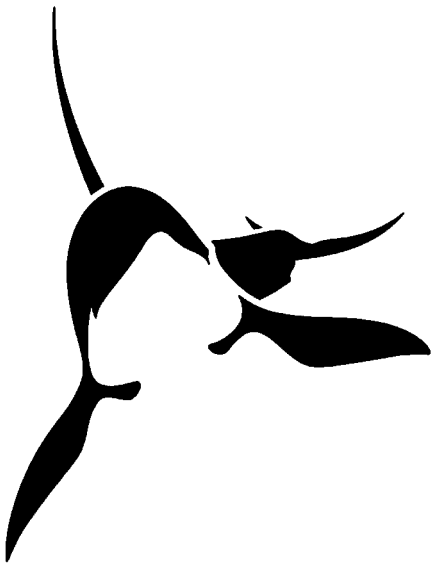
EUROPEAN RESEARCH ON CETACEANS - 18

PROCEEDINGS OF THE EIGHTEENTH ANNUAL CONFERENCE OF THE EUROPEAN CETACEAN SOCIETY, KOLMÅRDEN, SWEDEN 28-31 MARCH 2004



EDITORS: P. G. H. EVANS, L. BUCKINGHAM & M. AMUNDIN

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Proceedings of the Eighteenth Annual Conference

of the European Cetacean Society,

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European Cetacean Society, Kiel, Germany

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INTRODUCTION

The Eighteenth Annual Conference of the European Cetacean Society was held at Kolmårdens Djurpark, Sweden between 28th and 31st March 2004. It was attended by 331 people.

The theme this year was "Experimental Approaches to Marine Mammal Research", and speakers invited to give keynote addresses to this theme included: Vincent Janik on "Using Acoustic Playbacks to Study Signature Whistles and their Significance in Dolphin Communication", Ann Pabst on "Thermal Biology of Delphinid Cetaceans: Insights from Anatomy, and Captive and Wild Animal Studies", and Simon Northridge on "Experimental Approaches to Cetacean Bycatch". In addition to these, there were 39 other talks and 148 posters.

Associated with the Conference, there were workshops on the following themes: Application of photo-identification techniques, Estimating g(0) in Line Transect Surveys of Cetaceans, Marine mammals in the Baltic: History, Present Status and Challenges for the Future, and Current Research, Threats and Issues faced by European Common Dolphins. In addition a student workshop was held on Careers in Marine Mammal Science.

The Society is very grateful to the Conference Organiser Mats Amundin of Kolmårdens Djurpark, and other members of the Organising Committee: Geneviève Desportes, Greg Donovan, Troels Jacobsen, Thierry Jauniaux, Roland Lick, Christina Lockyer, and Lotta Nilsson. Special thanks also go to the team of student helpers: Lisa Albinsson, Heidi Andreasen, Martin Boye, Lisette Buholzer, Kristina Bylund, Ida Eskesen, Pierre Gallego, Alenka Hribar, Maria Iversen, Stéphane Jérémie, Maja Kirkegaard, Ewa Krzyszcyk, Line Kyhn, Helena Larsson, Nette Levermann, Laura Mandleberg, Miguel Miguels, Luca Mirimin, Lotta Nordenstein, Hanna Nuuttila, Ellie Owen, Niels Petersen, Linda Rosager Poulsen, Aviad Scheinin, Cecilia Vanmann, Katja Vinding Petersen, Abi Virjee, and Rebecca Walker.

We also gratefully acknowledge the following bodies for their generous sponsorship of the conference: Fiskeriverket, Formas, Natur Vårdsverket, Svenska Naturskyddsföreningen, Carlsberg, and Servera.

A Conference Scientific Committee was chaired by Geneviève Desportes and also comprised Mats Amundin, Greg Donovan, Peter Evans, Phil Hammond, and Christina Lockyer. The following persons have reviewed abstracts: Alex Aguilar, Mats Amundin, Liselotte Andersen, Michel André, Giovanni Bearzi, Simon Berrow, Arne Bjørge, David Borchers, Florence Caurant, Chris Clark, Ted Cranford, Enrique Crespo, Krishna Das, Cathy Debier, Genevieve Desportes, Rune Dietz, Eric Delory, Greg Donovan, Manuel Dos Santos, Kathleen Dudzinski, Peter Evans, Alexandre Gannier, Damon Gannon, Manuel Garcia-Hartmann, John Goold, Jonathan Gordon, Christophe Guinet, Phil Hammond, Ed Harland, Sara Heimlich, Rus Hoelzel, Aleta Hohn, Vincent Janik, Thierry Jauniaux, Paul Jepson, Toshio Kasuya, Christina Lockyer, Klaus Lücke, Kelly MacLeod, Peter Teglberg Madsen, Tony Martin, Michel Milinkovitch, Lee Miller, Todd O'Hara, Simone Panigada, Bill Perrin, Graham Pierce, Daniel Pike, Antonio Raga, Andy Read, Randy Reeves, Vincent Ridoux, Emer Rogan, Begoña Santos, Ursula Siebert, Tiu Similä, Jeanette Thomas, Paul Thompson, Jacob Tougaard, Nick Tregenza, Peter Tyack, Marie Van Bressem, Ursula Verfuss, Magnus Wahlberg, and Mike Walton.

Contributions have been arranged broadly by subjects, and within subjects, they are arranged alphabetically. All abstracts were subject to a review process and represent all those submissions that were accepted for the conference. Extended summaries have been edited to improve clarity and to maintain a uniformity of presentation.

A very great deal of effort has gone into the editing and production of these Proceedings. In this connection, I should like to thank my co-editors Lucy Buckingham and Mats Amundin for their invaluable help. Finally, I should like to thank Roland Lick for his help with the final production of the Proceedings.

Peter G.H. Evans

ACOUSTICS

ACOUSTIC REACTION OF DOLPHINS TO DIFFERENT KINDS OF ECHOLOCATION SIGNALS

M. Azzali[1], C. Coccioli[1], S. Catacchio[1], J. San Juan Rodriguez[2], and R. Tizzi[2, 3]

[1] *Marine Fisheries Research Institute, National Research Council, Largo Fiera della Pesca, 60125 Ancona, Italy (m.azzali@an.ismar.cnr.it)*
[2] *Delfinario di Rimini, Lungomare Tintori 2, 47900 Rimini, Italy (raftizzi@tin.it)*
[3] *Associazione Oceanomare, Via delle Gondole 109, 00121 Roma, Italy*

This study investigates how *Tursiops truncatus* acoustically react to sonar signals of three classes of dolphins - A) adult males, B) adult females and C) young - belonging both to its own community and to an unknown community. The signals were recorded from free swimming dolphins at Palablu and Rimini delphinaria using a Brüel and Kjær hydrophone (type 8105). Later the clicks of each dolphin were extracted and six sets of data (*active stimuli*) were stored on a magnetic tape. Each set contained the sonar signals of a class of dolphins belonging to either Rimini or Palablu community. A set was 12 minutes long and was formed by six blocks of clicks alternated with six silence blocks. The experiments were conducted in Rimini Delfinario playing back the six sets of data and recording the acoustic responses of the subjects. Each experimental session was formed by three phases: in the first phase (*pre-stimulus*) the hydrophone and the projector were lowered in the pool and presented for 15 minutes to the subjects; in the second phase (*stimulus*) a set of acoustic data was played back for 12 minutes; in the third phase (*post-stimulus*) the apparatus remained in the pool for further 10 minutes. Only the adult male responded to the active stimuli with sonar signals in all the sessions, while the other animals (a pregnant female and two young) remained silent. The number of signals emitted by the male during the second and third phase was higher when the stimuli of its own community were played back, independently from the class of dolphins. However, the similarity measure among the responses of the subject split the signals into two clusters, and one outlier: responses to females (first cluster), responses to young dolphins and to its own signals (second cluster) and responses to the dominant male of Palablu (outlier).

SOUNDWAVES: AN INNOVATIVE DOLPHIN ACOUSTIC PROJECT

S. Berrow and B. Holmes

Shannon Dolphin and Wildlife Foundation, Merchants Quay, Kilrush, County Clare, Ireland

Soundwaves is an innovative new project integrating dolphin research and conservation with the Vodafone mobile phone network. Soundwaves aims to transmit bottlenose dolphin vocalisations from the Shannon estuary to a land station in real time, through the mobile phone network. The project has three phases, i) to identify a suitable site to locate a fixed hydrophone (summer 2003), ii) to develop a system of transmitting and receiving dolphin vocalisations (winter 2003/2004), and iii) to deploy an operational system for field trials (summer 2004). If successful, this project will not only provide essential information for monitoring and impact assessment but provide an imaginative facility to educate people about dolphins and the acoustic world in which they live. During August to October, 2003 four sites were assessed to determine their suitability for picking up dolphin vocalisations and intensity of ambient noise. Dolphin clicks and whistles were recorded at three of the four sites but at one site (Kilcredaun Head) dolphin clicks were heard on 48.3% of samples and clicks on 30% (n = 60 hours). Ambient noise consisted mainly of snapping shrimps (100% of samples at Kilcredaun Point) and boat traffic, including dolphin-watching vessels and tankers. A range of dolphin vocalisations were recorded onto a Sony TCD8 DAT to measure the bandwidths of the different vocalisations which the network will be required to transmit. Initial indications suggest vocalisations below 4kHz (clicks, groans, squarks) can be transmitted in real time but whistles (>5kHz) will have to be modified before transmission.

DIRECTIONAL PULSE SOUNDS IN BOTTLENOSE DOLPHINS, (*TURSIOPS TRUNCATUS*), IN HUMAN CARE, RECORDED WITH AN ACOUSTIC TAG DURING AGGRESSIVE INTERACTIONS

C. Blomqvist and M. Amundin

Research&Education Department, Kolmårdens Djurpark, S-618 92 Kolmården, Sweden

The ability of dolphins to address aggressive signals of selected conspecifics was studied. Three adult bottlenose dolphins (*Tursiops truncatus*), living in a resident breeding group of 14 animals at the Kolmårdens Djurpark, were desensitised to comfortably carry an acoustic tag on the dorsal fin. The tag was designed to record trains of pulses containing energies within two narrow frequency bands, centered at 120 and 70 kHz. In 22 hours of trials, 236 "echolocation click trains", 425 "slow and irregular pulses", and 68 "pulse bursts" were recorded by the tag, most of them in conjunction with aggressive interactions. The number of sounds of these categories, recorded within the audio band, was 2580, 723 and 2158, respectively. In close encounters it was evident that, synchronuous with the amplitude variations in the tag recordings, the most likely transmitter aimed its rostrum towards the animal carrying the tag. This strongly suggests that these sounds were directional, and that they were intentionally aimed at the animal wearing the tag. Most "pulse bursts" recorded on the tag occurred during high intensity aggressive interactions, and were mainly emitted in series of several in a row, with the opponents oriented face-to-face. They contained pulses of longer duration than traditional echolocation clicks, and often had a double-pulse pattern. Taking into consideration that the dolphin ear is an energy detector, we suggest that this was an attempt to maximise the acoustic energy output, in order to inflict acoustic discomfort or even pain in the other. The directionality would reduce the chance of other members of the group being hit and hence involved, whereas the emphasised energy in the audible range, which is less directional, would make it possible for them to follow the interaction from any position.

WHISTLE RECOGNITION IN BOTTLENOSE DOLPHINS (*TURSIOPS TRUNCATUS*) MOTHER-CALF PAIRS

K. Bylund[1], I. Mello[2], M. Amundin [3, 4], and C. Blomqvist[3, 4]

[1]*Department of Animal Ecology, EBC, Uppsala University, 752 36 Uppsala, Sweden*
[2] *University of Algarve, Faculty of Sea Sciences and Environment, 8000 Faro, Portugal*
[3] *Kolmården Wild Animal Park, Research and Education Centre, 618 92 Kolmården, Sweden*
[4] *Department of Biology, IFM, University of Linköping, 581 83 Linköping, Sweden*

One of the most commonly observed signals in the bottlenose dolphins (*Tursiops truncatus*) is the signature-whistle, which has a unique FM contour for each dolphin. Previous studies with dolphins in the wild have shown that mothers respond more strongly to the whistles of their own independent offspring than to the whistles of a familiar, similar-aged non offspring. These studies also show that independent offspring respond more strongly to the whistles of their own mother than to the whistles of a familiar, similar-aged female. The present study was designed to study the capacity of a dolphin to recognise the signature-whistles of other individuals. It was carried out at the Kolmården Wild Animal Park, Sweden. The signature-whistles of mother-calf pairs were played back using two underwater speakers and two hydrophones, connected with click detectors. The responses of the dolphins were recorded on DV tape during one hour, two times a day. The dolphins were free swimming and during a test the mother's signature whistle and a signature whistle from a non- related female were played back to the calf. It was considered to be positive recognition if the calf turned its head and/or sonar beam or swam towards the speaker transmitting its mother's signature whistle. The mothers were tested in the same way but with signature whistles from their calves and non-related calves. Preliminary results show that recognition of signature whistles is individual. Data suggests that calves show more interest in their mothers' signature whistles than vice versa. Further studies are needed to confirm these results.

SOUND VELOCITY IN SPERMACETI OIL FROM DIFFERENT LOCATIONS IN THE HEAD OF A SPERM WHALE (*PHYSETER MACROCEPHALUS*)

R. M. Culloch[1], P. Davies-Marshall[1], P. Gallego[1], E. Krzyszczyk[1], J. Lamb[1], R. Lott[1], S. McCully[1], J. McGee[1], M. Nelson[1], H. Nuuttila[1], A. J. Scullion[1], M. J. Tetley[1], C. Vanman[1], M. Weller[1], R. J. Reid[2], and J. C. Goold[3]

[1]*MSc Marine Mammal Science, University of Wales, Bangor, UK (rculloch@hotmail.com),*
[2]*SAC Veterinary Services, Drummondhill, Stratherrick Road, Inverness, UK*
[3]*Institute of Environmental Science, University of Wales, Bangor, UK*

INTRODUCTION The hypothesis of a sound focussing effect in the spermaceti organ was first suggested by Norris and Harvey (1972). Morris (1973, 1975) and Flewellen and Morris (1978) developed this idea further by describing the lipid structure of the organ. They also proposed the theory of the spermaceti sac acting as a large acoustic lens, with possible implications for echolocation. Goold *et al*. (1996) and Goold and Clarke, (2000) sampled spermaceti oil to investigate the influence of varying temperatures and pressures on the sound velocity properties of the oil. The aim of this study was to analyse oil samples from different regions of the head to further examine the possibility of a sound speed gradient in the spermaceti organ.

METHODS Cross sectional samples of spermaceti oil were taken within 12 hours of a sperm whales' death on the 6th August 1998. Three circular penetrations were made with an auger along the dorsal surface of the head at positions approximating to the front, centre and rear of the spermaceti sac (Figure 1). A plastic pipe acted as a hypodermic syringe to extract the oil from the locations at various depths. Sound velocity was measured in the spermaceti oil samples using the apparatus and methods of Goold *et al.* (1996) as illustrated in Figure 2.

RESULTS Results obtained show that sound velocity decreases with increasing temperature for all locations of the head sampled (Figures 3 and 4). Between 20°C and 30°C sound velocity is not as uniform as in temperatures 30°C to 40°C. Regression analysis of sound velocity and temperature shows that there is a significant relationship ($P = <0.001$) between the two, except for the M70 region ($P = 0.112$). Sound velocity observed at M70 appears to be faster and significantly different ($P = <0.001$) at both pressures (220 and 440 psi) (Figures 5 and 6) than the other sampled oils.

DISCUSSION A functional relationship exists between increasing temperatures and decreasing sound velocity of the spermaceti oil at both pressures. Between 30ºC and 40°C the velocity decreases, however, spermaceti oil from all other regions of the head show clustered slopes, indicating synchrony. Temperatures lower than this (20°C-30°C) lack uniformity, suggesting the sampled regions of the head are not working in unison for efficient sound transmission. No variations were detected throughout the regions of the head sampled, with the exception of M70 which showed a significantly faster sound velocity. Although this may indicate a key area of structural importance for sound manipulation in the head, further analysis showed that there was no functional relationship between increasing temperature and sound velocity. The anomalous result for this location raises questions of whether this could be a significant finding or be due to experimental errors, possibly contamination of oils from various other locations. If this is not an error, and that sound velocity in this area is faster than the rest of the spermaceti oil, it could have a role in directing the sound upwards. However, results are unable to show if this is an error or of significant importance.

CONCLUSION In conclusion this study has shown that temperature had the most effect upon sound velocity of spermaceti oil. This has important implications for subsequent theories of sound production in sperm whales.

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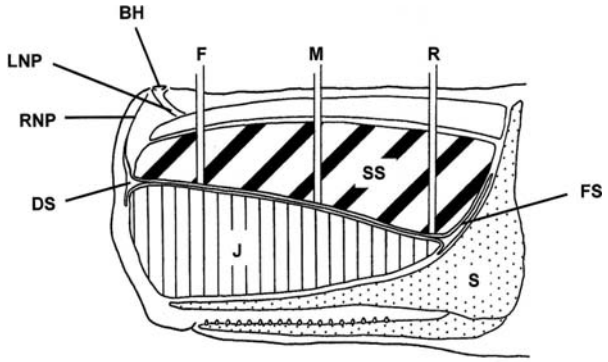

Fig. 1. Diagram showing the positions from which spermaceti oil samples were taken. F front, M middle, R rear, SS spermaceti sac, S skull, J junk, FS frontal sac, DS distal sac, LNP left nasal passage, RNP right nasal passage, BH blow hole

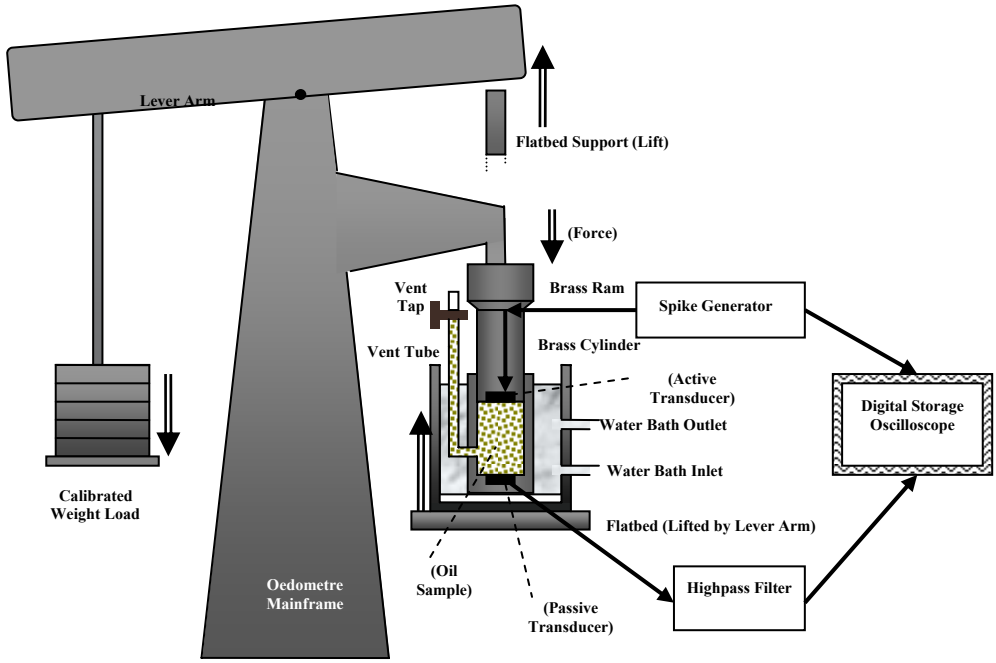

Fig. 2. Apparatus used to measure sound velocity through spermaceti oil samples at different temperatures and pressures

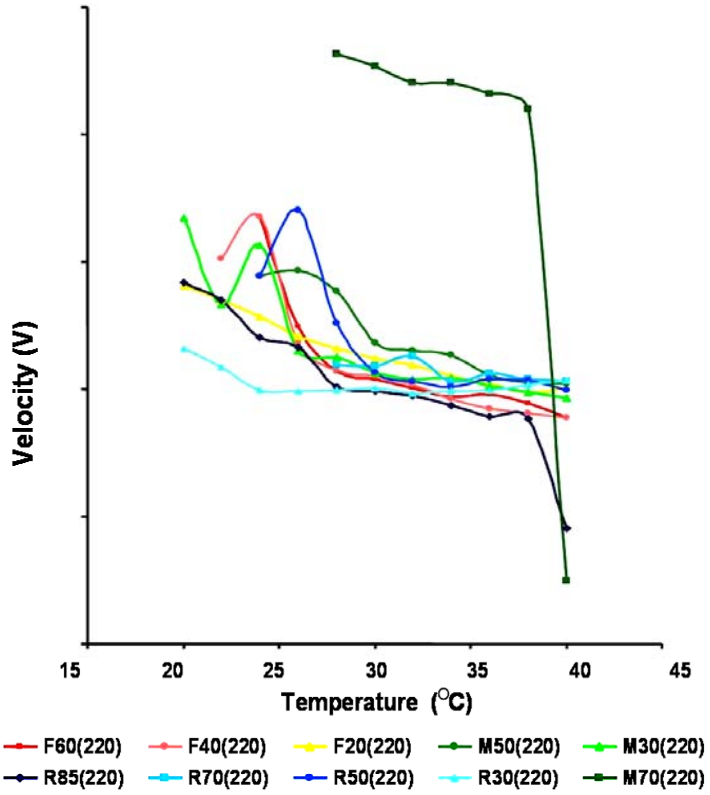

Fig. 3. Histogram of the sound velocity changes with temperature of spermaceti oil from several locations within the head, sampled at 220 psi

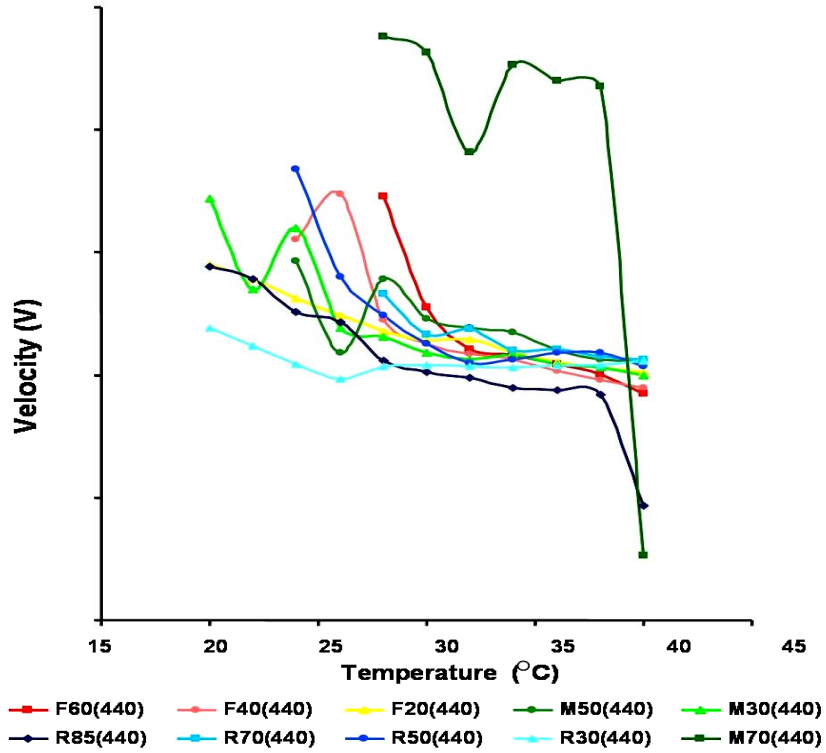

Fig. 4. Histogram of the sound velocity changes with temperature of spermaceti oil from several locations within the head, sampled at 440 psi

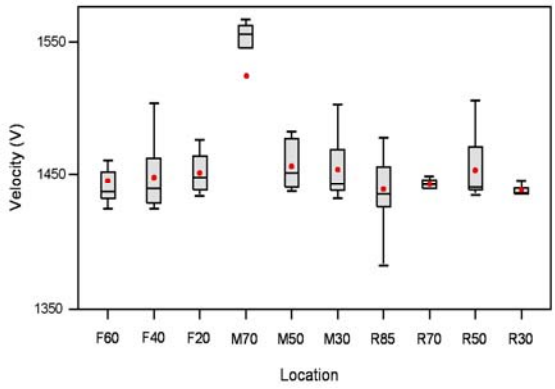

Fig. 5. Sound velocities of oil sampled from different areas of the head, tested at 220 psi. One significant difference was observed between the locations (ANOVA; P = <0.001). Means, Inter-quartile ranges & Standard deviations are shown.

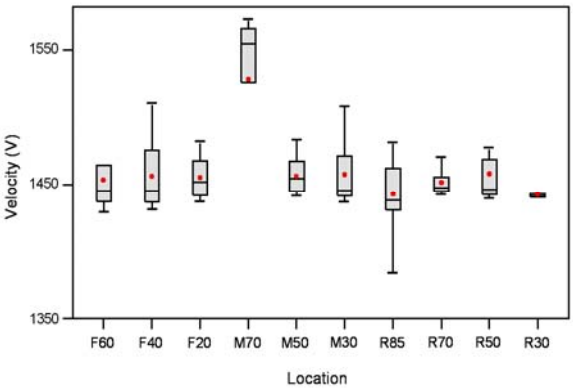

Fig. 6. Sound velocities of oil sampled from different areas of the head, tested at 440 psi. One significant difference was observed between the locations (ANOVA; P = <0.001). Means, Inter-quartile ranges & Standard deviations are shown.

IMPACT ON HARBOUR PORPOISES FROM THE CONSTRUCTION OF THE NYSTED OFFSHORE WIND FARM IN DENMARK: ACOUSTIC MONITORING OF ECHOLOCATION ACTIVITY USING PORPOISE DETECTORS (T-PODS)

O. D. Henriksen, J. Carstensen, and J. Teilmann

National Environmental Research Institute, Department of Arctic Environment, Frederiksborgvej 399, Box 358, DK-4000 Roskilde, Denmark

Offshore wind farms are a new emerging field within renewable energies. One of the first larger wind farms (>100 MW) was constructed during 2002-2003 in a shallow coastal area in the Danish part of the western Baltic Sea, an area believed to be an important habitat for harbour porpoises, *Phocoena phocoena*. This study investigates the impact on harbour porpoises from the first part of the construction work by means of acoustic porpoise detectors (T-PODs) continuously monitoring porpoise echolocation activity. The monitoring program was established as a modified BACI design with 6 T-PODs deployed - 3 within the wind farm construction site (impact area) and 3 in a control area 10km away. Waiting times, defined as the period between two consecutive encounters of echolocation activity, generally increased from 2 hours prior to the onset of the construction work to 4 hours in the wind farm area during the construction, while the porpoise activity in the control area increased slightly. A pronounced additional effect was found during ramming and vibration of steel sheet piles into the seabed around a single wind turbine foundation, resulting in an increase in waiting times from 4 hours to more than 24 hours. The ramming and vibration activity was combined with the use of pingers and seal scrammers. The analysis shows that harbour porpoise habitat use was significantly impacted by the offshore wind farm construction. Continuous logging of echolocation activity has proven useful for assessing both short and long-term environmental impacts on harbour porpoises in smaller defined areas.

USING ACOUSTIC PLAYBACKS TO STUDY SIGNATURE WHISTLES AND THEIR SIGNIFICANCE IN DOLPHIN COMMUNICATION

V. Janik

Sea Mammal Research Unit, Gatty Marine Laboratory, School of Biology, University of St Andrews, Fife, UK

Many animals recognise the identity of a calling individual by listening to its voice. Voice features are caused by the individually distinctive anatomy of the vocal tract and affect all calls produced by an individual. Bottlenose dolphins (*Tursiops truncatus*) also produce individually specific signature whistles, which consist of distinctive frequency modulations over time. The pronounced differences in these modulation patterns suggest that this parameter encodes identity in dolphin communication. Occasional copying of signature whistles may serve to address specific individuals. However, several questions remain. It is still unclear whether dolphins require voice features to recognise familiar individuals or whether the information provided in the frequency modulation of the whistle is sufficient. What kind of differences in the modulation pattern is the animal able to hear in whistles of different individuals? Can animals be addressed by playing back their own signature whistles? How do dolphins use whistle copying in the wild? I will present results of several experimental studies on wild and captive animals that aim to understand more about functional aspects of dolphin whistling behaviour. The results show that dolphins encode individual identity in frequency modulation but also that whistle use is more complex than proposed by the signature whistle hypothesis. The main technique used in these studies is playback of natural and artificial whistle stimuli. I will discuss methodological problems of such studies and outline future research directions that can help to significantly further our understanding of dolphin communication.

THE STRAIT OF GIBRALTAR AS A FEEDING GROUND FOR SPERM WHALE (*PHYSETER MACROCEPHALUS*)

C. Laplanche[1], R. De Stephanis[2, 3], O. Adam[1], M. Lopakta[1], X. Demoulin[4], O. Savanier[5], F. Rondepierre[6], N. Pérez Gimeno[2, 3], P. Verborgh[2], C. Guinet[5], and J. F. Motsch [1].

[1] *Laboratoire d'Informatique Industrielle et d'Automatique (LiiA), Université Paris XII, 61 av Gaulle, 94000 Creteil, France*
[2] *CIRCE, Conservation Information and Research on Cetaceans, C/Cabeza de Manzaneda 3, Algeciras-Pelayo, 11390 Cadiz, Spain*
[3]*Laboratorio de Acústica y Vibraciones de la Universidad de Cádiz. CASEM, Polígono Río san Pedro s/n Puerto Real Cádiz, Spain*
[4] *MAREE, 21 rue Ed. Manet 56260 Larmor-Plage, France*
[5] *Centre d'Etudes Biologiques de Chizé (CEBC-CNRS), 79 360 Villiers en Bois, France*
[6] *Laboratoire d'Océanographie Dynamique et de Climatologie (LODYC), Université Pierre et Marie Curie, 4, place Jussieu, 75252 PARIS cedex 05, France*

The oceanography of the Strait of Gibraltar is characterised by a surface inflow of Atlantic water to the Mediterranean sea and a deep outflow of Mediterranean waters. Sperm whales have been sighted in the Strait of Gibraltar, from whale watching platforms and from the CIRCé research ship Elsa since 2001. A total of 394 sightings were recorded with a great majority of lone individuals: 1551 pictures of both flukes and dorsals. 21 individuals have been photo-identified. Recaptures of individuals ranges from 0 to 24 times. To investigate the diving behaviour of the animals in the Strait we used a vertical array of 4 hydrophones in May 2003. From the recorded signals, we wanted to calculate sperm whale diving depth. However high level of shipping noise and strong currents, reduced the efficiency of this system: the hydrophone array was never vertical and noise had a masking effect. A method to track the sperm whale dive using only one hydrophone has been developed. The instantaneous energy, estimated from the signal wavelet transform, enables an automatic detection of sperm whale clicks corrupted by noise. No threshold is necessary. The additional detection of echoes from the sea bottom and from the sea surface of each sperm whale click then facilitates, by measuring delays, an estimation of the depth and the range of the sperm whale. Such localization also estimates the depth of the hydrophone. The localization of clicking sperm whales is then possible using a single hydrophone at an unknown depth and a GPS receiver. The animals sampled were found to be diving at depths comprised of between 600 and 800 metres. These results suggest (1) that sperm whales use the Strait of Gibraltar as a feeding place and (2) that they forage mainly on prey associated with the deep outflow Mediterranean water.

THE RECOGNITION OF MODIFIED SIGNATURE WHISTLES IN BOTTLENOSE DOLPHIN (*TURSIOPS TRUNCATUS*) MOTHER-CALF PAIRS

H. Larsson[1], I. Mello[2], M. Amundin[3, 4], and C. Blomqvist[3, 4]

[1] *Department of Animal Ecology, Uppsala University, 752 36 Uppsala, Sweden*
[2] *University of Algarve, Faculty of Sea Sciences and Environment, 8000 Faro, Portugal*
[3] *Kolmården Wild Animal Park, Research and education Centre, 618 92 Kolmården, Sweden*
[4] *Dept. of Biology, IFM, University of Linköping, 581 83 Linköping, Sweden*

The signature whistle in the bottlenose dolphin (*Tursiops truncatus*) has been thoroughly studied, but many aspects are still unknown. Although supposed to signal the identity of the transmitter, it has not been clearly shown that other dolphins really do recognise the signature whistles of their conspecifics. This study was done to investigate what parametres (frequency and duration) of the signature whistle make it recognisable. Signature whistles were modified in four different ways: they were made shorter and longer (no frequency change), and higher and lower in frequency (no change in duration). These sounds were used in playback experiments with the bottlenose dolphins at Kolmården Wild Animal Park, Sweden. The dolphins tested were mother-calf pairs. The tests were conducted in the Lagoon, one of three different pool sections in the Dolphinarium, and the dolphins were allowed to swim freely between these sections. Two underwater speakers and two hydrophones were mounted in the Lagoon, with click detectors connected to the latter. One modified "test sound" and one "normal" sound (from a non-related dolphin) was played back to the test dolphin, when the other individual of the mother-calf pair was absent in the Lagoon. A response would be considered positive if the dolphin turned its head and/or sonar beam or swam towards the speaker from whom the modified sound was transmitted. The responses of the dolphins were video filmed from two separate camera angles, and sound recorded on one of the camera sound tracks. Preliminary results indicate that changes in duration are not as important as changes in frequency for recognition. Furthermore, the calves seemed to be less sensitive to whistle modifications than their mothers. However, there are considerable individual variations, among mothers as well as calves. Further studies are needed to confirm these results.

THE ACOUSTICS OF THE BELUGA (*DELPHINAPTERUS LEUCAS*) DURING HUNTING BEHAVIOUR

J. Lazareva[1] and V.S. Belkovich[2]

[1] *Department of Zoology, Moscow State Universityand NBS, Moscow, Russia*
[2] *Shirshov`s Oceanology Institute RAS, Russia*

The echolocation signals of the beluga whale (*Delphinapterus leucas*) were recorded in the White sea, in open water, using three hydrophones that were situated at a distance of 100m between each other, where on average three animals were hunting. The tape-recorded had a frequency range between 0.06 and 19 kHz. We made a complete PC recording of all signals. In a series we measured: number of clicks in series, duration of the series, and the number of clicks per a second in each series, using all previous parametres we measured a distance between animal and its target. Three distinct modes of signals were observed. Mode 1 "near distance location" (target not further than 37 metres) 27%; mode 2 "middle distance location" (target between 37 and 100 metres) -34%; mode 3 "far distance location" (target is further than 100 metres) - 38%. The time budget of the belugas "searching for fish situation" has been obtained. In this situation the location activity of an animal was only 19.55% from all of the studied period, other activities were: strikes by tail on water 13.65%; breathing 12.8%; vowel sounds 2-3%; silence between actions 51.15%.

BIOMECHANICS AND DYNAMICS OF THE SPERM WHALE SOUND GENERATOR WITH IMPLICATIONS FOR FORAGING

P.T. Madsen[1], M. Johnson[2], and P. Tyack[1]

[1] *Biology Department, Woods Hole Oceanographic Institution, Woods Hole, MA 02543, USA*
[2] *AOP&E Dept., Woods Hole Oceanographic Institution, Woods Hole, MA 02543, USA.*

The sperm whale (*Physeter catodon*) carries a huge nasal complex that may makes up 1/3 of the body length, and reaches a weight of more than 10 metric tonnes in adult males. The structures of this giant nose are homologous with sound generating nasal structures of dolphins. Sperm whales produce the highest sound pressure levels of any animal, and it has been proposed that such powerful clicks may serve as a biosonar and/or have a debilitation function during foraging at great depths. It remains, however, up until now a conjecture that the sperm whale nose is a sound generator. To shed light on the biomechanics and dynamics of the sperm whale sound generator, Dtags were non-invasively attached with suction cups to record depth, 3-D movements and sound with a sampling rate of 96 kHz. Here we present data to unequivocally demonstrate that the sperm whale nasal complex is a giant sound generator, that is actuated by pneumatic action of a limited, recycled air volume. We show that the primary sound pulse of sperm whale usual and creak clicks has been reflected by air sacs and propagated through the spermaceti filled compartments of the nose before emission into the water. Evidence is presented to suggest that active beam-forming is taking place and that clicks with very different properties are produced. In the transition from usual clicks to creak clicks during a bat-like prey capture, the directionality and frequency content of the clicks is increased and the acoustic output is decreased by 30 dB. Modelling of the received sound pressure levels demonstrates negative evidence for the theory that sperm whales acoustically debilitate their prey. It is concluded that the sperm whale nose is a pneumatically driven, highly dynamic sound generator that serves to produce biosonar clicks for long-range echolocation, but not for acoustic prey debilitation.

MEASURING HEARING IN AN ECHOLOCATING FALSE KILLER WHALE

P. Nachtigall

Hawaii Institute of Marine Biology, University of Hawaii, P.O. Box 1106, Kailua Hawaii 96734, USA

The recording of acoustic brainstem responses (ABR) from the surface skin on the heads of cetaceans has allowed us the opportunity to measure hearing by examining electrical brain responses to a variety of sounds. Echolocating odontocete cetaceans produce an intense (over 230 dB re 1 micropascal) outgoing echolocation click that is immediately followed by a relatively quiet echo. We have recently adapted the ABR technique to not only measure audiograms but to also measure how well a false killer whale hears both the intense outgoing echolocation clicks that she produced as well as the quiet echoes generated when those clicks were reflected from objects. The animal was trained to wear soft latex suction cups containing human-type EEG sensors to record electrical evoked potentials while she echolocated and reported the presence or absence of small aluminum cylinders. During each trial the animal swam into a hoop, stationed, a screen was lowered, the animal echolocated and then reported. If a cylinder was present 8m away the animal pressed a small response ball, if not she remained still. Either correct response resulted in reinforcement with two fish. While the animal maintained an overall echolocation accuracy exceeding 95%, we found that both ABR responses to the emitted clicks and to the echoes were of comparable amplitudes in spite of the large intensity differences of these two sounds. In other words, the ABR response levels indicate that the whale heard both the intense clicks and the quiet echoes at about the same level. These data indicate that the animal must either utilise some sort of functional mechanism for either (1) masking the outgoing signal (e.g. like the stapaedial reflex of the middle ear in bats), or (2) releasing the echo from the masking caused by the powerful outgoing signal, or (3) a combination.

CODA PLAYBACKS TO SPERM WHALE SOCIAL GROUPS

L. Rendell[1] and H. Whitehead[2]

[1] *Gatty Marine Laboratory, School of Biology, University of St. Andrews, Fife, UK*
[2] *Department of Biology, Dalhousie University, Halifax, N.S., Canada.*

Playback experiments in the lab and field are a powerful technique for studying communication and predator-prey interactions, and are a core technique in research on other animal groups. However, with a few notable exceptions, playbacks remain underutilised in marine mammal studies. In the study of birds for example, playbacks are a crucial tool in understanding the function of vocal dialects. They hold great potential for the same questions in marine mammal species that show vocal dialects. Sperm whales show vocal dialects in usage patterns of codas, short stereotyped patterns of clicks generally heard in social situations. We played back codas to groups of female and immature sperm whales off northern Chile, subsequently dividing playback bouts into those where the stimuli matched the clan of the focal group, and those where stimuli did not match the focal group clan. Playbacks were conducted to four different groups on five different days. We used the difference between the number of codas made by the focal group before and after playback as the response variable. There was no consistent response to coda playback overall, nor a consistent differential response to same-clan over different-clan codas. However, our data did suggest that same-clan codas tended to produce a greater variance in response, but interpretation of this result is problematic given the lack of consistent response to coda playback in general. The experience of scientists that study birdsong is that often many pilot studies are required on any given species before effective experimental playback protocols can be developed, and this is likely to be the case in marine mammals too. Marine mammal researchers should therefore not be discouraged by initially inconclusive studies, but should be aware of the difficulties involved in field playbacks, and that, as in birds, there will be a steep learning curve.

AN ANALYSIS OF STABILITY AND GROUP-SPECIFICITY OF STEREOTYPED WHISTLES IN WILD KILLER WHALES (*ORCINUS ORCA*) INTHE COASTAL WATERS OF BRITISH COLUMBIA

R. Riesch[1], J.K.B. Ford[2], J. Parzefall[1], and F. Thomsen[1]

[1] *ZoologischesInstitut und Museum, Martin-Luther-King-Platz 3, 20146 Hamburg, Germany*
[2] *Marine Mammal Research Programme, Pacific Biological Station, Nanaimo,B.C., V9R 5K6, Canada.*

Whistles are an important carrier of underwater communication in delphinids. The function of stereotyped whistles as individual contact-calls in long-range communications of several species, most notably the bottlenose dolphin (*Tursiops truncatus*), has been thouroughly investigated. In contrast to that, members of the northern resident community of killer whales (*Orcinus orca*) off northern Vancouver Island, British Columbia produce whistles at high rates during close-range interactions such as socializing and social-travelling. Some of them are highly stereotyped and can be classified into six distinct types. They appear not only in interactions within the social group but also very often in intergroup interactions. It is therefore likely that stereotyped whistle-types are used to coordinate close-range interactions within as well as between subgroups of the community. The aim of this study was an investigation of stability and group-specificity of stereotyped whistles in northern resident killer whales. We analysed field recordings from 1978 -2001 using real-time and power-spectrum-analysis. The parametres of a subset of 475 stereotyped whistles were measured. Based upon our earlier studies, stereotyped whistles could be classified into 12 discrete categories. Parametres such as duration and carrier frequency of most whistle-types proved to be stable over a minimum of fifteen years. At least two of the three acoustical clans of the community shared 10 of the 12 types. The results of our study show that stereotyped whistles of northern resident killer whales are highly stable overtime. The apparent lack of group-specificity suggests, that stereotyped whistles play a role not only within the social-group, but also serve an important function in close-range interactions among subgroups of the community. Future studies comparing the whistle repertoire of northern residents with those of neighbouring communities will determine if variation exists on a higher level.

LISTENING TO FIN WHALE CALLS ON A FEEDING GROUND IN THE ST. LAWRENCE ESTUARY

F. Samaran[1] and Y. Simard[1, 2]

[1]*ISMER, Université du Québec à Rimouski, 310 Allée des Ursulines, Rimouski, Québec G5L 31A, Canada*
[2] *Maurice Lamontagne Institute, Fisheries and Oceans Canada, P.O. Box 1000, Mont-Joli, Québec G5H 3Z4, Canada*

Continuous day and night acoustics recordings associated with whale sightings and distances measured with rangefinder binoculars were made from shore linked hydrophones deployed at a depth of 150m in a feeding ground of the Saguenay–St. Lawrence Marine Park (Canada), from September 23rd to 1st October 2002. An ensemble of 4056 typical 20-Hz fin whale pulses, emitted in long bouts, composed of repeated series with a regular inter-pulse interval were recorded. These vocalizations were automatically detected with an algorithm, which also extracted their main features on the spectrogram. Source levels were estimated to 188.4 ± 3.6 dB re 1 µPa² / Hz, using a spherical spreading model for transmission loss with the ranges measured with the rangefinder binoculars for a 250-300m distant whale. Pulse characteristics closely matched those reported in the literature (frequency ranges between 20.6 ± 1.3 Hz and 19.5 ± 0.7 Hz, and a mean duration of 1.6 ± 0.5 s). However, 5% of those 20-Hz pulses occurred occasionally and differed from the majority. They were referred to as "low pulses". They had a slightly (~2 Hz) lower frequency and had a longer pulse interval from preceding vocalizations (16.9 ± 2.5 s vs 10.7 ± 1.4 s). This suggests that a change in the whale activity, possibly related to its feeding activity, brakes the vocalisation rhythm. We propose that this may be the deglutition process, which involves temporary changes in the laryngeal configuration, preventing the production of a normal vocalization.

SINGING WHALES, SONOBOUYS, STUGERON AND WINTER IN THE NORTH EAST ATLANTIC: LONG TERM MONITORING OF LOW FREQUENCY SPECIALISTS IN THE FAROE-SHETLAND CHANNEL

R. Swift[1], G. Hastie[2], and S. Mendes [3]

[1]*University of Aberdeen Lighthouse Field Station, George Street, Cromarty, Ross-shire, Scotland, UK, IV11 8YJ;*
[2]*Fisheries Centre, Lower Mall Research Station, 2259 Lower Mall,*
The University of British Columbia, Vancouver, BC, Canada, V6T 1Z4
[3]*University of Aberdeen, Department of Zoology, Tillydrone Avenue, Aberdeen, Scotland, UK, AB24 2TZ*

Information on distribution and ecology of baleen whales in the Northeast Atlantic is limited, particularly during the winter. In this paper we describe the initial results of a long-term monitoring programme using low-frequency omni-directional sonobuoys to record fin and blue whale vocal behaviour. The feasibility of using sonobuoys to study fin whale spatio-temporal distribution was also investigated. Sonobuoys were deployed in May 2000, 2001, 2003, October 2000, 2001, 2002, 2003, and December 2000, from a platform of opportunity at deep-water hydrographic stations (>200m). Recordings were made to hard-disk via a modified VHF receiver and post-processing of the data allowed low-frequency vocalisations to be identified. Fin whale presence-only data was used to generate habitat suitability maps using depth sand slope as predictor variables in Ecological Niche Factor Analysis (ENFA); these were compared with maps computed from a sightings database. Sonobuoys were deployed at 198 stations. Fin whales were the most frequently detected of the 2 species (Detection rate (FW) = 29% > (BW) = 1.5%). Fin whale vocal behaviour showed a marked seasonality with 98% detections made in October. Blue whales were only recorded in September 2003. Fin whale detections were widely distributed through the Faroe-Shetland Channel and over the Wyville-Thomson Ridge, while blue whales were only detected in the latter area. Results were in accordance with published data on the seasonality of fin and blue whale vocal behaviour in the area. Marginality coefficients for sonobuoy and sightings ENFA models were similar, but sonobuoy data resulted in increased specialisation and a narrower habitat suitability map. While sonobuoys deployed from platforms of opportunity can be an effective tool for long term monitoring of baleen whales, their value to produce habitat models is currently limited by the lack of independence between sampling stations and wide detection range (>30km).

ON THE PERFORMANCE OF AUTOMATED PORPOISE-CLICK-DETECTORS IN EXPERIMENTS WITH CAPTIVE HARBOUR PORPOISES (*PHOCOENA PHOCOENA*)

F. Thomsen[1, 2], V. Brock[2], N. Van Elk[3], and W. Piper[2]

[1] *Zoologisches Institut und Museum, Universität Hamburg, Martin-Luther-King-Platz 3, D-20146 Hamburg, Germany*
[2] *Biologisch-landschaftsökologische Arbeitsgemeinschaft, Gotenstraße 4, D-20097 Hamburg, Germany*
[3] *Research and Rehabilitation Centre, Dolfinarium Harderwijk, Strandboulevard Oost, 13840 GC Harderwijk, The Netherlands*

Underwater acoustics have become an essential tool for long-term monitoring of cetaceans in the wild. It is especially promising for analysing fine-scale patterns of habitat-use, based upon diurnal acoustic activity. Recently, automated porpoise-click-detectors (T-POD's, Chelonia-Marine-Research) have been used intensively in monitoring harbour porpoises (*Phocoena phocoena*) in the North and Baltic Sea. However, the automated click-detection mechanism has led to questions on the reliability of the detection process. It is also poorly known if T-POD's are suitable to record changes of diurnal acoustic activity. We investigated these questions in experiments with six harbour porpoises at the Research and Rehabilitation Centre of the Dolphinarium Harderwijk (Netherlands). Four sub-adult males were housed in one pool (A), two adult males in another (B). One to two POD's were placed for over a week in the centre of pools A and B respectively. The behaviour of the porpoises was logged through visual observation during the study period. Data were analysed using the T-POD-software-program. A total of 860.000 clicks were recorded during 310hrs of logging. Most of the click-trains were classified as being with a 'high-probability' from porpoises. However, there was a sufficient number of trains classified as being only of 'low-probability' or even 'doubtful'. Individual click-trains showed nearly identical characteristics as those reported in the literature. However, we also recorded trains with very high PRF's of more than 1000/s. There was a clear diurnal trend in click activity, with high click-rates during the night and lower rates during daylight hours. The acoustic activity was also high during play with objects introduced into the pools. We conclude that T-POD performance is reliable in detecting porpoise clicks. They might also be useful in recording diurnal patterns of acoustic behaviour. Therefore, T-POD's are a promising tool in studies on habitat-use of harbour porpoises.

BEHAVIOURAL CONTEXT OF BOTTLENOSE DOLPHIN (*TURSIOPS TRUNCATUS*) VOCALISATIONS IN THE SHANNON ESTUARY, IRELAND

C. R. Weir

Ketos Ecology, 4 Compton Road, Kingsbridge, Devon TQ7 2BP, UK

The behavioural context of vocalisations produced by the bottlenose dolphin (*Tursiops truncatus*) has been studied in captivity and increasingly in free-ranging animals. This study presents an analysis of the acoustic behaviour of a wild population of bottlenose dolphins in the Shannon Estuary, Ireland. The study had two main objectives: (1) to describe the vocalisations of the Shannon Estuary dolphin population, and (2) to examine the behavioural context of the vocalisations. Data were collected using group-follow protocols from a RIB, with simultaneous acoustic data collected via a Magrec HP30 hydrophone and DAT recorder. A total of 116 sample minutes of correlated acoustic and visually observed behaviour was collected between 29th May and 2nd July 2003. Analysis of the spectrograms identified vocalisations including broadband click trains, creaks, burst-pulse sounds, whistles and jaw-claps. There was a significant positive association between group size and both the number of burst-pulse vocalisations and percentage of click occurrence. Total click occurrence was significantly higher during foraging/feeding (74.5% presence) than other behaviours. Creaks were primarily produced in association with socialising (0.33 creaks/dolphin/min) and to a lesser extent feeding. Burst-pulse sounds showed a strong significant association with active feeding (2.07 calls/dolphin/min), with 'food brays' produced during active capture of fish at the surface. Jaw-claps were produced only during feeding, and principally during foraging. Unexpectedly, whistle production did not differ significantly between behavioural categories, with all behaviours resulting in a whistle rate of between 0.50 and 1.49 whistles/dolphin/min. The study indicated that certain call types produced by the Shannon bottlenose dolphin population are utilised during particular behavioural contexts, and provided further information on the possible function of dolphin vocalisations.

THE INFLUENCE OF ANTHROPOGENIC NOISE ON BOTTLENOSE DOLPHIN BEHAVIOUR AND DISTRIBUTION

J.C. Wharam, J. A. M. Gibbons, and E.J. Harland

Durlston Marine Project, Lighthouse Road, Swanage, Dorset, BH19 2JL, U.K. (JoDMP@aol.com)

INTRODUCTION Since its inception in 1994, the Durlston Marine Project has been conducting detailed studies of the bottlenose dolphin population in Dorset. In 2001, English Nature agreed to further this work by supporting a three-year study through the Biodiversity Grant Scheme. The study seeks to investigate the presence and distribution of small cetacean species within the Durlston Marine Research Area (DMRA), and to assess the source and levels of anthropogenic noise within that environment. The importance of such research was reiterated in the Final Statement of the Council of the European Cetacean Society, following the 2003 Annual Conference. The Council stated that "research on the effects of man-made noise on marine mammals is urgently needed and must be conducted to the highest standards of scientific and public credibility, avoiding all conflicts of interest".

An investigation of boating intensity and associated underwater noise in the DMRA was undertaken to assess whether the seasonal distribution of dolphin sightings was caused by the seasonality of boat traffic. This work builds upon the study by Wharam *et al.* (2003) and extends the number of vessels categorised, allowing an estimation of the likely impact of the associated underwater noise on potential immediate damage to bottlenose dolphins (*Tursiops truncatus*) and/or potential subsequent displacement from the DMRA.

MATERIALS AND METHODS A team of trained, experienced volunteers conducted regular, systematic surveys of the Durlston Marine Research Area to gather data on dolphin presence and shipping activity. The concept of 'dolphin sighting-days' has been developed to guard against duplication of sightings. This parametre is defined as a day when bottlenose dolphins have been observed, irrespective of group size and/or the number of times they have been sighted during that day.

The acoustic data for vessel noise were obtained using the fixed hydrophone deployed in 7m of water in Durlston Bay, according to the methodology described in Wharam *et al.* (2003). In order to characterise the acoustic signatures of the vessels using the DMRA, the hydrophone was marked by a buoy and the boats instructed to pass as close as possible to the buoy. Visual observations during the tests showed that all passes used for analysis were within 3m of the buoy. Each test craft was asked to make at least two passes at each speed and to pass at two or three speeds. In each case the speed over ground was measured using an onboard GPS receiver. Of the seven vessel categories recorded in the DMRA, only five have so far been characterised.

RESULTS The incidence of peak dolphin activity in late spring/early summer and in late autumn is shown in Figure 1. Their absence during the peak summer holiday period occurs at the peak of the boat traffic levels as shown in Figure 2. Anecdotally, this was thought attributable to the onset of leisure craft and, in particular, motorised vessels, *e.g.* diving (RIB), motor boats and jet skis. This inspired the investigation of noise sources generated in the DMRA and their likely impact upon bottlenose dolphin presence. Figure 3 shows year-by-year annual sighting-days totals from 1988 to 2003. The obvious downturn in sighting-days with the incidence of anthropogenic noise may well be coincidental and biological forces could influence the absence of these animals. Unfortunately, no coincidental evidence is available to account for the reduced sightings in 1990 and 1993. Again the build-up of sightings from 1988 to 1995 may be biological or due to an increase in the number of observers; records are not available to support the latter, but from 1995 onwards the number of observation hours have remained sensibly constant and not obviously responsible for the perturbations thereafter. This figure highlights the possibility of other anthropogenic noise sources contributing to the reduction of sighting-days, e.g. seismic testing, fast ferries and military sonar. From the shipping data, typical values of shipping intensity at any time of the year may be calculated. This yields values for leisure traffic at the peak summer period of 723 vessels per month for motor boats and 543 for sailing boats, compared with winter values of 25 and 9. The likely influence of a single vessel upon bottlenose dolphin presence within the DMRA is dependent upon its noise characteristic and the time for which it is present. The latter is defined here as the 'dwell time' as shown in Figure 4.

DISCUSSION From the above it can be seen that individual craft can be heard over an appreciable distance by the animals as evidenced by Table 1, thus giving them sufficient time for evasive action. During the summer months there are sufficient numbers of craft within the DMRA for the sound fields to overlap. This causes the noise levels to rise sufficiently to impair communication between animals and also reduce their echolocation performance.

CONCLUSIONS Since 1999, it has not been possible to define a seasonal pattern of bottlenose dolphin distribution within the DMRA, this may well be due to noise disturbance. Sightings continue to occur, however, there is no distinguishable pattern to these. A high intensity of boat traffic within the DMRA may cause underwater noise to rise to levels that impair communication between animals and also reduce their ability to echolocate. This may increase the chance of a collision. A noisy boat does alert dolphins to its presence and, if given time, allows for the animal to take evasive measures. However, quiet, fast moving boats may not be detected audibly. Speeds of 5 knots or less, giving rise to 'no wake', are unlikely to acoustically disturb bottlenose dolphins with regard to feeding and socialising. Intensity of noise from various man-made sources i.e. high numbers of boats, seismic testing and military sonar, may be sufficiently disturbing to totally disrupt a semi-resident pod resulting in its disappearance from the area. Essentially, these findings support the guidelines drawn up by the DETR (1999) with regard to noise disturbance.

Future work Two main areas of work are identified: 1) To produce a catalogue of acoustic signatures for underwater noise sources within the DMRA and to develop a rigorous mathematical treatment of the noise levels generated by the multiplicity of vessels and its likely effect upon dolphin disturbance; and 2) To employ both visual and acoustic monitoring of cetaceans to assess their distribution within the English Channel. This approach demands further development of acoustic detection systems.

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Table. 1. Estimated range over which bottlenose dolphins detect vessel noise

Vessel type	Speed (knots)	Detection distance (m)	Time for evasive measures (s)
Potting/netting	5	100	<40
Diving	7	250	60
	15	150	20
	33	1500	90
Motor boat	7	1000	240
	15	2000	240
	25	>5000	>300
Large ferry	10	>5000	>300
Jet ski	Variable	<100	<30

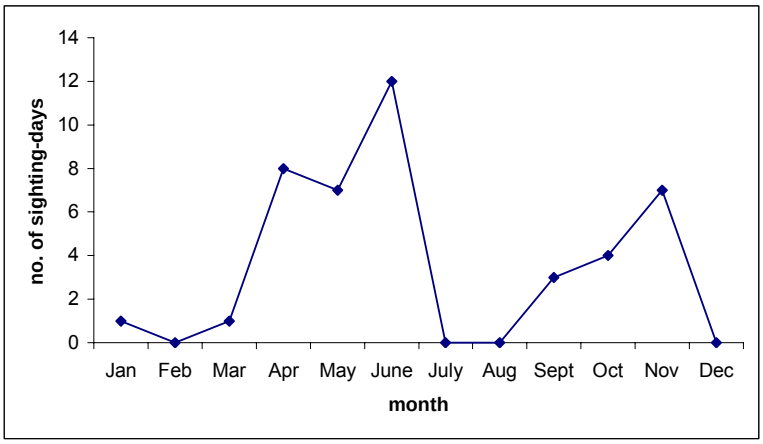


Fig. 1. Typical seasonal variation of dolphin sighting-days

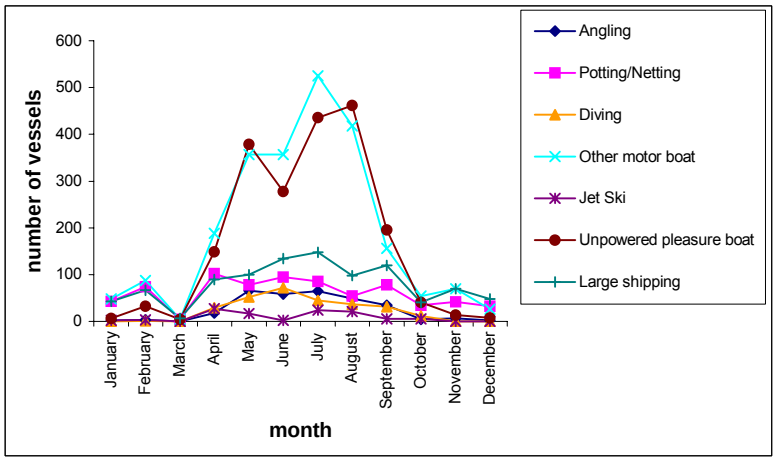


Fig. 2. Typical seasonal variation in boat traffic levels

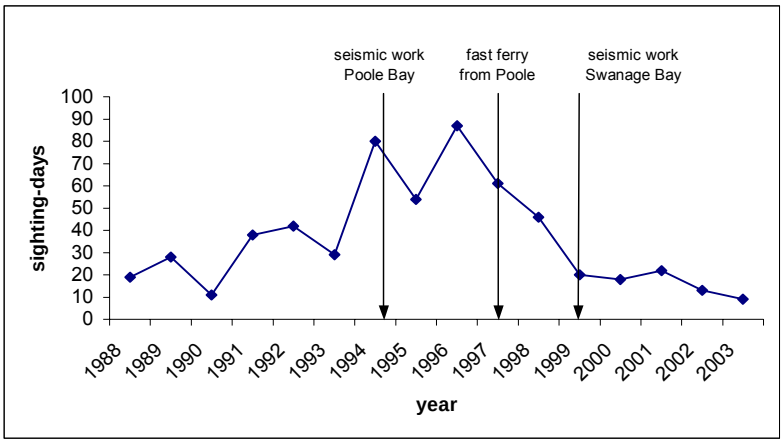


Fig. 3. Annual sighting-days 1988 to 2003

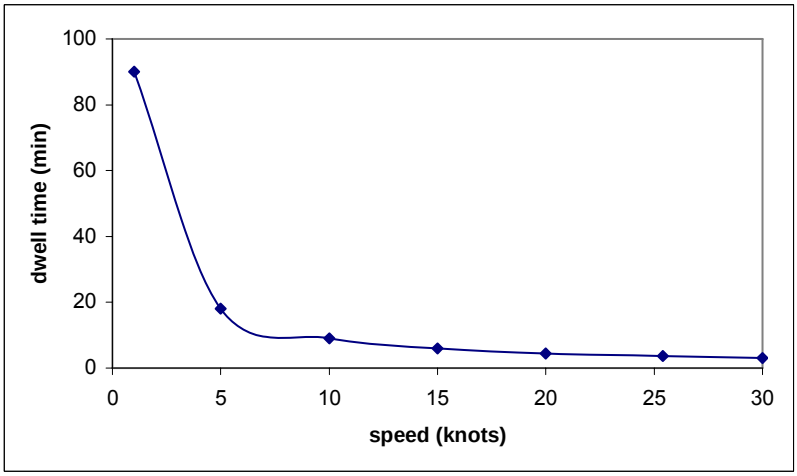


Fig. 4. Dwell time of vessels

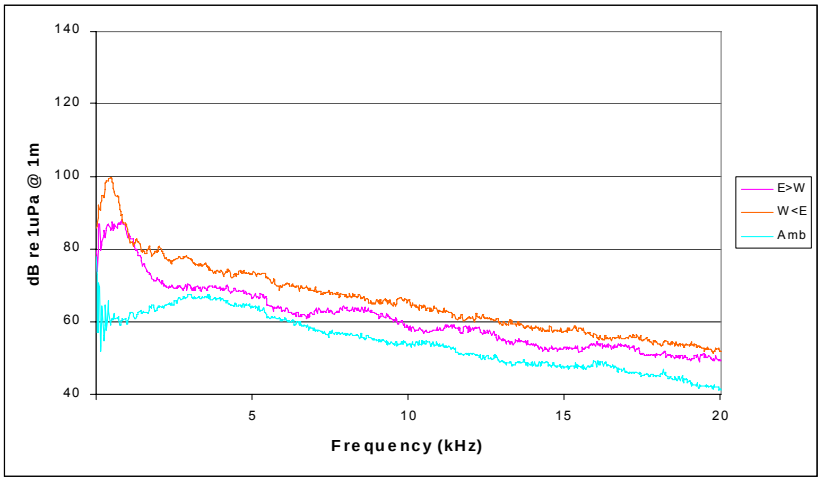


Fig. 5. Acoustic characteristics of potting/netting vessel

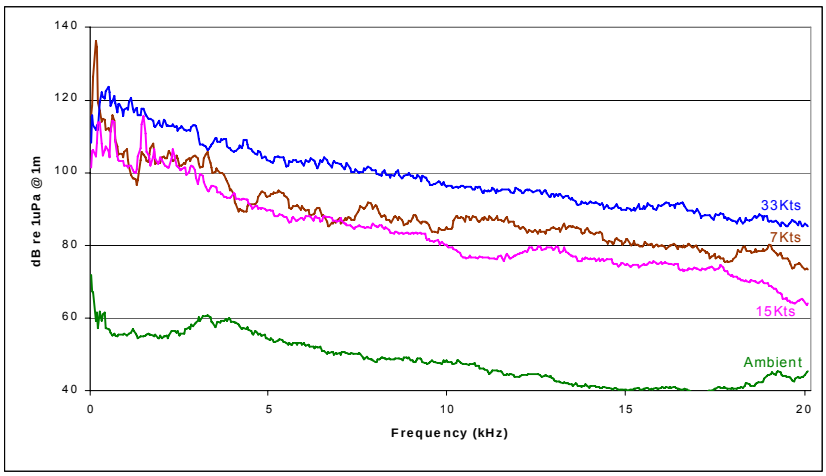


Fig. 6. Acoustic characteristics of diving vessel

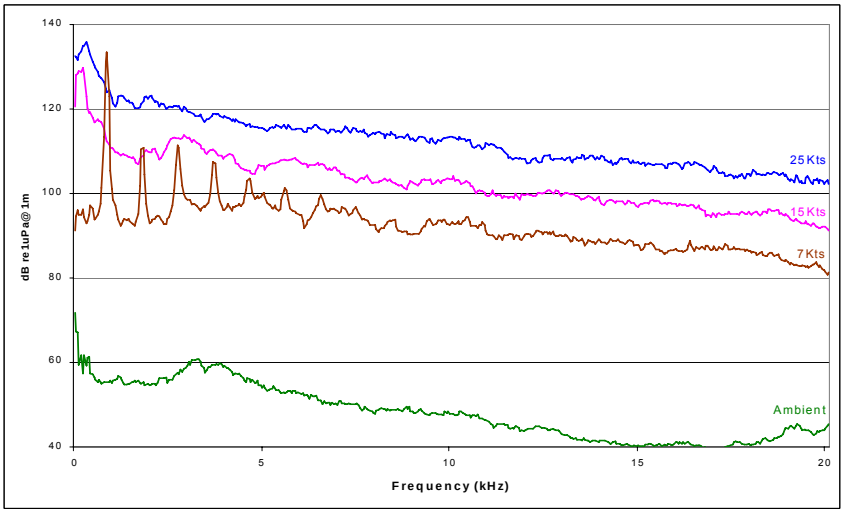


Fig. 7. Acoustic characteristics of motor boat

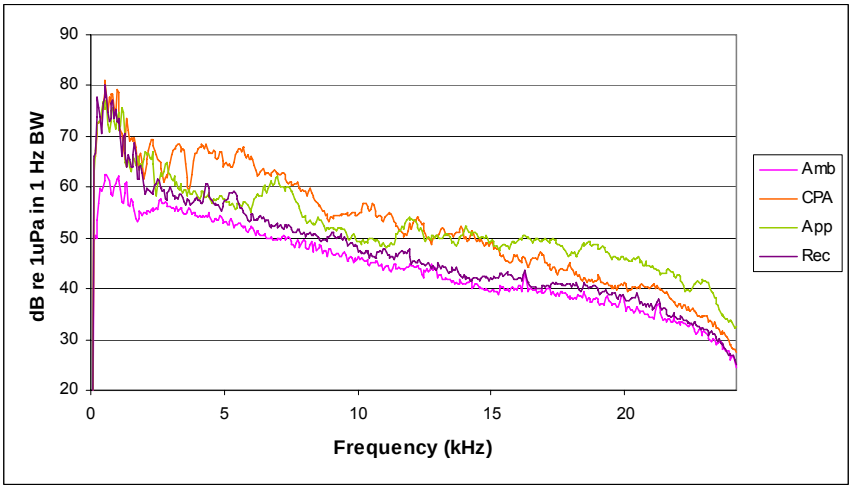


Fig. 8. Acoustic characteristics of large ferry

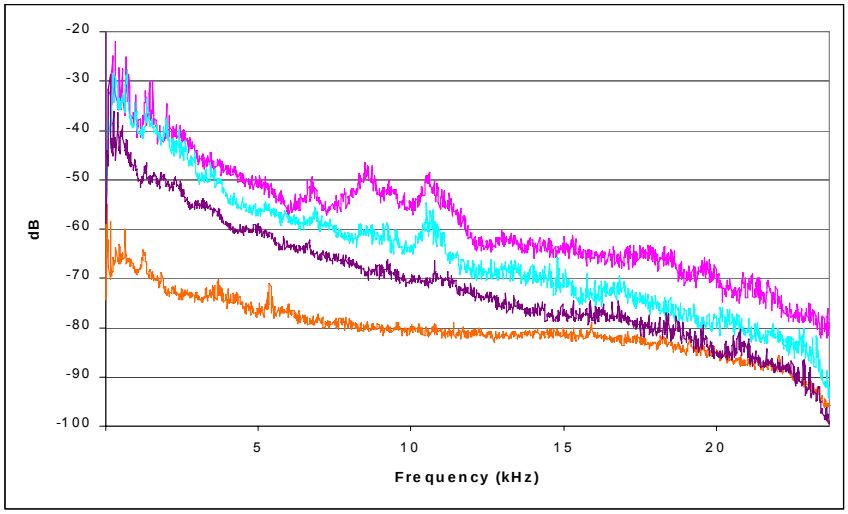
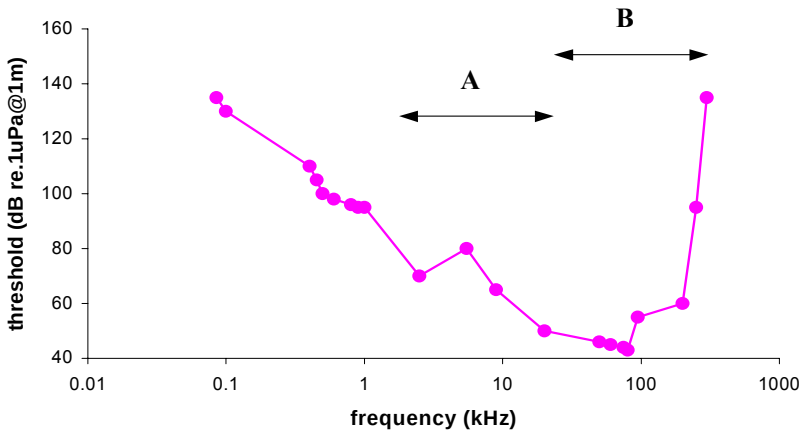


Fig. 9. Acoustic characteristics of jetski



A – whistle frequencies
B – echolocation frequencies

After Richardson *et al* (1995)

Fig. 10. Hearing sensitivity of bottlenose dolphin

BATHYMETRY, METEOROLOGY, AND DIURNAL PATTERNS IN SPERM WHALE BEHAVIOUR

A. J. Wright[1], J. C. Goold[2], S. A. Kuczaj[3], R. Thames[3], J. J. Newcomb[4],
D. K. Mellinger[5], and M. Snyder[6]

[1] *41 Burlington Road, Enfield, Middx, EN2 0LL, UK (marinebrit@netscape.net)*
[2] *University of Wales, Bangor, Institute of Environmental Science, Deiniol Road, Bangor, Gwynedd, LL57 2UW, UK*
[3] *University of Southern Mississippi, Department of Psychology, Box 5025, Hattiesburg, MS 39406-5025, USA*
[4] *Naval Research Laboratory, Code 7185, Stennis Space Center, MS 39529-5004, USA*
[5] *Oregon State University and NOAA/PMEL, Cooperative Institute for Marine Resources Studies, 2030 S. Marine Science Drive, Newport, OR 97365, USA*
[6] *Naval Oceanographic Office, Stennis Space Center, MS 39529, USA*

INTRODUCTION The regular or "usual" clicks produced by sperm whales (*Physeter macrocephalus*) typically occur in click trains at rates of around 2 clicks per second (Backus and Schevill, 1966; Whitehead and Weilgart, 1990). It is hypothesized that these regular or usual sperm whale clicks are employed as echolocation for searching during foraging (e.g., Backus and Schevill, 1966; Gordon, 1987).

Although foraging is the predominant behaviour exhibited by sperm whales (Whitehead and Weilgart, 1990), reports of diurnal patterns in foraging behaviour are often conflicting. Gordon (1987) found some evidence that afternoon dives are longer than dives made at other times, while Watkins *et al.* (1993) noted that dives were possibly more protracted after dark. Interestingly, Papastavrou *et al.* (1989) found little difference in dive depths between day and night, suggesting that there is no discernable diurnal pattern, while Lockyer (1977) reported longer and deeper dives in the evening (16:00 to 20:30) than earlier in the day, although no surveys were conducted during the night. Bowles *et al.* (1994) implied a similar pattern after recording more sperm whale acoustic activity during the day than at night however, Whitehead and Weilgart (1991) found that foraging behaviour was more common over night and during the morning than throughout the afternoon.

This range of results suggest that there may be some variation in the diurnal patterns seen in sperm whale foraging, and thus click production, around the world, but does not suggest why. One option is the differences in bathymetry between regions, as the physical boundary presented by the sea floor will almost certainly influence the whales' behaviour, including foraging behaviour. Another possibility is the variation in the predominant meteorological conditions of an area, which would influence the physical and acoustic properties of the marine environment. Notably, Knudsen *et al.* (1948) listed "water motion" as one of three main source categories in an analysis of marine ambient noise, describing it as highly dependent on weather condition. Including interrelated water- and wind-generated sources, this noise tends to increase in level with strengthening winds and rougher seas becoming an important component of ambient noise at frequencies above 100 Hz (Wenz, 1964).

It is likely that most cetaceans are affected by the sounds generated at the water surface by intense storm activity. Although there have been reports that severe weather conditions may have contributed to cetacean fatalities (Mignucci-Giannoni *et al.*, 1999), non-lethal effects of meteorological disturbances have not been previously studied due to the complications of surveying during such conditions. There have, however, been reports of sperm whales responding to other reasonably low-frequency disturbances such as ship engine noise. Such reactions include a decrease in blow interval; an increase in time spent at the surface; more frequent heading changes; a reduction in the time before click production at the beginning of a dive (Richter *et al.*, 2003); and group scattering and silence (Watkins *et al.*, 1985). However, André *et al.* (1997) reported that engine sounds at received levels of approximately 160 dB re 1µPa did not appear to have an impact on the whales' vocal or physical behaviours. Here we examine sperm whale click occurrence before, during and after a storm in the northern Gulf of Mexico.

MATERIALS AND METHODS Three autonomous hydrophone instruments - EARS buoys (see Newcomb *et al.*, 2002) - were deployed along an approximately 18km track in the northern Gulf of Mexico (approximately 28° 15' N 88° 50' W; Fig. 1) between 16th July and 1st September 2001. The hydrophone of each buoy was 50 m from the bottom resulting in depths of around 950m, 750m, and 550m (labelled EARS 1, 2 and 3 respectively). A digital sampling rate of just over 11.7kHz provided a frequency range of approximately 0 to 5.5kHz. An analogue bandpass filter and a lowpass

digital brickwall filter were used to facilitate anti-aliasing, to pre-whiten, and to generate a flat (±3 dB) response over the range 10 – 5500 Hz.

Nineteen days of recordings, centred on the Gulf-borne lifespan of Tropical Storm (TS) Barry (2nd to 6th August 2001), were selected for analysis to assess any impact that the storm may have had on the vocal behaviour of sperm whales at each of the EARS sites. Internal electronic noise and embedded time-stamps were removed from each of the nearly-6-minute-long audio files in the 1,368 hours of recordings made during this period. The acoustic analysis software package Ishmael (Mellinger, 2001) was then employed to detect clicks automatically in the acoustic data. Ishmael was configured to generate noise-equalized spectrograms and calculate an average spectral energy. After applying additional energy threshold criteria for frequencies over 2 kHz, Ishmael then detected and stored clicks in the recordings. The Ishmael output, combined with the use of the acoustic analysis package Raven (Cornell Laboratory of Ornithology, 2002), allowed anomalous sounds to be identified in the data, including pulse noises (e.g., those generated by seismic airguns) and more consistent noise (e.g., shipping noise). Furthermore, the unique multi-pulsed structure (Goold and Jones, 1995) of the clicks was periodically confirmed in order to verify that a sperm whale had produced them. Data containing no detected clicks, as well as detections generated predominantly by non-sperm whale sounds or considerable consistent noise, were removed from subsequent analyses.

The whole study period was broken down into three periods (see Table 1) based on the 2001 National Hurricane Center (NHC) advisories for TS Barry. The storm period was defined by the time of the first and last advisories (1 and 17; NHC, 2001), with pre- and post-storm periods defined accordingly. Although the EARS sites were only directly affected by TS Barry for 24 hours, this definition allows the storm period to include the effects of both increasing and decreasing wave heights. An additional "average" condition was tested by combining all the periods together, for a total of four conditions. Another factor analysed was depth, with one depth for each of the three instruments, plus an additional condition of all depths grouped together. In order to assess the effects of both instrument depth and the storm on the recorded diurnal patterns, every day was split into six 4-hour segments (00:00:00 to 03:59:59, 04:00:00 to 07:59:59, etc, GMT) to which each file was assigned by virtue of its start time. Statistical significance of differences between the various conditions was determined using Kruskal-Wallis tests to examine the null hypothesis that neither storm activity nor depth had any impact on diurnal patterns in sperm whale vocal behaviour. Only relative comparisons of click rate were made; evaluations of absolute values were not possible due to the increased noise during the storm period and the resulting masking issues (see Wright, 2003).

RESULTS Each of the 16 possible combinations of bathymetric and meteorological conditions generated diurnal patterns that were found to be significantly non-uniform ($p<0.001$). However, the patterns were not consistent with each other (Fig. 2). The average trend produced in the comparison of the entire data set (Entire Period, All Depths) indicated a tendency for sperm whales to be least vocally active around dawn, with no obvious peak in click production. Most of the other averaged patterns (e.g., at all depths for a single period, or over the whole period at one site only) reflected this trend, but the pattern generated for the entire period at 950m showed a peak in click production just after dawn. Furthermore, only one of the detailed analyses demonstrated the same pattern (After Barry, 750m), with the other combinations displaying clear peaks in click rate over night (During Barry at 750 and 950m and After Barry at 550 and 950m) or during the day (Before Barry at all depths and During Barry at 550m).

Vocal behaviour appeared to have been disrupted during Tropical Storm Barry, producing diurnal patterns in click production very unlike those beforehand (Fig. 2). The disturbance continues somewhat into the post-storm phase, with trends similar to those seen during the storm. The notable exception to this is at 950 m where the post-storm distribution closely resembles the pre-storm pattern.

CONCLUSIONS The results show that diurnal trends in click production vary considerably between the EARS sites and between meteorological conditions. Although the patterns at the 550m and 750m buoys show similarities, the diurnal behaviour recorded at the 950m buoy is completely different despite the fact that there is only 18km between EARS 1 and 3. Consequently, these differences are most likely due to the influence of bathymetry, and associated oceanographic conditions, on the behaviour of the whales. This could also explain the variety in the diurnal patterns reported from around the world.

Behaviour at the 950m buoy also appears to have been affected the most by the passing storm, displaying a pattern almost opposite to that of the pre-storm period. Interestingly, this is also the only site where post-storm diurnal patterns

resemble pre-storm trends, although there are other residual effects in the data (Wright, 2003). Such changes may indicate that the sperm whales within recording range of each buoy have altered their behaviour during the passing of the storm. However, this is unlikely as any storm-induced mixing was probably limited to the surface waters (around 200 m) and, in any case, should have simply lessened the severity of any trends in a behaviour linked to foraging as prey would have been more evenly distributed throughout the water column. It is more probable that Barry displaced the whales at the deployment sites, as well as those in other areas closer to the storm. If whales in nearby areas (i.e., EARS 1 and 2) can show such different patterns in their diurnal production of clicks, then it follows that those from further away (i.e., in the path of Barry) might also behave differently. The observed results could, consequently, be produced if the whales do not alter their behaviour, despite the change of location.

The mechanisms behind the observed affects cannot be determined from this data set. Consequently, alternative influences, while their actions may be less plausible, may be involved, demonstrating a clear need for further research in this area.

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Table 1. The three time periods, as defined using National Hurricane Center advisories (NHC 2001)

Time Period	NHC Advisory Number(s)	Start of Period		End of Period	
		Date	Time (GMT)	Date	Time (GMT)
Pre-storm	Pre-1	26-Jul-2001	00:00	2-Aug-2001	18:59:59.99
During	1, 17	2-Aug-2001	19:00	6-Aug-2001	08:59:59.99
Post-storm	Post-17	6-Aug-2001	09:00	13-Aug-2001	23:59:59.99

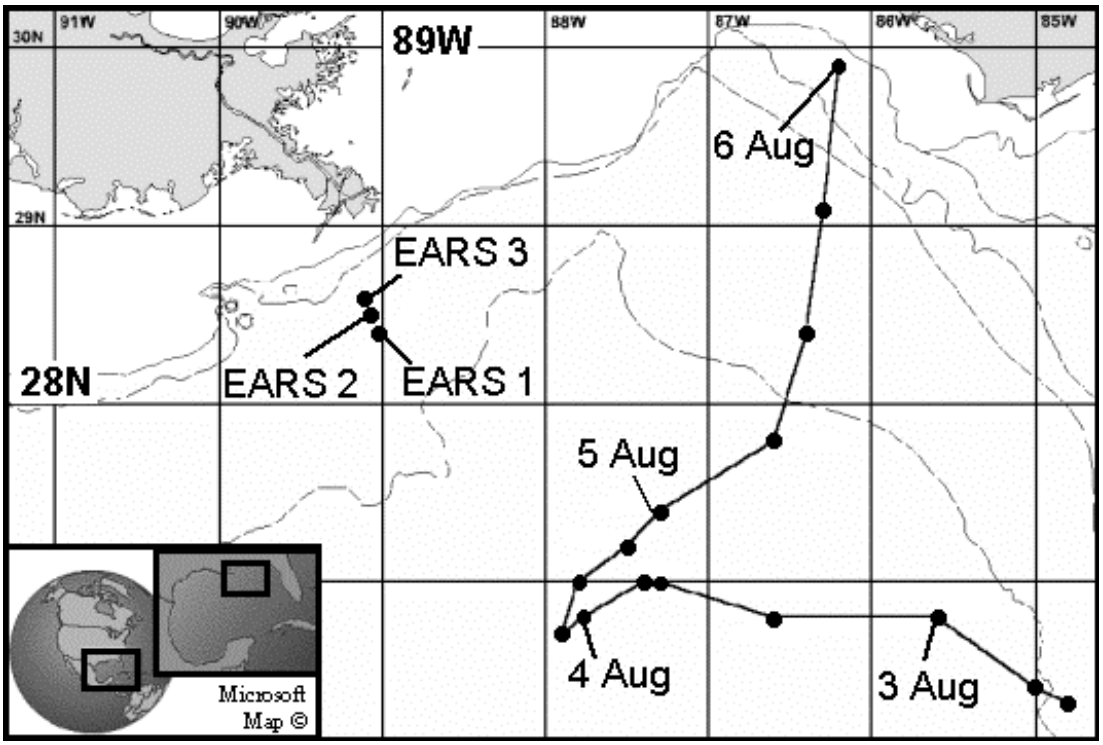

Fig. 1. Tropical Storm Barry's track and the. The instrument deployment sites in the northern Gulf of Mexico with the path of Tropical Storm Barry

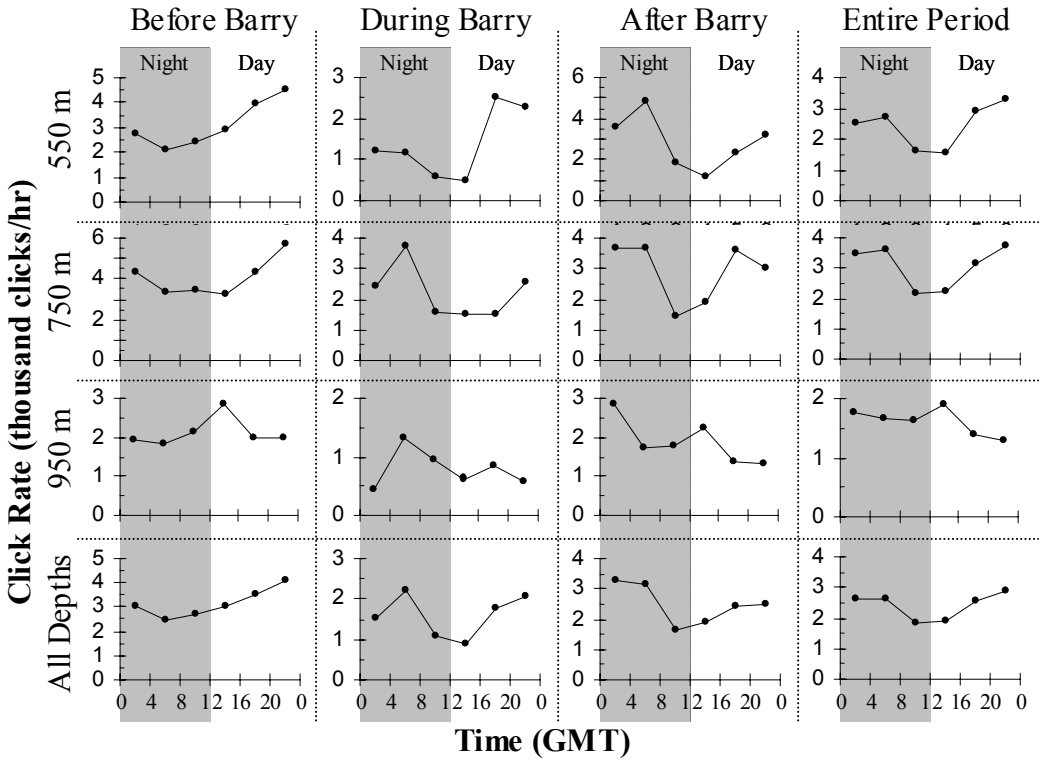

Fig. 2. Mean click rates under each set of conditions illustrating disparity in diurnal pattern. Shaded area represents approximate hours of darkness locally (local time = GMT -5 hrs). Diurnal variation for each combination of conditions is significantly non-uniform to $p<0.001$

BEHAVIOUR

SHORT- AND LONG-TERM EFFECTS OF WILDLIFE TOURISM ON INDO-PACIFIC BOTTLENOSE DOLPHINS (*TURSIOPS* SP.) IN SHARK BAY, WESTERN AUSTRALIA

L. Bejder[1], A. Samuels [2], H. Whitehead[1], J. Mann[3], R. Connor[4], and M. Heithaus[5]

[1] *Biology Department, Dalhousie University, Halifax, Nova Scotia, B3H 4J1 Canada*
[2]*Department of Conservation Biology, Chicago Zoological Society, Brookfield IL 60513 USA, & Biology Department, Woods Hole Oceanographic Institution, Woods Hole MA 02543 USA*
[3]*Department of Biology, Georgetown University, Washington, DC 20057-1229, USA*
[4]*BiologyDepartment, University of Massachusetts, Dartmouth, Dartmouth, MA, 02747, USA*
[5]*Department of Biological Sciences, Florida International University, Miami, FL, USA*

The long-term nature of research on resident bottlenose dolphins in Shark Bay, Australia, provided favorable conditions for assessing short- and long-term effects of vessel-based tourism on target animals. To evaluate short-term responses, experimental vessel approaches to dolphin groups were conducted at an "impact" site where dolphin tourism has been on-going since 1993, and at a "control" site where dolphins seldom encounter vessels. Before, during and after approaches (n=78), group behaviour was recorded from land-based theodolite stations. Records of dolphin identities for each experiment documented complete segregation of individuals between sites. Canonical variate analyses showed that approaches elicited significant behavioural changes at both sites. During approaches, groups had greater cohesion, higher rates of change in membership, and less consistent speeds and headings. Responses were stronger and longer lasting at the control site. To evaluate long-term effects, habitat use within the impact region was compared between 1994-98 *vs* 1998-2002 (one *vs* two tourism operators), based on ~7000 dolphin group encounters. A nonlinear logistic model, including a term for changes in dolphin abundance over time, related total numbers of identified individuals within each of 144 500m^2 grid cells to numbers of surveys conducted per cell. The model was fitted using least squares; parametre estimate confidence was estimated by boot-strapping on cells; and logistic curves were fitted for each time period. Results indicated an average 9.6% (95% CI = 1.74-14.6%) reduction in dolphins per cell during the period of more tourism – an alarming result. This long-term response suggests that short-term responses at the impact site are unlikely a result of habituation to vessel activity. Instead, a segregation of individuals may have occurred over time, precluding sensitive animals from the disturbance area. Absence of a long-term perspective undermines management efforts when moderated short-term responses to anthropogenic stimuli are erroneously interpreted as positive outcomes for targeted wildlife.

SEA OTTERS AND INTERACTIONS WITH RECREATIONAL ACTIVITIES: IS THERE EVIDENCE OF CHRONIC STRESS IN SEA OTTERS?

D. M Benham[1], T. Sinclair[1], S. Collins[1], and M. Staedler[2]

[1] *Nottingham University, University Park, Nottingham NG7 2RD, England*
[2] *Sea Otter research and Conservation group, Monterey Bay Aquarium, Cannery Row, Monterey, CA. USA.*

Wildlife tourism (WT) is a fast growing industry often relying on fragile habitats and species. Though WT has positive impacts, e.g. encouraging conservation and environmental education, it can also damage the natural resources it relies upon. This research focuses on interactions between the threatened southern sea otter and recreational vessels in the Monterey National Marine Sanctuary (MBNMS), an area popular for marine recreational activities. This sea otter population has been slow to recover and suffers from high mortality rates due to infectious disease, contamination and fisheries interactions among others. Interactions with recreational vessels may be causing chronic stress to sea otters, a condition causing changes in behaviour, immune system suppression and cardiovascular damage in other species which could increase sea otters susceptibility to the aforementioned pressures. This research aims to determine if disturbance from recreational vessels is causing significant changes in sea otter behavioural time budgeting indicative of chronic stress and to improve management of WT/sea otter interactions. Data has been collected for two years between June-September at several study sites in the MBNMS using scan sampling, focal otter observations and radio tracking – over 500 hours of observations have been made. Analysis has shown that two factors (head on approaches and noisy/excited behaviour) out of ten investigated (including number, orientation and speed of boats) predict over 70% of the disturbances recorded. Sea otters in sites with high levels of boat traffic spend significantly more time exhibiting alert behaviours indicating an aroused state associated with chronic stress. These results and collaboration with local stakeholders have led to the development of a 'wildlife watchers card' for recreational boats, displaying images of alert behaviours and viewing guidelines, which it is hoped will lead to an immediate reduction in disturbance events.

PREY DETECTION IN EXPERIMENTAL FISH TRAPS BY HARBOUR SEALS (*PHOCA VITULINA*)

P. Brembeck[1], A. Fjälling[1], and M. Hultgren[1]

Swedish National Board of Fisheries, Ekelundsgatan 1, S-401 26 Göteborg, Sweden
(arne.fjalling@fiskeriverket.se)

INTRODUCTION There has long been a conflict between seals and fisheries in the Swedish coastal waters. Seals cause economical loss due to damage to catch and fishing gear and through competition for the resource, although the latter is of minor importance. Furthermore, there are indirect losses caused by a changed fishing strategy. The gears have to be examined more frequently and the presence of seals may frighten fish away from the area. Static gears – traps, gillnets and fykes – are the most exposed gears. In 1997, the direct economical losses were estimated to be in the range of 11-33 million SEK (Westerberg, Fjälling & Martinsson, 2000). The seals, on the other hand, get caught and drown in the fishing gears.

The most important step towards a solution of the conflict is to modify the existing fishing gears and to develop new fishing methods. An example of this strategy is the production of a new fish chamber and other modifications of salmon traps, which deprive the seal of a reward. This has had a long-term mitigation effect and has changed the local fishery in the north Baltic. However, it has not proved to be equally efficient for all fish species; whitefish, for example, pass through the large meshes in the gear (Lunneryd, 2001). Studies with a scaring device have shown that the only category of acoustic scaring devices that seem to work over time are the so called Acoustic Harassment Device (AHD), which produces signals strong enough to induce pain and discomfort when the seal come too close. But long time trials have shown that this method is only applicable for very few restricted fishing methods (Sven-Gunnar Lunneryd, pers. comm.). It is of great importance to learn more about which prime senses seals use during prey detection at static gears. Knowledge of this kind is likely to enhance the development of seal-safe gears or efficient deterrent actions which would favour both seals and fisheries.

MATERIALS AND METHODS The experiments were conducted on four captive harbour seals, one male and three females, at the Fjord and Belt Centre (FBC) in Kerteminde, Denmark, during April-May 2002. The seals were kept in an outdoor enclosure with an underwater tunnel, above the tunnel there is a bridge for visitors.

Cubic boxes with openings measuring 500x500mm were constructed from extruded aluminium profiles with connecting corners of zinc and were fitted with side panels. The top and bottom panels were made of sheets of foamed PVC Expohard, 515x515x10mm. The pores in the material at the sawed edges were sealed by PVC glue. These panels were covered on the inside with a 10mm thick soft foam PE plastic to improve sound insulation. The front side of the box, through which it was possible for the seals to inspect the inside of the box, had an opening of 400x400mm. This opening had a curtain made from 10mm thick and 120mm wide slits of neoprene in two layers to ensure both visual and acoustic blocking. The curtain was fastened to the lower inside edge of the opening, taking advantage of the buoyancy of the material and the direction of the entering animals. The side of the box facing the observer in the tunnel was made of standard float glass, 510x510x4mm. A well stretched, seal-proof Dynema net with meshes of 20x20mm was permanently placed 20 mm inside the side panels during all trials to prevent the fish from escaping and also the fish from creating noise when bumping into the sides. The left and right side panels of the box, acting as the sensory interface to the seals, were replaceable. According to a semi-randomised treatment schedule, sheets of thin transparent plastic, black plastic and/or standard float glass, 2x4x510x510mm with an air space in between (to provide acoustic insulation), were placed on the sides of the box, in order to block the different sense. A PVC plastic tube, 70mm in diametre and 3m long, wrapped with 10mm foamed PE for sound insulation was attached to the top panel of the box to allow live fish to be released into the box from the bridge. A fish loading device was constructed from two PVC discs held 300mm apart by a rod, in-between which the fish was placed. To be able to let fish down into the box without giving cues to the seals by the presence of the experimenters on the bridge, a 20m long fishing line was attached to the loading device. This made it possible to release the fish from a distance. A number of diver's weights were attached under the boxes to compensate for the buoyancy of the foamed plastic materials.

All on-line observations and video recordings were made from the tunnel. Two cameras (Ikegami, one suited with a Cosmican/Pentax 3.7mm 1:1.6 TV lens and the other with a Cosmican/Pentax 4.2mm 1:1.6 lens) were placed in front of

the underwater windows with the suspended fish boxes. The cameras were connected to a video splitter (Color Quad Processor) that mixed the video signal from these two cameras with the one from a surveillance camera overlooking the seal enclosure, and displayed these in quadrants on the TV monitor (Panasonic). Another monitor (Grundig) showed a close-up of the box in which the fish were to be released. A VITC time code generator (ACE box^{tm} 8/18/28 standalone LTC/VITC generator) was connected between the camera and the VCR. One video recorder (Video JVC, A2/nicam digital stereo) recorded the split images and another video (Hitachi, VT-L11 00 ER) recorded close-up. During the dark hour trials IR-lights were placed in front of the underwater windows to light up the inside of the boxes.

The seals were allowed to get accustomed to the boxes for six days. During this period the boxes had their basic sidewall interface, i.e. nets only. The first day the right side box, without any fish, was lowered into the water. The second day the same box was left in the water for the whole day and two fishes were released. The third day the seals were taught to take fish from the box by lowering the neoprene curtain of the right box manually and releasing fish. The fourth day both the left and the right box were deployed, the fifth day only the left box and the sixth day both boxes were deployed. Fishes were released and taken by seals in both boxes. All the seals explored the boxes during this acclimatisation stage.

During each trial, the two boxes were placed in front of separate windows in the tunnel, 10m apart. Both boxes had the same sidewall interface. Fish were released randomly in one of the boxes. The order of treatments, i.e. the type of sidewall interface, was decided by random between blocks of trials (Table 1). Each series of trials lasted for six days and contained treatment 1 – 6. The trials were conducted in blocks of two; one day sidewall interface allowed the seals to use a specific sense (control) and the day before or after, that sense was blocked (test). All experiments were performed after 5.00p.m., when the facility was closed to the public.

During the trials, one person was responsible for making observations and managing the recording gear in the tunnel and whilst another loaded fish into the loading device from the bridge. The time intervals between fish being released into the boxes were a minimum of 20 minutes after the seals caught the previous fish. During loading, both loading devices were pulled up and lowered simultaneously, although fish was only placed in one of them. The loading devices were first lowered to a level just above the roof of the boxes and then halted. Seals probably could hear this process. The fish was then released as quietly as possible from a distance after a random time delay, so the seals would not know when it happened. Both loading devices were let down in the boxes simultaneously. The ambition was to avoid releasing the fish when seals were inside or just outside the boxes. At least once during every trial a "blind loading" was conducted to check whether the seals would explore the box every time the loading devices were operated.

The fish used in all trials were cod (*Gadus morhua*) varying in length between 150-250mm and weighing 70-160g, except for two days (7 and 8) when eelpout (*Zoarces viviparus*) were used because there was no cod available. During each trial 5 fish were released. Day 11 and 14-18 were resting days to increase motivation in the seals. The trials of the 24th day had to be cancelled. The visibility of the water was measured daily with a Secchi-disc; it was always more than 3m. Sound recording was made during one trial to measure how much sound was generated during every step of the experiment.

The recordings were analysed using the computer program Observer VideoPro 4.0 (Noldus Information Technology) with a configuration of the behavioural elements. The time between the release of a fish into the box and the moment a seal put its head into the box (T) was measured. For each day an average was calculated and at the end of the experiment a mean for every treatment over the whole series of trials was computed. Heterogeneity of variance was tested using Cochran's test. Because of significant heterogeneity, the T-values were ln-transformed before analysis of variance (ANOVA). Planned comparisons (linear contrasts) were also performed, with procedures following Underwood (1997).

Three comparisons were made due to the different treatments:

Comparison 1: Test for differences between treatment 1 and treatment 2 to evaluate effects of blocking of vision (hearing and vibrissae already blocked).

Comparison 2: Test for differences between treatment 3 and treatment 4 to evaluate effects of blocking of hearing (vision and vibrissae already blocked).

Comparison 3: Test for differences between treatment 5 and treatment 6 to evaluate effects of blocking tactile senses (vision already partly blocked, but hearing intact).

Furthermore, as a control of the experimental procedures, differences in attack rates between the two boxes expressed as the ratio the seals´ choice of left or right box at fish release, were analysed using ANOVA.

RESULTS A total of 39 hours of recordings, comprising 83 trials, were collected during 17 days of trials. The following behavioural elements - the seals putting their head into the box (head in), looking into the box through the side walls (looking), exploring the box from the sides with their vibrissae (touching), exploring the entire box using their mouth, flippers and the rest of the body except the vibrissae (exploring), pushing on the box, making it move (pushing) - were recorded and the number of times per minute they were performed per treatment calculated (Table 2).

Two of the four harbour seals, both females (Gnejs and Naya), were clearly more active with the boxes than the others. Naya explored the box most frequently, whereas Gnejs was dominant in looking into the box from outside. Gnejs and Naya explored the box from the sides with the vibrissae almost equally. Only Gnejs caught the fishes inside of the box.

Fish were released into the boxes a total of 83 times during the 17 days of trials. Gnejs put her head directly in the correct box (containing fish) 43 times (52%) and in the wrong box (containing no fish) 19 times (23%). In 21 trials (25%) Gnejs was already inside the box when the fish were released; this was calculated as a null result. No significant differences in the "correct-wrong-ratio" were observed either within or between the treatments.

In comparison 2 there was a difference in T (the lag time from the fish release to the seal putting its head inside the box) when all senses were blocked compared to when only hearing could be used ($p=0,02$): the mean T of treatment 3 was 7,0 seconds and of treatment 4 71,0 seconds (Figure 1). In comparison 1, testing the differences in T when all senses were blocked compared to when only vision was used, there was no significant difference ($p=0.09$): the average T of treatment 1 and 2 were 15,5 seconds and 118,7 seconds, respectively. In comparison 3, the mean T of treatment 5 of 27,1 seconds was not significantly different from the 40,0 seconds found in treatment 6 ($p=0.8$).

The difference in attack rates between the two boxes was significant ($p=0.05$), with a preference for the left box.

CONCLUSIONS The aim of this study was to investigate which senses (vision, hearing or touch via the vibrissae), harbour seals primarily use to detect fish inside the experimental fish traps. Our test of blocking different senses shows that both hearing and visions play an important role. In the case of hearing the result was significant (Figure 1) when comparing the lag time (T) between the release of fish and the seal putting its head into the box. The time to detect fish when hearing was blocked was significantly longer than when hearing could be used. This indicates that hearing was an important sense for prey detection and confirms Kastak and Schusterman (1998) reporting good hearing in harbour seals. There was a strong trend in the time to detect fish, taking longer time when vision was blocked compared to when vision could be used. The difference would probably have been significant unless trials had not been discontinued due to safety reasons (seals began to chew on neoprene). The comparison was then skewed, and only a sample of two days. Despite this, the result was close to significant ($p=0.09$) and the average lag time (T) clearly indicates that that vision was of major importance. An earlier study by Renouf (1989) showed that harbour seals have excellent vision and can detect prey in the very dim light at a depth of 300 metres. The test of vibrissae, touch sense, was done in darkness in an attempt to reduce vision. But since the FBC was situated in the middle of a town, with indirect light from surrounding streetlights, the vision was probably only partially blocked. The hearing could not be blocked either during the test or control of vibrissae. However, since pinnipeds have the largest and most highly developed vibrissae of all mammals (Mills & Renouf, 1986) and since harbour seals recently were found to be able to detect minute water movements (Dehnhardt *et al.*, 1998) and are able to follow a trail of a fish (Dehnhardt *et al.*, 2001) it is possible that the vibrissae also constitute a sense of importance for investigation and detection of prey at close range. For a future experiment it would be interesting to test the vibrissae in combination with effectively blocked hearing, e.g. with masking noise, and the vision blocked, e.g. by performing the test inside a completely dark compartment.

Although not the main goal of our study, a comparison of different behaviours (Table 2) indicates that the rate of the behaviour(s) depends on which sense or combination of senses the seal could use. The most frequent behaviour during the whole experimental period was to put the head inside the boxes. But when the seals were allowed to use vision they did not put their head in as frequently as when vision was blocked. This may be because they chose to look inside the

box through the glass side panels. The frequency of the seals touching the boxes with their vibrissae was higher during the trials in daylight than during the trials in darkness, which seems contradictory. The seals pushed on the boxes and made them move almost exclusively during dark hours and that behaviour was nearly not at all observed during daylight. A possible explanation for this behaviour is that the seals wanted the fish to move and expose itself.

All the seals explored the experimental fish traps before the trials started, but after the start, two of them, Gnejs and Naya, showed a markedly higher interest in the boxes, they also performed most of the individual behaviours. Gnejs was the only seal in the group that caught fish inside the boxes, which indicates that she was dominant in the group (confirmed by the FBC trainers. pers. comm. Gwyneth Shepard) or supports theories about specialist seals. This theory implies that in a group of seals, one or a few seals are the only ones that take fish from fishing gears. Although during all trials Naya was always in the vicinity of Gnejs, she never put her head inside the boxes during fish release, not even when she detected the fish before Gnejs. Gnejs put her head inside the correct box on 52% occasions, but during another 25% of the times, she was already inside the box when the fish was released. This can partly be explained by an unfortunate delay in time from remotely releasing the loading devices until the fish actually was released into the boxes. Also the fact that the loading devices produced noise may have contributed, even if the final step was done as silently as possible. Sound recordings made on day 19 showed that both the loading devices and the experimenters could be heard by the seals (Mats Amundin, pers. comm.). 23% of the time Gnejs chose the wrong box, which may be because she did not detect the fish or the fact that the fish compartment of the loading devices a few times did not enter the boxes simultaneously.

Observations indicate that seals are curious and are able to adapt to new conditions. When the interface black plastic covered the side panels of the boxes, Gnejs and Naya put their head between the window in the tunnel and the box glass in order to look inside the boxes. They could also be seen lying with their heads against the loading tube, apparently listening for any fish inside or maybe detecting possible movements from it. In the middle of the trial period it seemed like the seals lost the intense interest in the boxes and in an attempt to remedy this, day 11 and day 14 – 18 were introduced as resting days. The lack of interest could be explained by the seals having learned how the traps worked so did not bother to patrol between and explore the boxes anymore but instead waited for the sounds of the loading devices to indicate when it was worthwhile to do so.

Since this project was a pilot study, comparing the importance of three senses in harbour seal prey detection, many factors could not be controlled in advance. A common problem when working with marine mammals is the small sample sizes, and consequently the results presented here have to be treated with great care. They account only for the subjects of the study, in this case the four captive harbour seals at Fjord and Belt Centre in Kerteminde. However, they can still give us an indication about how the prey detection behaviour may work.

ACKNOWLEDGEMENTS We would like to thank Mats Amundin and Sven-Gunnar Lunneryd for all their help, support and useful comments, and to Genevieve Desportes at the FBC for taking such good care of us. Thanks also to the seal trainers and the rest of the staff at the FBC for their great patience with us; and to Inês Mello, Christer Blomqvist, Mats Lindegarth and Michael Mayntz for help with the analysis of the data.

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Table. 1. The box sidewall interfaces allow the seals to use a pre-determined number of senses at a time when detecting fish inside the boxes

Treatment	Set-up	Light cond.	Testing	Unaffected senses for the seals		
				Vision	**Hearing**	**Vibrissae**
1	Net + glass	Daylight	Vision	X	-	-
2	Net + glass + black plastic	Daylight	Vision	-	-	-
3	Net + black plastic	Daylight	Hearing	-	X	-
4	Net + glass + black plastic	Daylight	Hearing	-	-	-
5	Net	Darkness	Vibrissae	(-)	X	X
6	Net + transparent plastic	Darkness	Vibrissae	(-)	X	-

Table. 2. The number of times per minute each behaviour was performed by the four seals during each treatment. The duration of a treatment was in average 2 hours and 17 minutes

Behaviour	Unaffected vision	Blocked vision	Unaffected hearing	Blocked hearing	Unaffected vibrissae	Blocked vibrissae
Head in	0,27	0,77	0,75	0,63	0,34	0,42
Looking	2,25	0,35	0,16	0,19	0	0
Touching	0,41	0,18	0,19	0,27	0,01	0
Exploring	0,66	1,01	0,55	0,53	0,03	0,06
Pushing	0,01	0	0	0,04	0,21	0,24

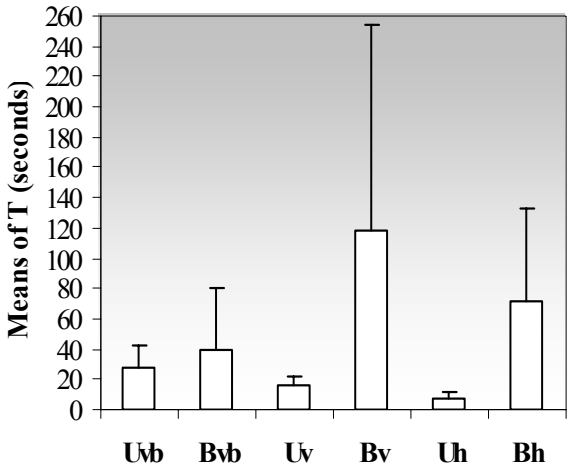

Fig. 1. The total means of T (the lag time between the fish release and the seal putting its head inside the box) calculated as an average for each day of trials and at the end of the experiment as a mean for each treatment. (Uvb = Unaffected vibrissae, Bvb = Blocked vibrissae, Uv = Unaffected vision, Bv = Blocked vision, Uh = Unaffected hearing and Bh = Blocked hearing)

BEHAVIOURAL AND HORMONAL ASPECTS OF THE SOCIAL STRUCTURE OF A GROUP OF CAPTIVE PINNIPEDS : PILOT STUDY ON THE SOUTH AFRICAN FUR SEAL *ARCTOCEPHALUS PUSILLUS PUSILLUS*

O. Brock[1], J. Sulon[2], P. Poncin[1], A. Salbany[3], G. Lacave[4], and A. Caudron[1]

[1] Behavioural Biology Unit, University of Liege, Zoology Institute, Quai Van Beneden 22, 4020 Liege, Belgium (O.Brock@student.ulg.ac.be – Abigail.Caudron@ulg.ac.be)
[2] Physiology of Reproduction, Veterinary Faculty, University of Liege, Sart Tilman Bat B41, 4000 Liege, Belgium
[3] Zoomarine Park, Aquatico S.A., Est. Nac. 125, Guia, 8200-864 Albufeira, Portugal
[4] Marine Mammal Veterinary Services, Betferkerklaan 158, 8200 Brugge, Belgium

INTRODUCTION The aim of this study was to test the compatibility of behavioural and hormonal approaches used to evaluate the social structure of animal groups; and to test in parallel, a less invasive sampling method used to measure physiological stress (salivary cortisol assay).

The behavioural and the endocrinological aspects of stress are related via the secretion of a steroid hormone: the cortisol. Stress is defined as the disruption of an individual's homeostasis generating the activation of a series of physiological and psychological responses which ultimate goal is to optimise the ability of an individual to regain homeostasis thus increasing his chances of survival (Chrousos and Gold, 1992). In mammals (and so in humans), the main physiological response to stress is the activation of the HPA axis, leading to a cortisol release in blood; it is possible to measure a peak of the free form of this hormone (or unbound form) diffusing from the plasma to the saliva (Lac, 2001). In humans, the secretion of cortisol shows a natural daily rhythm with a peak early in the morning (6 to 8 am) and a minimum at night (0 am); in addition to this diurnal variation, a series of daily pulses of secretion characterises cortisol (Fig. 1) (Kenyon, 2000).

We focused on a group of seven captive South African fur seals (*Arctocephalus pusillus pusillus*) because they are easy to observe (large size and amphibious) and to train (natural "curiosity") (Turner, 2002). The South African fur seal shows a strong sexual dimorphism (♂: 250kg for 2.50m long - ♀: 75kg for 1.50m long), an amphibious lifestyle (feeding in water and reproducing on shore) and reproduces in a flexible polygynous system (intermediate system between "harem defence" and "territory defence", Rand, 1956).

MATERIALS AND METHODS This study was conducted from February to June 2003 on two distinct groups of South African fur seals. The first group located at Paradisio Park (Ath, Belgium) allowed us to develop a behavioural approach: the second one located at Zoomarine Park (Albufeira, Portugal) allowed us to adjust a less-invasive sampling method from saliva.

Ethology section The fur seal group of Paradisio Park included six females (two juveniles and four adults) and two males (a newborn and a sub-adult). These individuals did not perform any show, nor were they trained, so that they evolved within a "natural" social structure freely interacting with each other. Moreover, the infrastructure was roomy. We therefore could develop a detailed behavioural approach including a descriptive part (ethogram) showing the individuals' behavioural repertoire and a quantitative part (time budgets and sociograms). This last part emphasized the individuals' main daily occupations, as well as the affinitive and agonistic bonds between individuals, allowing us to outline the social hierachy. We devoted more than 350 hours of observations to this approach (daily observation from 09:30 to 17:30), recording 1152 behavioural scans per individual under study (used to establish the time budgets) and 677 interaction occurrences (used to build sociograms) (scan sampling and all-occurrence sampling , Altmann, 1974).

The fur seal group of Zoomarine Park included nine males and two females (from 4 to 20 years old). All the individuals performed several daily shows and a detailed regular medical training; however, in between shows, the fur seals were kept in individual pools in order to avoid the development of a strong social hierarchy that would disturb animal's training. This separation strongly limited the potential to study interactions and the social structure adopted by this species in captivity.

Endocrinology section To measure cortisol in fur seals, we had to adapt a method allowing collection of adequate samples. It is known that, in humans, cortisol can be measured in various body fluids such as urine, blood, saliva or sweat. In this study, preliminary observations quickly led us to abandon urine sampling because fur seals urinated most of the time in the pool making any urine collection impossible. We then focused on saliva sampling, known to show many advantages compared to blood sampling: (1) it is less-invasive for the individual sampled (causing neither stress nor pain) and facilitates multiple samples collection, (2) salivary cortisol is very stable (one week at room temperature – not affected by repeated freezing and thawing) and assays are technically easier (direct and without extraction because it contains a very low concentration of contaminants), (3) there usually is a very good correlation between salivary cortisol and free plasmatic cortisol proving that salivary assay provides a reliable measurement of the biologically active form of cortisol (2 to 10 %), (4) saliva is cheaper to sample and to assay and risks of infection are smaller for the person performing the assay (Lac, 2001).

The most common saliva sampling method implies the use of cotton-based material in order to absorb saliva in the mouth of the study individual. We used dental cotton rolls (ABC Dental & Pharma: Roeko, Luna, size 2) glued on untreated woodsticks, in order to move them easily in the mouth of fur seals (mainly on the inner side of the cheeks and under the tongue). Saliva was then recovered from the wet cottons by centrifugation thanks to a double vial where the internal portion, (where cotton is squeezed) is pierced, allowing the recovery of saliva in the deeper external portion.

We used a traditional assay method for steroid hormones: the radioimmunoassay or RIA. This method is based on a reaction where an antigen (Ag) is recognised by an antibody (Ab) to form an antigen-antibody complex (Ag-Ab) which can be precipitated. RIA uses the competition between molecules of the antigen that we seek to measure (Ag° = cortisol of the sample) and radioactively labelled molecules of this antigen that we add in known quantity during the assay (Ag* = labelled cortisol). This technique is sensitive (10 pg/vial), specific (high specific activity of antiserum and tracer), reproducible and allows small sample volumes (50 µl X duplicates) (Chard, 1995).

RESULTS AND DISCUSSIONS Ethology section Before looking into the distribution of the interactions within the group (sociograms) or establishing the percentage of time spent on each activity (time budgets), we described in detail these interactions and activities by completing and correcting an ethogram already established for this species (Caudron, 1995). We focused on maintenance (non-social) behaviours such as swimming, floating, self-grooming, resting, and on social interactions such as nuzzling, biting, bumping, escaping etc and finally on playing. The limitations of our observations are obvious, the five month study was based soley one mono-male group of seven captive fur seals, however it is nevertheless representative of the social activity and maintenance of such a captive group of South African fur seals. Compared to the natural behaviour of this species in the wild, artefacts introduced by captivity (restricted number of individuals, limited vital space) can result in the disappearance or outbreak of particular behaviours. We noted the lack of territorial behaviours and the presence of stereotypes in our study group.

One of the basic quantitative tools to describe the behaviour of an animal is its time budget, i.e. the percentage of time spent on various activities. We performed a detailed time budget for the eight individuals studied using the following behavioural categories: normal swimming, stereotyped swimming, floating, locomotion out of the water, self-grooming, resting, feeding and playing (Fig. 2). These data show that: (1) the main activity in juveniles (n=2304 scans for 2 individuals) was normal swimminig (about 28% of observation time) whereas adults (n = 4608 scans for 4 individuals) spent much more time floating (about 25% of observation time); (2) the proportion of inactivity is comparable in adults and juveniles (about 24% of observation time); (3) the rate of stereotypy is much higher in adults (about 16% of observation time) whereas the proportion of time spent playing is more important in juveniles (about 12% of observation time). Within these general time budgets, we can stress variations by comparing, for example, the time budget in an adult female twelve years apart (Fig. 3). These data show a very clear decrease in the time spent swimming as well as a strong increase in the amount of time spent floating and resting. It thus seems that when a fur seal ages, its activity decreases while its passive behaviours increase.

It is commonly suggested that individuals of a group do not interact at random. In order to test the assumption of hierarchical existence within the group, we looked for particular relationships between the individuals studied. We classified the social interactions observed (n=677) in three main categories: (1) aggressive agonistic interactions (biting, bumping etc.); (2) submissive agonistic interactions (running away etc.); (3) play and greeting interactions (nuzzling, sniffing etc.). The three sociograms built using these interaction categories give a realistic representation of the hierachy within this group but they are difficult to interpret because of the number of links between individuals; we can simplify

this structure as a linear hierarchy between females. This data proves to be useful in the management of the group, notably the idenitification of sub-groups of individuals to isolate in quarantine or to help organise feeding sessions with a minimum of risk of aggressiveness from the animals.

Endocrinology section The development of a saliva sampling method in order to assay a stress hormone allowed us to collect a total of 140 samples. Nevertheless, the main difficulty was to get enough saliva on the cotton. From the 44 samples collected at Paradisio Park, only four contained enough saliva to be assayed after centrifugation of the cotton (percentage of success of the sampling method was only 9% for the first attempt of saliva sampling in untrained captive fur seals). On the other hand, by repeating these tests in fur seals of the same species but regularly trained for medical purpose (Zoomarine Park), we managed to collect 96 samples, of which 51 could be assayed, within a few days (percentage of success of 53%). From measurable samples (cotton soaked with enough saliva), we tested a few parametres: (1) the effect of the sampling matrix (cotton vs latex); (2) the correlation between salivary and plasmatic cortisol; (3) the variation of cortisol concentration over the day. Cotton proved to be a more reliable collection support than latex, this last one (Swanfoam padding, Cuxson Gerrard) containing a contaminating component (probably a form of soap). Unfortunately, the reduced number of paired plasma/saliva samples does not allow us to draw conclusions. This is mainly due to the limited success of blood sampling; the only type of blood sample relevant in the frame of this study is non-invasive, i.e. collected thanks to a medical training allowing a voluntary presentation of the fur seal and thus with a minimum sampling stress for the animal, followed up by a saliva sampling within the next three minutes. Lastly, we performed a serial sampling (n=9 samples) from 9am to 6pm in a non-castrated adult male fur seal at Zoomarine Park (11 years old, 235kg) (Fig. 4). We observe a progressive decrease in the saliva cortisol concentration over the day; this seems to suggest that these mammals also show a natural daily cycle of cortisol. Recent studies offer the first plasmatic cortisol values in others marine mammals (*Phoca vitulina*, *Tursiops aduncus* and *Orcinus orca*) that confirm a diurnal cycle of cortisol similar to the one in man (Oki and Atkinson, 2004; Suzuki and Aida, 2003).

Within the time frame of this project, we did not have the opportunity to perfect the development of the saliva sampling method. Several problems need to be solved if we want to offer this method as a tool to evaluate the well-being of captive pinnipeds. The most obvious are: (1) the cooperation of the study animal requires the necessity of a behavioural conditionning program and a meticulous medical training, (2) the amount of saliva collected shows the need to soak the collecting support as much as possible, (3) the potential evaporation of samples suggests a need to centrifuge the collection support as soon as possible after collection and to store the collected fluid in air-tight vials to avoid any desiccation. In spite of these problems, we managed to show a progressive decrease in the saliva cortisol concentration over the day in a fur seal and the values obtained range between 0.1 and 3.89ng of free cortisol/ml of saliva; these values are very close to those usually measured in humans (from 0.1 to 8.0 ng/ml). However, due to the lack of training at Paradisio Park and lack of correlated samples, we did not manage to relate specific behaviours to physiological stress levels; we could have assayed cortisol in: (1) juveniles and adults in order to see if stereotypies corresponded to high cortisol concentrations or if passive behaviours corresponded to low cortisol concentrations; (2) dominant/subordinate individuals in order to understand which social status was the most stressful for the animal.

CONCLUSIONS The ethology section highlights that our study group is socially well-balanced thanks to a diversified behavioural repertoire (in agreement with the previous studies on this species in captivity and with its behaviour in the wild) and to the high number of social interactions, in particular successful elements of reproduction (Brock, 2003, not presented here). It also highlights the main occupations of a captive South African fur seal: swimming, floating and resting.

The endocrinology section allows us to submit the first values of cortisol concentration in the saliva of a pinniped. We tested the possibility of using otariid saliva as a fluid in which to assay a stress hormone while developing a less-invasive sampling method; this procedure proved to be fruitful as we managed to assay cortisol in each salivary sample of a sufficient volume. The concentrations we measured suggest a range of values comparable to those in humans, moreover, the concentration of salivary cortisol we followed in one otariid shows a decrease over the day, suggesting a diurnal profile comparable to the one observed in humans.

Our saliva sampling method obviously has to be improved however it offers potential for endocrinology analyses performed in the frame of the behavioural studies requiring minimal disturbance of animals, in particular when studying stress. This potential extends from fundamental research allowing a better understanding of the animals' behaviours by

measuring their hormonal responses using methods that are compatible with ethology to the applied field of medical husbandry of captive (marine) mammals.

Prospects This study is followed up by a second project aimed at evaluating the effects of the enrichment of captive conditions in pinnipeds; we would like to define environmental stimuli bringing an optimal psychological and physiological well-being to the animals. To do this, we want to optimise and apply the less-invasive sampling method tested above, in order to collect hormonal data (cortisol) to relate to behavioural data. Our aim is to establish and validate a framework of reference values about: (1) the natural daily cycle of cortisol,; (2) the comparison between males and females; (3) the comparison between various species of otariids; (4) the correlation between salivary and plasmatic cortisol; (5) potentially stressing events such as shows or isolations in quarantine, as a reliable basis before testing the effects of captivity enrichment on the mean level of stress in pinnipeds.

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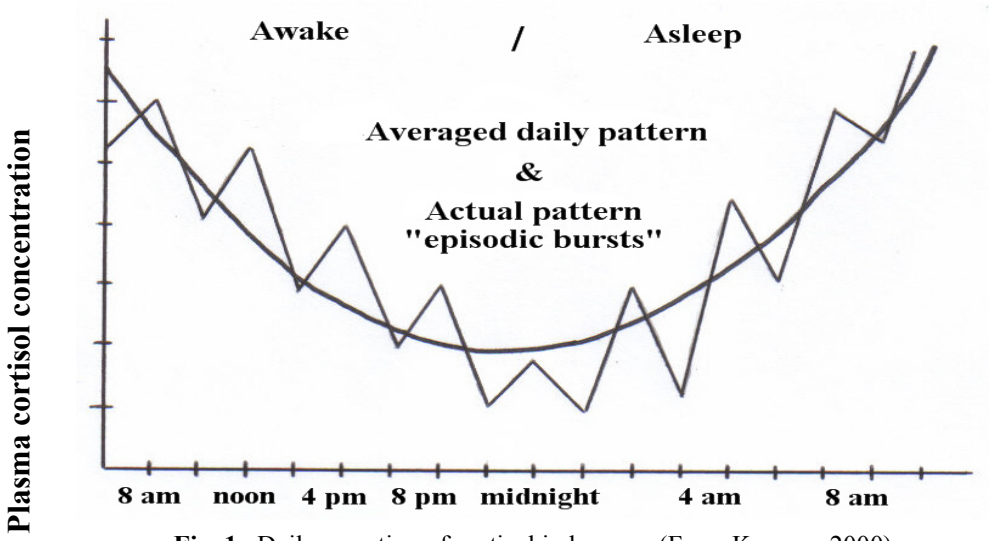


Fig. 1. Daily secretion of cortisol in humans (From Kenyon, 2000)

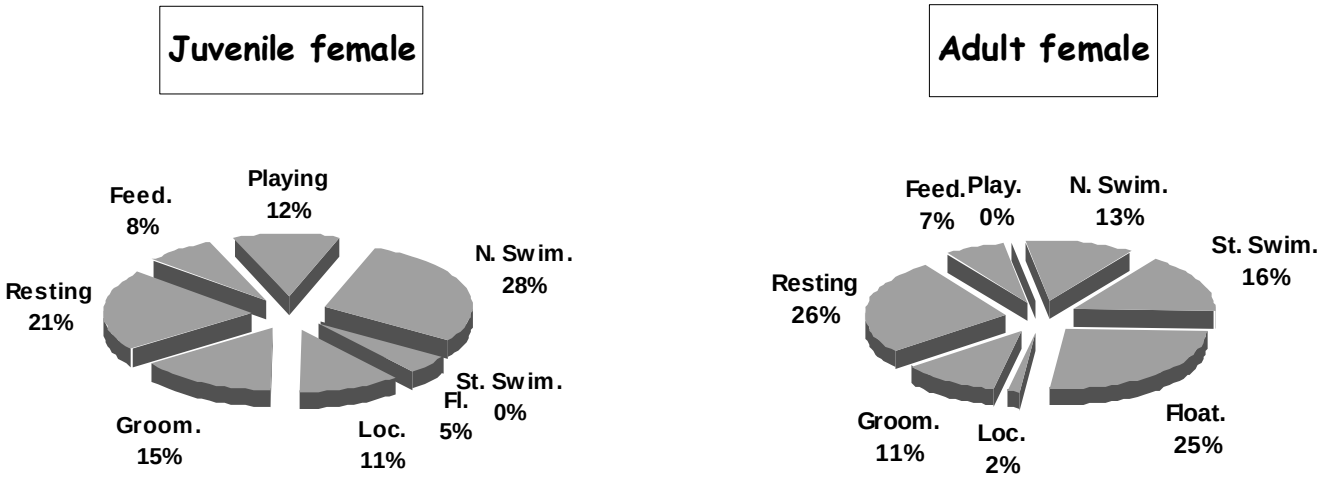
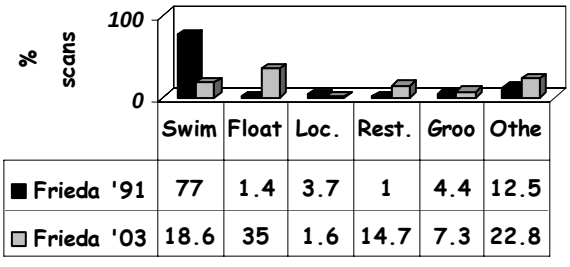


Fig. 2. Comparison of time budgets between a juvenile female and an adult female South African fur seal in captivity (n = 180 hours of observation). Behaviours are normal swimming, stereotyped swimming, floating, locomotion out of the water, self-grooming, resting, feeding and playing



	Swim	Float	Loc.	Rest.	Groo	Othe
Frieda '91	77	1.4	3.7	1	4.4	12.5
Frieda '03	18.6	35	1.6	14.7	7.3	22.8

Fig. 3. Comparison of time budgets in an adult female South African fur seal twelve years apart (1991, n = 389 scans – 2003, n = 1152 scans)

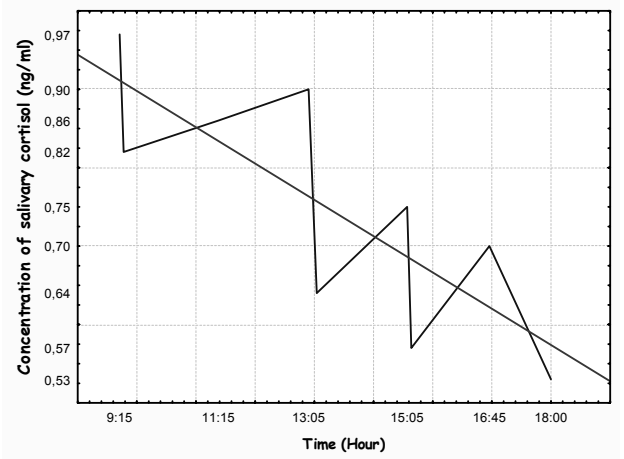


Fig. 4. Variation of salivary cortisol concentration over the day in an adult male South African fur seal in captivity

STUDY OF THE POSSIBLE SPECIALISATION OF HERDS OF *TURSIOPS TRUNCATUS* IN THE PREDATION OF DIFFERENT FISHERIES

J. M. Brotons and A. M. Grau

Direcció General de Pesca, Govern Balear, Foners 10, 07006, Palma de Mallorca. Spain
(jmbrotons@dgpesca.caib.es)

INTRODUCTION The existence of interactions and conflicts between different populations of bottlenose dolphin (*Tursiops truncatus*) and fishing activities is well documented around the Mediterranean Sea (Duguy *et al*., 1983; Consiglio *et al*., 1992; Bearzi *et al*., 1992; Pascucci *et al*., 2002; Casale, 2002). In the Balearic Islands, this interaction has been known for many years (Silvani *et al*., 1992; Prats, 1997). The "European Union" and the "Direcció General de Pesca" supported a project to study this problem between the years 2000-2003. Its main goal was to evaluate the real interaction by means of continued control of fishing boats, the recognition of different herds of dolphins by photo identification, the analysis of the strandings and the interviews to the fishermen. Results derived from this project suggested the possibility that different herds of dolphins specialised in the predation of different fisheries (Brotons and Grau, 2003). In order to respond this and other questions the "DIrecció General de Pesca" began a project in September 2003. This study is structured in 4 parts: 1) photo-identification of the different groups of dolphins and the analysis of behaviour patterns related to the fishing practice, 2) bisotope analysis, 3) banalysis of stomachs contents, and 4) monitoring of the fishing activities. In this proceeding, the first collected data of points 1) and 4) take shelter and analyse.

MATERIAL AND METHODS **Study Area** for the monitoring of the interactions between fishermen and dolphins an area of approximately 1.250 km^2 in the SW of the Majorca Island has been delimited (Figure 1). The presence of dolphins in the zone is well documented. The area includes a high variability of types of bottom, slope and bathymetry. The brotherhood of the "Port d'Andratx" (in the centre of this area) is an important nucleus of fishing activities (industrial and artisanal). Their boats use a great variety of fishing gears: bottom trawl net, longline, purse seine, gillnet, trammel net, pound net.

Boat surveys Every five months standardised surveys have been made. Surveys were conducted in Beaufort sea-states 3 or lower, at a steady speed of 12 knots Studies were not conducted on consecutive days. A constant lookout for dolphins was maintained. All the itinerary is registered by means of a GPS map (Garmin map 76S). All data referring to fishing was also registered (presence of boats or fishing gear, types...). Once sighted, schools of dolphins were pursued until the exhaustion of fuel or a deterioration in the weather occurred. The pursuit of dolphins was also abandoned if sight of the animals was lost for more than 10 minutes. During each encounter, data referring to the behaviour of the dolphins was recorded and photographs of all members of the school were taken where possible.

Photographic Identifications Photo-identification of bottlenose dolphins relies on matching marks and nicks on their dorsal fins and flanks. A digital reflex auto-focus camera (Canon EOS D10) with a Canon 75-300 mm (f 4-5.6) telephoto auto-stabilising zoom lens was used. The use of the digital technology has facilitated the analysis process of dorsal fin images (sorting, matching and cataloguing)

Associations The strength of the behavioural relationships was represented using the simple ratio association index. To illustrate the association patterns of the dolphins sighted, average-linked cluster analyses were constructed.

RESULTS Due to the delay in the delivery of the boat, at the moment it has only had the data of four standard surveys and six preliminary. In total, 51.86 hours of survey were made in 10 different days. Bottlenose dolphins were encountered on eight occasions, totalling 30.7 observations hours. Group-size estimates of 8 (SD=4, range=4-12, median=10, n=8) were recorded. With the reduced dataset, it is premature to carry out exhaustive analysis. Nevertheless, this first approach suggests very interesting findings. According to the cluster diagram (Figure 2) the 16 identified individuals (100% of animals sighted) associate clearly in two independents groups ("a" and "b"). In 78% (9,438 hours) of the 12.1 hours of monitoring of group "b", predation of bottom trawl boats was observed. The rest of the time was spent in displacement. During the 18.6 hours of monitoring group "a", predation on fishing gears was not observed. Graphically, the relation between trawl net and group "b" can be observed in Figures 3a and 4. The squares of greater fishing effort (dark grey in Figure 3), agree with those of greater presence of group "b" (dark grey in Figure 4). The data

seems to indicate the specialisation of group "b" in the parasitation of trawling boats. Nevertheless, group "a" does not present the same behaviour although both groups share the same zone.

CONCLUSIONS Firstly, the data required to make solid these conclusions are few. It is hoped that continued monitoring will strengthen conclusions drawn from the initial observations recorded. Early indications suggest the existence of groups of dolphins specialised in taking advantage of the trawling boats, while other groups within the same zone do not share this behaviour. This fact raises new questions: what is the degree of isolation between groups? How do the different groups respond to fishing variables (changes in fishing schedules (e.g. holidays, Saturdays and Sundays), changes of fishing gears, changes of target species...)? Answers to these questions may expose new solutions to the problems associated with interactions between fishermen and dolphins.

ACKNOWLEDGEMENTS Many people have collaborated in one form or another during this project, we thank them all. Special thanks to Lluis, Carolina, Eugenio, Cristina, David, Toni, Jaume, Sara... for boardings and their data; To Gloria Fernandez for her contribution to the strandings data; to Pep Coll for the commentaries on statistics; To Alvaro and Mikelet for essential aid with the English text; To those collaborating with the fishermen during the project; To Eduardo and the Cabàs Vell for afternoons of relaxation; To Atila and family at home, without their support and understanding of the vast number of hours at sea this research would not have been possible.

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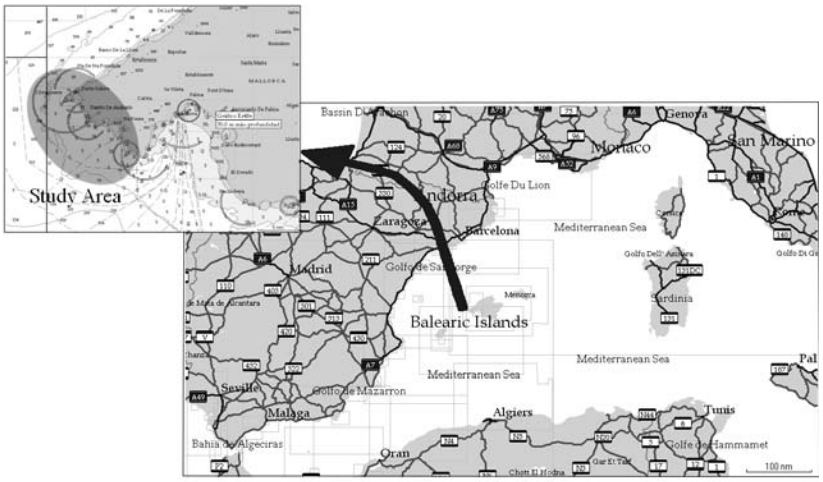

Fig. 1, Study Area

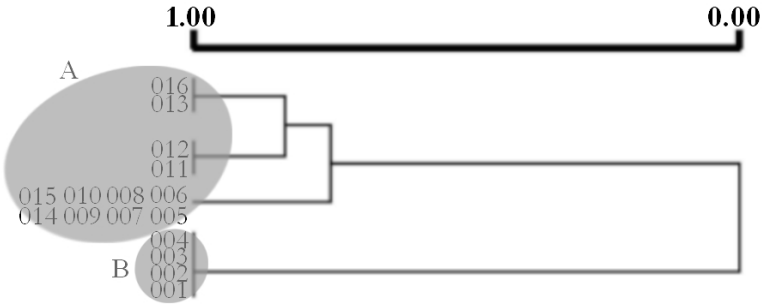

Fig. 2. Cluster analysis of associations

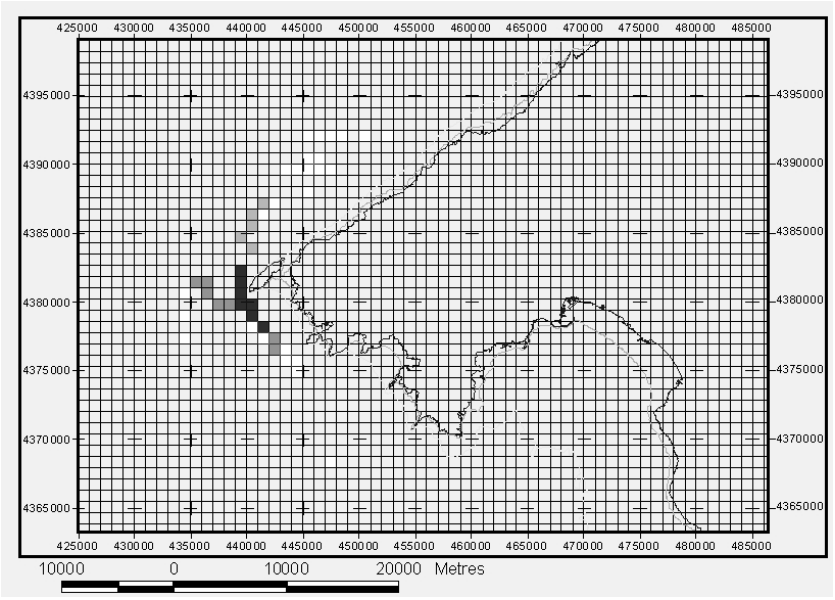

Fig. 3. Presence of trawls

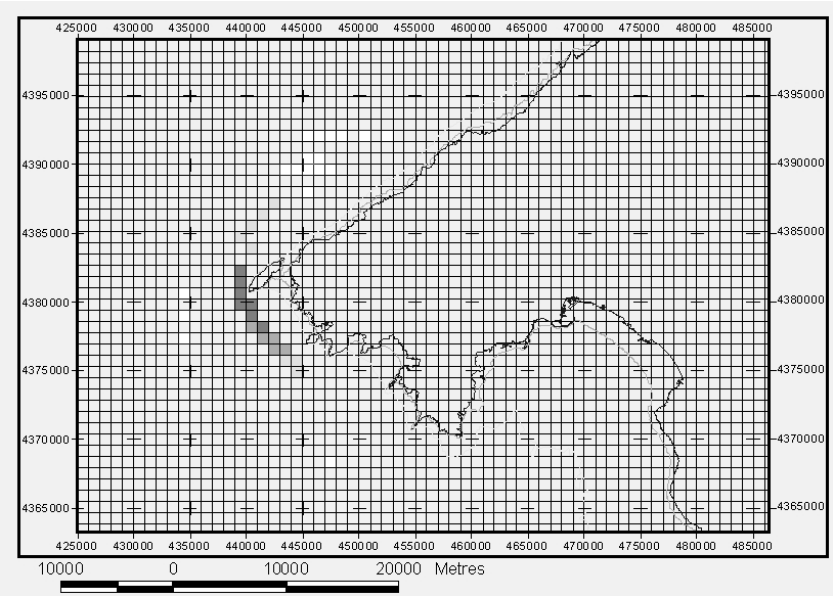

Fig. 4. Presence of "group b"

ARE HARBOUR PORPOISE TEMPORALLY SEGREGATED FROM BOTTLENOSE DOLPHINS AT ABERDEEN HARBOUR, SCOTLAND?

S. J. Canning, P. G. H. Evans, K. A. Stockin, and G. J. Pierce

[1] *School of Biological Science (Zoology), University of Aberdeen, Tillydrone Avenue, Aberdeen, AB24 2TZ, UK*
[2] *Sea Watch Foundation, 11 Jersey Road, Oxford, OX4 4RT, UK*

Harbour porpoise and bottlenose dolphins are known to frequent the area around Aberdeen on the northeast coast of Scotland (UK), but information on how they interact is limited. Within the Moray Firth, bottlenose dolphins are known to behave aggressively towards harbour porpoises, and more recent observations have suggested that the same may be happening around Aberdeen. Land-based surveys of Aberdeen Harbour were carried out between November 2002 and November 2003. The area was scanned every 15 minutes for presence of either species, along with information on sea state and visibility. Data for sea states above 4 were not included. A total of 234 hours of data was collected. During this period there were 82 sightings of bottlenose dolphins and 19 for harbour porpoise. Both species appear to feed in the area (based on observations of milling and chasing fish). Bottlenose dolphins were seen during every month of the year, with a peak in October, while harbour porpoise were seen in only six months, with most sightings between April and June. The co-occurrence of both species was analysed at different temporal scales, from monthly to individual scans. Harbour porpoises were never recorded during the same scan and only once during the same hour as bottlenose dolphins. Of the 8 weeks in which harbour porpoises were sighted, bottlenose dolphins were also seen during six of those weeks. Thus there is some evidence of fine-scale temporal segregation, perhaps indicating that porpoises normally avoid feeding in the harbour area when dolphins are present.

ENCOUNTER WITH A SCHOOL OF PYGMY KILLER WHALES (*FERESA ATTENUATA*) IN THE SOUTHEAST TROPICAL PACIFIC

C. Castro

Pacific Whale Foundation, Asunción y América 534, 4to. Piso. Edificio Cajiao, Quito – Ecuador. www.pacificwhale.org.

On September 1st, 2003, a school of approximately 70 pygmy killer whales of several sizes (lengths varying from approximately. 1 to 2.5m) was sighted. The sighting was made around the La Plata Island (17M 0500149, UTM 9851624) at a depth of about 40m. The school of dolphins was traveling at a speed of around 30 km/hour. Although so far acrobatic behaviours have not been described in this species, for the duration of the observation the animals were frequently observed leaping with their whole body outside of the water as they travelled. Within the school, individuals of approximately one metre in length were observed, which were probably calves. These calves did not come close to the boat. During the first minutes of the observation some adult dolphins approached and swam parallel to the boat. After approximately ten minutes, the individuals started to bow ride the waves in the front of the boat, frequently changing position between the sides of the boat and the back of the boat to then again stay in the bow wave. We were able to observe that the individuals were staying close together in the bow area and the sounds they produced were audible above the water. The length of the whistles was around 5 seconds. The species was observed at a close distance (2nm) from the Isla de la Plata and about 18 nm from the continental coast of Ecuador at a depth of about 40m. The marine area around the Isla de La Plata, is an area of reproduction and calving for humpback. One could infer that the presence of the large group of pygmy killer whales in this shallow coastal area was caused by the presence of humpback whale calves as potential prey.

THE SOCIALITY OF BOTTLENOSE DOLPHINS IN THE OUTER SOUTHERN MORAY FIRTH, NE SCOTLAND: IMPLICATIONS FOR CURRENT MANAGEMENT PROPOSALS?

S. M. Eisfeld[1,2] and K. P. Robinson[1]

[1] *Cetacean Research (& Rescue) Unit, P.O. Box 11307, Banff, AB45 3WB, Scotland, UK*
[2] *School of Biological Sciences, University of Wales, Bangor, LL57 2UW, Wales, UK (pine@nexgo.de)*

INTRODUCTION Ascertaining group composition and the affiliation of individual animals within a dolphin population are prerequisites fundamental to our understanding of the social structure and behaviour of these long-lived mammals. The general procedure to convert long-term photographic identification databases into models of social structure is to define and calculate association indices between all pairs of identified animals that together make up an association matrix (Cairns & Schwager, 1987; Ginsberg & Young, 1992). Utilising methodologies such as cluster analyses or sociograms, the association matrices for a particular dataset can be displayed. In order to test for preferred companionships, permutations of association measures can further be used (Whitehead, 1999a).

Since 1989, studies of individually identifiable bottlenose dolphins (*Tursiops truncatus*) using the inner Moray Firth in NE Scotland (57º40´N, 3º30´W) have examined the size, distribution and health of this population (Hammond & Thompson, 1991; Wilson, 1995; Wilson & Thompson, 1996; Wilson *et al.*, 1997), and the environmental threats it faces (Curran *et al.*, 1995). As one of just two known populations of bottlenoses in British waters and the only population in the North Sea, the Moray Firth animals have both national and international importance. Currently estimated at 129 individuals (Wilson *et al*., 1999), the small size and isolated position of this population makes it undoubtedly vulnerable to extinction. In this respect, a greater understanding of the social formation and ecology of the bottlenoses known to use the coastline of the outer southern Moray Firth is considered particularly relevant to the development of conservation policies for their protection.

Using original data collection and an established bottlenose dolphin identification database, the principle objectives of this study aimed: (i) to determine the group size and composition of bottlenose dolphins frequenting the coastline of the southern outer Moray Firth; (ii) to calculate and define the association indices between pairs of identified animals; (iii) to evaluate and interpret patterns of affiliation between individual dolphins; and (iv) to estimate the probabilities of association between individuals over time.

METHODS Data were collected from dedicated boat-based surveys conducted between July 1997 and August 2003 along an 83km stretch of coastline of the southern outer Moray Firth in NE Scotland, between Lossiemouth and Fraserburgh (Fig. 1), using photo-identification methodologies as a central methodology. Half Weight Indices (HWI) of association (Equation 1) were used to calculate coefficients of association (CoA's) between individual dolphins from the study area with the application of SOCPROG v1.3 developed by Whitehead (1999a, b) for MATLAB v5.1.

$$\text{HWI} = \frac{X}{X + \frac{1}{2}(Ya + Yb)} \qquad (1)$$

After Cairns & Schwager (1987) where:

X = the number of times both individual a and b were seen together in the same group,
Ya = the number of times individual a was seen, and
Yb = the number of times individual b was seen.

The SOCPROG software was used to test observed association patterns of individual dolphins against those expected from random associations. The social organisation of the population for the entire study period could then be graphically presented using a hierarchical cluster analysis (average linkage method) of the HWI matrix. This technique clustered individuals not only by preferred partnerships, but also using least preferred partners (Whitehead, 1999a). The significance of the association indices of all possible pairs (or dyads) of animals in the sample used, and therefore the significance of the groups discriminated by the cluster analyses, was assessed using a Monte Carlo randomisation

approach (Manly, 1995; Bejder *et al.*, 1998; Whitehead, 1999b). In this test, individuals within groups were randomly permuted keeping group size, and the number of times each individual was seen, the same as in the original dataset. The number of permutations performed was increased until the *P* value obtained from the Monte Carlo simulation became stabilised and the confidence intervals decreased. If more than 95% of the expected HWI were found to be smaller than the observed HWI, a pair of dolphins was defined as a preferred companionship, i.e. the pair was more likely to be seen together than by chance. A Mantel test, using 1,000 permutations, was applied to examine the dataset for differences in association depending on sex. Variations in lagged association rates were calculated for all associations to determine the stability of associations amongst individuals.

RESULTS Group sizes were found to range from 1 to 44 animals with a mean of 11.07 ± 7.93 animals (n = 132). From a sample of 40 known individuals identified 5 or more times (19 females, 17 males and 4 of unknown sex), calculated half-weight CoA's ranged from 0.00 to 0.73 (mean = 0.11 ± 0.04) (Fig. 2). The dolphins were typically found in mixed-sex groups, but associations between and within sex classes were not found to be significantly different from one another (Mantel test, t = 0.024, p = 0.51) (Fig. 3). Inter-sexual associations were seen to be as strong as intra-sexual associations (Table 1). Both sex classes were found to show a tight network of associations with 24% of the males and 21% of the females displaying HWI of ≥ 0.50. Permutation tests for non-random associations indicated that dolphins in this population did not associate preferentially with or avoid other individuals (random, permuted mean = 0.10819, observed mean = 0.10836, p = 0.87520). No clear divisions were found in the community, the echelon pattern of the resulting dendrogram (Fig. 2) expressing no clear architecture, as defined by Lusseau *et al*. (2003), except for dyads, triads and their multiple networks. Analyses of lagged association rates suggested short-term associations of individuals over periods of days, with rapid disassociations, except for a smaller number of constant companions, by the end of a few weeks.

CONCLUSIONS Group sizes of bottlenose dolphins in the southern outer Moray Firth were found to be significantly larger than those occupying the more estuarine-like conditions of the inner Moray Firth. Whilst this might be attributed to environmental differences between the two areas, group size and formation in this dolphin community are likely to be affected also by the feeding ecology in this area of the firth, the availability of prey items, and the potential risk of predation.

The composition of this bottlenose dolphin community was found to be dissimilar to other bottlenose populations, in that the animals were found to live in large mixed-sex groups, where strong associations occurred within and between both sexes. Perhaps unusually, no clear sub-units were found to exist in this community, yet some males and females did tend to spend more time together than others. The changeability of units and sub-units recorded was found to be directly related to the differences in occurrence patterns observed, and this was considered to reflect the extensive home range and migratory/seasonal movements identified in this North Sea bottlenose population.

The preferred associations were typically mixed, with relationships lasting just several days to a few weeks. A small number of individuals, however, were predicted to form longer-term associations. Females of the same reproductive status were seen to group together, as in other bottlenose dolphin populations. In addition, a small sample of mature male individuals showed strong male-male associations indicating the possibility of alliance formation between mature males within this bottlenose community, which certainly warrants further investigation.

Associations between males and females were primarily attributed to the reproductive state of the female in the present study, but other factors such as relatedness, dispersal and anthropogenic impacts are all considered to shape the sociality of this species in this North Sea coastal location. The implications of this preliminary study may be particularly significant to management proposals currently aimed at this internationally important bottlenose population.

ACKNOWLEDGEMENTS We would like to thank Drs. Jonathan Wright and John Goold from the University of Wales, Bangor, for providing sound advice when needed, Prof. Hal Whitehead for much appreciated assistance with the SOCPROG programme, and numerous friends, colleagues and volunteers at the Cetacean Research & Rescue Unit for their invaluable assistance and support with boat work and data collection.

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Table. 1. Mean and maximum half-weight indices (HWI) between and within sex classes. SD = Standard Deviation.

	Mean HWI (SD)	Maximum HWI (SD)
All individuals	0.11 (0.04)	0.48 (0.13)
Female – Female	0.10 (0.03)	0.40 (0.11)
Male – Male	0.12 (0.05)	0.39 (0.17)
Female – Male	0.12 (0.05)	0.40 (0.13)

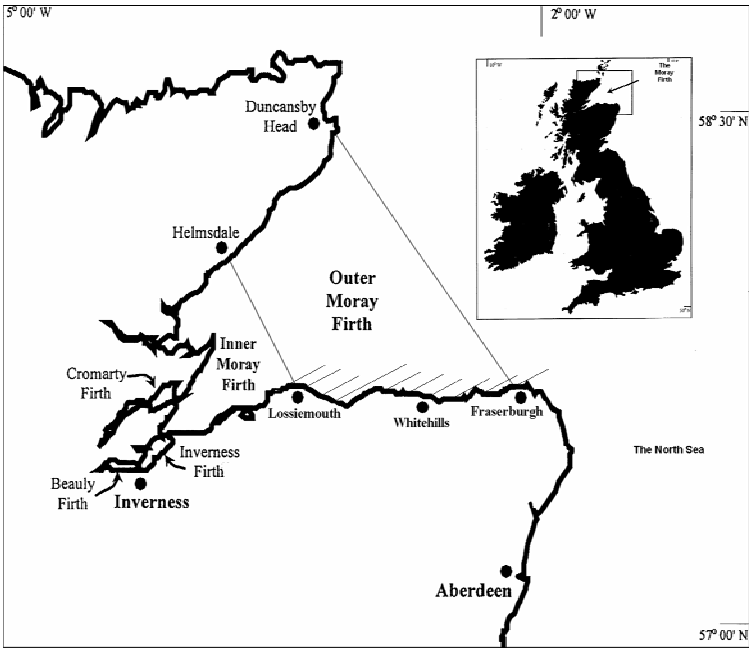

Fig. 1. Map of Northeast Scotland showing the location of the Moray Firth and the area in which the present study was carried out (shaded area)

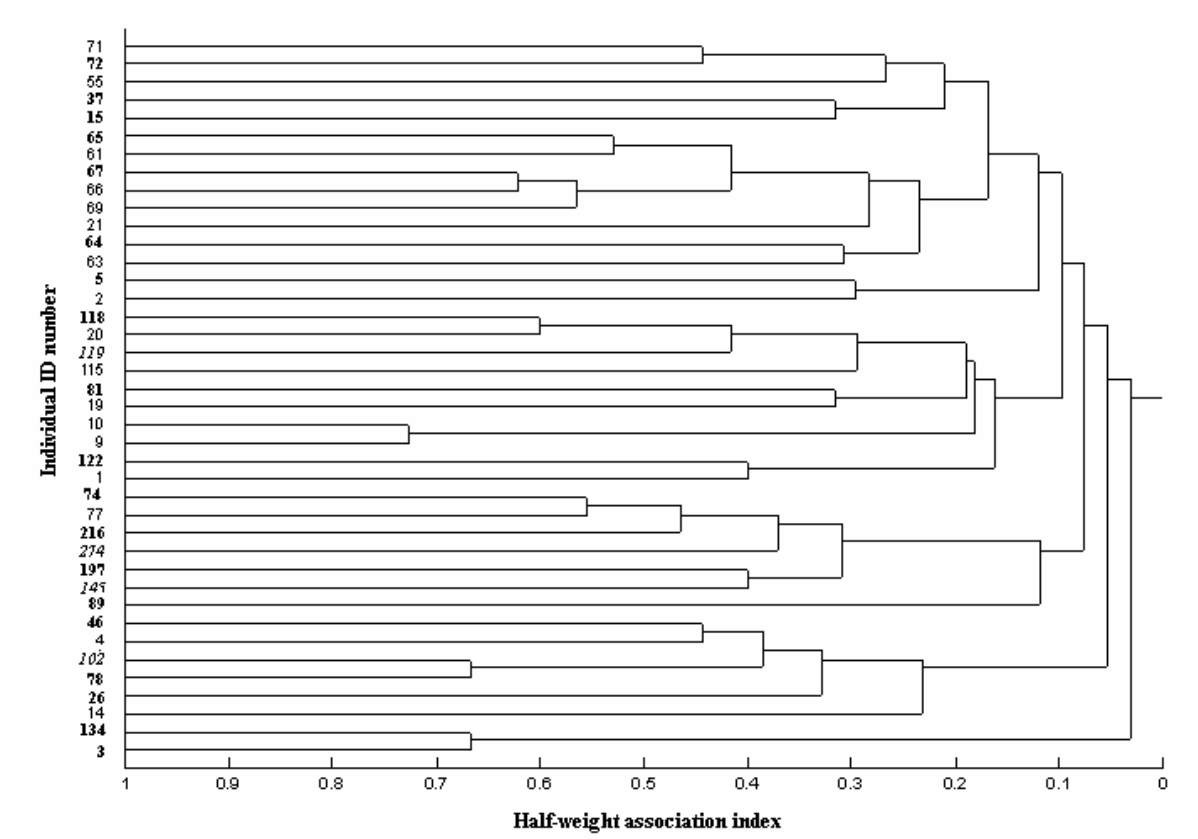

Fig. 2. Dendrogram showing the average-linkage cluster analysis of associations between 40 selected bottlenoses seen ≥ 5 times in the study area between 1997 and 2003. Ordinary type ID numbers represent known males, bold type known females, and italics individuals of unknown sex

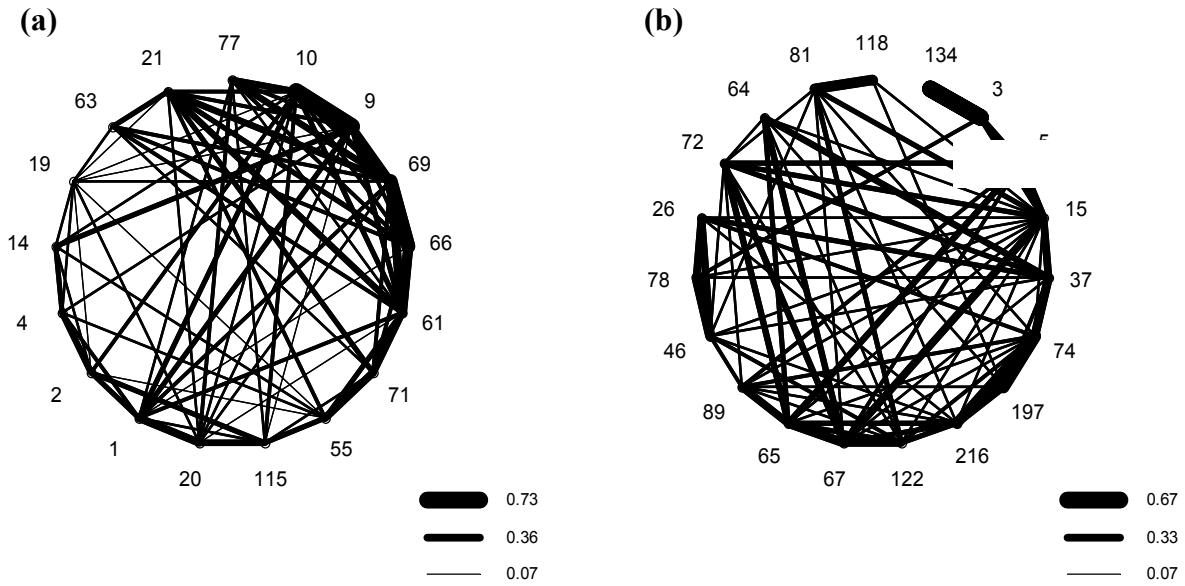

Fig. 3. Sociogram representations of (a) male-male and (b) female-female half-weight coefficients of association. Dolphin identities are indicated by their ID number. Lines of increasing thickness correspond to the increasing strength of pairwise associations (see legend)

HABITAT PREFERENCE AND GROUP STRUCTURE OF *SOTALIA FLUVIATILIS* (GERVAIS, 1853) IN THE BRAZILIAN AMAZON RIVER

C. Faustino[1], and V.M.F. da Silva[2]

[1] *Lisbon, Portugal (e-mail: claudiaesf@yahoo.com.br)*
[2] *Laboratório de Mamíferos Aquáticos, Instituto Nacional de Pesquisas na Amazônia, Brasil*

Two river dolphin species are present in the Amazon, tucuxi (*Sotalia fluviatilis*) and Amazon river dolphin or boto (*Inia geoffrensis*), both widely distributed along the river area. A multidisciplinary study on these two river species has been carried out in the central Brazilian Amazon since 1994, some 500km West of Manaus and about 2500 river kilometres from the mouth of the Amazon, within the Mamirauá Sustainable Development Reserve. The dominant feature there is that it lies in the Amazon floodplain and incurs seasonally cyclic water levels with a range of 10 to 12m. This annual transformation has a very significant influence on both wildlife and people of the region. It acts directly on the dolphins by allowing or restricting access to large areas of prey-rich habitat, and indirectly through its influence on prey populations' density and distribution.

Data recorded between November 1994 and August 2003, is being analysed regarding some aspects on the biology of tucuxis. Habitat preference and group structure are the two main topics of this analysis. We look for areas of avoidance/ preference, as well as time of day and monthly presence. Regarding species groups, we aim for size and both intra and inter specific relations. Factors used are lake systems, time, season and water level. The data indicates tucuxi preference for main channels of rivers and large lakes where access is not limited by a narrow or shallow channel; tucuxis are most frequently observed from December to March, or during periods of increased water levels; groups are composed mainly of one to six individuals and it seems difficult to identify a clear birth season. Interactions between tucuxis and botos are not found, indicating no habitat or food competition between them.

EXPERIMENTAL INVESTIGATIONS OF THE ROLE OF PLANNING IN DOLPHIN PROBLEM SOLVING

J. D. Gory and S. A. Kuczaj II

Department of Psychology, University of Southern Mississippi, 118 College Dr ~5025, Hattiesburg, MS 39406-5025, USA (e-mail: s.kuczaj@usm.edu)

INTRODUCTION Although we sometimes seem very slow to learn from our mistakes, and often solve problems through the process of trial and error, humans can generate correct novel solutions to novel problems without trial and error, a process that involves both insight and planning. In order to solve problems in such a manner, it is necessary to represent the nature of the problem and the desired outcome as well as possible future states and behaviours that might achieve the desired outcome, perhaps even state and behaviours that have neither been seen nor performed previously. In order to accomplish such creative problem solving, an understanding of the casual relations that are pertinent to the problem at hand is essential. In essence, then planning is the ability to use casual knowledge in order to create novel action sequences that are appropriate for achieving a goal in a particular problem environment.

There is some evidence to suggest that dolphins engage in behaviours that might be planned intelligent actions. Connor, Smolker and Richards (1992) reported that dyads and triads of male dolphins sometimes cooperate to herd female dolphins away from female groups in order to more easily mate with the "captured" females, a behaviour that suggests planning across as well as within individuals. The symbiotic cooperative interaction between human gill net fisherman and bottlenose dolphins in South America that Pryor, Lindbergh, Lindbergh and Milano (1990) described is consistent with the notion of cooperative planning, in this case across species. Dolphins have also been known to carry large sponges on the tips of their rostrums as they scour the bottom of the ocean floor for small fish (Smolker, Richards, Connor, Mann and Berggren, 1997), perhaps to prevent injury from stingrays and other sharp objects. These are but a few examples of naturally occurring dolphin behaviours that appear to be planned actions. But are the dolphins that engage in such behaviours actually planning their behaviour to produce specific outcomes? Or is there a simpler explanation?

In order to decide whether dolphins can plan at least some of their behaviours, it is necessary to first specify what is meant by planning. We can begin by eliminating behaviours that are clearly not planning. For example, many animals, from insects to mammals, engage in behaviours that appear to be intelligent planned actions, but are instead instinctive. Such behaviours do not involve planning, but are instead simple reactions to environmental stimuli. Animals can also accidentally discover useful behaviours for obtaining goals. In the cases of instincts and serendipitously learned behaviours, the animal need not mentally create a novel solution to a problem prior to executing the solution. To us, this creative act is at the heart of planning.

Before one can decide if an animal's spontaneous behaviour reflects some form of planning, it is necessary to know the developmental history of the target behaviours. Otherwise, it is difficult to decide if the behaviours were the result of some instinctual process, serendipitously learning, trial and error learning, observational learning, or planning. It is often difficult to ascertain the developmental history of naturally occurring behaviours. However, in an experimental context, animals can be exposed to novel problems, making it possible to document the complete history of the behaviours that emerge as the animals attempt to solve the problems.

In the remainder of this paper, we will describe two problems that were presented to two male Atlantic bottlenose dolphins (*Tursiops truncatus*), named Bob and Toby. Both problems were designed so that the dolphins could more efficiently obtain a goal if they planned their behaviour. Bob and Toby were both approximately 15 years of age at the start of the first test. Both dolphins also participated in a long term study designed to discern how sophisticated dolphins could become at learning to use symbols, located on a large keyboard, to communicate with humans.

MATERIALS AND METHODS Multiple-Weight Test The Multiple-Weight Test required the dolphins to use weighted cylinders of PVC pipe connected to a ring that made it easy for the dolphins to transport the weights from one location to another. Specifically, the dolphins needed to drop four of these weights into an apparatus in order to release a fish that they could then eat.

The apparatus was constructed of clear lexan. It consisted of a 30cm square by 1m long vertical square tube. A buoyant transparent box that could slide up and down was located inside this tube. The buoyancy of the box caused it to rise in the tube until it was stopped by a bar of plastic. An open side compartment in the box was used to hold fish for the dolphins. The fish was held in place by the side of the tube when the cube was in the up position. When sufficient weight was deposited on the top of the cube, it would slide down, resulting in the fish to fall from a slot in the side of the tube. In this test, the amount of flotation required four weights to depress the tube. For each trial, eight weights were placed around the apparatus located on the bottom of the 8m deep main aquarium in which the dolphins lived.

Bob and Toby learned to operate the multiple-weight site by observing human divers. During the learning phase, on each trial one dolphin was released from a separate holding area. When the dolphin approached the diver, the diver first looked at the food compartment until the dolphin noticed the fish. Next, the diver picked up one of the weights and dropped it into the apparatus. He then looked at the food compartment to see if the food was released. When it was not, the diver got one more weight and dropped it into the apparatus, again looking at the food compartment. This continued until the fourth weight was deposited, which released the food for the dolphin to consume. Within several trials, the dolphins were taking part, dropping weights into the apparatus. Eventually, the divers were removed from the setting, leaving the dolphins to obtain the fish by themselves.

It is important to emphasize that even though the divers demonstrated how to operate the multiple-weight apparatus, they did so by gathering and depositing only one weight at a time. We were curious to see if the dolphins would continue to use one weight at a time or realize that it was more efficient to gather and deposit multiple weights on each trip to the apparatus. Of course, the most efficient strategy would be to gather and deposit four weights in one trip. Again, the dolphins had neither seen multiple weights used nor ever done so themselves.

Test trials were started once the dolphins were operating the multiple-weight apparatus on their own. Each dolphin was run through a total of 50 trials. These results are simple to summarize. The dolphins continued to use a one-weight-at-a-time approach to operate the apparatus.

At this point, we speculated that even though it is more efficient to use multiple weights, perhaps with the weights distributed relatively closely around the apparatus, the difference in effort may not have been enough to motivate the dolphins to plan their behaviour. In the second phase of this test, the weights were placed approximately 45 metres from the apparatus, thereby making it much more costly to use the one-weight-at-a-time approach. The dolphins were given another 50 trials in this FAR condition.

When the weights were placed in the FAR condition, the dolphins quickly began gathering multiple weights. Toby almost immediately began to average two weights per trip. Toby's average rose to about 3 weights per trip, but he returned to his two weights per trip strategy (perhaps because carrying three weights to the apparatus still required one more trip to obtain the crucial fourth weight). Bob steadily increased the number of weights he carried per trip until at the end of the test he was carrying four or five weights per trip to the apparatus, meaning he had to make only one trip.

The dolphins were tested individually and had no opportunities to observe one another's behaviour in the Multiple Weight Test. The fact that both dolphins independently used a one weight at a time strategy when the weights were near the apparatus but independently adopted a multiple weight at a time strategy when the weights were far from the apparatus suggests that the dolphins were each capable of planning a novel behaviour, namely carrying more than one weight when the distance made this a more efficient strategy.

Retaining Weight-Site Test The Retaining Weight-Site Test involved a weight and three boxes, each of which contained a fish. When a single weight was deposited into the top of a box, the weight deflected a hinged surface. This in turn retracted a pin at the base of a food compartment and caused food to be released. Each box was mounted on a stand such that the bottom of the box was approximately one metre from the floor of the aquarium.

All three of the boxes were present for each trial. Two of the boxes contained open bottoms. In these cases, when a dolphin dropped a weight into the top of the box, the weight fell through the open bottom after deflecting the hinged surface. This allowed the dolphin to retrieve the weight beneath the box and to then use it on one of the other boxes. However, the third box had a vertical tube that extended down to the floor of the aquarium. Thus, when the weight was dropped into this box, the weight was contained inside the extension, and so the dolphin could not retrieve it for further

use. For each trial, the three boxes were arrayed in an arc with the boxes approximately 1.3 metres apart. Each box was loaded with an equal amount of fish. One weight was placed 8.5 metres away from the center of the array. While the other dolphin remained out of sight in a holding pool, one of the dolphins was released and given the opportunity to use the weight on the boxes.

The location of the retaining box varied randomly across trials at each of the three possible positions in the array, appearing equally often in positions A, B, and C. If the dolphin operated the retaining box last, it would obtain all of the available food. If not, the dolphin would receive only one or two loads of food, depending upon whether it used the retaining box on the first or second attempt.

If a dolphin was incapable of planning the order in which it utilized the boxes, then it should have used the retaining box equally often as the first, second, and third site visited across trials. Alternatively, if the dolphin could plan the order in which it used the boxes, then it should use the retaining box more often as the last site.

Initially, the dolphins were equally likely to use the retaining box as the first, second, or third choice. However, they quickly discovered that the retaining box prevented further use of the weight, after which time they became much more likely to use retaining box last. Thus, both dolphins quickly began to order their use of the boxes to maximize the amount of food obtained. It is important to note that the dolphins were rewarded with fish when using any of the boxes, including the retaining box. The rapid onset of the appropriate ordering in using the boxes suggests that they understood the causal relations involved with dropping the weight into the retaining box, including its role in obtaining different amounts of food.

CONCLUSIONS In summary, the dolphins' behaviour in these two tasks suggests a limited ability to plan their behaviour. The Multiple-Weight Test showed that the dolphins could plan their behaviour to be more efficient at obtaining a goal. They created a behaviour that they had neither seen nor done previously. In the Retaining Weight Site Test, the dolphins were able to follow a simple plan to use the retaining box last in order to optimise their reward.

The most convincing evidence of planning is the ability to create novel and appropriate behaviours to deal with novel situations. The two dolphins demonstrated such ability in the tasks described in this paper, implying an ability to engage in causal reasoning about novel future-directed behaviour. The basic planning by these dolphins demonstrates that such ability does not require human language-like skills. It is possible that the powerful cognitive ability of planning emerged in human ancestors prior to language, and perhaps even facilitated the emergence of language abilities. Consistent with this possibility, referential symbol use (i.e., the use of symbols to direct the attention or thoughts of another) requires an ability to plan (i.e., an intention to direct the attention or thoughts of another).

The fact that the dolphins created novel appropriate behaviours within domains so unlike any natural dolphin behaviour suggests a fairly generalised ability to plan, rather than one restricted to domains that are particularly relevant to the niche occupied by dolphins. This demonstrates that in addition to studying how the cognitive abilities of species are formed by ethological factors across evolution to create specific niche dependent abilities, it is also useful to search for generalised cognitive abilities that engender flexibility within species to deal with ecological challenges.

The ability to represent, reflect upon, and reorganise action sequences into appropriate novel behaviours is one of the hallmarks of successful human problem-solvers. The extent to which dolphins can restructure their behaviour to solve novel problems is unknown. Future work should focus on discovering the boundaries of dolphin planning abilities, knowledge that will help to delineate the similarities and differences between dolphin problem solving and that of other species.

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THE NUMBER SENSE OF THE BOTTLENOSE DOLPHIN

A. Kilian, L. Von Fersen, and O. Güntürkün

Ruhr-Universität-Bochum, Fakultät für Psychologie,Biopsychologie, 44780 Bochum, Germany
Tiergarten Nürnberg, Am Tiergarten 30, 90480 Nürnberg, Germany

The cognitive skills of bottlenose dolphins have been studied intensively, yet little is known about their numerical abilities. It is conceivable that such an ability could provide ecologically relevant information, for instance, to assess food amounts or the group size of conspecifics. The aim of the present study was to demonstrate numerical competence in a bottlenose dolphin. The subject, 'Noah', born and housed at the Zoo Nuremberg,was trained to discriminate two simultaneously presented stimuli differing in numerosity (defined by the number of constituting elements). After responding correctly to stimuli consisting of three-dimensional objects, the dolphin transferred to two-dimensional stimuli. Thus, his choice behaviour then was exclusively based on visual perception. Initially, a variety of stimulus parametres covaried with the numerosity feature. By systematically controlling for these stimulus parametres, it was demonstrated that some of these attributes, such as element pattern and overall brightness affected the animal's discrimination performance. However, after all confounding parametres were under control, the dolphin was capable to discriminate the stimuli exclusively on the basis of the numerosity feature. The animal then achieved a successful transfer to novel numerosities, both intervening and numerosities outside the former range. These findings provide substantial evidence that the dolphin could base his behaviour on the numerosity of a set independent of its other attributes, and that he represents ordinal relations among numerosities. The study also reveals that bottlenose dolphins readily use their visual sense to perceive and discriminate features such as pattern and number. It is thus suggested that these animals also apply a number sense to their natural environment.

IDENTIFICATION OF HARBOUR SEALS (*PHOCA VITULINA*) ATTACKING FYKE NETS

S. Königson[1], K. Lundström[1], and S. Lunneryd[1, 2]

[1] *National Board of Fisheries, Box 423, 401 26, Gothenburg, Sweden*
[2] *Tjärnö Marinbiologiska laboratorium, 452 96, Strömstad, Sweden*

The coastal fishery for eel is an important segment of the Swedish fishing industry on the Swedish West Coast. Eel fykenets have been used since the beginning of the 20th century and remain the principal type of fishing gear used for catching yellow eel. However, during the last decade, there has been an increase in damages to both fishing gear and catch caused by harbour seals (*Phoca vitulina*) and possibly cormorants (*Phalacrocorax carbo*). The damages consist of tears and smaller holes mainly in the fishhouse where the eel and fish gather. This results in lost or damaged catch. In order to develop sealsafe fishing gear it is important to determine which species causes the damage. It is also important to specify the attackers behaviour around fishing gear to develop the most efficient methods of reducing damages. To determine if seals are responsible for the bulk of the damages an underwater video camera was mounted close to a fykenet. Fykenets were filmed for 600 hours during daytime between 1999 and 2000. Seals visited the fykenet twice but did not attack the fykenet. In 2001, underwater filming was conducted both day and night time with IR-lamps, altogether 521 hours. During that period, harbour seals attacked the fykenet six times. No attacks from cormorants were recorded. Analysis of recorded film sequences showed a specific harbour seal visiting the fykenet at least four of the six occasions. These results suggest that foraging in fishing gear might be behaviour specific to certain seals, rather than a more general adaptation in the seal population. The fishing gear was mainly visited during the night or in the early morning. On all occasions the seal was around the fyke net for about 30 minutes.

SOCIAL STRUCTURE OF COMMON BOTTLENOSE DOLPHINS IN NORTH EASTERN SARDINIA, ITALY

F. Magnone[1], J. Jeglinski[2], G. Aplington[1], A. Fozzi[1], E. Bernuzzi[1], V. Tobbia[1], D. Castiglioni[1], I. Galante[1], A. Pizzo[1], M. Bacchetta[1], A. Cecchetti[1], S. Di Marco[1], E. Tamborini[1], and E. Della Vedova[1].

[1] *Dolphin Research Centre, CTS, Caprera Island, Sardinia, Italy*
[2] *University of Hamburg, Zoological Institute and Zoological Museum, Martin Luther King-Platz 3, D-20146 Hamburg, Germany*

Bottlenose dolphins (*Tursiops truncatus*) have been regularly monitored in the Maddalena Archipelago National Park since 1999. Between July 2002 and August 2003, 154 days were spent surveying, resulting in 597 hours of sea surveys, 95 sightings and 510 observations, with an overall sighting frequency of 0.159. Sighting frequencies have shown marked seasonal variations. Over the two summers a total of 358 observations were recorded (70.1% of the total). The lowest number of sightings occurred in autumn 2002 with 10 observations (2% of the total), and winter 2002-2003 with 34 observations (6.7%). In spring 2003, 108 observations (21.2%) were recorded. Mean group size varied seasonally, with minimum averages of 2.50 individuals in autumn and peaks of 7.75 in early summer. Between June and September gradual reductions in group size possibly related to the dolphin's breeding season were recorded. Associations of 3 individuals were most frequently observed followed by groups of 2. Females with calves were present within the observed group in 58.9% of the cases. 4 newborns and 17 juveniles were recorded in summer 2002; 16 newborns and 31 juveniles were observed in 2003, with births occurring between the beginning of March and the end of August. 56 individuals have been photoidentified over the study period; the number of sightings for each photo-identified dolphin varies between 1-8. Summer ratios of new photo-identified dolphin/resighted individuals are 0.10 in 2002 and 0.09 in 2003. Photo-identified individuals have been classified in the following categories according to resighting frequencies and the timing of each sighting: Resident (2%), seasonal resident (43.1%), transient (9.8%), migratory (7.8%). Although representative of only a small portion of their home range, the study area represents crucial breeding grounds for the dolphin's. As the breeding season coincides with the heavy tourist season urgent conservation measures are required to protect the species.

POD-SPECIFIC BEHAVIOUR AND SOCIAL INTERACTIONS IN TENERIFE'S RESIDENT PILOT WHALE POPULATION

C. J. Melia

Atlantic Whale Foundation, St. Martins House, 59 St. Martins Lane, Covent Garden, London WC2N 4JS, UK

Three stable pods of pilot whales (*Globicephala macrorhynchus*) have been determined within Tenerife's resident population (Butler, 2002). This study assesses the degree of behavioural differences between these key pods, and examines the degree of interaction with pilot whales outside these pods. Photo-identification data used in determining the key pods (1997-2001) was re-assessed to include behaviour and the occurrence of whales outside stable pods. Distinct behavioural differences between pods were found. The quantity of behaviour data recorded was insufficient to allow statistical analysis therefore the results identify potential trends without being conclusive. Behaviours were expressed as a percentage of occurrences in all sightings for a given pod. Results include a tendency for Pod 1 to interact most frequently with bottlenose dolphins (*Tursiops truncatus*), and a high tendency for displaying 'flipper out' behaviour. Pod 2 individuals display mostly group behaviours (logging, milling or travelling), with travelling being the response to 56% of sightings. Pod 3 individuals are most frequently sighted in the presence of calves. Individual whales from different stable pods do not interact. Three notable whales outside stable pods were found to interact with all three pods over different time scales. This provides an insight into the stability of social interactions, and may be linked to mating opportunity. Tenerife's pilot whales form variable social groupings with complex and sex-dependent interaction occurring (Heimlich-Boran, 1993). Continued data collection and further analysis of associations between whales outside stable pods will reveal whether those regularly interacting with pods are part of a sub-pod, or acting in isolation. Calculation of the residency of individuals and comparison of photo-identification records from surrounding islands will determine if whales showing variable and weak associations between pods are non-resident or resident. Determination of the sex of individuals will enable the motivations behind changes in social structure to be better assessed.

SWIMMING GAITS, PASSIVE DRAG, AND BUOYANCY OF DIVING SPERM WHALES (*PHYSETER MACROCEPHALUS*)

P. J. O. Miller[1, 3], M. Johnson [2], P. L. Tyack[3], and E. A. Terray[2]

[1] *Sea Mammal Research Unit, University of St. Andrews; St. Andrews, Fife, KY16 8LB, UK*
[2] *Department of Applied Ocean Physics and Engineering, Woods Hole Oceanographic Institution, Woods Hole, MA, 02543, USA*
[3] *Department of Biology, Woods Hole Oceanographic Institution, Woods Hole, MA 02543, USA*

Drag and buoyancy are the primary external forces acting on diving cetaceans, and modulate the energetic cost of movement. We used a high-resolution digital tag to record depth, 3-D orientation, and sounds heard and produced by 23 deep-diving sperm whales in the Ligurian Sea and Gulf of Mexico. Periods of active fluking versus gliding were identified through analysis of oscillations measured by a 3-axis accelerometer on the tag. Descent speeds (1.45 ± 0.19 m/s) were slower than ascent (1.63 ± 0.22 m/s), even though sperm whales fluked steadily (glides 5.3 ± 6.3%) throughout descents and employed predominantly stroke-and-glide swimming (glides 37.7 ± 16.4%) during ascents. Accelerations measured during 382 glide periods from 20 ascents of five whales were fit to a model of drag, air buoyancy and constant tissue buoyancy forces with an r2 ranging from 99.1-99.8% for each whale. Model predictions correlated with observed descent glide accelerations, with an offset consistent with a 0.064% decrease in tissue density due to warming of tissues at the surface (and cooling at depth). The model obtained mean (±sd) estimates for drag coefficient (0.00305 ± 0.00012), air-volume carried from the surface (26.7 ± 4.0 l/MT), and tissue density (1030 ± 0.7 kg/m3) for these five animals. The model predicts strong positive buoyancy forces in the top 100m of the water column decreasing to near neutral buoyancy at 250-850m. The link between predicted forces and observed swimming gaits supports the hypothesis that buoyancy affects behavioural swimming decisions in diving animals. Four whales made prolonged glides of over 300m during ascent, while three other whales glided more during descent than ascent, suggesting variation in tissue density in different whales. We observed two whales that remained at ~20m depth for more than 10 minutes without fluking, apparently by regulating the volume of air they carried.

RESIDENCY PATTERNS OF THE SHORT-FINNED PILOT WHALE, *GLOBICEPHALA MACRORHYNCHUS*, OFF THE SOUTH-WEST COAST OF TENERIFE

J. A. Oakley

The Reefs, 87 Stanhope Road, Cippenham, Slough, Berkshire SL1 6JR, UK

Tenerife´s population of short-finned pilot whales is considered to be resident. However, patterns of residency have not been tested. Using sightings and photo I.D. data collected by volunteers of the Atlantic Whale Foundation between 1997 and 2000, 297 individual whales were investigated. Residency indices for each whale were calculated and a relative residency category of Rare, Semi-resident or Resident was allocated. Semi-resident whales were further categorised as Sporadic, Summer or Winter whales, depending on patterns of sightings and compared to the three known stable pods. Results show a high degree of at least seasonal site fidelity in pilot whales. There are distinct residency patterns for individual whales ranging from totally resident (Residency Index 1.36-3.6, seen almost every month), to rare (Residency Index 0.01-0.25, seen only once or twice out of the entire study period). The number of new whales sighted each year is decreasing, suggesting that there are still some whales to be identified before a complete record of the population can be obtained. Although the key pods show stable associations between years, individuals also show variations in residency within these pods. The seasonal changes in abundance and the high number of animals only identified on single occasions shows that Tenerife represents only part of the home range for many members of the population. The movement of the animals beyond Tenerife are as yet unknown and must be considered when planning further research and the implentation of any management plans.

DEFINING CONTEXT IN THE CALLS OF WILD BOTTLENOSE DOLPHINS

N. J. Quick, and V. M. Janik

Sea Mammal Research Unit, School of Biology, University of St Andrews, Scotland, UK

Many studies of the communicative abilities of bottlenose dolphins have focused on captive restrained dolphins but very little is known about the specific contexts of signal use in wild unrestrained dolphins. This is particularly the case concerning whistle types, where studies of functionality and variability in wild populations are sparse. A series of focal follows of bottlenose dolphins off the east coast of Scotland have been completed to enable correlation of behavioural events with recordings of vocalisations. Analysis of ten focal follows from eight separate days and comprising 235 minutes of recordings has yielded 541 individual whistles. Of these 541 whistles, 497 (92%) can be attributed to four follows, totalling 133 minutes. During these four follows, dolphins were found in fluid groups numbering 12-40 individuals and were involved in bouts of socialising (i.e. bellies up, touching), aerial behaviour (i.e. leaps, flips) and feeding (i.e. fish tossing, fast surface rushing) for 78% of the time (all follows combined). For the remaining six follows, totalling 102 minutes, only 44 (8%) whistles were recorded. These follows concerned groups of dolphins numbering from 5-15 individuals found in tight formation groups and engaged in socialising, aerial behaviour and feeding for only 11% of the time (all follows combined). This analysis highlights much variability in the call use of wild bottlenose dolphins. It appears that animals are more vocal when groups are fluid and engaged in three defined behaviours, namely socialising, aerial behaviour and feeding. This is in contrast to when groups are smaller and found in tight formation exhibiting little surface activity and producing fewer whistles.

MULTIDISCIPLINARY APPROACH TO THE STUDY OF *TURSIOPS TRUNCATUS* PREGNANCY: A CRUCIAL VALUE?

R. Tizzi[1,2], D.S. Pace[2], P.A. Accorsi[3], M. Gamberoni[3], J. San Juan Rodriguez[1], S. Catacchio[4], and M. Azzali[4]

[1] *Delfinario di Rimini, Lungomare Tintori 2, 47900 Rimini, Italy (raftizzi@tin.it)*
[2] *Associazione Oceanomare, Via delle Gondole 109, 00121 Roma, Italy (dpace@telethon.it)*
[3] *Dipartimento di Morfofisiologia Veterinaria e Produzioni Animali, Università degli Studi di Bologna, Via Tolara di Sopra 50, Ozzano Emilia (BO), Italy (accorsi@vet.unibo.it)*
[4] *Marine Fisheries Research Institute, National Research Council, Largo Fiera della Pesca, 60125 Ancona, Italy (m.azzali@an.ismar.cnr.it)*

Pregnancy in all mammals is characterised by a progression of biological and behavioural factors that lead the animals to reproduce successfully. The relative weight of each factor is still un-investigated in almost all cetaceans, since the research is generally focused on one or a few aspects. In order to attempt an integrated approach to the study of *Tursiops truncatus* pregnancy, we report data on three different disciplines – behaviour (A), physiology (B) and acoustics (C). Ultrasound pregnancy confirmation in two females gave us the opportunity to conduct a simultaneous investigation across the three approaches. A) As for the ethological approach, "Individuals follow continuous sampling" method with specific ethogram was applied to monitor the females' behavioural repertoire with a total number of 192h of observation. B) Physiological investigation included the examination of respiration rates - 192 sessions lasting 15mins each – and blow samples weekly collection - in order to hopeful point out possible perturbations of stress hormones. C) Acoustic signals were analysed once a month during 1-hour long free-swimming session by means of Brüel and Kjær Type 8105 hydrophone and Matlab platform. Some locomotory and postural displays together with social preferences revealed specific trends (both in frequency and duration) while approaching parturition also underlined by a significant increase of apnoea duration. Similarly, pregnancy seemed to affect the acoustic habits of the subjects, slowing down the number of the emitted clicks. Far from providing complete answers, this multidisciplinary approach seems to make available significant information on bottlenose dolphin pregnancy via remote, non invasive sampling. Results obtained from cross analysis help to avoid false indication of imminent delivery, sometimes coming from singular flexions patterns or from a not-related-to-birth period of withdrawing from association with other animals. Further studies are strongly recommended for the acquisition of multidisciplinary relevant information to manage successful breeding programs.

CONSERVATION/MANAGEMENT

HIGH CONCENTRATIONS OF BEAKED WHALES OBSERVED CLOSE TO THE SHORE OF EL HIERRO (CANARY ISLANDS)

N. Aguilar[1], M. Johnson[2], C. Aparicio[1], I. Domínguez[1], F. Díaz[1], A. Hernández[1], M. Guerra[1], A. Bocconcelli[2], A. Brito[1], and P. Tyack[2]

[1]*Unit of Marine Sciences, Dept. Animal Biology, La Laguna University, 38256 La Laguna, Tenerife, Canary Islands. (e-mail: naguilar@ull.es)*
[2]*Woods Hole Oceanographic Institution, Woods Hole. MA, USA*

INTRODUCTION The Canary Islands have a high abundance and diversity of cetaceans, with 26 species recorded in the archipelago (Dominguez & Aguilar 2000, Brito *et al*. 2002). Five of these belong to the family *Ziphiidae*: Blainville´s (*Mesoplodon densirostris*), True´s (*M. mirus*), Gervais' (*M. europaeus*) and Cuvier´s (*Ziphius cavirostris*) beaked whales and the northern bottlenose whale (*Hyperoodon ampullatus*). El Hierro is the most westward island of the Canaries archipelago. Its volcanic origin gives rise to a steep shelf with water depths of up to 2000m being found less than 3nm from the shore. Occasional coastal surveys of El Hierro performed by La Laguna University (ULL) since 1998 indicated the presence of beaked whales. In 2003, ULL and Woods Hole Oceanographic Institution (WHOI) performed two field seasons in El Hierro, with the objective of studying the distribution of the populations and tagging beaked whales using DTAG, an acoustic and motion recording tag attached with suction cups (Johnson & Tyack, 2003). During the April cruise, groups of beaked whales were observed on 8 of the 9 survey days. During the October cruise, 31 groups of *Ziphius cavirostris* were observed along with 18 groups of *Mesoplodon densirostris* and 7 groups of unidentified beaked whales in 15 days of sea-effort. Four groups of Blainville's beaked whales presented calves. Data from focal follows of *M. densirostris* indicate high site fidelity to the island. Two Blainville´s beaked whales were tagged for 16 and 4 hours and seven dives to depths around 800 were recorded, with mean lengths of 50 minuts. Ultrasonic clicks and buzzes typically related with foraging were heard at the bottom of the deep dives, the buzzes often followed by impact sounds. Results suggest that El Hierro constitutes a calving and feeding area for *M. densirostris*.

Between 1985 and 2003, at least seven mass strandings of beaked whales have been recorded coinciding with naval manoeuvres in the archipelago, involving a minimum of 55 dead whales (Martín, 2001). A direct relationship between the last one in September 2002 and the use of military sonar has been suggested (Jepson *et al*. 2003). This kind of sonar has been previously related with mass strandings in Greece (Frantzis 1998) and Bahamas (Balcomb & Claridge, 2001, Evans & England 2001). The present study is part of a coordinated effort by La Laguna University and Woods Hole Oceanographic Institution to try to understand the behaviour of beaked whales, in order to provide an insight into their apparent acute sensitivity to anthropogenic sound and to help identify areas of high density of beaked whales, where the use of military sonar should be avoided. In this paper we present data on the social structure and distribution of two little-known beaked whale species in relation to environmental factors in El Hierro, an area that may hold one of the greatest coastal concentrations of Blainville's and Cuvier's beaked whales in the world.

METHODS The work aimed to gather a broad range of data from the whales and their environment, using suction cup-attached tags that record motion and sound up to 48kHz (DTag, Johnson & Tyack, 2003), together with visual and photo ID methods and sampling of oceanography and prey. The main study platform was the 12m engine powered vessel "DONA PI". The track of the vessel was recorded continuously with a GPS connected to the software Logger (Guillespie, IFAW) and NMEALog (Grund, WHOI) and displayed in real time in GIS format by NMEA-IF (Zimmer, Saclancten). Four visual observers were searching at any time 360º around the boat. Data on the social composition of the groups, movements and behaviour of the whales were recorded directly onto the computer during focal follows of the whales. An inflatable boat was used for the final tagging approach and the DTags were carefully deployed with a hand-pole. Tracking of the tagged whale was aided by a radio beacon on the tag, used also to locate and recover the tag after its release. Identification photographs of the whales in a group were taken and stored in a database, classified as males, females, juveniles, calves or unidentified (based on body size, head shape and the presence of scratch marks and teeth). A third data collection platform was situated on a high point on land to help locate and follow the beaked whales using a radio to communicate with the main vessel. Oceanographic data was recorded at 8 sites with a CTD deployed to 900m depth. Findings of freshly-severed pieces of deep water squid and fish at the surface near diving beaked whales provided circumstantial evidence of possible prey species.

Area of study El Hierro is the youngest and most westward island of the volcanic Canaries archipelago. Its marine perimetre is defined by a short shelf that extends from three wide bays with a steep slope, reaching depths of up to 3000m at just 2 nm from the coast. The location of the visual effort from the base port of La Restinga in the longer cruise in October is shown in Figure 1.

RESULTS AND DISCUSSION The two cruises *Roases I* and *Roases II* (April & October 2003) produced 24 good weather days, of which beaked whale sightings were recorded on 20 days (8 out of 9 days in April and 12 out of 15 days in October), plus 2 days that were dedicated to oceanographic data collection.

The *Ziphiidae* species recorded were Blainville´s, Cuvier´s and unidentified beaked whales. Sightings in *Roases II* were more abundant, their locations are shown in Figure 2. A total of 71 groups were observed (18 in April, 53 in October), and the number of successive sightings of groups is represented in Figure 3. Figure 4 shows the length of time that we were able to follow each individual group (focal follow). A real time identification of the groups was intended, but in case of uncertainty the new sightings were classified as a new group, which probably resulted in an overestimation of the number of groups encountered. To solve this problem, ID photos were taken of 18 groups (4 in April, 14 in October) and classified in a database containing a total of 58 good quality pictures of up to 31 individuals, with results shown in figures 5 and 6. Pictures were classified noting the side and the area of the body, divided in 4 sections (head, thoracic region, dorsal fin region and caudal peduncle). Only 4 individuals could be confirmed to be photo re-captured on different days, although there were characteristic groups that could be identified visually. The sighting rate from land was higher than from the boat, in spite of the lower number of observers (figure 9). The field of view was 170º from the observation land site and the sighting ranges from the coast varied from 300m up to 7000m.

The social composition and number of individuals per group were highly variable. The mean group size of Blainville´s beaked whales was on average bigger than that of Cuvier´s beaked whales as shown in figure 8. In addition, four groups of *M. densirostris* were seen with calves. Data on the social composition of the groups agrees with Claridge *et al.* (1999) on the harem reproductive strategy of Blainville's beaked whale, since only one male was observed at any time with a given group of females-calves-juveniles. However, a high variability on the composition of the groups was observed as it is shown in figure 7.

CTD data was collected at eight sites covering the study area during the autumn cruise. The sea temperature ranged from 24ºC at the surface to 8ºC at 900m. Results showed a clear difference between the oriental and occidental study zones separated by the bank off the southern end of the island. This might be related to the different sighting rate of the Blainville's and Cuvier" beaked whales in both areas (figure 2).

Two Blainville´s beaked whales were tagged for 16 and 4 hours respectively. Seven dives to depths around 800m were recorded, with mean lengths of 50 minutes. Both tagged whales remained near the coast of El Hierro during that time. These data reinforce the observations during the focal follows about the fidelity of these whales to the El Hierro coast. In addition, ultrasonic clicks and buzzes typically related with foraging were heard at the bottom of the deep dives, the buzzes often followed by impact sounds (Johnson *et al.*, in press). Results suggest that El Hierro constitutes a calving and feeding area for *M. densirostris*. However, the degree of residence of Blainville's and Cuvier's beaked whales is still unknown.

ACKNOWLEDGEMENTS This project was funded by SERDP under research program CS1188 with the collaboration of the Council of Environment of the Canaries Government. The research was supported by the Government of El Hierro, the fishermen association Ntra. Sra. de la Virgen de los Reyes, the office of the Marine Reserve Mar de las Calmas-Punta de La Restinga and Canarias Multináutica.

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Fig. 1. Vessel effort lines in *Roases II*

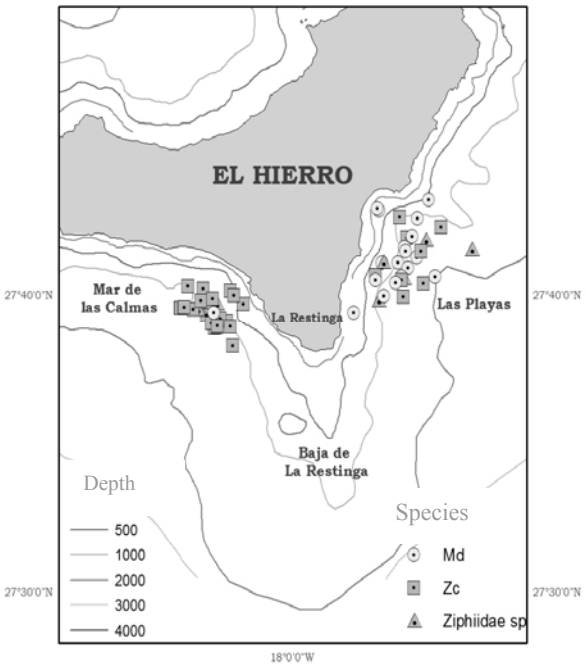

Fig. 2. Beaked whale sightings in *Roases II*

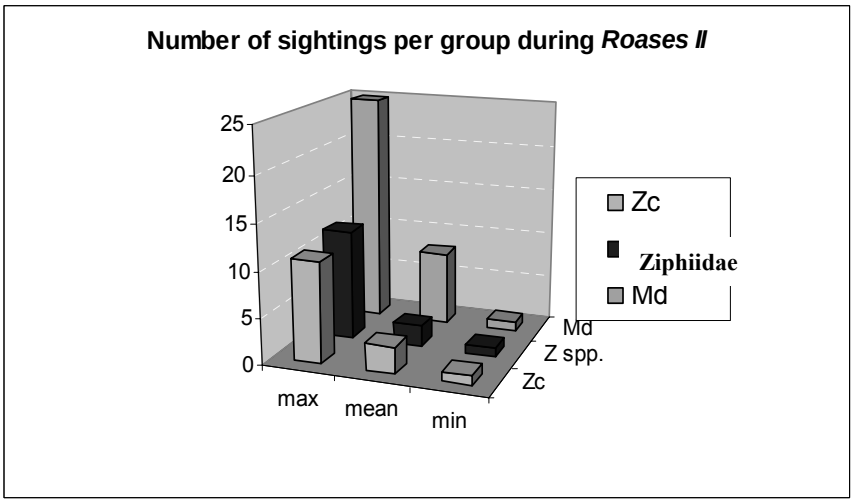

Fig. 3. Number of surfacing periods (sightings) recorded per individual group during *Roases II* cruise

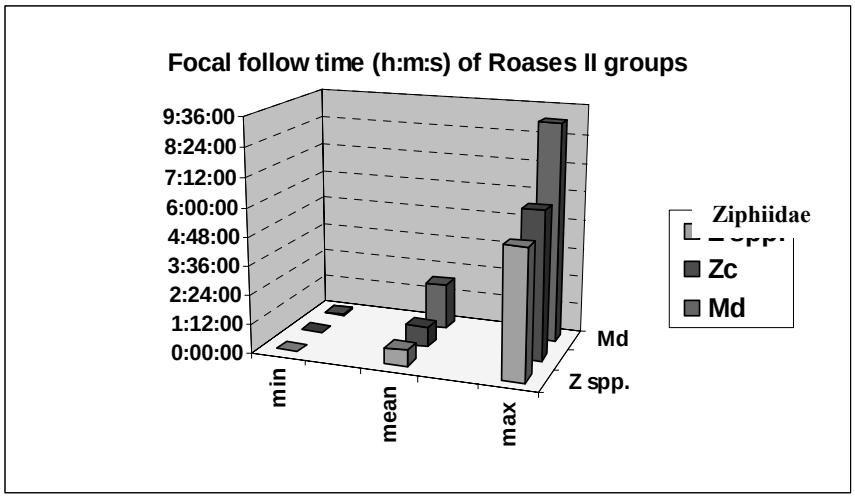

Fig. 4. Time from the first to the last sighting of an individual group (focal follow time)

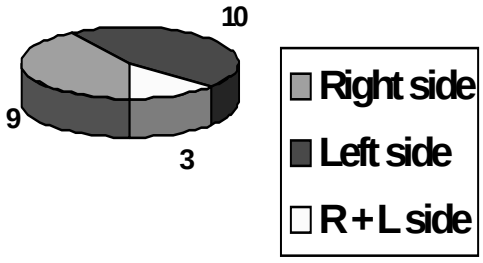

Fig. 5. Number of identified Blainville's beaked whales: Min: 13; Max: 22

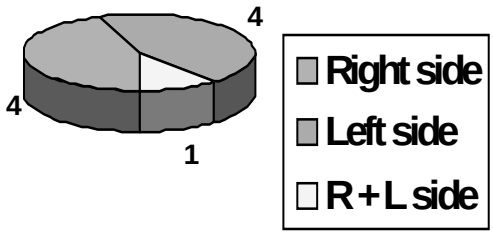

Fig. 6. Number of identified Cuvier's beaked whales: Min: 5; Max: 9

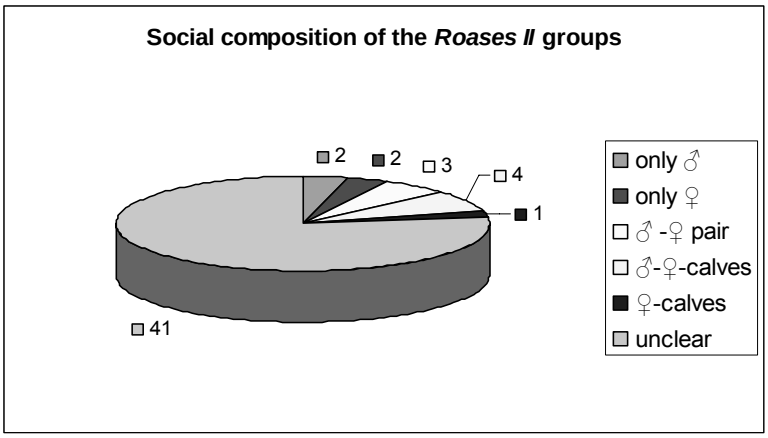

Fig. 7. Social composition of the *Ziphiidae* groups during Roases II cruise

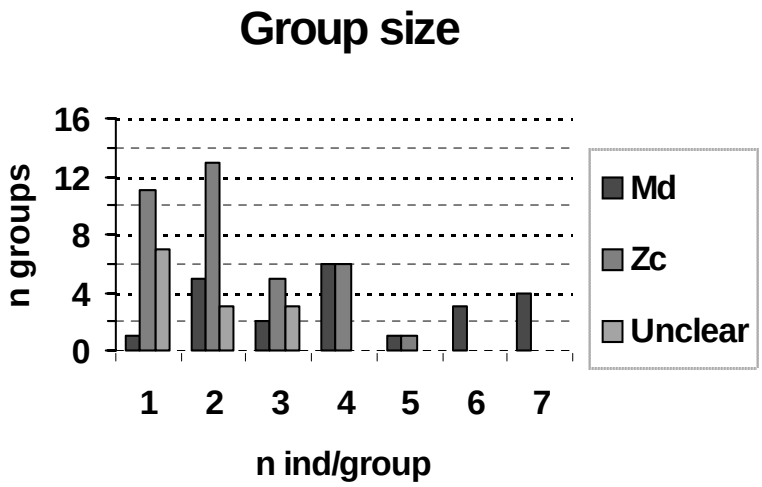

Fig. 8. Number of individuals per *Ziphiidae* group

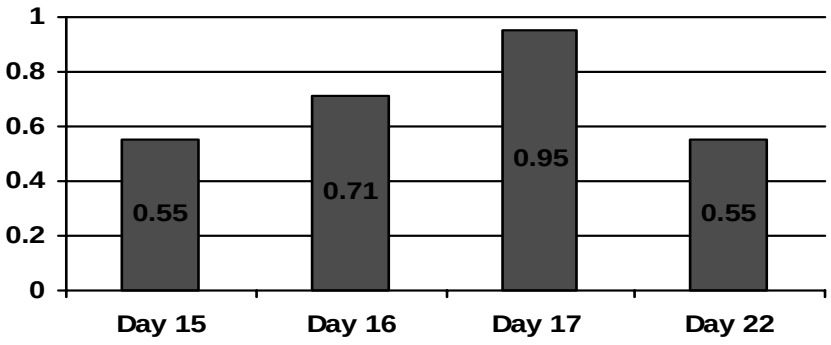

Fig. 9. Sightings from land during *Roases II*: number of groups per unit of effort (1 hour*2 people watching with binoculars)

THE POTENTIAL BENEFIT OF RESAMPLING STATISTICS IN MARINE MAMMAL BYCATCH STUDIES: THE EXAMPLE OF THE NEWFOUNDLAND COD FISHERY

S. Benjamins[1], J. Lawson[2], and J. Lien[1]

[1] *Memorial University of Newfoundland, Whale Research Group, Biology Annex, 297 Mt.Scio Road, St.John's, NL, A1C 5S7, Canada*
[2] *Department of Fisheries and Oceans, Marine Mammal Section, P.O.Box 5667, St.John's, NL, A1C 5X1, Canada*

Marine mammal bycatch studies frequently have to cope with a low number of recorded capture events per unit of fishing effort. This often results in unreliable bycatch estimates due to a small or skewed data distribution. Also, it is often unclear what the 95% confidence intervals of these estimates represent. It is recognised that better observer training and fisheries coverage would probably solve some of these problems, but this is frequently impossible due to financial and/or logistical constraints. A possible means of improving estimates of bycatch for small-scale or otherwise statistically biassed observer datasets might be found in an analytical methodology known as resampling, or bootstrapping. We applied a resampling statistical software package to a dataset of harbour porpoise bycatches reported in inshore, small-boat fisheries for cod and other groundfish along the coasts of Newfoundland and Labrador (Canada). Bycatch records from a selected group of fishermen were used to estimate total bycatch levels in this fishery per unit effort, using both a conventional raising factor and a bootstrap. The results generated by the bootstrap methods were of the same order of magnitude as those generated by the conventional raising factor (for example, for the east coast of Newfoundland, one bootstrapping run estimated an average of 1399 bycaught porpoises in the 3d quarter of 2002, while the conventional method estimated 693 bycaught porpoises). In addition, the bootstrapping method allowed for the determination of 95% confidence limits for these estimates (in this example, between 401 and 2846 bycaught porpoises) while accounting for non-normality in the data. These results show that bootstrapping data is a useful method in approximating total marine mammal bycatch. Its application may provide bycatch estimates in which uncertainty is taken into account more fully. However, a minimum amount of reliable fishing effort data is required for its succesful application.

PAN-EUROPEAN CETACEAN MONITORING: THE ATLANTIC RESEARCH COALITION

T. Brereton[1], D. Wall[2], A. Williams[3], J. Vasquez[4], D. Curtis[5], P. Cermeno[4], and C. Martin[3]

[1] *Atlantic Research Coalition, 1 Sunnyside, Main Street, Bothenhampton, Bridport, Dorset. DT6 4BL, UK*
[2] *Irish Whale and Dolphin Group, c/o Mammal Research Group, University College Dublin, Belfield, Dublin 4, Ireland*
[3] *Biscay Dolphin Research Programme, 6 Manor Way, Lee on Solent, Hampshire, PO13 9JH UK*
[4] *Ambar, c/o C/ Blas de Otero, 18, 5 iz. 48014. Bilbao, Spain*
[5] *Plymouth to Santander Marine Survey, Chy-an-Meneth, Callington, Cornwall PL17 8HL, UK*

The Atlantic Research Coalition (ARC) is an evolving new partnership of marine research and conservation bodies that undertake offshore cetacean surveys using similar scientific methods. The partnership was established in 2001 as a collaborative, pan-European approach to the annual monitoring of cetaceans in west European waters. ARC is currently represented by partners from three European countries including Great Britain (the Biscay Dolphin Research Programme and the Plymouth to Santander Marine Survey), Ireland (the Irish Whale and Dolphin Group) and Spain (Ambar). Collectively, the partners undertake monthly, year-round monitoring across four seas: the Bay of Biscay, Celtic Sea, English Channel, and Irish Sea, using commercial ferries which follow set routes. The groups receive passage and other sponsorship from the commercial ferry route operators. During the course of the ARC surveys in 2001 over 600 cetacean sightings, totalling approximately 10,000 animals of 15 species were recorded by the four research teams. The sightings included large numbers of striped dolphin (*Stenella coeruleoalba*) and fin whale (*Balaenoptera physalus*) in the Bay of Biscay and important seasonal populations of common dolphin (*Delphinus delphis*) and harbour porpoise (*Phocoena phocoena*) in the Celtic Sea, western English Channel and Irish Sea. Regionally uncommon species recorded included the false killer whale (*Psudorca crassidens*), Cuvier's beaked whale (*Ziphius cavirostris*), northern bottlenose whale (*Hyperoodon ampulatus*) and sperm whale (*Physeter macrocephalus*). The chief aim of the ARC surveys is to generate annual indices of abundance for cetacean species in west European waters and to detect longer-term population trends. It is hoped that the data can be used to detect population changes of conservation concern, identify conservation threats and inform marine resource management policy for the benefit of these spectacular animals.

THE IMPACT OF DOLPHIN-WATCHING BOATS ON THE RESIDENT BOTTLENOSE DOLPHINS (*TURSIOPS TRUNCATUS*) IN THE SADO ESTUARY, PORTUGAL

I. Cascão[1], R. Gaspar [2], and A. L. Custódio [3]

[1]Rua Brito Camacho lote 1606, Quinta do Conde 2, 2975-320 Quinta do Conde, Portugal
(e-mail: irma.cascao@clix.pt)
[2] Institute of Conservation of Nature, Portugal
[3] Department of Mathematics, Faculty of Sciences and Technology, New University of Lisbon, Portugal

INTRODUCTION The Sado Estuary resident bottlenose dolphin (*Tursiops truncatus*) population is very small, with approximately 30 animals (Gaspar, 2000). The population size has been declining due to non-existent immigration, diminutive recruitment and ageing of the adults. Dolphin-watching has become an important economic, educational and recreational activity in the Sado Estuary (RNES, 2001). The increasing dolphin-watching activities may further threaten this declining population. In order to understand the response of these dolphins to boats, this study monitored dolphin respiration and behaviour in the presence and absence of boats.

METHODS During the summer months of 2000 and 2002, dolphin and boat-dolphin encounters were observed from two land-based stations, on the north shore of the Sado Estuary (Fig. 1). Observations were made using the focal group sampling method (Martin and Bateson, 1993). A boat was considerate as being present when operating approximately within 300m of dolphins.

Specific data recorded:

i) Respiration parametres
- duration of surfacing sequence
- blows per surfacing sequence
- blow interval
- dive duration

ii) Behavioural parametres
- activity alteration
- change of orientation
- group alteration
- tailslaps

Analysis:

i) *Z-test* – testing for difference between two means in situations without and with boats.
ii) *Linear regression* – correlation between parametres and number of boats.
iii) *Chi-square test* – testing whether significant changes exist due to a specific number of boats.

RESULTS A high number of recreational boats observed the bottlenose dolphins, but tourism boats spent longer periods of time with the animals. In 2000, the mean number of boats watching dolphins per day was 12.09 (SE=1.28), ranging from 2 to 22. While in 2002 the mean number decreased to 7.62 (SE=1.37), varying from 1 to 32. Tables 1 and 2 present the results of the four respiration parameters studied (represented in Fig. 2), while the results of the behavioural parametres are summarised in Table 3 and 4 (represented graphically in Fig. 3).

CONCLUSIONS In the presence of boats, dolphins significantly decreased their blow intervals, prolonged their dives, as well as they increased their tailslaps, significantly changed their activity, orientation and group composition or spatial structure. Blow interval, dive duration and tailslaps were significantly correlated with the number of boats. Reactions were the same regardless of boat type. The number of boats and negligent boat handling influence bottlenose behaviour. Regulating dolphin boat tours may avoid further disturbance.

ACKNOWLEDGEMENTS We are grateful to the Institute of Conservation of Nature for funding this project in 2002. For logistic support, we thank the Natural Reserve of the Sado Estuary and Vertigem Azul. Appreciation is extended to all the volunteers for their precious help in the fieldwork.

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Table. 1. Respiration parametres studied during the summer months of 2000

Respiration parametres	Boat-dolphin encounters	Correlation between resp. & nº of boats	Changes due to a specific nº of boats
Duration of surf. seq.	**Signif. shorter** $Z = 2.916$, $P < 0.01$	Not correlated adj. $R^2 = 0.130$ $F = 1.596$, $P > 0.05$	-
BLOWS PER SURF. SEQ.	**Signif. reduced** $Z = 1.899$, $P < 0.05$	Not correlated adj. $R^2 = -0.285$ $F = 0.114$, $P > 0.05$	-
BLOW INTERVAL	**Signif. shorter** $Z = 5.017$, $P < 0.01$	**Signif. correlated** adj. $R^2 = 0.902$ $F = 37.980$, $P < 0.01$	3 boats up $\chi^2 = 22.033$ $df = 3$, $P < 0.01$
Dive duration	**Signif. longer** $Z = -3.315$, $P < 0.01$	**Signif. correlated** adj. $R^2 = 0.778$ $F = 15.001$, $P < 0.05$	3 boats up $\chi^2 = 16.491$ $df = 6$, $P < 0.05$

Table. 2. Respiration parametres studied during the summer months of 2002

Respiration parametres	Boat-dolphin encounters	Correlation between resp. & nº of boats	Changes due to a specific nº of boats
Duration of surf. seq.	Not signif. longer $Z = -1.526$, $P > 0.05$	Not correlated adj. $R^2 = 0.246$ $F = 2.305$, $P > 0.05$	-
BLOWS PER SURF. SEQ.	**Signif. increased** $Z = -3.394$, $P < 0.01$	Not correlated adj. $R^2 = -0.216$ $F = 0.290$, $P > 0.05$	-
BLOW INTERVAL	**Signif. shorter** $Z = 10.244$, $P < 0.01$	**Signif. correlated** adj. $R^2 = 0.875$ $F = 28.976$, $P < 0.05$	1 boat up $\chi^2 = 50.241$ $df = 5$, $P < 0.01$
Dive duration	**Signif. longer** $Z = -4.413$, $P < 0.01$	**Signif. correlated** adj. $R^2 = 0.928$ $F = 52.523$, $P < 0.01$	1 boat up $\chi^2 = 12.371$ $df = 5$, $P < 0.05$

Table. 3. Behavioural parametres studied during the summer months of 2000

Behavioural parametres	Boat-dolphin encounters	Correlation between behav. & nº of boats	Changes due to a specific nº of boats
Activity alteration	**Signif. increased** Z = -2.345, P < 0.01	Not correlated adj. R^2 = 0.404 F = 3.715, P > 0.05	-
CHANGE OF ORIENTATION	**Signif. increased** Z = -2.339, P < 0.01	Not correlated adj. R^2 = 0.371 F = 3.357, P > 0.05	-
Group alteration	**Signif. increased** Z = -3.614, P < 0.01	Not correlated adj. R^2 = 0.135 F = 1.626, P > 0.05	-
Proportion of tailslaps	**Signif. increased** Z = -5.217, P < 0.01	**Signif. correlated** adj. R^2 = 0.914 F = 43.632, P < 0.01	1 boat up χ^2 = 5.317 df = 1, P < 0.05
Number of tailslaps	**Signif. increased** Z = -5.386, P < 0.01	**Signif. correlated** adj. R^2 = 0.953 F = 82.468, P < 0.01	1 boat up χ^2 = 5.317 df = 1, P < 0.05

Table. 4. Behavioural parametres studied during the summer months of 2002

Behavioural parametres	Boat-dolphin encounters	Correlation between behav. & nº of boats	Changes due to a specific nº of boats
Activity alteration	**Signif. increased** Z = -2.760, P < 0.01	Not correlated adj. R^2 = -0.324 F = 0.022, P > 0.05	-
CHANGE OF ORIENTATION	**Signif. increased** Z = -3.428, P < 0.01	Not correlated adj. R^2 = -0.057 F = 0.784, P > 0.05	-
Group alteration	**Signif. increased** Z = -4.287, P < 0.01	Not correlated adj. R^2 = 0.274 F = 2.506, P > 0.05	-
Proportion of tailslaps	**Signif. increased** Z = -1.968, P < 0.05	**Signif. correlated** adj. R^2 = 0.915 F = 44.123, P < 0.01	No changes χ^2 = 2.864 df = 1, P > 0.05
Number of tailslaps	Not signif. increased Z = -0.722, P > 0.05	**Signif. correlated** adj. R^2 = 0.735 F = 12.100, P < 0.05	No changes χ^2 = 2.864 df = 1, P > 0.05

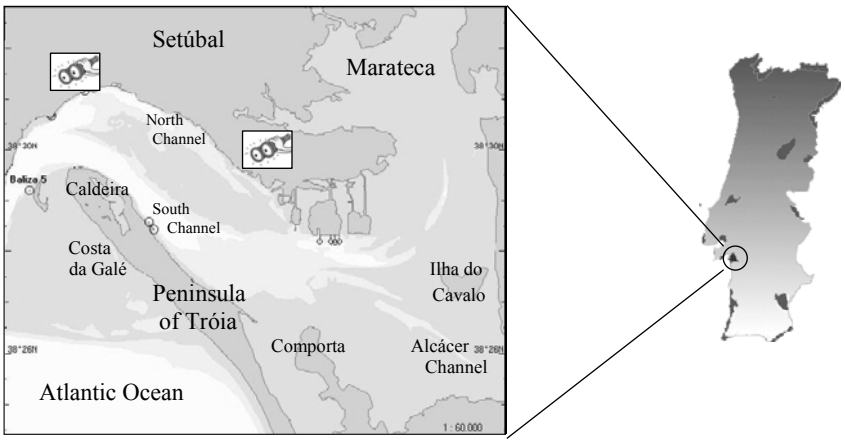

Fig. 1. Two land-based stations, on the north shore of Sado Estuary

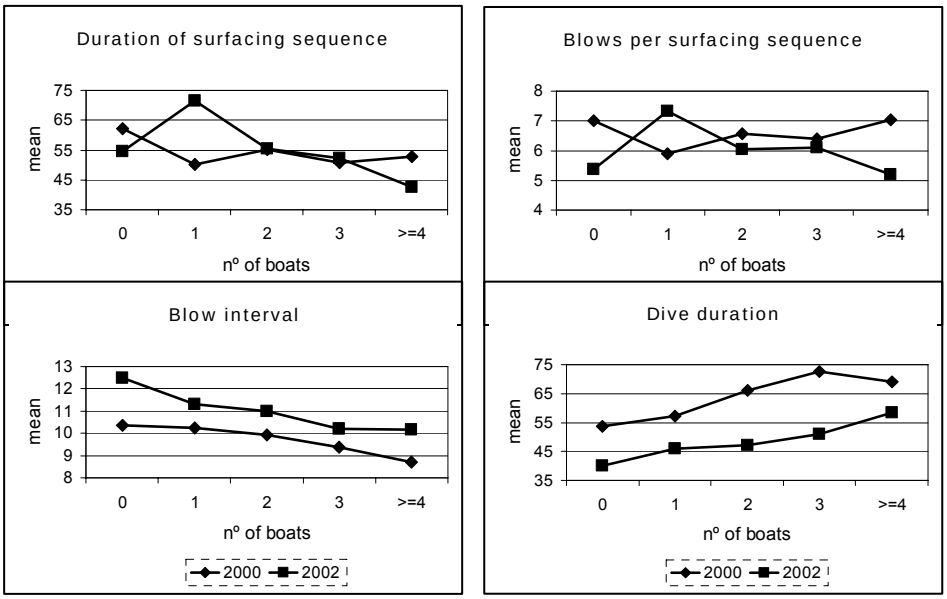

Fig. 2. Effect of the number of boats on respiration parametres. Mean values of each parametre for each number of boats are shown

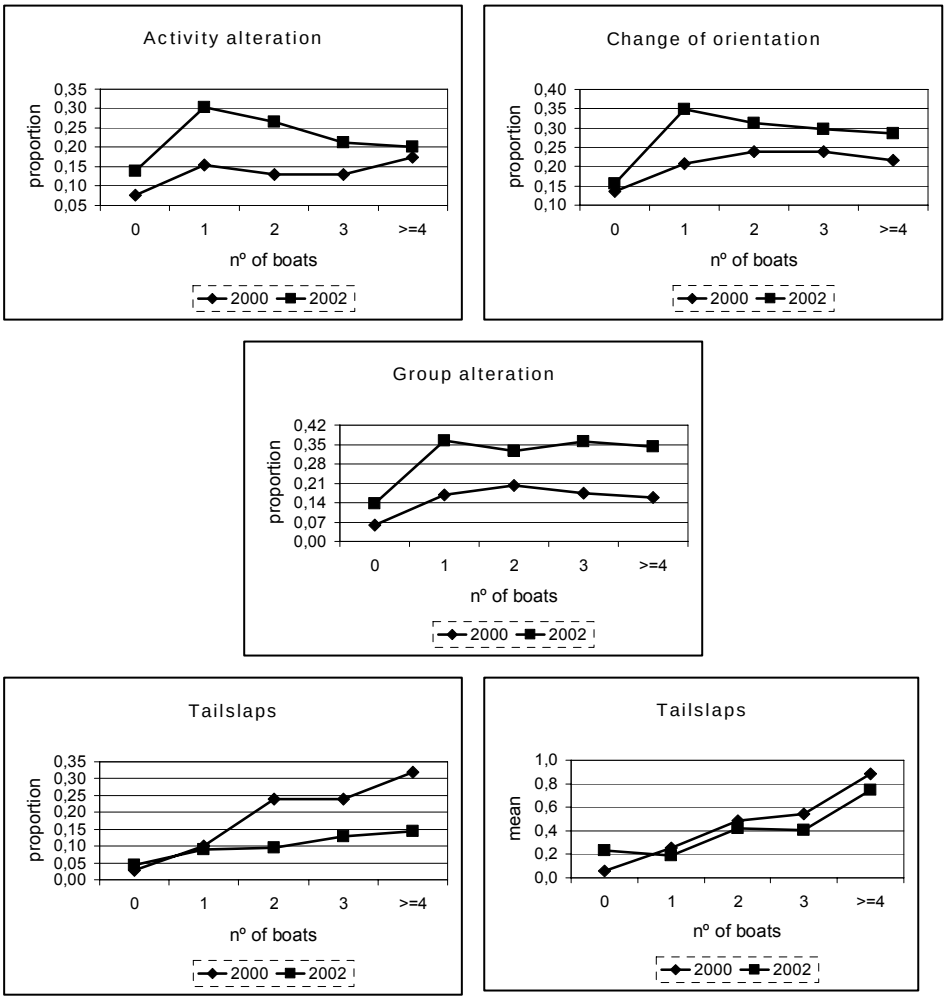

Fig. 3. Effect of the number of boats on behavioural parameters.
Proportion or Mean values of each parametre for each number of boats are shown

THE MAKING OF RICH WHALE PREY PATCHES:
AN EXAMPLE WITH KRILL ON A WHALE-WATCHING SITE IN THE ST. LAWRENCE ESTUARY

C. Cotté[1], and Y. Simard[1, 2]

[1] *ISMER (UQAR), 310 allée des Ursulines, Rimouski, Québec, G5L 3A1, Canada*
[2] *Maurice-Lamontagne Institute, Fisheries and Oceans Canada, P.O. Box 1000, Mont-Joli, Québec, G5H 3Z4, Canada*

Hydroacoustics (38 and 120kHz) was used to estimate the abundance and three dimensional distribution of krill and small pelagic fish at the downstream end of Isle Rouge bank (St. Lawrence Estuary) during the semi-diurnal tidal cycle in July 2002. During the flood, upwelling and strong tidal currents (> 1 m.s-1) forced the krill to aggregate against the Isle Rouge bank slope. This rich krill patch is then advected in the Laurentian Channel during the ebb. The krill mean density changed from 4 g.m-2 in the neighbouring layers of the Laurentian Channel to 500 g.m-2 in the shoaling zone where the patch is formed. This aggregation is ascribed to the interaction between the semidiurnal tidal currents, the local topography, and the negative phototactism of krill. The euphausiids forced towards the bank during the flood, swim downwards to fight the vertical currents in order to maintain a light level that minimises the risk of visual predation. The rich krill patches, composed of *Thysanoessa raschi* and *Meganyctyphanes norvegica*, were locally accompanied with capelin (*Mallotus villosus*) and sand-eel (*Ammodytes americanus*) feeding on these flood aggregations during the daytime. The recurrent and tidally predictable availability of rich krill patches makes this part of the Isle Rouge bank a highly attractive area for predators such as small pelagic fish and whales, the latter foraging on these two types of prey during the flood. The above dynamics is an example of "patchiness" in action, an essential oceanographic process incorporated in whale feeding strategy and survival.

THE ROLE OF GENOMIC DIVERSITY IN THE DEVELOPMENTAL STABILITY OF THE EASTERN NORTH ATLANTIC POPULATION OF HARBOUR PORPOISE

C. J. De Luna[1], L. W. Andersen[2], K. A. Tolley[3], and A. R. Hoelzel[1]

[1]*School of Biological and Biomedical Sciences, University of Durham, Science Laboratories, South Road, Durham, DH1 3LE, UK*
[2]*National Environmental Research Institute, Dept. of Coastal Zone Ecology, Kalø, Grenåvej 12, DK-8410 Rønde, Denmark*
[3]*Zoology Department, University of Stellenbosch, Private Bag X1, Matieland 7602, South Africa*

Developmental stability refers to the mechanisms responsible for ensuring a constant phenotype under genetic, environmental and developmental variation. But when the action of environmental or genetic stressors acts upon an organism during development, they can deplete the level of developmental stability. Fluctuating asymmetry (FA) has been used as a measure of developmental stability. Non-directional alterations from perfect symmetry for morphometric characters represent measures of FA. This study determines the level of developmental stability by means of FA in the eastern North Atlantic population of the harbour porpoise. Six bilateral characters were chosen for the determination of FA. All characters were scored on the left and right side of the skull. Asymmetry was recorded by calculating the absolute difference in length between right and left sides. Tissue samples were obtained from some of the animals measured. They were genotyped for twelve microsatellites loci. Genomic diversity was determined by calculating Mean d2 (squared difference in repeat units between alleles at a microsatellite loci averaged over all loci), which could be used to record the effects of inbreeding. Four of the six traits showed significant differences among the five subpopulations studied (Norwegian, Ireland and Wales, British North Sea, Danish North Sea, and Inner Danish Waters). The most frequent pattern found was that the Norwegian subpopulation contained the more asymmetric animals. It also found a significant correlation between FA and genomic diversity. Measure of fitness such as developmental stability has found to be correlated with genetic diversity. The more diverse the genome of the porpoises is, the less asymmetry they showed. This suggests that the porpoises living in these subpopulations could be under different kinds of environmental and/or genetic stress. Therefore, local management policies for conservation should be implemented.

PRELIMINARY EVALUATION OF TOUR BOATS IMPACT ON FOUR CETACEAN SPECIES IN MADEIRA ISLAND

A. Dinis, L. Freitas, and F. Nóbrega

Whale Museum, Largo Manuel Alves, 9200 - Caniçal, Madeira, Portugal

In the past few years, demand for cetacean observations in the wild increased in Madeira Island. That led to tour operators looking for encounters in their sightseeing trips. The present work aimed to evaluate the impact of tour boats on four cetacean species. The target species were bottlenose dolphins, short finned pilot whales, Atlantic spotted dolphin, and the sperm whale. These four species are regularly sighted in these waters and use them for feeding and reproduction. The study area was determined based on the area that tour vessels use most often. From a high cliff land station, a digital theodolite with computer software connected (Pythagoras), was used to establish surfacing positions of both boats and animals. Tracking data obtained indicates that of the four species, the Atlantic spotted dolphin most frequently interacts with boats. Both bottlenose dolphins and Pilot whales seemed to avoid the area and sperm whales increased their surfacing behaviour and changed their speed whenever boats were in the area. It was also noticed that, with the exception of Atlantic spotted dolphin, the presence of the other three species decreased when the presence of tour boats increased in the study area.

LIFE HISTORY CHARACTERISTICS OF NEW ZEALAND SEA LIONS (*PHOCARCTOS HOOKERI*) INCIDENTALLY CAUGHT IN FISHERIES AROUND NEW ZEALAND, 1997-2002

N. Gibbs[1, 2], P.J. Duignan[2], and G.W. Jones[2]

[1] *New Zealand Wildlife Health Centre, IVABS, Massey University, Palmerston North, New Zealand*
[2] *Department of Conservation, Wellington, New Zealand*

Each year between January and April, New Zealand sea lions are incidentally caught in the offshore squid trawl fishery. Life history parametres and cause of death were determined for 116 animals caught in 1997 (n = 27), 1999 (n = 6), 2000 (n = 22), 2001 (n = 40) and 2002 (n = 21). There was no significant difference in the sex ratio. Age was estimated based on counting dentinal growth layer groups (GLGs) of mandibular canine teeth. There was no significant difference in the age structure between sexes, with the mean age of males at 7.3 years (range 2 to 15 years) and the mean age of females at 6.2 years (range 2 to 12 years). Histological examination of the testes and epididymis was used to classify males as immature, pubescent, mature-inactive, or mature-active. Reproductive maturity in females was determined from gross and microscopic examination of the uterus and mammary glands, and of the ovaries for corpora albicantia and corpora lutea. Most (96%) males had mature testes, with 73% classed as mature but inactive. The two males that were not mature were classed as pubescent. The histological appearance of the testes was consistent with the interval between date of capture and the peak of breeding activity in December. Most (97%) of the females were mature, of which 95% had an active corpus luteum in one ovary. This was consistent with capture dates in February and March when mature females should be in the early stages of pregnancy. Forty (66%) females were also lactating suggesting that they had given birth to a pup that season and were suckling the pup at time of death. The data support field observations suggesting that in some females sexual maturity may be achieved at three years with first parturition during their fourth year.

CETACEANS OF THE NORTHERN BLACK SEA AND THE SEA OF AZOV AS AN OBJECT OF FOOD CONSUMPTION

E.B. Gol'din[1], and P.E. Gol'din[2]

[1] *Crimean State Agricultural and Technological University, Crimean State Medical University, 122/89, Kievskaya Street, P.B. 2223, Simferopol, Crimea, 95043, Ukraine, (e-mail: Evgeny_goldin@mail.ru.)*
[2] *Dept. of Zoology, V. I. Vernadsky Taurida National University, 4, Vernadsky Avenue, 95007 Simferopol, Crimea, Ukraine,(e-mail: oblako@home.cris.net.)*

INTRODUCTION Take of cetaceans in the Black Sea and the Sea of Azov in fisheries, mainly for human consumption and animal food production, lasted for 19-20 centuries (Silantyev, 1903; Semenov Tyan Shansky, 1910; Shikhov, 1923; Kleinenberg, 1956), until 1966 in the Northern Black Sea. Since that time, numerous incidental by-catches of cetaceans have been reported (Pavlov *et al*., 1996). In 1966-1991, by-caught cetaceans were legally used for domestic animal consumption. In early 1990s, cases of human consumption and market trade occurred. After 1994, the conservation status of all cetacean species was improved in the Ukraine (Szczerbak, 1994), and food consumption of by-caught animals was prohibited. However, economical use of by-caught and stranded cetaceans by coastal residents is still occurs. Nevertheless, this problem was not studied in the region because of a number of constraints. As a rule, the particular details remain unknown to scientists and the authorities therefore, anonymous reports on the consumption of cetaceans including personal experience, evidence of consumption by parents, neighbours and friends were requesed from the student audience. This approach was found to be very effective and has brought very interesting results (Gol'din and Gol'din, 2003).

MATERIALS AND METHODS We analysed the results of students' poll in 2002-2004 involving 587 respondents from the Ukrainian coast of the Black Sea and the Sea of Azov, from Odessa to Taganrog, and some anonymous reports by residents of the eastern Crimea (Ukraine). The questionnaire contained confidential questions about economical use of animal carcasses by coastal residents (for human consumption, domestic animal feeding, cases of incidental and non-incidental catches, etc.) (Gol'din and Gol'din, 2004).

RESULTS AND DISCUSSION In total, 47 cases of food consumption were reported with 13 respondents reporting repeat cases. Almost all the cases were observed in 1998-2003 (Fig. 1). 38.2% of cases were reported from the Southern coast of Crimea (east), 21.3% from the Sea of Azov and Kerch Strait, 17.8% from Calamita Gulf. 46.8% of cases refer to human consumption (mainly in Calamita Gulf and adjoining area (from the Donuzlav Lake to Kacha River) and in the eastern part of Southern Crimean coast), 53.2% to animal feeding in poultry and hog households, dog and cat feeding (Calamita Gulf and the Sea of Azov) (Fig. 2). The most cases, in which the species was identified, refer to harbour porpoise. The least number of cases was observed in economically developed regions. Two geographical areas differing by the character of food consumption were distinguished: (1) the coast of the Sea of Azov and Kerch Strait: The human consumption is particularly oriented to porpoise fat traditionally believed to be a medicine; the dog consumption of meat is routine; the main source is incidental by-catch; (2) the Black Sea coast of Crimea: The human and animal consumption of meat is occasional and involves stranded, as well as by-caught animals. Three cases of café/restaurant service in cities were reported. Two cases of direct take were reported marking a dangerous tendency in human-cetacean interaction.

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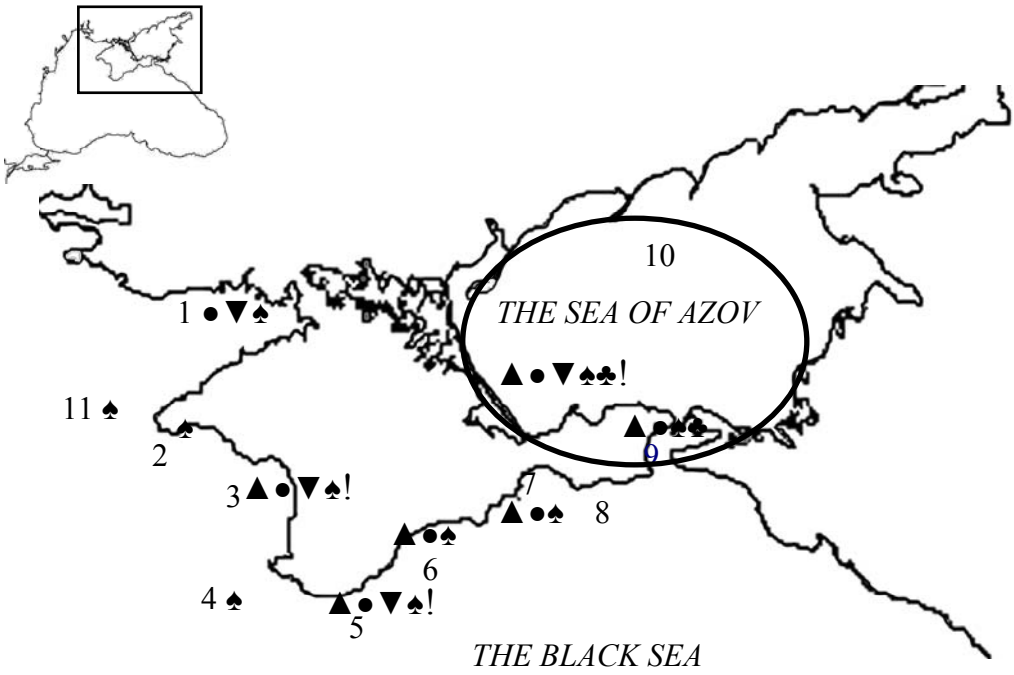

Coastal regions:

1 – Karkinit Gulf
2 – southern coast of Tarkhankut peninsula
3 – Calamita Gulf
4 – Herakleya peninsula
5 – Southern coast of Crimea (west)
6 – Southern coast of Crimea (east)
7 – Feodosia Gulf
8 – southern coast of Kerch peninsula
9 – Kerch Strait
10 – the Sea of Azov (southern and northern coast)
11 – the north-western Black Sea coast

Symbols:
▲ human consumption
● dog and cat consumption
▼live stock and fowl consumption
♠ findings of animals butchered
♣ medicinal use of fat
! reports of direct takes
__ region of traditional medicinal use of fat

Fig. 1. Distribution of cases of cetacean food consumption in the Northern Black Sea and the Sea of Azov

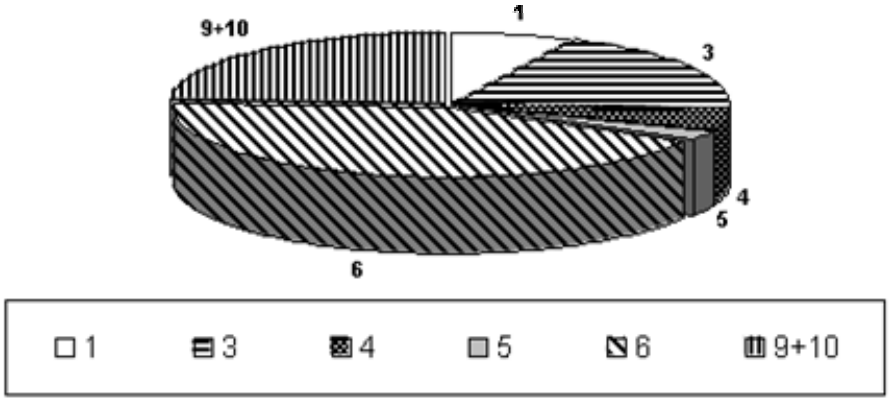

Fig. 2. Regional distribution of reports of cetacean consumption
(Region codes are indicated by Figures 1-10; see above)

PUBLIC ATITUDES TO CETACEAN CONSERVATION IN SCOTLAND

C. Howard [1,2] and E. C. M. Parsons [3,4]

[1] *School of Life Sciences, Heriot-Watt University, Edinburgh, Scotland.*
[2] *Current address: Environment Agency, Richard Fairclough House, Knutsford Road, Warrington, Cheshire, WA4 1HG, England (E-mail: claire.howard@environment-agency.gov.uk)*
[3] *University Marine Biological Station, Millport, Isle of Cumbrae, Scotland.*
[4] *Current address: Department of Environmental Science & Policy, David King Building, George Mason University, 4400 University Drive, Fairfax, Virginia 22030-4444, USA. (E-mail: ecm-parsons@earthlink.net)*

INTRODUCTION To date, 24 species of cetaceans have been recorded in Scottish waters (Evans, 1980, 1992; Shrimpton and Parsons, 2000; Weir *et al.,* 2001; Reid *et al*., 2003). However, the protection of these habitats, and subsequently the necessary conservation of many species of marine life (including cetaceans) is not without its problems. Global threats to cetacean populations are also endemic in Scotland. For example, fisheries by-catch, which is considered to be a major source of cetacean mortality worldwide (Read, 1996; Morizur, *et al*., 1999; Read, *et al*., 2003), is also an issue in Scotland. Although perhaps not such a serious matter on the west coast due to a lack of gillnet fishing effort (Gill, 1999), it is certainly a problem in eastern waters of the North Sea, where levels of by-catch are deemed to be unsustainable (Northridge and Hammond, 1999). Entanglement in marine litter, is also a cause for concern in Scotland (e.g. Gill, *et al.,* 2000). As with the rest of the world concern over the impacts of anthropogenic pollutants on cetaceans is also another cause for concern for cetaceans in Scotland, particularly organochlorine contaminants such as PCBs and DDT (McKenzie, *et al*., 1997; McKenzie, 1999). On a more local level, the effects of other chemicals and pathogens borne by largely untreated sewage have also been highlighted (Grillo *et al.,* 2001). Finally, the global depletion of fish stocks is of concern not just for marine mammals but in terms of wider marine ecosystems (Omerod, 2003); certainly Scottish waters, in particular the North Sea (Wolff, 2000), have experienced long-term fisheries over-exploitation. At present there are no definite links between declined fish stocks and a reduction in cetacean populations, though it is reasonable to infer that there will be some correlation of the two (Mulvaney and McKay, 2000).

There are also regional conservation issues within Scotland that are of particular concern at least on a local level, if not on a larger scale. Such issues include disturbance caused by military activities on the West Coast of Scotland, which amongst other concerns, have resulted in decreased cetacean sightings rates during military exercises (Parsons *et al*., 2000). In addition, cetacean habitat degradation has been caused by organic and chemical discharges from aquaculture facilities, and disturbance due to acoustic anti-predator devices installed at fish farm sites (Parsons and Shrimpton, 2000; Shrimpton, 2001; Grillo, *et al*., 2001).

These issues may be of concern to conservationists in Scotland, but are these concerns shared by the Scottish public? Are they even aware of these issues? What does the public consider needs to be done to ensure the conservation of Scottish cetaceans? Do these opinions match with professionals, such as advocates and policy makers, who are actually involved in cetacean conservation? To address these questions a survey was conducted in the summer of 2003 in the two largest Scottish cities of Glasgow and Edinburgh.

MATERIALS AND METHODS In June and July 2003, members of the public (n=250) were interviewed according to a pre-designed questionnaire in Scotland's two largest cities: Glasgow and Edinburgh. These study sites were chosen, as these two cities, and their satellite towns, encompass the majority of the Scottish population, and thus opinions expressed by interviewees would be representative of the Scottish public at large. The aim of the survey was to target typical Scottish residents; however both cities have a high proportion of foreign visitors, so to avoid misrepresentation, it was deemed necessary to avoid places with high concentrations of tourists. Participants were chosen through random sampling and care was taken to ensure that all questions were asked in an identical manner and were freely answered with no prompt or influence.

Participants were presented with a series of issues that were considered to be threats to cetaceans, based on previous works (e.g. Scott and Parsons, 2001). The participants were asked to decide and rank each issue as to whether they considered each one to be a "serious", "moderate", "minor" threat to cetaceans, whether the issue posed "no threat" or whether they felt that they didn't know. Participants were also asked whether they considered legislation to protect cetaceans in Scotland was sufficient and if improved Government expenditure on marine conservation would alter their political stance. The questionnaire used in the surveys can be found in Howard (2003).

Demographic information was also collected from participants, namely the location of the interview (*i.e.* Glasgow or Edinburgh), their gender, age and profession. Detailed information on the demographic spread of the participants can be found in Howard (2003). Data was analysed where appropriate with a χ^2 test.

RESULTS Overall, public concern with regard to cetacean conservation was high. The issues considered to be the greatest threats to cetacean populations were generally pollution-related: oil spills, and chemical and sewage pollution (68%, 65% and 63% of respondents considered these to be serious threats, respectively; Table 1). Concern was also high about depletion of cetacean prey by over-fishing (serious threat: 54%; moderate threat: 26%; Table 1).

Concern about commercial whaling was, however, divided: almost as many respondents considered it to be a serious threat (37%) as not a threat at all (31%). Other issues considered serious threats included entanglement in fishing gear, marine litter and global warming (51%, 44%, and 43%, respectively; Table 1).

Conservation issues that are of particular concern in Scottish waters were also noted: military activities, fish-farming and oil exploration, but levels of concern were lower than for more global issues (serious threat: 16.2%, 21.2% and 22.8%, respectively; Table 1). Concern over noise pollution was low, with majority of participants as considering this issue to be of minor or no threat to cetaceans (56.4%). Least levels of concern were expressed about whale-watching (serious threat: 3%; moderate threat: 8%; not a threat: 48%; Table 1).

It was noted that women (χ^2; $p<0.0001$) and older respondents (χ^2; $p<0.0001$) expressed significantly higher levels of concern about cetacean conservation.

When asked if they considered current legislation for the protection of cetaceans to be sufficient in Scotland, the majority (60%) of participants felt that they were unable to answer the question. However, when asked whether legislation should be introduced specifically for the conservation of cetaceans in Scotland (e.g. a Cetacean Protection Act), 80% of participants stated that they would be in favour of such a piece of legislation. To ascertain whether such legislation might affect their political stance, participants were asked whether the proposal of a law specifically for the protection of cetaceans would make them view a political party or politician more favourably. Forty percent stated that such a proposal from a politician, or party, would make them view those involved more favourably.

Finally, in order to improve public knowledge of cetaceans and marine conservation issues in Scotland, it was proposed to participants that, perhaps, that the Scottish school curriculum should include more education about not only of the cetaceans that inhabit Scottish waters but also of the marine environment in general. Eighty percent of those interviewed agreed with this statement.

DISCUSSION The results from this study show that oil spills, chemical and sewage pollution were, by far, considered to be the most serious threats to cetaceans in Scottish waters. These results are similar to the responses detailed for surveys conducted in rural coastal communities in Argyll, in south-west Scotland (Scott and Parsons, 2001) whereby oil spills, pollution from land-based sources and bacteria from sewage produced the highest proportion of serious to moderate answers for threats to cetaceans, alongside a reduction in the availability of prey from over-fishing. However, it is to be noted that the percentage ratings for the serious to moderate threats were considerably higher in the major cities than those from Argyll. This is not to say that people of Glasgow and Edinburgh are more concerned but that it is more likely that the communities of Argyll, many of which are largely dependent, either directly or in-directly upon the surrounding marine environment economically, would have a different perspective of what constitutes a serious threat, particularly if the resource in question provides a source of income.

Pollution from oil, chemicals and sewage are all very visual contaminants, with the obvious effects of oil slicks and eutrophication (from high levels of bacteria in sewage) being likely to receive more press coverage than perhaps the associated affects of noise pollution. To put this into perspective many participants were not even aware that noise pollution (it was explained that such sources would include; marine traffic, seismic surveys, coastal quarrying or military activities) would be a potential problem for cetaceans.

Over-fishing also ranked quite highly as a serious threat and this is possibly due to the large amount of media coverage that this issue has received in recent years. Many participants were aware that it was a problem, noting without prompting that over-fishing would result in the depletion of prey for cetaceans.

Entanglement in or the ingestion of litter and entrapment in fishing gear were perceived as moderate to serious threats. Again images of whales and dolphins that have suffered as a cause of fishing practices or sheer human negligence due to the inappropriate dumping of litter, provides emotive visuals for people to react to.

Global warming was another issue that two thirds of participants perceived to be a moderate to serious threat. It is possible that the majority of these were actually unaware of the implications that climate change would have on cetacean populations. Again extensive media coverage in recent decades has created a "popular" environmental problem and the connotations of "global warming" are likely to provoke an automatic negative response.

Commercial whaling could be perceived as being of no threat to cetaceans in Scottish waters, owing to the fact that the direct taking of cetaceans in UK waters is illegal: many of those that ranked commercial whaling of little or no threat tended to pre-empt this decision by noting that commercial whaling was not carried out within Scotland.

In general, oil exploration and military activities were not perceived as being of major concern to cetaceans. Oil exploration was an issue that had to be frequently explained, i.e. of the potential impact of seismic surveys on cetacean populations and the resulting degradation of cetacean habitats. As a result one in five people did not rank the threat. Oil exploration is of particular concern in Scottish and adjacent waters (e.g. Simmonds and Murray, 1998; Harwood and Wilson, 2001) as companies quest to discover more oil fields off the Outer Hebrides and on the Atlantic Frontier, though as yet the threats to cetaceans are uncalculated.

The west of Scotland is the site of several military activities, in particular submarine exercise areas occupy most waters in the region (Parsons, *et al.*, 2000). However, many people were unaware of any military activity or at least to the extent at which it dominates Scottish waters. This is highlighted by the fact that one in four people were unable to pass judgement. It is possible that this is an issue that may never receive the scale of attention from the media as for example oil spills currently do, partly due to the secrecy in which military exercises are conducted.

Fish farming was a topic that many people believed they should know more about. Participants were aware that the issue had featured quite predominantly in the national press and one in five people (one in four of which were women) were ready to admit they were unsure of what the associated problems of fish farming would have to cetaceans and so did not rank the threat.

Whale-watching trips ranked as the least serious threat to cetaceans, with many people surprised that such an activity could even be considered a potential problem. There have been major concerns about the impacts of dolphin-watching activities on bottlenose dolphins in the Moray Firth (Arnold, 1997), concerns that led to the initiation of the Dolphin Space Programme – a scheme to reduce disturbance to these dolphins by boat traffic. Although, in general, whale-watching in Scotland is generally viewed to be relatively benign (Woods-Ballard *et al*., 2003). However, the few that expressed concern over the seriousness were aware of how such an industry needs to be managed and regulated, since exploitation will only lead to further problems.

With respect to cetacean conservation measures, a large number of people were unsure of whether there was sufficient legal protection for cetaceans in Scottish waters. This contrasts greatly with southwest Scotland (Parsons and Scott, 2001) where nearly half of the participants in that study believed that there was not sufficient protection. It could therefore be assumed that current knowledge of cetacean legislation is higher in Argyll. However, despite uncertainties about levels of protection, the majority of participants did support the proposal of a law specifically to protect whales and dolphins in Scotland.

The current level of concern in Scotland, with respect to the threats faced by cetaceans and other marine environmental problems, is an encouraging sign in the on-going pursuit for improved environmental welfare and knowledge. Moreover, the figures for a majority outcome in favour of improved legislation to protect cetaceans is one that the appropriate authorities should be made aware of. Such a move could prove to be a prolific step forward in the venture to approve a Cetacean Protection Act for Scotland.

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Table. 1. Ranking of threats to Scottish cetaceans by percentage of participants interviewed

	Serious Threat	Moderate Threat	Minor Threat	No threat	Don't know
Commercial whaling	36.7	9.3	12.7	30.1	11.2
Entrapment in fishing gear	51.0	33.6	9.7	1.9	3.9
Injury by boats	25.9	32.4	27.8	7.7	6.2
Litter entanglement /ingestion	44.4	39.0	11.2	1.5	3.9
Oil spills	68.3	20.1	8.9	0.8	1.9
Oil exploration	22.8	34.4	17.0	5.0	20.8
Military activities	16.2	25.1	26.3	7.7	24.7
Chemical pollution	64.5	24.7	7.3	1.5	1.9
Sewage pollution	63.3	22.0	8.1	3.1	3.5
Noise pollution	6.9	24.3	30.9	25.5	12.4
Whale-watching trips	3.1	8.1	33.6	47.9	7.3
Fish-farming	21.2	19.3	23.9	15.1	20.5
Over-fishing	54.1	26.3	8.9	4.2	6.6
Global warming	42.5	26.3	10.4	6.9	13.9

ANALYSING ATTITUDES TOWARDS MARINE MAMMALS CRITICALLY

T. Jensen

Fisheries and Maritime Museum, Tarphagevej 2, DK-6710 Esbjerg, Denmark, (e-mail: tj@fimus.dk)

INTRODUCTION Being involved in both cultural and natural history, the Fisheries and Maritime Museum is bombarded with conflicting points of view on how nature management should be dealt with on a daily basis. I have tried to structure the substance of some of these statements, in the hope that such a scheme will shed light on some of the fundamental views and expectations of nature management shared by the general public. I have picked a number of ordinary and well-known examples to ease the understanding of the rather imprecise expressions commonly used.
I have chosen the following examples: the Pilot whale kill on the Faeroe Islands, the life and death of Keiko, seal hunting in Denmark, Bowhead whaling, rehabilitation of abandoned or sick seal pups, and cleaning of birds caught in oil slicks as an example outside the marine mammal world. For the sake of a better overview I will structure the various views in the following categories: the eco-biological point of view, the animal protection point of view, the animal welfare point of view, and the ethical emotional point of view

Eco-biological Point of View The eco-biological point of view puts emphasis only on matters concerning animal populations, e.g. on factors that threaten these populations with decline. The life and death of the individual animals in this context is of no interest at all. Darwinism prevails: the survival of the fittest individual is regarded essential for maintaining a healthy population.

Animal Protection Point of View This point of view considers the individual animal and its protection. We could call this term "passive care taking". According to the Danish Animal Protection Act §1, animals must be treated well and be protected against pain, suffering, trauma, permanent injury and any significant disadvantage. Animal protection hence deals with how well we treat the animals in human care, either as pets, for hobby purposes, in zoos or on farms. For animals in the wild, including so-called vermin, protection regulations commonly focus on how the animals are killed during a hunt or other types of pursuit. §13 of the Danish Animal Protection Act states that putting down animals must be as quick and as painless as possible. Killing by drowning is forbidden.

Animal Welfare Point of View This point of view goes beyond mere protection. While the protection act speaks of preventing pain, suffering etc, animal welfare also considers the natural needs of animals. We could call this term "active care taking". Concerning domesticated animals it is considered important that animals experience their natural diurnal, annual and life cycles. Defining the welfare needs of wild animals is of course a much more difficult task. The setting up of nature reserves will presumably increase the welfare of animals living there. The existence of areas where wild animals can live their normal lives without human interference must be assumed to promote the welfare of the individual animal.

The Ethical Emotional Point of View In the media, terms like animal protection and animal welfare are increasingly confused with animal ethics and all three terms are occasionally used synonymously. Nevertheless it is important to stress the difference between the three because they represent fundamentally different points of view. Whereas animal protection and welfare relate to the individual animal, animal ethics are primarily based on human self-consideration. Fortunately for the animals this self-consideration includes the demands for proper protection and welfare measures. Therefore our self-consideration will in most cases automatically include caring for the animal. Beside an animal protection and welfare component, animal ethics also carry demands that have roots in aesthetical and existential thoughts and human needs.

Aesthetics Like other animals humans are programmed to react to visual signals from our fellow creatures. We react positively to the sight of a baby seal, and as far as I understand humans all over the world react negatively to snakes. The rounded and soft looks of the seal pup with its large black eyes trigger our nursing instinct; otherwise we would not be human.

Existentialism or"the meaning of life" As humans beings we have an inborn desire to understand the meaning of life – and this includes the meaning of the animals' lives. Therefore the big question of animal ethics is: what is the purpose of killing the animal? From the eco-biological point of view, one would ask if the killing is a threat to the population, or is it a sustainable cull that in the long run does not cause a decline in the population. From an animal protection point of view, one would rather ask whether the kill is performed quickly and painlessly in a humane way.

Animal classification There is no equal compassion for all animal groups and this is reasonable as long as we base our judgment on how well developed senses and behaviour are in the particular animal group. Unfortunately,

compassion goes along with popularity, not the level of development or presumed needs. There are beautiful, ugly, evil, stupid and cute animals to their lives we confer a meaning.A phenomenon within the realm of animal ethics is an inborn acceptance of discrimination. Animals are not equal. At the top of the hierarchy are domestic pets. Hobby animals such as horses also rank very high and, increasingly during the last decades, also wild animals. Among the wild animals again there are some that are more popular than others, and no doubt marine animals in particular are at the top, while vermin, represented by moles and rats, rank among the lowest mammals today.

Anthropomorphism and projection of human needs Finally there is the issue of anthropomorphism regarding animals as "small people" like in the fables of Aesop and projection the phenomenon of granting animals our own needs.

Bearing in mind the four points of view, one may attempt to analyse a number of simple and familiar cases.

Pilot whale kill From an eco-biological angle, the Faroese slaughter of pilot whales is an outstanding case of sustainable exploitation of a marine source. The cull does not threaten the stock of pilot whales because the drive catch only exploits the accessible pods – those that approach the islands and hence can be driven ashore. From an animal protection point of view the killings are more problematic, not so much the killing itself, by bloodletting, but the stressful drive from the time the animals are detected until they are killed at the catch site. Before the implementation of the current regulations the whales were driven towards the coast with lances and stones, clearly acts of cruelty to animals. An animal welfare point of view will regard the pilot whale cull as neutral. There is no effect on the quality of life of the wild stock as such just because some pods are driven ashore and killed. Animal ethics in the strict sense applied here will regard the killings as sheer cruelty.

The Life and death of Keiko We all know this story and looking at it from an eco-biological point of view, one has to admit that the North Atlantic stock of killer whales would have gained nothing from this reintroduction. Even from an animal protection or animal welfare point of view, freeing an animal that spent 23 years of its life in captivity is very questionable. On an ethical and emotional level, there is no doubt what should be done. We give animals – or rather enforce on them – our own human needs. Therefore Keiko should be released into the sea again to "gain its personal freedom and receive enough space and company from its old kin."

Seal hunting Until 2002, the possible resumption of seal hunting was under discussion because the growing seal population was in conflict with the ecologically gentle leg of the Danish fisheries. The Danish populations of the common seal have more than tripled since they were fully protected in 1978. From an ecological point of view, reintroducing seal hunting is not a problem. If not hunted, the population will grow further until it reaches carrying capacity, most likely limited by food resources. Factors regulating the size of a population are interdependent. Hunting would be a limiting factor, but in the absence of hunting, another factor – most likely starvation - would automatically arise.

The animal protection problems in connection with seal hunting are linked to the actual killing. The use of clubs – as on the Danish island of Anholt in the 1800s – would be the safest and most humane, but it is extremely unlikely that anyone would dare resume that method. Traps and gill nets can likewise be excluded since they would contravene the Animal Protection Act. If reintroduced, hunting would most likely be conducted with firearms. Animal protection aspects should be evaluated, comparing the seals' alternatives: death by firearms or by natural causes. Seals in Danish waters have no natural enemies, so their prospect, like humans', is to die of disease, starvation or old age. Based on the many collected specimens, we have excellent knowledge of the causes of natural death among seals. There is no doubt that in the animal protection sense, a rifle shot is much more acceptable than a slow suffering death on the beach. But a seal hunt will cause problems from an animal welfare point of view. We must presume that the hunt will reduce the quality of life of the seal population due to an increased alertness among seals.

Neither from a biological nor an animal protection point of view would a sustainable seal hunt meet objections. The problems lie on the ethical and emotional level, here implied as narrow human self-consideration. At this level, the biggest problem is that marine mammals have achieved sacrosanct status in the western world both with the media and the public. The USA has a total import ban on marine mammal products, and all over the "civilized world" rehabilitation centers for injured or traumatized marine mammals are popping up.

Bowhead whaling The Alaskan Inuit have a quota on Bowhead whales although this species is listed in Appendix I of both the CITES Convention and the Bonn Convention and in Appendix II of the Bern Convention. The reason for giving the Inuit a quota of whales is that the IWC considers the take as non-commercial and as a subsistence catch stemming from an old tradition.

This argument is not acceptable from an eco-biological point of view. Here the effect of the total mortality on the

population matters, regardless of how and by whom the whales are killed. The catch itself is conducted with small guns and hand-held harpoons from small boats, a method that from an animal protection point of view is very problematic. When we, in spite of everything, accept this type of whaling, it must be because it is conducted by indigenous people and not by a commercial whaling company.

Rehabilitating abandoned or sick seal pups In 1995, Denmark stopped the rehabilitation of abandoned or sick seal pups. Unfortunately, and contrary to public belief, collecting, rearing and reintroducing sick seals into a healthy and growing seal population is both questionable and risky, and of no benefit to the wild population. Natural selection has presumably already doomed the sick and abandoned pups, letting only strong animals that endured the first tough months of a seal's life survive.

Cleaning of birds caught in oil slicks In Denmark, cleaning and rehabilitating birds that have suffered injuries in connection with oil spills is prohibited. Nonetheless, every now and then TV stations feature the cleaning of such birds. In a biological context the cleaning is generally considered useless and very few birds survive the cleaning process. Also from an animal protection view, cleaning birds caught in oil slicks may be disputed. That the bird should understand that it is suffering for its own good is of course illusory. From an ethical and emotional angle, cleaning birds trapped in oil is naturally considered compassionate and positive. We are doing something for nature instead of being inactive and we talk ourselves into the belief that the consequences of such disasters can be solved or reduced in this way.

CONCLUSION The table below emerges as a conclusion from all these aspects. Particularly interesting is the comparison between the biological point of view and the ethical/emotional point of view. They disagree on all counts. As seen in the table, eco-biological and ethical considerations are often in conflict. Human beings are the only species on Earth that care about other species and "pitty" them. Mother Nature herself does not care at all. As human beings we have taken on this task and feel obliged to consider all the angles. Prioritizing them is very important. Any regulation or management plan dealing with animals and nature should first and foremost be based on eco-biology first. Thereafter follows animal protection and animal welfare. This is also where we could stop. These three angles can be treated universally and objectively despite differences of culture and religion. The ethical emotional level is difficult to apply in a legal framework and any use of it should be avoided. Legal matters based on emotions may give the impression that "now something has been done for nature." very often, quite the opposite is true.

Table. 1. Summary table of activities and alternative points of view

Cases	Pilot whale kill	Freeing Keiko	Seal hunting	Bowhead whaling	Rehabilitation of seal	Cleaning oil- birds
Eco-biological point of view	OK	No	OK	No	No	Use-less
Animal protection point of view	?	?	OK	No	? No	No
Animal welfare point of view	OK	?	? No	OK	-	-
Ethical/ emotional point of view	No	Yes	No	Accept	Yes	Yes

LIFE HISTORY CHARACTERISTICS OF HECTOR'S DOLPHINS BEACH-CAST OR BY-CAUGHT AROUND NEW ZEALAND, 1997-2002

G. W. Jones[1], P. J. Duignan[1], and N. Gibbs[2]

[1] *New Zealand Wildlife Health Centre, IVABS, Massey University, Palmerston North, New Zealand*
[2] *Department of Conservation, Wellington, New Zealand*

Each year, particularly during summer from November to March, Hectors dolphins are found beachcast or incidentally caught in the inshore set-net gill fishery. Life history parametres and cause of death were determined for 62 animals caught in 1997 (n = 4), 1998 (n =17), 1999 (n = 7), 2000 (n = 12), 2001 (n = 16) and 2002 (n = 6). The sex ratio was predominantly male (n = 35, 56%). Age was estimated based on counting dentinal growth layer groups (GLGs) of mandibular teeth. Males were predominately older, with the mean age of males at 4.3 years (range 0.5 to 7.5 years) and the mean age of females at 2.7 years (range 0.5 to 7 years). Histological examination of the testes and epididymis was used to classify males as immature, mature-inactive, or mature-active. Reproductive maturity in females was determined from gross and microscopic examination of the uterus and mammary gland, and of the ovaries for corpora albicantia and corpora lutea. The majority of males (70%) and females (77%) had immature gonads. The reproductive status of five males and three females were not determined as the gonads had been scavenged. The data support observations from other studies suggesting that sexual maturity is achieved in males at approximately 5-6 years and in females greater than 7 years old.

DEVELOPING SOLUTIONS TO BYCATCH IN THE BASS TRAWL FISHERY

A. I. Mackay, S. P. Northridge, D. Sanderson, and R. Woodcock

Sea Mammal Research Unit, Gatty Marine Laboratory, St Andrews, Fife, KY16 8LB, UK

The pelagic trawl fishery for bass in the English Channel has an unacceptably high by bycatch of common dolphins. Working with skippers in the fishery since 2001 we have been making on board observations while simultaneously testing potential mitigation measures. Because of the urgency of resolving this issue we have adopted ad hoc methods to find a solution. Any solution needs to reduce dolphin bycatch rates close to zero while minimising the effect on bass catches. Observations of seasonality, location and nature of bycatch have been used to test a series of possible mitigation measures that we describe here. These include the possibility of seasonal or area closures, the use of pingers in different locations in the net, and the use of an exclusion grid both with and without an acoustic sensor that may act as a deterrent. We review the results of these various possible methods. Observations of bycatch locations do not support any discrete closure areas. Observations of seasonality suggested highest bycatch rates in March, which is also the peak of the fishery. Most animals appeared to have drowned in the last 30m section of the net, many apparently trying to push through the net to escape. We have therefore focused efforts on trying to keep them away from this net section. Nets in which pingers had been deployed around the mouth of the net and further back in the net did not appear to be effective. An exclusion grid and a Scanmar grid sensor unit were tested in March 2003. This combination of devices appeared to keep animals out of the rear net section. Four different versions of the grid have been built and deployed, and several escape hatch designs are also being trialled. The rationale for each is explained. Avenues for further research are also discussed.

NOVEL MICROSATELLITE LOCI IN THE COMMON DOLPHIN (*DELPHINUS DELPHIS*): MARKERS FOR THE STUDY OF DOLPHIN POPULATIONS

L. Mirimin, J. Coughlan, E. Rogan, and T. Cross

Department of Zoology, Ecology and Plant Science, National University of Ireland, Lee Maltings, Prospect Row, Cork, Ireland

Microsatellite DNA loci have proved to be of great utility in wildlife conservation studies. The population genetics of several cetacean species have been widely investigated but this is not the case in many other species that are often endangered by anthropogenic factors as well as other causes. Here we describe the isolation and characterization of eight microsatellite loci in the common dolphin (*Delphinus delphis*), seven of which are polymorphic and are being used in the investigations described below. For the polymorphic loci, number of alleles and observed heterozygosity ranged from 5 to 11 (mean 7.2) and from 0.55 to 0.95 (mean 0.79), respectively, in 20 specimens examined. No evidence of linkage associations between loci was found. The microsatellite loci have also been tested across three other species of dolphin (*Tursiops truncatus*, *Stenella coeruleoalba*, and *Lagenorhynchus acutus*) and one porpoise (*Phocoena phocoena*) found in Irish waters. Primers designed for common dolphins yielded homologous products in most of the locus/species combinations. We intend to use these loci to screen samples taken from mass strandings and/or from by-catch events. The causes of mass stranding events are largely unclear and we will examine relationships between these animals to gain a better understanding of these phenomena. At present very little is known about population structure of any cetacean species found in Irish waters and many aspects of social behaviour are still poorly understood. It is hoped therefore that these loci will help to define population structure and elucidate social interactions among these species in future studies.

USING COMPUTER SIMULATIONS AND MODELS AS AN EXPERIMENTAL TOOL

D.L. Palka

NMFS, 166 Water St.Woods Hole, MA, 02543, USA

Computer simulation and modelling are powerful approaches to experimentally test hypotheses related to marine mammals. As examples, two such marine mammal computer simulations/models are discussed. The first involved bottlenose dolphin by-catch in a gillnet fishery, and used data collected from observers on fishing vessels to examine the relationship between dolphin by-catch and fishing practices and gear characteristics. The modelling results indicated that soak time of the gear significantly affected bottlenose dolphin by-catches. The second example investigated the robustness of line-transect analysis methods in estimating cetacean abundance. Simulated data were used to mimic a two-platform, shipboard line transect sighting survey for cetaceans, and included observational heterogeneities due to platform, team, weather, school size, and cue. The simulation results revealed that the greatest bias in cetacean estimates occurred when there were large differences between the two sighting teams.

PROTOTYPE OF INTERACTIVE PINGER TESTED ON WILD NAIVE HARBOUR PORPOISES (*PHOCOENA PHOCOENA*)

L.R. Poulsen[1,2], G. Desportes[2], M. Amundin[3], F. Larsen[4], J.H. Rye[2], I. Eskesen[2], L. Buholtzer[2], T. Jepsen[2], N. Eriksen[2], and C. Vanman[2]

[1]*Department of Zoophysiology, University of Aarhus, DK-8200 Aarhus, Denmark (Linda.poulsen@biology.au.dk)*
[2]*Fjord&Bælt, DK-5300 Kerteminde, Denmark (genevieve@fjord-baelt.dk)*
[3]*Kolmarden Djurpark, S-61892 Kolmarden, Sweden (mats.amundin@kolmarden.com)*
[4] *Danish Fisheries Research Institute, DK-2920 Charlottenlund, Denmark (fl@dmu.min.dk)*

Several studies have shown that bycatch in gillnet fisheries is above sustainable levels for several harbour porpoise populations in European waters. Different mitigation methods have been tested and acoustic alarms (pingers) have proven especially efficient. Recently the NAPER project developed a prototype of an interactive pinger, which only emits a deterrent sound when triggered by a harbour porpoise sonar click, i.e. only when needed. The present study tested the effect of a single such device on the behaviour of free-ranging, naive porpoises. This was done by obtaining the overall movement pattern, calculating the median approach distance to the pinger, and comparing several parametres between the dives where a deterrent sound was emitted (D-dives) with dives during baseline conditions (B-dives). The observations were conducted at Fyns Hoved (Denmark), on three separate occasions in 2002 and 2003. The interactive pinger was deployed approximately 3m below a small boat that was anchored 150m from the shore where the water reached approximately 7m in depth. Porpoise movements around the device were recorded by use of a digital theodolite placed on a cliff with a good view of the experimental area. In 27 of the 89 tracks obtained, a deterrent sound was emitted. The D-dives were significantly different from B-dives in 3 out of 4 parametres tested, and the effect disappeared in the subsequent or second dive after the D-dive. The median approach distance was 114m for the active pinger and 72m for the inactive pinger. In conclusion, the interactive pinger was effective in deterring the harbour porpoises and only seemed to have a short-term effect on their behaviour. Compared to a traditional, beacon-mode pinger it transmitted significantly less noise into the marine environment.

COMPARATIVE STUDIES IN AGE STRUCTURE BETWEEN TWO MASS MORTALITIES IN DANISH HARBOUR SEAL POPULATIONS

T. Rasmussen, T. Jonas, and R. Dietz

National Environmental Research Institute, Department of Arctic Environment, Frederiksborgvej 399, 4000 Roskilde, Denmark

In May 2002, the European harbour seal (*Phoca vitulina*) population was hit by the Phocine Distemper Virus (PDV) when more than 32,000 harbour seals died. In 1988, the European harbour seal population was also infected by the same virus where approximately 18,000 dead seals were found. This study compares the age distribution from the epizootic in 2002 and 1988, based on samples from dead harbour seals from Danish waters. These parameters are otherwise not easily studied on seals under normal conditions. From the 2002 epizootic in Denmark, 630 canine teeth were extracted from dead seals and used for age determination. The age determination was done by counting growth layer groups from stained slides of the mid-longitudinal plane of the canine teeth. In Kattegat, the resulting age distribution shows that unlike the 1988-epizootic, the disease in 2002 killed young seals (1-4 years) in the same magnitude as older age segments (2.3% lower than expected in 2002 compared to 39.3% in 1988). In addition, the 2002 age distribution showed that only 0.6% of the dead seals were older than 13 years, compared to 13.7% from the 1988 epizootic. The age distribution from Limfjorden shows, that unlike the results in Kattegat, young seals were greatly underrepresented (2002:54% lower than expected). The age distribution in Limfjord was in general more unstable than in Kattegat. The low young percentage in Kattegat and in Limfjorden may to some extent be explained by age- and sex specific haul-out behaviour and in Limfjorden because of an unstable ecosystem. Further research is needed to explain the low portion of young seals in the samples. The lower percentage of old seals is likely because of the large number of seals that died in 1988, and survivors from 1988 may have achieved immunity against PDV.

THE BLUE CLASSROOM: TEACHING THE YOUNG

B. Reinhard, and A. Kilian

Tiergarten Nürnberg, Am Tiergarten 30, 90480 Nürnberg, Germany

Education is an important tasks of Zoos. In an Educational Programme implemented at the Dolphinarium of the Zoo Nuremberg, students of all ages can learn about various aspects of the biology of marine mammals. In the Blue Classroom, a room facing the underwater windows of one of the dolphin tanks, students take part in a training session with the bottlenose dolphins and get a close-up view of the animals. The dolphins are also trained to show some behaviours directly in front of the windows (e.g., open mouth, release air from the blowhole, vocalize, show belly). These hands-on experiences continue with a close-up presentation of Sea Lions. A film shown afterwards informs visitors about the species diversity of whales, their natural habitats; and highlights threats and examples of conservation measures. The Programme then closes with an open discussion with the students. The importance of Educational Programmes becomes obvious when the knowledge of the students is tested during lessons. Almost none of the students have ever heard about harbour porpoises living in German Waters, and many other biological and conservational aspects of whales and seals are also unknown. To fill in these gaps and create an awareness for these animals is thus an urgent matter. A study carried out by one of the authors (2) with 11-year-olds revealed that those with hands-on experience in the Blue Classrom had a significantly better memory of biological facts than those who only had a lesson at school. These findings demonstrate the educational value of such Programmes as a contribution for the conservation of marine mammals.

DIRECT AND INDIRECT IMPACT OF THE ERIKA OIL SPILL ON CETACEANS OF THE BAY OF BISCAY: DISCRIMINATING PAROXYSTIC EVENTS FROM BACKGROUND VARIABILITY

V. Ridoux[1, 2], F. Caurant[2], P. Bustamante[2], W. Dabin[1], C. Delcroix[2], M. Léonard[1], L. Meynier[1, 2], O. Van Canneyt[1], and J. Spitz[1]

[1] *Centre de Recherche sur les Mammifères Marins, Port des Minimes, Avenue du Lazaret, 17000 La Rochelle, France*
[2] *Laboratoire de Biologie et Environnement Marins, E.A. 3168, Université de La Rochelle, Avenue Michel Crépeau, 17000 La Rochelle, France*

Oil spills can have direct effects on marine organisms (mortality or morbidity), indirect effects (through alteration of lower trophic levels). In addition, oil spills may lead to increased exposure to oil compounds (trace elements as markers). The Erika oil spill from 12th December 1999 to early spring 2000 was characterised by a long period during which oil drifted offshore before it reached the coasts. Pelagic habitats were more heavily impacted than in coastal oil spills. It can be assumed that if the oil spill had any effect on pelagic cetaceans, anomalies in stranding rate, cause of death, biodemographic characteristics of stranded animals, diet composition or concentrations of trace elements would be detected in the impacted areas, during the months following the spill. We investigated mortality, population structures, diets and concentrations of vanadium in the liver of common dolphins, *Delphinus delphis*, stranded along the French Atlantic coasts, before and after the oil spill, comparing impacted and non-impacted areas. PAHs were not used as markers of contamination as they are metabolised and would not be readily transmitted via trophic relationships. An increase in mortality was found, but its associated causes of death and population structures were typical of multiple stranding events related with episodes of severe by-catch in pelagic fisheries. The diet was highly variable in the year 2000, but this could not be linked with the spill as it appeared to be an inherent characteristic of the common dolphin feeding ecology. Vanadium concentrations were chronically high and did not increase after the spill. However, the order of magnitude of these concentrations was similar to previous results from areas chronically affected by oil leakages. No measurable effect of the Erika oil spill was found on the common dolphin; chronic contamination and repeated interactions with fisheries appear to be more serious conservation issues than catastrophic events.

SOCIO-ECONOMIC ASPECTS OF THE WHALE-WATCHING INDUSTRY IN TENERIFE, CANARY ISLANDS

A. Servidio, and C. Elejabeitia

Sociedad Española Cetáceos (SEC), Nalón 16, La Berzosa,E-28240 Hoyo de Manzanares, Madrid, Spain

The whale-watching industry in Tenerife has evolved into an important economic resource for the island. The favourable and peculiar environmental conditions, available infrastructure, high predictability of sightings, and easy accessibility of sites are all elements that have positively influenced the spectacular development of this activity. Since 2002, the NGO "Sociedad Española de Cetáceos" (SEC) has carried out an extensive analysis for the Canary Islands´ Government. Several socio-economic aspects of the whale-watching industry in Tenerife have been exhaustively and systematically studied through: 1) Field research based on undercover visits on each operational whale-watching boat, and interviews with whale-watchers, operator company owners and their workers. 2) Report and data base creation. 3) Analysis of statistic and historic data provided by the public authorities and field research data. During 2003, 32 boats (from 22 operator companies) were authorized for the activity in Tenerife, with a total carrying capacity of 2,787 passengers. While the number of operators and dedicated boats has decreased by 35% since 1996, the average boat capacity has increased by 70%, showing a tendency toward whale-watching vessels of a greater capacity. The total number of passengers (official data and estimations) reached 404,000 in 2002, which remarkably differs from quantities estimated in previous studies. The direct gross income for 2002 was estimated as 12,200,000 €. Despite its mandatory presence (Decree 178/2000), an officially enabled whale-watching guide was found in only 47% of the boats. A guide's presence on every whale-watching excursion is expected to be fulfilled in 2004 thanks to new licenses granted by the regional Government in response to this industry's problem. The average whale-watching user is a type of tourist without a true environmentalist and conservationist conscience, not different than the ordinary holidaymakers who visit the island.

BEHAVIOUR AND RANGE OF A LONG-TERM RELEASED CAPTIVE KILLER WHALE AND ITS WILD CONSPECIFICS

M. Simon[1], L. Murrey[2], B. Hanson[3], and F. Ugarte[1]

[1] *Cardigan Bay Marine Wildlife Centre, New Quay, Wales,UK*
[2] *Moeller Design & Development, Inc. Seattle, WA, USA*
[3] *NOAA/NMFS, Seattle, Wa-USA.*

A long-term captive killer whale, Keiko, was equipped with a VHF-transmitter and satellite-linked dive recorder (SLDR), and released into Icelandic waters. Information about Keiko's dives collected by the SLDR, together with geographic locations, was downloaded from the internet via the ARGOS system. During July 2002, Keiko was radio-tracked 24 hours a day as he followed wild Icelandic killer whales, allowing us to record the behaviour and movements of these whales. During August, Keiko moved east, at a distance from the wild whales and reached the Norwegian coast in early September, where he encountered humans. The wild whales followed by Keiko showed clear diurnal cycles, foraging on spawning herring in areas with abrupt bottom topography during the day (noon+/-6 hrs) and travelling during night (midnight+/-6 hrs). The whales used two feeding areas: one at the beginning of the study (July 07-July 21) and one at the end (July 22-July 31). The distance between Keiko and the wild whales diminished during the study period, suggesting that acclimatization may have occurred. Keiko's diving behaviour evolved, resulting in deeper and longer dives towards the end of the study. A drastic regression occurred when he encountered people in Norway. During the period when Keiko's diving activity was highest, his dives were on average less frequent and shallower, but of similar duration as those reported for wild killer whales in the same area. Despite the lack of direct evidence, several factors suggest that Keiko did forage during his trip from Iceland to Norway. The combination of satellite and VHF telemetry proved useful for monitoring the behaviour of a released long-term captive whale while he was in the wild without human contact. The VHF tracking of a previously captive whale released into the wild was an effective way to gather information about the habitat use of wild whales.

NEW THREAT FOR COASTAL WATERS OF NORTHERN EUROPE: PERFLUOROCHEMICALS IN HARBOUR PORPOISES

K.I. Vande Vijver[1], P.T. Hoff[1], K. Das[2], W. Van Dongen[3], E.L. Esmans[3], U. Siebert[2], J.M. Bouquegneau.[4], R. Blust[1], and W.M. Decoen[1]

[1] *Department of Biology, University of Antwerp, Groenenborgerlaan 171,2020 Antwerpen, Belgium*
[2]*Forschung- und Technologiezentrum Westkueste, Christian-Albrechts-Universitaet Kiel, Werfstrasse 6, D-25761 Buesum,Germany*
[3]*Toxicological Center, University of Antwerp, Universiteitsplein 1, 2610Wilrijk, Belgium*
[4] *Laboratory for Oceanology, Liège University B6,B-4000, Liège Belgium*

A growing concern has been expressed about perfluorinated organic compounds. Previous studies suggest that perfluorochemicals, in particular perfluorooctane sulphonic acid (PFOS), are spread worldwide in wildlife and humans, but toxic effects are scarcely documented. This is the first study to evaluate the occurrence of PFOS and related compounds in by-caught harbour porpoises from waters around Iceland, Norway, and Denmark and in the German Baltic Sea. Furthermore, this study tried to reveal the possibility of using fluorinated compounds to discriminate harbour porpoises in different regions in the waters around Norway. This was done by combining our toxicological data and stable isotope measurements. Liver samples were collected from 41 harbour porpoises caught incidentally in fishing nets. Concentrations of perfluorinated compounds were determined using high performance liquid chromatography combined with electrospray tandem mass spectrometry (HPLC-MS/MS). Of all perfluorinated chemicals measured, PFOS seemed to be the predominant compound (levels up to 1149 ng/g). A geographical difference could be observed with a decreasing trend in levels from south to north. Concentrations of all compounds measured (PFOS, PFDA, PFUA, PFDoA) were higher in porpoises from the Baltic Sea than those from Iceland and Norway. Within the samples of Norway, a significant difference could be detected between the concentrations of PFOS of porpoises from North Norway/Barents Sea (118.24± 44.70 ng/g) and the Southwest coast of Norway (343.91± 248.50ng/g). Analysis of the stable isotope ratios of porpoise muscle tissue of the two regions in Norway, showed that there is a difference in feeding habits, regarding food source (Fontaine *et al.*, in preparation). In conclusion, harbour porpoises from Northern Europe are heavily contaminated with PFOS and perfluorocarboxylates to a lesser extent. Based on these ecological data, we might consider that even remote regions without a direct pollution source of perfluorochemicals, such as North-Europe, have become critical habitats.

CONSERVATION STATUS OF THE BLACK SEA BOTTLENOSE DOLPHIN (*TURSIOPS TRUNCATUS PONTICUS*): AN ASSESSMENT USING MORPHOLOGY AND GENETIC VARIATION

K.Viaud[1], R.L. Brownell[2], and A.J. Bohonak[1]

[1] *Department of Biology, San Diego State University, 5500 Campanile Drive, San Diego, CA 92182-4614, U.S.A.*
[2] *International Protected Resources, Southwest Fisheries Science Center, Pacific Grove, CA 93950, U.S.A..*

The bottlenose dolphin (*Tursiops truncatus*) is one of three species of cetaceans living in the Azov-Black Sea basin. Until 1966, Black Sea cetaceans were mainly threatened by dolphin fisheries. Since then, anthropogenic impacts from pollution, diminishing food resources, live catches, diseases and physical injuries have killed more than 5 million Black Sea cetaceans. Despite many studies of bottlenose dolphins elsewhere, data on Black Sea populations are scarce. Thus, the overall status of Black Sea bottlenose dolphins is unclear and previous attempts to protect them have failed. The aim of this study is to estimate the degree of morphological distinctiveness and genetic isolation of Black Sea bottlenose dolphins from Mediterranean populations. Cooperation with researchers from countries surrounding the Black Sea facilitated access to genetic material and skulls for morphological analysis. Seventy-four bottlenose dolphin skulls from the Black Sea (27), the Mediterranean Sea (27) and the Atlantic Ocean (20) were sampled for 31 cranial measurements. Mitochondrial DNA (mtDNA) variation in 102 bottlenose dolphins was compared among the same localities, which were analysed as putative populations. Results from 500 base pairs of the control region show low haplotype diversity among the 40 Black Sea samples. Only 5 haplotypes were found among which 2 were shared with Mediterranean Samples. The most common Black Sea haplotype had a frequency of 0.63 and no haplotypes were shared with the Atlantic samples. Principal component analysis performed on 31 skull variables indicates that size is the major discriminant component between populations. Black Sea bottlenose dolphins are significantly smaller than the contiguous Mediterranean populations. Conservation and management policies are typically implemented based on genetic or morphological data in absence of the other. This study shows how a more rigorous assessment of the evolutionary and ecological status of cetacean populations can be attained by combining morphological and genetic data.

MODELLING SITE FIDELITY IN CUVIER'S BEAKED WHALES

A. D. Williams[1], J. A. Vasquez[2], T. Brereton[1], and C. Martin[1]

[1] *Biscay Dolphin Research Programme, 6 Manor Way, Lee on the Solent, Hampshire, PO13 9JH United Kingdom*
[2]*C/ Blas de Otero, 18, 5 iz. 48014. Bilbao. Spain*

Photo identification of Cuvier's beaked whales has been limited in the past due to the infrequency of sightings and the subsequent poor quality of images. Using a conditional probability model it has been possible to use sub-optimal images to identify individuals. Using standard capture recapture techniques combined with a distribution matrix based on a Poisson distribution technique, it has been possible to develop a model showing the site fidelity of a small number of individuals within the study area. Described by a variety of event trees, the probability of re-encounter at a given location can be placed into the model and available data extrapolated to provide site fidelity maps for the individuals. This model suggests that ranging within the study area is variable but that a high degree of site fidelity occurs for the individuals studied.

ECOLOGY

NICHE DIFFERENTIATION OF CETACEANS IN THE NORTHEAST ATLANTIC

P. Anderwald[1], L. Gygax[2], and P. G. H. Evans[3]

[1] *School of Biological and Biomedical Sciences, University of Durham, South Road, Durham, DH1 3LE, UK*
[2] *Brunngasse 9, 8001 Zurich, Switzerland*
[3] *Sea Watch Foundation, 11 Jersey Road, Oxford, OX4 4RT, UK*

Qualitative descriptions of the typical habitat of different cetacean species exist for several regions in the Northeast Atlantic, but no quantitative analysis on niche differentiation over this wide geographical scale has been performed so far. We tried to classify the 13 most common cetacean species around Britain and Ireland according to physical parametres of the environment (salinity, sea surface temperature, depth, maximum and mean bathymetric gradient) and group size in quantitative pair-wise comparisons, using logistic regressions for every possible pair. On the whole, the 13 species could be separated easily. All six parametres were necessary for a successful classification, although their relative importance varied between pairs. Salinity, depth and the bathymetric gradients were important in separating the typical deep-water species occurring mainly beyond the continental shelf (fin whale, sperm whale, pilot whale and striped dolphin) from those species occurring primarily in coastal (minke whale, Risso's dolphin, bottlenose dolphin and harbour porpoise) or offshore waters on the shelf (common, white-sided and white-beaked dolphins). Group size was the most important in separating the large whales (fin, minke, sperm and northern bottlenose whales) and the harbour porpoise, which usually form small groups, from the majority of the delphinids, which mostly occur in larger aggregations (pilot whale, Risso's, common, striped, white-sided and bottlenose dolphins). Differences in the classification success were detected between seasons, suggesting that interspecific competition is not equally high throughout the whole year. The overall results of the analysis show that a minimum estimate of niche differentiation between Northeast Atlantic cetaceans can be obtained according to differences in their physical environment and group size over a wide geographical scale. Given the strong overlap in diet between some species, their successful classification by environmental parametres suggests that habitat partitioning is likely to be an effective strategy to reduce interspecific competition on a large scale.

LEAD CONTAMINATION OF SMALL CETACEANS OF THE EUROPEAN COASTS: THE USE OF STABLE ISOTOPES FOR IDENTIFYING THE SOURCES OF LEAD EXPOSURE

A. Aubail[1], P. Bustamante[1], O. Van Canneyt[2], E. Rogan[3], A. Guerra[4], M. Addink[5], and F. Caurant[1]

[1]*LBEM,Université de La Rochelle, France*
[2] *CRMM, La Rochelle, France*
[3]*University College Cork, Cork, Ireland*
[4]*Instituto de Investigaciones Marinas, Vigo, Spain*
[5]*Nationaal Natuurhistorisch Museum of Leiden, The Netherlands*

This work is part of the European project BIOCET which aims to quantify and model the effect of bioaccumulation of persistant organic pollutants in small cetaceans in European waters by taking into account confounding factors, in particular trace elements. Among them, lead and especially the stable isotope analysis allows us to distinguish between potential sources of lead exposure in the environment. Analysis were carried out by ICP/MS (Inductively Coupled Plasma Mass Spectrometry) in the bone and the teeth of 57 individuals belonging to 3 species of small cetaceans (33 *Delphinus delphis*, 19 *Phocoena phocoena* and 5 *Stenella coeruleoalba*), collected along the Netherlands, Irish, French and Spanish coasts between 1999 and 2003. Lead concentrations were higher in teeth (0.867 ± 0.833 µg Pb.g-1 dry weight) than in bones (0.560 ± 0.461 µg Pb.g-1 dry weight), but highly correlated between the two tissues ($r = 0.92$, $p < 0.001$) suggesting that they are both relevant for monitoring long term accumulation of lead in cetaceans. Lead accumulated with age in bone as well as in teeth, irrespective of the sex. The species and the geographical origin of cetaceans did not show any influence on lead concentrations which were similar among individuals of similar age, and lower than threshold value which induce toxic effects in human.. Small cetaceans from this study exhibited large variations of 206Pb/207Pb values (from 1.10 to 1.27) corresponding to natural and anthropogenic sources. Thus alkyl lead in essence would be the main cause of lead contamination for the cetaceans from the English channel, although the industrial source would be predominant for small cetaceans from the Southern North Sea. At last, the stable lead isotope results suggest that the atmospheric source would be more important than the trophic one in the lead contamination of small cetaceans.

FINE-SCALE TEMPORAL DISTRIBUTION BY HARBOUR PORPOISE (*PHOCOENA PHOCOENA*) IN NORTH WALES: ACOUSTIC AND VISUAL SURVEYS

S. V. Calderan

Old Butchers, Queen Street, Hook Norton, Oxon OX15 5PJ, UK

Harbour porpoises (*Phocoena phocoena*) were surveyed at a single site off the coast of Anglesey, North Wales, both visually and acoustically, to determine fine-scale cycles of temporal distribution. Acoustic data were collected using a statically deployed porpoise detector (T-POD). This enabled porpoise echolocation activity to be monitored and logged continuously throughout the study period. Porpoise activity was analysed on the basis of the number of click trains detected by the T-POD per hour, and compared with fine-scale temporal variables. Visual data were collected by land-based surveys; presence/absence and high activity behaviours indicative of foraging were compared with fine-scale temporal variables. Two survey methods were used to provide the best evidence of temporal patterns, given the difference in the type and quantity of data provided by the two methods. Both acoustic and visual data showed that harbour porpoise observed regular and predictable cycles of distribution and apparent foraging at the study site. Presence, apparent foraging behaviour and number of train detections were tidally influenced, being significantly higher during the flood phase of the tide than the ebb phase ($p<0.0001$). There was a strong difference between acoustic detections during daylight hours and during the night; acoustic activity during the day was significantly higher than during the night ($p<0.0001$). There was also a pattern to acoustic detections over the course of the 24-hour cycle, with elevated activity at sunrise and sunset. However, time series analysis of T-POD data showed the quantitatively reliable serial correlation was with tidal cycles. This study provides further evidence of the influence of fine-scale temporal variables on harbour porpoise distribution and behaviour, and of the utility of the role played by passive acoustic survey techniques in such studies.

NARWHAL MOVEMENTS, STOCK COMPOSITION, DIVE BEHAVIOR AND HABITAT SELECTION

R. Dietz[1], M. P. Heide-Jørgensen[2], P. Richard[3], K. L. Laidre[4], J. Orr[3], and H. C. Schmidt[2]

[1] *Department of Arctic Environment, National Environmental Research Institute, Roskilde, Denmark*
[2] *Greenland Institute of Natural Resources, Nuuk, Greenland*
[3] *Department of Fisheries and Oceans, Central and Arctic Region, Arctic Research Division, 501 University Crescent, Winnipeg, Manitoba R3T 2N6, Canada*
[4] *School of Aquatic and Fishery Sciences, University of Washington, Box 355020, Seattle, Washington 98195, USA*

The movements and diving behaviour of 61 narwhals (*Monodon monoceros*), over an 8-year period, have been examined using satellite-linked time depth recorders. The results have been obtained from three summering locations in Canada (Tremblay Sound, Creswell Bay and Admiralty Inlet) and Melville Bay in Northwest Greenland. The movements have identified the timing and routing of the summer distribution, autumn migration and winter habitats of the whales. No mixing of summering population has been observed so far and less than 5% of the animals have visited other summering areas during the autumn migration. In the autumn, the whales are forced southward as the temperature drops and ice is begins to form. So far two different wintering grounds have been identified. Repeat tagging from the same summer locations suggest that whales choose the same migration routes and wintering sites year after year. Also transmitters lasting more than a year have indicated, that the whales will return to the same summering site. Dive data has been used to document vertical use of water column relative to areas, depths and seasons. In addition, the percent of time spent at the surface has been calculated for different seasons to correct aerial survey counts of actual population numbers. Summer habitats are high Arctic fjords with quite variable depths, ice extent and hunting pressure. Winter habitats are typically between 500-1500m in depth. Short term recordings from TDR and Crittercams have provided high-resolution data on the local use of the summering sites and verifies the adaptation of this species to a bottom feeding behaviour.

HABITAT SHARING AND AVOIDANCE PATTERNS OF HARBOUR PORPOISES (*PHOCOENA PHOCOENA*) AND BOTTLENOSE DOLPHINS (*TURSIOPS TRUNCATUS*) IN IRISH COASTAL WATERS

A. M. Englund[1, 2], S. N. Ingram[1, 2], and E. Rogan[1]

[1] *Department of Zoology Ecology and Plant Science, The Maltings, University College Cork, Cork, Ireland*
[2] *The Coastal and Marine Resources Centre, University College Cork, Ireland*

The use of Irish coastal waters by bottlenose dolphins and harbour porpoises was investigated using passive acoustic dolphin and porpoise detectors 'T-PODs'. Data was collected continuously for four months in 2003 (July to late October) at three sites along 150km^2 of the Connemara coast, Co. Galway. The level of activity (detection positive minutes) as well as diurnal and tidal patterns was compared between the sites. In total, acoustic detections were made on 65 out of 108 days of surveillance. The results showed variations in habitat use between sites. Dolphin activity was highest at Killary Fjord particularly during the month of September and lowest at Ballynakill Harbour (a sheltered narrow bay). Crump Island, which is situated between the two other sites, showed a high level of porpoise activity with 90% of all porpoise detections. There were no apparent diurnal or tidal patterns at Killary while Crump had the majority of dolphin detections recorded during the night (76%). For porpoises the activity at this site was higher during the day (85%). Dolphins and porpoises were using the same sites on 18 days of the study. However, 50% of these detections were separated by more than two hours. Furthermore, during days when dolphin activity was high at Crump Island, porpoise activity decreased and simultaneous detections (within 10 minutes) occurred only on five days. These results suggest that Killary Harbour is important for bottlenose dolphins during the summer months and Crump Island similarly for harbour porpoises. The results indicate movement of dolphin schools between sites during the night. A certain degree of habitat sharing and possible indications of avoidance between the species is also indicated. This is further supported by findings of similar detection patterns in the outer Shannon Estuary where T-PODs were deployed for calibration purposes during the autumn of 2002.

FIRST PHOTO-IDENTIFICATION DATA OF BOTTLENOSE DOLPHINS (*TURSIOPS TRUNCATUS*) IN SLOVENIA

T. Genov, P. Kotnjek, A. Hribar, and K. Kolarič

Morigenos - marine mammal research and conservation society
Jarška cesta 36/a, 1000 Ljubljana, Slovenia (tilen_genov@msn.com, www.morigenos.org)

INTRODUCTION The Slovenian Sea, which represents a small portion of the Gulf of Trieste (Northern Adriatic sea), appears to be a part of the home-range of the resident population of bottlenose dolphins (*Tursiops truncatus*) despite the belief that dolphins are absent from this area with only rare sightings of individuals thought to be lost. So far there has been no photo-identification data from Slovenia regarding cetaceans. Moreover, no long-term research has been conducted in the area. Bottlenose dolphin is the only regular species of cetaceans in the Northern Adriatic Sea (Kryštufek and Lipej, 1993; Notarbartolo di Sciara and Bearzi, 1992). Other species, such as striped dolphin (*Stenella coeruleoalba*) and Risso's dolphin (*Grampus griseus*) have been reported occasionally (Francese *et al.*, 1999). The objective of our study was to confirm the year-round presence of bottlenose dolphins and to estimate the size of bottlenose dolphin population inhabiting Slovenian sea.

MATERIALS AND METHODS We started preliminary observations in 2002 and began conducting photo-identification in 2003. Surveys were done from small vessels and land observation points. Presence of dolphins was assessed visually, with the help of binoculars. Other research procedures included the collection of environmental, navigation and behavioural data. Photo-identification, based on natural marks on dorsal fins was done following standard procedures (Würsig and Jefferson, 1990; Bearzi, 1994a; Bearzi, 1994b). A Nikon F80D motor-drive 35mm camera with zoom lens Sigma 70-300mm was used. Films used were mainly Fuji Sensia and Kodak Elite Chrome (ISO 100 and 200). When observations were done from land observation points, photo-identification was not possible.

RESULTS We observed 17 groups of bottlenose dolphins (Fig. 12), with group sizes ranging from 1 to 30 individuals. The mean group size was 9 dolphins. Dolphins were seen in February, March, May, June, July, August and September 2003. Additional reports from local people, fishermen, tourists, harbour masters, Marine biological station staff and maritime police during other months confirmed the year-round presence of dolphins. Apart from sightings in Slovenia, we had 4 opportunistic sightings in the waters of Croatia and 1 in the waters of Italy (all close to the national borders of Slovenia). Although these sightings were not in the Slovenian sea, they obviously represent the same population of dolphins.

During 2003, 23 individuals in Slovenian sea have been photo-identified, named and catalogued (a few examples are shown from both sides of the dorsal fins in Figs. 1-10). Only well marked and easy recognisable individuals are considered "identified", while slightly marked animals that may not be re-identified with certainty are considered "unidentified". These dolphins were used for group size estimates and other analyses. Five identified dolphins are believed to be females, because of their close associations with calves and newborns. More females with calves have been observed, however they were not identified.

CONCLUSIONS We established that bottlenose dolphins are present in the area all year round and we present the first photo-identification data from Slovenia. This clearly shows that bottlenose dolphins are a regular cetacean species in the area and the population seems to be resident. Photo-identification surveys will be continued, with a goal to estimate the size of a bottlenose dolphin population inhabiting these waters. Present and future photographic data will be compared to data of other research organisations from other areas of the Adriatic Sea (various areas in Italy and Croatia) to study the home range of dolphins in Northern Adriatic Sea. A future plan is also to contribute photo-identification data to the Europhlukes database. The estimation of a bottlenose dolphin population in the Gulf of Trieste is the fundamental information for dolphin management in Slovenia and Northern Adriatic Sea.

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Fig. 1. Cate with a calf

Fig. 2. Cate with a calf

Fig. 3. Vasilis

Fig. 4. Vasilis

Fig. 5. Morigenos

Fig. 6. Morigenos

Fig. 7. Moni with a calf

Fig. 8. Moni with a calf

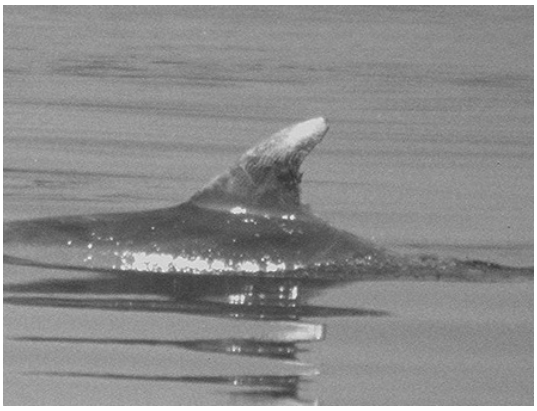

Fig. 9. Deinon

Fig. 10. Deinon

Fig. 11. Bottlenose dolphin in front of Piran, a Slovenian coastal town

Fig. 12. Bottlenose dolphin sightings (dots) in Slovenian Sea

POPULATION STATUS AND FORAGING BEHAVIOUR OF KILLER WHALES (*ORCINUS ORCA*) ON RED TUNA (*THUNNUS THYNNUS*) IN THE STRAIT OF GIBRALTAR

C. Guinet[1], R. De Stephanis[2, 3], N. Pérez Gimeno[2], P. Verborgh[4], and P. Dominici[5]

[1]*CEBC-CNRS, 79360 Villiers-en-Bois, France*
[2] *CIRCé Cabeza de Manzaneda 3, Pelayo, 11390 Algeciras, Cadiz, Spain*
[3] *LAV, Laboratorio de Acústica y Vibraciones de la Universidad de Cádiz, CASEM, Polígono Río San Pedro S/N, Cadiz, Spain*
[4] *CIRCé, Musé Maritime de la Rochelle, BP 3053, 17031 La Rochelle Cedex 01, France*
[5]*CNR, Località Sa Mardini, Torregrande, Italy*

The red tuna (*Thunnus thynnus*) migrates through the Strait of Gibraltar, entering the Mediterranean Sea in the spring to breed and leaving the Mediterranean Sea in the summer. Tuna are the main fish prey of killer whales in this area. Between 1999 and 2003 killer whales were observed during both spring and summer preying on red tuna or interacting with the tuna fishery. On each encounter, observations were conducted and pictures taken, including interactions with fishermen and tuna predation by the whales. In spring, two different groups of killer whales with a minimum of 10 different individuals were observed. Hunting consisted in a long and high speed chase of tuna in shallow waters. The fish were followed for 30 and 45 minutes before being captured. The catch was qualified as successful when fish were seen in the mouth of the whales. Based on previous data on maximum anaerobic respiration and maximum sustained swimming speeds of red tuna and other tuna species, a likely hypothesis is that killer whales may chase the tuna until they are exhausted, in order to facilitate capture. Acoustic recordings reveal that killer whales were mostly silent when trying to locate the tuna, as they produced only rare, irregular clicks. In the summer, killer whales were observed in the western central part of the Strait where the red tuna drop line fishery is operating. None of the killer whales seen in the spring were observed in the summer and a total of 14 different individuals were identified. The regular re-sightings of the same individuals suggest that the same groups of animals were interacting with fishermen during all these encounters. The interactions with fishery and depletion of red tuna stocks due to over-fishing are likely to have a negative impact on both killer whales and fishermen in this area.

FACTORS AFFECTING HAUL OUT BEHAVIOUR OF HARBOUR SEALS AND GREY SEALS AT RØDSAND, DENMARK

P.B. Harders[1, 2], J. Teilmann[2], J. Carstensen [3], J. Tougaard [2], and R. Dietz [2]

[1]*Institute of Biology, University of Southern Denmark, DK-5230 Odense M, Denmark*
[2] *National Environmental Research Institute, Department of Arctic Environment, DK-4000 Roskilde, Denmark*
[3] *National Environmental Research Institute, Department of Marine Environment, DK-4000 Roskilde, Denmark*

The Danish seal sanctuary Rødsand, a sand bar in the Western part of the Baltic Sea is used by approximately 200 harbour seals and 20 grey seals and is the largest haul out site in the area. In the summer of 2003 a large offshore wind farm was constructed 4 km from the sanctuary. As a reference for assessing potential impacts of the wind farm on the seals, a baseline study of the haul out behaviour of seals was carried out during the summer 2001. Visual observations using a telescope were made from an observation tower located 1100m from the seals. Observations were in the form of snapshot counts every hour between 7am and 10pm on 43 individual days from the beginning of June to the end of August 2001. Measurements of various meteorological variables were also collected every hour. The number of seals hauled out varied considerably, from days with no seals to a maximum of 116 seals hauled out simultaneously. Parametres found to correlate with number of seals on land were month of year, time of day, wind direction and wind speed. Highest counts of harbour seals on land in the observation period was at the end of August. In day-to-day comparisons, the highest numbers were seen at low wind speeds and for westerly wind directions. Daily counts peaked at noon. Grey seal numbers peaked at the end of July and during south westerly winds and low wind speeds. Daily counts peaked between 2pm and 4pm. This study demonstrates that season, time of day and meteorological parametres correlate significantly with the number of hauled out seals. It is thus important to include these abiotic factors as covariates when comparing haul out behaviour before and after construction of the wind farm.

TAKING EXPERIMENTAL WORK TO SEA – THE EFFECT OF PREY ENCOUNTER RATE ON FORAGING BEHAVIOUR

S. K. Hooker and I. L. Boyd

Sea Mammal Research Unit, University of St Andrews, Fife, KY16 8LB, UK

Studying marine mammal foraging at sea is problematic. Although time-depth recorders allow great insight into the diving behaviour of animals, we still know little about foraging events. Investigation of foraging theory predictions has therefore generally required captive experimentation. However, by measuring prey encounter rate at sea, we can also use field observations to validate these predictions. During the past three austral summers (2000-2003), we have used a digital video camera linked to a time-depth recorder (Wild Insight Ltd) to record the prey-field ahead of diving Antarctic fur seals. Images were recorded at frame rates of 0.3 Hz (n = 17) or 15 Hz (n = 1). Antarctic krill, the primary prey of these seals, were apparent in a large proportion (up to 28%) of images, although there were significant differences between individual seals and between seasons of observation. Images were catalogued based on krill presence in terms of reliability of image identification and estimation of krill biomass. The proportion of krill images recorded per dive was used as a proxy for prey encounter rate. This allowed us to investigate optimality of diving behaviour in terms of variation in diving parameters according to both prey depth and prey encounter rate. As expected, in many cases the prey encounter rate decreased over the duration of a dive bout, and was greater for deep dives. The relationship of prey encounter rate to standard classification of dives allowed us to identify foraging signatures from diving behaviour. This in turn will allow more accurate prediction of the energy gain function allowing consequent application of the marginal value theorem to fur seal foraging.

PLASTIC DEBRIS IN THE STOMACH OF A MINKE WHALE (*BALAENOPTERA ACUTOROSTRATA*) STRANDED ON THE FRENCH CHANNEL COAST

F. Kerleau

GECC, Groupe d'Etude des Cétacés du Cotentin, 50130 Cherbourg-Octeville, France
(Corresponding author: f.kerleau@wanadoo.fr)

INTRODUCTION The impact of floating debris on marine fauna has been documented in mammals, birds, turtles, fishes and a few invertebrates. Plastic matter constitutes the vast majority of this debris and its ingestion by marine animals can result in death. Many cetacean species, particularly toothed whales (odontocetes), are victims of such debris.

MATERIALS AND METHODS On 6th April 2002, a dead juvenile female Minke whale (*Balaenoptera acutorostrata*) was washed ashore on a Normandy beach (French Channel coast). The size (3.97m long) of this whale suggested that it had probably not been weaned. Analysis of the whale's stomach contents revealed that this organ was completely obstructed by a compact mass of plastic debris. A viscous black fluid covered the debris and the gastric mucous membrane was necrosed. No trace of animal prey was observed.

RESULTS After cleaning and drying the debris, we counted 18 pieces of plastic (Table. 1) representing a total surface area of 3.95m², along with a few smaller fragments of plastic. We found three supermarket plastic bags (16.7%), five plastic pockets (27.8%) and ten pieces of plastic sheeting (55.5%) in the stomach. The average surface area was 0.22m² and the area of the largest piece was 0.66m² (Fig. 1). Of the 18 pieces of plastic, 16 were opaque or translucent and only two were transparent (Fig. 2).

CONCLUSION In France, the 10 cases described since 1984 of marine debris ingestion in cetaceans involved only toothed whales (odontocetes) stranded on the Atlantic and Mediterranean coasts (data CRMM, National stranding network). This discovery represents the first reported case of the ingestion of plastic debris by baleen whales (mysticetes) in France.

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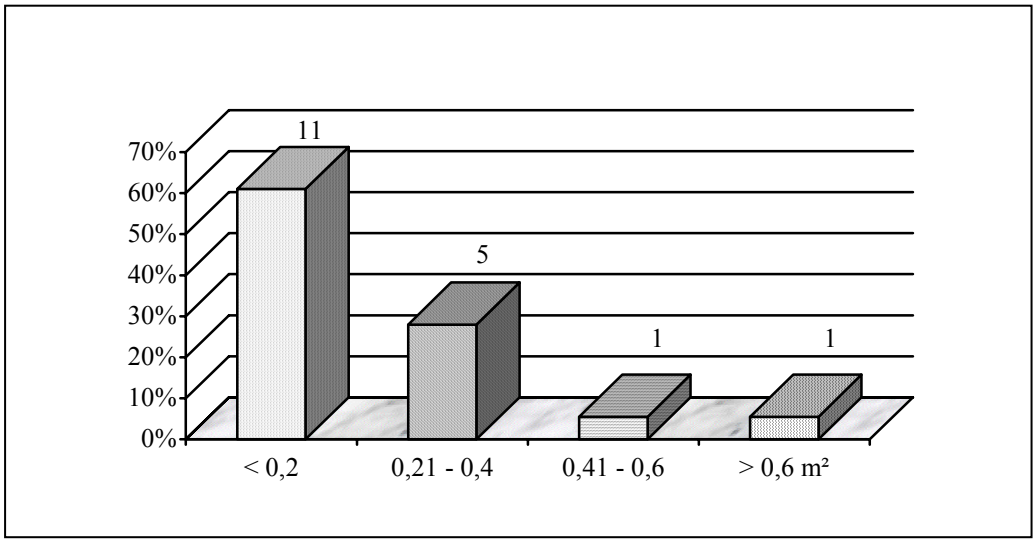

Fig. 1. Size of the 18 plastic's pieces

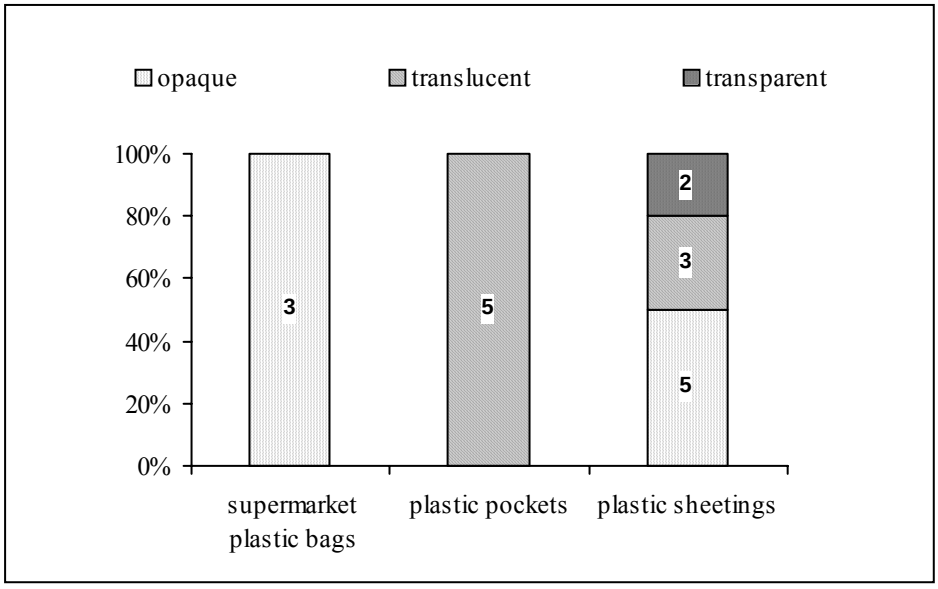

Fig. 2. Description of the 18 plastic debris

Table. 1. Review of the plastic debris found in the Minke whale's stomach

FOREIGN OBJECTS	DESCRIPTION	SIZE
Supermarket plastic bag	Opaque / white with blue letters	40*40 = 1 600 cm²
Supermarket plastic bag	Opaque / white with blue letters	40*30 = 1 200 cm²
Supermarket plastic bag	Opaque / white	20*25 = 500 cm²
Plastic pocket	Translucent / greyish	100*30 = 3 000 cm²
Plastic pocket	Translucent / greyish	65*40 = 2 600 cm²
Plastic pocket	Translucent / white with blue letters	40*25 = 1 000 cm²
Plastic pocket	Translucent / blue	35*20 = 700 cm²
Plastic pocket	Translucent / white	27*15 = 405 cm²
Plastic sheeting (garbage bag)	Opaque / black	50*10 = 500 cm²
Plastic sheeting (garbage bag)	Opaque / black	80*30 = 2 400 cm²
Plastic sheeting	Opaque / white	110*60 = 6 600 cm²
Plastic sheeting	Opaque / white	50*40 = 2 000 cm²
Plastic sheeting	Opaque / white	10*20 = 200 cm²
Plastic sheeting	Translucent	70*50 = 3 500 cm²
Plastic sheeting	Translucent / white	110*30 = 3 300 cm²
Plastic sheeting	Translucent / white	25*20 = 500 cm²
Plastic sheeting	Translucent / greyish	30*45 = 4 050 cm²
Plastic sheeting	Translucent / black	30*25 = 750 cm²

FIRST INSIGHTS INTO THE DISTRIBUTION AND DIVE BEHAVIOUR OF OFFSHORE BOTTLENOSE DOLPHINS IN THE DEEP OCEANIC WATERS AROUND BERMUDA

L. Klatsky[1, 2], R. Wells[3], and J. Sweeney[1]

[1] *Dolphin Quest – Quest Global Management, 1880 Harbor Island Drive, San Diego, CA 92101, USA*
[2] *Biology Department, San Diego State University, 5500 Campanile Drive, San Diego, CA 92182-4614, USA*
[3] *Chicago Zoological Society, c/o Mote Marine Laboratory, 1600 Ken Thompson Parkway, Sarasota, FL 34236, USA*

The first investigation of offshore Atlantic bottlenose dolphins (*Tursiops truncatus*) in deep oceanic waters around Bermuda was initiated in the summer of 2003. Satellite-linked time-depth recorders (SL-TDRs) were attached to three dolphins to determine summer distribution and dive behaviour. Maximum dive depth, duration, and time-at-depth were recorded and compressed in four six-hour periods per day. Daily locations were received for 5-45 days with an average of 7.8 transmissions per day. Dolphins travelled in close proximity to the 100 – 1000 fathom contour around the Bermuda platform. All three dolphins performed deeper dives than have been previously reported for wild bottlenose dolphins, to depths of more than 450 metres. Hematocrit values of 51% - 59% were consistent with such deep dive capabilities. Statistical analyses were only performed on the data from one dolphin due to small sample sizes for the other two dolphins. Results indicate a greater number of regular nightly (21:00-02:29 local) dives to depths below 450 metres (mean±SD, 8.49±3.88) compared to dusk (15:00-20:59) (mean±SD, 1.49±0.65) and dawn (3:00-8:59) (mean±SD, 4.54±2.68). Approximately 98% of the time during the period of day (9:00-14:59) was spent within 50 metres of the surface compared to 52% during the night. An increased amount of time was spent at 150 metres (mean±SD, 8.90%±4.83%) and beyond 450 metres (mean±SD, 8.98%±5.40%) during the night compared to other depths. A similar but less pronounced pattern was observed during dawn and dusk. The largest mean duration of dives made at night was found for dives lasting longer than 5 minutes (mean±SD, 22.81±4.25). This study provided baseline information about the distribution of bottlenose dolphins near the island of Bermuda, and that the increase in nightly dive behaviour may be in response to the vertical migrations of prey species.

USING HEAVY METALS (CD AND HG) TO DISCRIMINATE DIETARY PREFERENCES OF COMMON DOLPHIN (*DELPHINUS DELPHIS*) AND STRIPED DOLPHIN (*STENELLA COERULEOALBA*) IN THE BAY OF BISCAY (FRANCE)

V. Lahaye[1], P. Bustamante[1], J. Spitz[2], V. Ridoux[1, 2], and F. Caurant[1]

[1] *Laboratoire de Biologie et Environnement Marins, E.A. 3168, Université de La Rochelle, Ave. Michel Crépeau, 17000 La Rochelle, France*
[2] *Centre de Recherche sur les Mammifères Marins, Port des Minimes, Ave. Lazaret, 17000 La Rochelle, France*

Top predators like marine mammals naturally bioaccumulate elevated concentrations of heavy metals during their life. Common and striped dolphins inhabit both neritic and oceanic areas of the Bay of Biscay, involving two different feeding behaviours. The use of cadmium (Cd) and mercury (Hg) as tracers of their diet was tested. We investigated the relationship of metal concentrations between predators and prey, from which the exposure of each population of dolphins has been estimated through their diet. Renal Cd and hepatic Hg were analysed in 38 common dolphins and 10 striped dolphins of similar ages stranded on the French Atlantic coast. Both metals were measured from the whole bodies in five fish and two cephalopod species. For both predators, Cd and Hg exposure was at least two times higher in oceanic than in neritic areas, the difference being more acute for striped dolphins: 1720 *vs* 495 µg Cd.day-1 and 250 *vs* 125 µg Hg.day-1. Striped dolphins were always more exposed to Cd than common dolphins (495 *vs* 290 µg Cd.day-1 for neritic and 1720 *vs* 660 µg Cd.day-1 for oceanic areas) and bioaccumulation of Cd was indeed higher in striped dolphins than common dolphins (9.6 ± 7.0 *vs* 2.0 ± 4.6 mg.kg-1 of fresh weight respectively). The higher exposure to both contaminants in oceanic predators was linked to the greater proportion of cephalopods (major source of Cd but also of Hg) and to the mesopelagic myctophids (highest source of Hg among fish) in the diet. Since striped dolphins are more teutophageous than common dolphins in all areas, bioaccumulation of Cd was always higher in this species, making this element the best tracer to discriminate species. Nevertheless, the use of both Hg and Cd appears to be necessary to further discriminate habitats.

DOES SPRING BLOOM TIMING AND INTENSITY INFLUENCE FIN WHALE DISTRIBUTION IN THE LIGURIAN SEA?

S. Laran[1,2,3], A. Gannier[1,2], S. Bourreau[1,2], A. Littaye[2], and C. Joiris[3]

[1] *Centre de Recherche sur les Cétacés, 306 avenue Mozart, 06600 Antibes, France (crc@marineland.fr)*
[2] *Groupe de Recherche sur les Cétacés, BP 715, F-06633 Antibes cedex, France*
[3] *Free University of Brussels, Pleinlaan 2, B-1050 Brussels, Belgium*

INTRODUCTION Field hydrological studies in the Ligurian Sea (NW Mediterranean Sea) and satellite imagery underline a frontal area between 10 and 50 km from the mainland and from Corsican coasts. This region provides a high level of primary production, peaking in March-April. To obtain results on seasonal variation of cetacean population, monthly transects were conducted between French mainland and Corsica between 2001 and 2003. The purpose of this study was to try to understand how fin whale (*Balaenoptera physalus*) year-round abundance could be affected by food availability in the area, using satellite remote sensed data. The food parametre was estimated by the Net Primary Production, considered as a good descriptor of food availability than surface chlorophyll pigment (Littaye *et al*., 2004).

MATERIALS AND METHODS **Field survey** Seasonal variation of fin whale abundance was assessed by 29 dedicated surveys carried out between the Cap d'Antibes and the Pointe de la Revellata from February 2001 to December 2003. Visual survey on the two parallel transect lines consisted of a continuous naked-eye observation by 3 observers (see Laran *et al*., 2003 for more details on sampling protocol). Only efforts with Beaufort scale ≤ 3 were used. Survey transects were cut every 20nm (37km) until the end of the day (or bad weather) and the remaining distance was included in the pool of data. Encounter rate (number of fin whale/km) were computed on sample unit and averaged by trip. Effort by monthly trip ranged between 111 and 326km (mean: 250; SD: 71).

Remote sensing: Net primary production (NPP), in $mgC.m^{-2}.d^{-1}$, was computed using Wimsoft ®6.13 (Kharu, 2003). Inputs parametres were obtained from remote sensing data (with agreement of Goddard DAAC) (Table 1). Numerical data was extracted from a strip of 5,760 km^2 (70x24 nm) around both transect lines (Table 2). This area was located on pelagic area (depth ≥2000m, 17km from shore). Pixel measurements were temporally averaged by month. As no SST data was already available from Nasa Pathfinder after June 2003, monthly averaged temperatures of 2002 were used with Chl*a* of 2003 and PAR of 2003 to compute an indication of monthly NPP from July to December 2003. NPP and mean encounter rates of whale were integrated over three periods: February to April as the spring bloom period, May to August as the summer period and September to December as the Autumn-Winter period. January was not included in those integrated periods.

RESULTS AND DISCUSSION **Fin whale** (Fig. 1). Fin whales occur year-round in the Ligurian Sea, with a maximum in summer. Whales were observed from February to October 2001, with a maximum encounter rate in August (0.109 whale/km). Then no sighting was recorded from December to February 2002, despite 744km of effort. In 2002, they peaked in July (0.057 whale/km). In 2003, the maximum encounter rate occurs in April (0.068 whale/km),

The best correlation between primary production and whale encounter rate was found with one month of time lag (Pearson $r = 0.254$, $n = 29$).

The bloom situation of 2001and 2002 were almost similar and for both years the whale maximum occurred in July-August, with a time lag of 4-5 months. Following the strong bloom intensity of 2003, the whale maximum occurred in April (time lag of one month) mainly spread in the central area instead of frontal distribution during spring 2001-02. A possible effect of a strong bloom intensity could be the early entrance of whales in the area which maybe attracted by aggregation of adult euphaisiids remaining from the previous year. However, no direct effect appears on summer abundance of whales. Littaye *et al*. (2004) showed that whale distribution from June to July was well correlated with spring primary production, then with summer progressing short-term processes became more significant. This interpretation is coherent with our summer situation (Figure 2): high level of NPP in summer 2001 was followed by the maximum concentration of whales, in August 2001.

CONCLUSION Spring bloom intensity seems to influence an early presence of fin whales in the Ligurian Sea. Moreover, a higher primary production level in summer may also favour a high relative abundance of whale in July and August.

ACKNOWLEDGEMENTS We thank Marineland (Antibes), the Ministère de l'Ecologie et du Développement Durable and the Conseil Régional de Provence-Côte d'Azur for having funded this study, the GREC for the logistic help and observers for their availability.

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Table. 1. Inputs parametres obtained from remote sensing data

Input parameter		Sensor	Products	Resolution
Surface Chlorophyll pigment concentration	Chl*a*	SeaWIFS	Level 3 NASA/DAAC	8 days / 9x9km
Photosynthetically Active Radiation	PAR	SeaWIFS	NASA/DAAC	8 days / 9x9km
Sea surface Temperature	SST	AVHRR	NASA Pathfinder program (processing 4.1)	8 days / 9x9km

Table. 2. Net Primary Production

Year	SPRING MAXIMUM start	end	MAY	June to December
2001	Middle of Feb.	End of April	Decrease to level similar to Jan.-Feb.01	Fast increasing - stable until Dec. From Sep., NPP ≈ spring level
2002	1st week of Feb.		Increase to level similar as Feb.02	Decreasing, NPP < Jan.02 level
2003	End of January		Decrease to Jan-Feb.03 level	Stable low level until Sep.

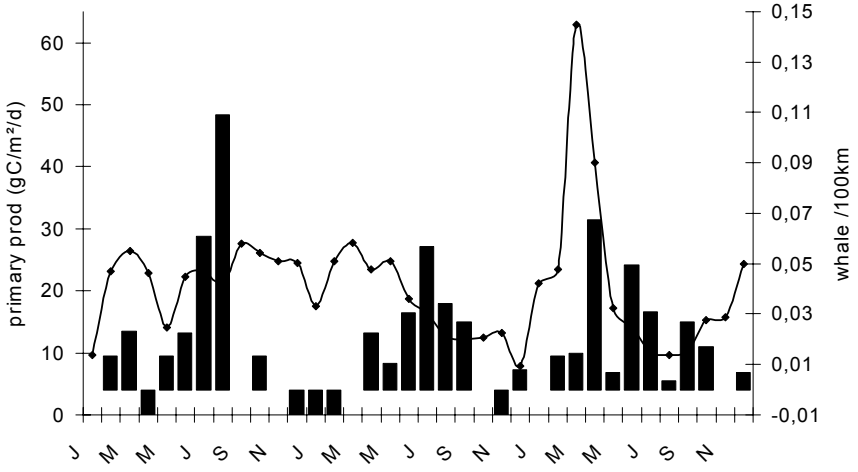

Fig. 1. Net Primary Production (NPP) and whale encounter rate (by 100km) in 2001, 2002 and 2003

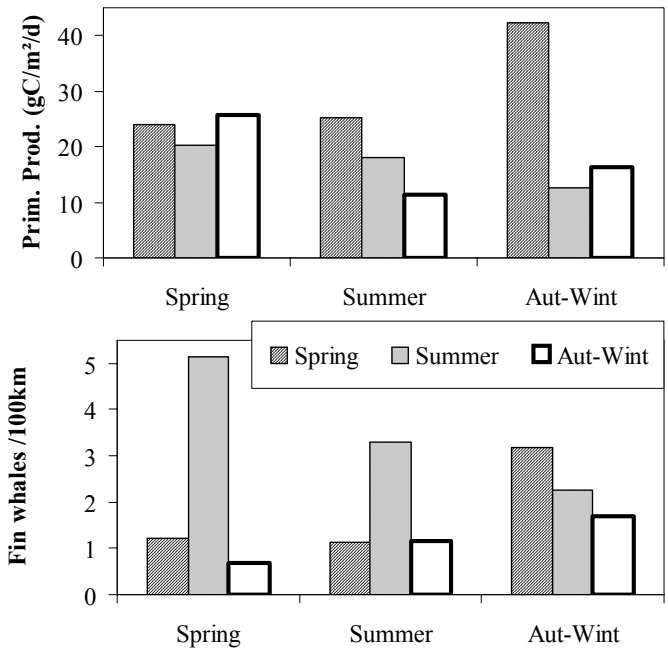

Fig. 2. Mean primary production and fin whale encounter rate

BATTLING BEAKED WHALES: CAN INTERSPECIFIC COMPETITION EXPLAIN THE DISTRIBUTION OF ZIPHIIDS IN THE NORTH ATLANTIC?

C. D. MacLeod[1], and A. Williams[2]

[1] *School of Biological Sciences (Zoology), University of Aberdeen, Tillydrone Avenue, Aberdeen, AB24 2TZ, UK*
[2] *Biscay Dolphin Research Programme, Blenheim, 6 Manor Way, Lee on Solent, Hampshire, PO13 9JH, UK*

Competition between species occupying similar ecological niches is hypothesised to influence the distribution of species through competitive exclusion. We investigated whether competition can explain the distribution of beaked whales in the North Atlantic. Prey, environmental and habitat preferences of each species were identified and a novel graphical modelling approach was used to investigate whether similarities and differences in these preferences are sufficient for the outcome of competitive interactions to explain the observed distribution of each species. Northern bottlenose and Cuvier's beaked whales were found to be dietary generalists, consuming large and small prey, and to prefer similar habitats. However, Cuvier's beaked whales were found to prefer warmer waters than northern bottlenose whales. In contrast, Mesoplodonts were found to be small prey specialists. The graphical models found that although Cuvier's beaked whales can out-compete and exclude northern bottlenose whales in warmer waters, northern bottlenose whales will be the dominant species in colder waters, explaining the observed geographic segregation. However, differences in prey preferences between these two and Mesoplodonts are sufficient to allow co-existence, explaining the observed sympatry. Within the Mesoplodonts, species are predicted to be segregated by habitat and water temperature. The predicted outcome of competitive interactions between northern bottlenose whales and Cuvier's beaked whales were compared to an independently gathered set of data from the Bay of Biscay which was not used in construction of the graphical models. Over a seven year period in the Cap Breton Canyon region, Cuvier's beaked whales were observed to increase in occurrence to first temporally and then spatially exclude northern bottlenose whales in line with the models predictions, providing an independent test and further support for these models. Therefore, similarities and differences in the niches of North Atlantic beaked whales are sufficient for competition to explain the observed distribution of each species.

COMPUTING HABITAT SUITABILITY MAPS FOR CETACEANS IN THE NORTHEAST ATLANTIC USING PRESENCE-ONLY DATA

S. Mendes[1], R. Swift[2], G. Hastie[3], and C. Macleod[1]

[1] *Department of Zoology, University of Aberdeen, Tillydrone Avenue, Aberdeen AB24 2TZ, UK*
[2] *46a Mount Street, Aberdeen AB 25 2QT, UK*
[3] *Fisheries Centre, Lower Mall Research Station, 2259 Lower Mall, University of British Columbia, Vancouver, BC, Canada V6T 1Z4*

Cetacean species are expected to be non-randomly distributed with respect to environmental variables. In order to build habitat suitability models we normally rely on presence/absence data. However, absence data are often difficult to obtain with certainty, because of detection difficulties associated with cetacean behaviour and the offshore nature of many cetacean habitats. Using Ecological-Niche Factor Analyses (ENFA), habitat suitability maps were computed for fin whales, sperm whales and delphinids in the Northeast Atlantic with presence-only data obtained from different sources (whaling records, sightings and acoustic detections, respectively) and using two ecogeographical variables (depth and slope). Sperm whales showed the lowest marginality coefficient (Msw=0.28 < Md=0.40 < Mfw=0.44) meaning that their habitat is the least different from the average conditions within the study area, which encompasses mostly deepwater. In addition, the specialisation coefficient was higher for sperm whales (Ssw=3.22 > Sfw=2.38 > Sd=2.07) meaning that this species is more restricted in the range of depths and slopes they inhabit, hence have a narrower niche than the other two groups of cetaceans. The computed maps showed that the three species groups overlap in their suitable habitat areas and reiterated the importance of the Northeast Atlantic area for a wide variety of cetaceans. Although depth and slope can explain much of the distribution of these animals, other factors such as sea surface temperature and primary productivity, together with the inclusion of a temporal component may allow for more representative models to be computed. For species that are difficult to observe in their environment, such ENFA-based models are robust and ecologically meaningful. The ENFA methodology can be applied to cetacean presence-only data collected using different methodologies, allowing the study of distribution and niche partitioning between species and has the potential to be used to provide scientific advice to environmental managers.

ANALYSIS OF STABLE NITROGEN AND CARBON ISOTOPE RATIOS IN CASPIAN SEALS AND FISHES IN CASPIAN SEA

N. Miyazaki[1], K. Nakamatsu[1], F. Hyodo[2], E. Wada[2], E. A. Petrov[3], and S. L. Khuraskin[4]

[1]*Ocean Research Institute, The University of Tokyo, Tokyo, Japan*
[2] *Research Institute for Humanity and Nature, Kyoto, Japan*
[3] *Limnological Institute, Irkutsk, Russia*
[4] *Caspian Scientific Research Institute of Fisheries, Astrakhan, Russia*

The Caspian seal (*Phoca caspica*) is an endemic species in the Caspian Sea and occupies the highest tropic level in the ecosystem. To know the ecological situation of Caspian seals in the Sea, we measured stable nitrogen (δ15N) and carbon (δ13C) isotope from muscle samples of 23 Caspian seals (18 females and 5 males) collected from Caspian Sea during 12th and 16th September, 1998. The stable isotopes of these four individuals from three fish species (*Rutilus rutilus caspica*, *Esox sp*. *Parasilurus asotus*) from Caspian Sea and/or the Volga River were also measured to compare with those in Caspian seals. Muscle samples of Caspian seals revealed no significant sexual difference for stable nitrogen isotope (mean ± SD:δ15N=13.4‰ ± 0.7 for males vs.13.6 ‰ ± 1.7 for females), and for stable carbon isotope (mean ± SD:δ13C=-20.3‰ ± 0.6 for males vs.-20.5‰±1.2 for females). Thus, combined data of both sexes were used in the following analysis. The relationship between δ13C and δ15N was indicated as the equation: Y =-0.81 X-3.13 (r=-0.57), Y: δ15N (‰), X: δ13C(‰). Comparison of stable nitrogen (δ15N) and carbon (δ13C) isotopes between Caspian seals and Baikal seals indicate that the former species indicate a higher value in stable carbon isotope than the latter, but was reverse in stable nitrogen isotope. This suggests that Caspian seals in Caspian Sea have different feeding strategy compared with Baikal seals in Lake Baikal. Ratio of Caspian seals to *R. rutilus caspica*, which is one of main food items of Caspian seals, was 1.16 for stable nitrogen isotope, indicating that stable nitrogen isotope might be useful tool to understand the tropic level of animals in Caspian Sea as well as other ecosystems. Among fishes in Caspian Sea, *R. rutilus caspica* showed the lowest value (11.7‰) and was followed by *Esox* sp.(14.7‰) and *P. asotus* (15.3‰) in that order.

DISTRIBUTION OF FIN WHALES IN THE WESTERN LIGURIAN SEA IN RELATION TO PHYSIOGRAPHIC VARIABLES

S. Panigada[1, 2], M. Zanardelli[2], and P. Hammond[1]

[1] *Sea Mammal Research Unit, University of St Andrews, St. Andrews, Fife, United Kingdom*
[2] *Tethys Research Institute, Viale G.B. Gadio 2, I-20121 Milan, Italy*

This paper presents an analysis of data collected during summer 1990-1999 in the recently established Mediterranean Sanctuary for marine mammals, as part of a long-term study on the habitat use and preferences of fin whales in this area. The information collected provides an insight on the presence and distribution of Mediterranean fin whales (*Balaenoptera physalus L.*) while in their major feeding ground. During the study period 870 days were spent at sea, surveying a total of 73,046km, resulting in 540 sightings of fin whales. To provide relative abundance indices of fin whales, the study area was divided into a grid of 546 cells 5' latitude by 5' longitude, each with a surface area of approximately 62.5km^2. Physiographic variables: mean, range and standard deviation of depth and slope, and distance from the nearest coastline were calculated for each cell using GIS tools. A Generalised Linear Model (GLM) was used to model the distribution of fin whales in relation to these variables. The response variable was the number of fin whale sightings in each cell in each year and the search effort, expressed in number of kilometres surveyed in each cell under positive conditions, treated as an offset. According to the characteristics of the response variable the Quasi Poisson distribution and the log link function were chosen. The GLM revealed that water depth was the most significant variable in describing fin whale distribution, with more than 90% of the sightings occurring in waters deeper than 2,000m. This study underlines the pelagic preferences of fin whales in this area, emphasises the crucial role that the pelagic portion of the western Ligurian Sea plays in the ecology of Mediterranean fin whales, and provides input for conservation and management measures in the area.

PROXIMATE ANALYSIS OF NEW ZEALAND SEA LION, *PHOCARCTOS HOOKERI*, MILK: INFLUENCE OF SEASON, MATERNAL AGE, BODY MASS AND CONDITION ON MILK COMPOSITION IN EARLY LACTATION

F. G. Riet Sapriza[1], P. J. Duignan[1], D. D. S. Mackenzie[2], A. McGibbon[3], I. S. Wilkinson[4], N. Lopez Villalobos[1], B. L. Chilvers[5], and B. Springett[6]

[1] *New Zealand Wildlife Health Centre, IVABS, Massey University, Palmerston North, New Zealand*
[2] *Department of Animal Science, Massey University, Palmerston North, New Zealand*
[3] *Fonterra Research Centre, Private Bag 11-029, Palmerston North, New Zealand*
[4] *Department of Conservation, Science & Research Unit, 65 Victoria Street, Wellington, New Zealand*
[5] *School of Biological Sciences, University of Canterbury, Private Bag 4800. Christchurch, New Zealand*
[6] *Ecology Group, Institute of Natural Resources, Massey University, Palmerston North, New Zealand*

The New Zealand sea lion (*Phocarctos hookeri*) is an endangered endemic species that breeds only on New Zealand's subantarctic islands. The population is small and despite full protection has not grown since the mid twentieth century. Low reproductive success through poor pup production, low weight gain and high neonatal mortality may be impeding species recovery. An additional factor may be scarce or variable prey availability between seasons and competition with commercial fisheries. In the early lactation period of five years (1999-2003), lactating females (n = 357) were captured, and while under anaesthesia, milk was sampled and body length and weight were measured. The milk composition was analysed using standard procedures applied in the dairy cattle industry however new to marine mammals research. The advantages of these new techniques will be reported. The main aim of this study is to test the hypothesis that milk composition is not related to season, month or maternal age, body condition and mass. Body condition was scored (BCS) from a combination of body mass and length. Analysis of variance indicated that variation in milk fat concentration was significantly affected by year and month ($p<0.05$). The interaction between year and BCS had a significant effect on milk fat and protein concentration ($p<0.05$). Year, month and age significantly affected the variation in BCS ($p<0.05$). We concluded that individual female characteristics contributed little to the variability in milk composition, but this suggests that changes in seasonal condition and/or changes in maternal investment in response to the demands of the pup may act on milk composition. We will continue to test the hypothesis in lactating New Zealand sea lions where attendance patterns, pup age and gender are known. In addition, the influence of diet on milk composition will be investigated through fatty acid signature analysis.

SATELLITE TRACKING OF SEVEN GREY SEAL PUPS IN THE BALTIC SEA. MONITORING THE INTRODUCTION OF ANIMALS BORN IN CAPTIVITY

A. Roos[1], I. Kuklik[2], and O. Karlsson[1]

[1] *Environmental Contaminant Research Group, Museum of Natural History, Box 50007, 104 05 Stockholm, Sweden*
[2]*Hel Marine Station, University of Gdansk, Poland, ul. Morska 284-150 Hel, Poland*

Seven grey seal pups were released to the Southern Baltic Sea in 2002 (n=3) and 2003 (n=4). All pups were born in captivity and were released to strengthen the fragile grey seal population in the southern part of the Baltic Sea. To monitor the movements of the introduced animals, all seals were equipped with satellite transmitters (Wildlife computers SPOT2-tags). Tags lasted between 2 days and more than 8 months. In at least two cases short deployments were connected to seals drowning in fishing gear. Seal movements were analysed by plotting track lines using GIS and the seals mean daily position were used to produce kernel plots to study area usage. Seal movements could be divided into two phases: (1) In the initial phase, lasting up to several weeks, seals moved long distances in several directions most likely in search for a suitable habitat; (2) In the second phase seals had settled in a habitat and movements were shorter and more predictable. Most movements in the second phase were between the haulout site and foraging at sea. Seals settled in different areas, but interestingly no seals settled in an area without present seal colonies. Instead seals moved several hundred kilometres into areas where seals were already present. This might be a dilemma for the reintroduction of seals into areas where they have once disappeared.

PECULIARITIES OF PHAGOCYTOSIS IN THE BLACK SEA BOTTLENOSE DOLPHIN (*TURSIOPS TRUNCATUS*) IN CORRELATION WITH MICROBIAL INDICES OF GR+ COCCUS IN UPPER RESPIRATORY TRACT OF THESE ANIMALS DURING THEIR ADAPTATION TO NOOGENIC ENVIRONMENT

O.V. Sokolova[1] and T.E. Denisenko[2]

[1] *119071, A.N. Severtsov Institute of Ecology and Evolution, Problems RAS, Lenin Avenue, 33, Moscow, B-71, Russia*
[2] *109472, K.I. Skryabin Moscow State Academy of Veterinary Medicine and Biotechnology, Skryabin's Street, 23, Moscow, Russia*

An interest for the study of ecological aspects of human and animal pathology, epidemiology and epizootology has increased nowadays. Ecologists and the general public have grown increasingly concerned over the growth of anthropogenic pollution of the world's oceans by toxic compounds (PCBs, DDT, heavy metal salines, radionuclides, etc). These toxic compounds accumulate in marine mammal organisms thereby weakening their immune system. Large amounts of different pathogenic microorganisms from humans and terrestrial animals get into the Black Sea drainage-basin with gutter and agricultural flowings, causing disease and often death of the dolphins. Similar problems arise during attempts to keep bottlenose dolphins in captivity conditions. Captivity represents a qualitatively new neogenic environment where dolphins collide with a multitude of unknown stress-factors. The present work is devoted to the study of the development of peculiarities within adaptive-protective phagocytosis mechanisms in the Black Sea bottlenose dolphin in response to microflora of neogenic origin. The work was undertaken in 2001-2002 at the Utrish marine station of A.N. Severtsov IEEP RAS. 36 adult bottlenose dolphins (*Tursiops truncatus*) were examined. A examination of haematological and biochemical indexes for clinical estimations of the dolphin common state was performed. A study of the absorbing and digesting activity of phagocytozing leucocytes of peripheral blood was completed with the help of bacteriological collectional strain Staphylococcus aureus №25923 ATCC. Simultaneously, the quantitative and qualitative composition of Gramm-positive coccous flora from the upper respiratory tract of animals was studied. As a result of this work, interesting peculiarities of the phagocytosis course were found which were similar to characteristic features of the course of phagocytic reaction in the pair hoofed animals. The results of this work may be useful for grading causes of marine ecosystem pollution.

FEEDING

CEPHALOPOD PREY OF SPERM WHALES FROM THE GULF OF MEXICO

N. B. Barros[1] and K. D. Mullin[2]

[1] *Mote Marine Laboratory, 1600 Ken Thompson Parkway, Sarasota, FL 34236 USA*
[2] *NMFS/SEFC, P.O. Drawer 1207, Pascagoula, MS 39568 USA*

Sperm whales are common inhabitants of the deep waters of the Gulf of Mexico. To date, no information exists on the diet of sperm whales in the Gulf. This study sheds light into their feeding habits by examining samples collected from free-ranging and stranded animals. Floating fecal materials were collected on seven different occasions near diving whales during ship surveys conducted in 2000 and 2001. Stomach contents of four animals stranded during 1994-2003 were also examined. Prey included a minimum of 13 species within 10 families of cephalopods, the only prey type observed. The most important prey of both free-ranging and stranded animals was *Histioteuthis*, a midwater squid important in the diet of sperm whales worldwide. Both groups of whales consumed *Histioteuthis* of similar sizes (63-90 mm estimated mantle length; 99-303 g estimated weight). Other important prey included the families *Cranchiidae*, *Chiroteuthidae*, *Pholidoteuthidae*, *Vampyroteuthidae*, *Octopoteuthidae* and *Onychoteuthidae*, among others. Most species of cephalopods consumed by Gulf sperm whales are meso to bathypelagic in distribution, being found from the surface to waters 2,500 m deep. Some of these prey are vertical migrators; others may be found near or at the bottom. The diet of Gulf sperm whales does not seem to include species targeted by the commercial fisheries.

INTEGRATED PASSIVE ACOUSTIC APPROACH PROVIDES EVIDENCE FOR A MAJOR SPERM WHALE FEEDING GROUND IN THE FRENCH MEDITERRANEAN SEA

V. Drouot[1, 2, 3], A. Gannier[2], and J. C. Goold[3]

[1] *Centre de Recherche sur les Cétacés, Marineland, 306 avenue Mozart, Antibes, France*
[2] *GREC, BP175 06600 Antibes Cedex, France*
[3] *Institute of Environmental Science, University of Wales, Bangor, Robinson Building, Deiniol Road, Bangor, Gwynedd LL57 2UW, UK*

Dedicated sperm whale surveys were performed during the summer field seasons from 2001-2003 in the western Mediterranean Sea. Visual and a wide range of acoustic variables were used to quantify the foraging activity and dive pattern of the species. The parametres recorded included surface/dive periods, blow counts and timings, whale positions, timing of click and creak activity, and inter-pulse interval (IPI) measurements within sperm whale clicks. During the surveys, 51 complete dive cycles were monitored, from 20 animals followed for at least one dive cycle. The whales exhibited dive cycles parametres consistent with those measured other parts of the world; approximately 46 min (SD=5.5) dive duration, 9 min surface period (i.e. inter-dive interval), 42 blows per surface period (SD=7.1), and 1.3 NM horizontal displacement between dives. The tracked whales never returned twice to the same area but seemed to follow an approximately steady heading, essentially along the bathymetry contours. An average of 25 creaks (SD=3.9) per dive, which would correspond to around 750 squid eaten per whale per day. The whale body size (estimated from IPI measurements) appeared to have a significant influence on both the number of creaks per dive and the dive time at which the first creak of the dive occurred, suggesting that larger whales may increase their prey intake and forage in deeper water layers than smaller whales. The timing of the first creak and the last click of the dive (around 6 min after the fluke-up, and just before the surfacing, respectively) suggest a foraging depth of between 500 and 800m, based on known descent rates. The study demonstrates the capacity of passive, non-invasive, acoustic techniques in addressing issues of major conservation interest such as habitat use and foraging activity patterns.

METHODS FOR STUDYING HARBOUR SEAL (*PHOCA VITULINA*) FOOD PREFERENCE IN THE FIELD

M. Hemmigsson[1], S.G. Lunneryd[1, 2], and S. Königson[1]

[1] *National Board of Fisheries, Box 423, 401 26 Gothenburg, Sweden*
[2]*Göteborg University, Tjärnö Marine Biological Laboratory, 452 96 Strömstad, Sweden*

Several methods are practicle for achieving knowledge about seal diet. Studies of remains of prey species in stomach contents or faeces are often used to determine occurring fish species in the diet. These methods require either a large number of dead seals or easy accessible haul-outs for collection of faecal samples. Another possible way to study prey preference is to offer a variety of fish species to wild seals. This study presents methods used for investigating the food preference of the Swedish harbour seals in the field. Results obtained by these studies are presented briefly. Three different methods have been tested by paired choice of different fish species. In the first kind seals were offered dead fish in specially designed net cages suspended at a depth of at least 1.5m close to haul-outs. The seals preferred cod before eel. The second method of feeding station consisted of dead fish attached to an anchored string in a haul-out area and in an eel fyke fishing area. Eel was preferred more often in the eel fishing area compared to the haul-out area. The last method consists of fykenets baited with live fish and placed in pairs at the seabed in an eel fishing area. In this case eel was very strongly preferred compared to cod, demonstrated by damage of the fykes from the seals. Methods like these include some potential biases that must be taken into account when interpreting results. However, the results show that the preferences are different either among the seals or depending on feeding area. Offering fish to wild seals can be a useful method for understanding diet preference and how this preference may differ between areas and seasons.

THE USE OF FATTY ACID ANALYSIS TO DETECT VARIATIONS IN THE DIET OF CETACEANS FROM EUROPEAN WATERS

J. A. Learmonth[1, 2], G. J. Pierce[1], M. B. Santos[1], C. F. Moffat[2], and L. Webster[2]

[1] *Department of Zoology, School of Biological Sciences, University of Aberdeen, Tillydrone Avenue, Aberdeen, AB24 2TZ, Scotland, UK*
[2] *FRS Marine Laboratory, 375 Victoria Road, Aberdeen, AB11 9DB, Scotland, UK*

Changes in the diet of marine mammals can have important consequences for individual health and population status. It is therefore important to determine and understand these variations. The majority of information on the diet of cetaceans is based on stomach contents analysis of stranded or by-caught animals. Results can be limited to detecting the recent diet and may also be biased towards prey species with robust hard parts that remain in the stomach. Fatty acid analysis of blubber samples offers an alternative source of information on diet, which avoids some of the biases of stomach contents analysis. The objective of this study was to assess sources of variation in the fatty acid profiles of different cetacean species from European waters and to compare the variations with the fatty acid profiles of putative prey species. Fatty acid analysis of the inner blubber layer of the harbour porpoise (*Phocoena phocoena*), common dolphin (*Delphinus delphis*), striped dolphin (*Stenella coeruleoalba*) and bottlenose dolphin (*Tursiops truncatus*) was used to determine if seasonal, geographical and individual variations in fatty acid profiles related to diet. Samples were collected from animals stranded or by-caught from around Scotland, Ireland, Holland, Belgium, France and Galicia (NW, Spain) between 2001 and 2003. The variations observed in the fatty acid profiles of cetaceans from the different regions, seasons, and the different individual variations, such as sex and body size-class, appear to be related to differences in diet. Firstly, the results were consistent with trends in diet previously determined from stomach content analysis. Secondly, the fatty acids that showed the most variability are thought to be dietary in origin and could be related to differences in prey fatty acid signatures. The results suggest that fatty acid analysis is a useful method of assessing variation in the diet of cetaceans.

DIET OF BALTIC GREY SEALS (*HALICHOERUS GRYPUS*): INDICATIONS FOR CHANGES IN FOOD COMPOSITION

K. Lundström[1], K. Alexandersson[2], and O. Karlsson[3]

[1]*Göteborgs Universitet, Fiskeriverket, Box 423, 401 26 Göteborg, Sweden*
[2]*Tjärnö Marinbiologiska Laboratorium, 452 96 Strömstad, Sweden*
[3]*Naturhistoriska Riksmuseet, Gruppen för Miljögiftsforskning, Box 50007, 104 05 Stockholm, Sweden*

Grey seals are a major predator in the Baltic Sea, but information about their fish consumption is scanty. This is the first study of grey seal diet in more than three decades carried out in Swedish Baltic waters and the results differ from previous studies, both regarding species composition and the number of prey taxa. Grey seal digestive tract samples collected from hunted, bycaught and stranded animals have been analysed for fish prey hard parts. Identification of otoliths resulted in a minimum number of over 1400 food items from at least 12 prey taxa. Herring were by far the most common prey item occurring in 86% of the samples. Other important prey species were common whitefish (24%) and sprat (16,4%). Herring has also previously been an important food item for Baltic grey seals, but the proportions have changed drastically. In a study from the early 1970s herring was found in less than a quarter of the samples, compared to 86% in the recent study. Cod was the second most common species in the earlier study but not a single cod otolith has been found in our study. The results indicate a massive change in diet during the last decades, with increased proportions of herring and sprat and a decrease of cod. This largely reflects the change in composition of available prey species for the Baltic grey seals. Due to a combination of increased fishing pressure and unfavourable environmental conditions the Baltic cod has declined considerably while the sprat stock biomass is presently high. The situation for the herring is different and more complex with a decrease during the last decades in the central Baltic and northern Gulf of Bothnia and an increase in the southern Gulf of Bothnia.

QUANTITATIVE FATTY ACID ANALYSIS: INTERPRETATION OF FATTY ACID PROFILES IN HARBOUR PORPOISE BLUBBER

G. J. Pierce[1], J. A. Learmonth[1], G. Stowasser[1], M. B. Santos[1], A. F. Zuur[2], and C. Moffat[3]

[1]*Department of Zoology, School of Biological Sciences, University of Aberdeen, Tillydrone Avenue, Aberdeen, AB24 2TZ, UK*
[2]*Highland Statistics, 6 Laverock Road, Newburgh, Aberdeenshire, AB41 6FN, UK*
[3]*Fisheries Research Services Marine Laboratory, PO Box 101, 375 Victoria Road, Aberdeen, AB11 9DB, UK*

Although fatty acid composition is now routinely used to make inferences about diet in various predators, since most fatty acids derive from prey ("you are what you eat"), detailed quantitative interpretation of fatty acid profiles remains difficult. In the present paper two approaches to quantifying the diet were explored: (a) a simple randomisation technique which scanned multiple random combinations of different prey types to seek that which best matched the blubber fatty acid profile and (b) a statistical approach based on canonical correlation analysis (CCA). The data used refers to concentrations of 31 fatty acids in the inner blubber layer of 110 porpoises from Scottish waters and in samples of 13 common prey species. Initial exploratory analysis using PCA showed that the prey species clustered into three groups based on their fatty acid composition: (a) haddock, whiting and flatfish, (b) clupeids, Norway pout and sandeels, and (c) cephalopods. Fatty acid patterns in porpoise blubber were clearly distinct from these of all three prey groups, indicating that blubber fatty acids do not simply represent an untransformed combination of prey fatty acids. Randomization tests suggested that most porpoises had fed predominantly on prey of either group A or group B. In order to reach some general conclusions about the quantitative interpretation of fatty acid profiles, these results are compared with statistical results, results based on subsets of the fatty acids (chosen to aid discrimination of key prey species), results from stomach contents analysis on the same set of porpoises and, finally a dataset from a captive feeding experiment in which fatty acids were determined in squid and their (fish and crustacean) prey.

MEDICINE AND DISEASE

MOLLUSC AS A NATURAL RESERVOIR OF MORBILLIVIRUSES

S.I. Belikov[2], A.A. Durymanova[1], I.G. Kondrat'ev[2], N.N. Denikina[2], E.N. Ustinova[1], and A.M. Shestopalov[1]

[1] *State Research Center of Virology and Biotechnology "Vector", Kol'tsovo, Novosibirsk region, 630559 Russia*
[2] *Institute of Limnology, Siberian Branch of Russian Academy of Sciences, St. Lermontova 281, Irkutsk, 664033 Russia*

In aquatic mammals, morbillivirus was first identified in 1987 during a Baikal seal epizootic. In 1987, over 10 000 seals in Lake Baikal and at least half of the bottlenose dolphin population of the Atlantic coast of the United States died. Morbillivirus caused death of over 17 000 common seals in the North Sea in 1988 and at least 10 000 Caspian seals in 2000. A second epizootic among the common seal of the North Sea occurred in May 2002, about 21 000 animals died by the end of October 2002. However, the source of the aquatic mammalian infection remains unknown so far, as well as the mechanism of infection circulation between the outbreaks. Therefore, we searched for morbilliviruses in various representatives of the Baikal fauna that are the candidate virus carriers and serve, presumably, as a source of seal infection. In this study, we identified and isolated morbilliviruses from the gastropodes (*Baicalia carinata* and *Lymnaea auricularia*) living in Lake Baikal. The morbilliviruses were identified using reverse transcription polymerase chain reaction (RT-PCR) and ELISA-method. The virus accumulated within the molluscs was tested for biological activity by infection of virus-sensitive animals, ferrets (*Mustela putorius*). The pond snails (*L. auricularia*) were homogenized. After centrifugation, the supernatant was injected into the ferrets. In the control group, ferrets were infected with the strain Snider-Hill. The clinical signs typical of canine distemper appeared in animals infected with strain Snider-Hill between the seventh and ninth day, and in animals infected with the mollusc homogenate between the fourteenth and sixteenth day. The virus antigen was detected in RT-PCR and serological methods in various organs of the infected animals. Thus, the molluscs were demonstrated to serve as a natural reservoir of morbilliviruses, where the latter are preserved and reproduce and are then transmitted to warm-blooded animals via food chains.

DIOXINS EFFECTS ON THE PROLIFERATION AND PROTEOME OF PERIPHERAL BLOOD MONONUCLEAR CELLS OF SEALS

C. Brenez[1], P. Gerkens[1], T. Jauniaux[2], E. De Pauw[1], and M-C De Pauw-Gillet[3]

[1] *Mass Spectrometry Laboratory , Faculty of Sciences, University of Liege, Belgium*
[2] *Department of Pathology, Faculty of Veterinary Medecine, University of Liege, Belgium*
[3] *Department of Anatomy and Human Histology, Faculty of Medecine, University of Liege, Belgium*

Marine mammals, inhabiting polluted coastal areas are known to accumulate high levels of environmental chemicals, which has been related to the occurrence of several abnormalities as immunosuppression. The goals of the study were to detect and characterize the effects of exposition to environmental pollutants on some functions of the immune system and to identify the effects on the proteome. The first part of the experiment was an in vitro functional evaluation of the immune system by determination of lymphoproliferative response to mitogens (phytohaemagglutinin –PHA-) on peripheral blood mononuclear cells (PBMC) of harbor seals (*Phoca vitulina*) held in captivity in order to establish optimal conditions. Tests were carried out in order to determine cellular viability, synthesis of DNA and synthesis of proteins before and after cell cultures were exposured to different concentrations of contaminants (mixture of dioxins and furans, as in nature). The second part of the experiment was the analysis of whole cellular proteins (proteome) before and after the contaminants exposition. The cellular proteins were separated by a 2D electrophoresis and were chemically digested. Resulting peptides were identified by mass spectrometry. Cells from each animal were evaluated in triplicate for each test. Based on the optimisation assays, conditions chosen to evaluate the effects were 0.1µg/ml for PHA, 105 cells/well and 24, 48 or 72hrs of incubation. Results on bovine and seal cells showed a decline in proliferative response, synthesis of DNA and proteins in response to increased dioxin concentrations. The analysis of 2D gel of proteom of intoxicated and control cells showed a difference in the expression of some proteins. Identified proteins were cytoskeletal proteins, enzymes, stress protein. Proteins should be selected as bioindicators of the dioxins-furans effect on the immune system.

SEROPREVALENCE OF TOXOPLASMA GONDII ANTIBODIES IN WILD DOLPHINS

FROM THE SPANISH MEDITERRANEAN COAST

O. Cabezón[1], A. R. Resendes[2], M. Domingo[2], J. A. Raga[3], C. Agustí[3], F. Alegre[4], J. L. Mons[5], J. P. Dubey[6], and S. Almería[1]

[1] *Departament de Sanitat i d'Anatomia Animals, Parasitologia i Malalties Parasitàries, Facultat de Veterinaria, Universitat Autònoma de Barcelona, 08193 Bellaterra, Spain*
[2] *Departament de Sanitat i d'Anatomia Animals, Histologia i natomia Patològica, Facultat de Veterinària, Universitat Autònoma de Barcelona, 08193 Bellaterra, Spain*
[3] *Departamento de Zoología e Instituto Cavanilles de Biodiversidad y Biología Evolutiva, Universidad de Valencia, P.O Box 22085, E-46071 Valencia, Spain*
[4] *Centre de Recuperació d' Animals Marins de Catalunya (CRAMC), 08330 Premià de Mar (Barcelona), Spain*
[5] *Aula del Mar de Málaga, Avda. Manuel Agustín Heredia nº 35 29001 Málaga, Spain*
[6] *Animal Parasitic Diseases Laboratory, Building 1001, Animal and Natural Resources Institute, Agricultural Research Service, United States Department of Agriculture, Beltsville, Maryland 20705-2350, USA*

Although the *Toxoplasma gondii* infection has been found occasionally in cetaceans, little is known of the prevalence of antibodies to *T. gondii* in wild dolphins. Antibodies to *T. gondii* were determined in serum samples from 66 dolphins stranded in the Spanish Mediterranean coast. Modified agglutination tests were used to determine *T. gondii* antibodies and a titer of 1:25 was considered indicative of *T. gondii* infection. Antibodies to *T. gondii* were found in 5 of 41 striped dolphins (*Stenella coeruleoalba*), in 4 of 7 common dolphins (*Delphinus delphis*), in 4 of 7 bottlenose dolphins (*Tursiops truncatus*), and in 1 harbour porpoise (*Phocoena phocoena*). Antibodies were not found in 9 risso's dolphins (*Grampus griseus*) or in 1 long-finned pilot whale (*Globicephala melas*) surveyed. This study indicated that *T. gondii* infection is frequent, even if it does not necessarily cause disease in western Mediterranean dolphins. Furthermore, at least four different Mediterranean species of dolphins can be infected, with infection being particularly prevalent in the coastal dolphin species.

AN INVESTIGATION OF THE ROLE OF HOOKWORM ENTERITIS AS A CAUSE OF PUP MORTALITY FOR NEW ZEALAND SEA LIONS (*PHOCARCTOS HOOKERI*)

A. Castinel[1], P. J. Duignan[1], and N. Gibbs[1, 2]

[1] *NZ Wildlife Health Centre, IVABS, Massey University, Palmerston North, New Zealand*
[2] *Department of Conservation, Wellington, New Zealand*

The New Zealand sea lion (*Phocarctos hookeri*) is one of the rarest and most endangered members of the Otariid family. The breeding colonies are found exclusively on the Auckland Islands and Campbell Island. Since 1998 when an epidemic occurred on the Auckland Islands, disease has been recognised as a significant factor and two further epidemics have occurred in 2002 and 2003. Apart from these epidemics, endemic diseases probably also contribute to natural mortality. One such disease is enteritis and anaemia in pups caused by hookworm (*Ancylostomatoidea*) infection. The objective of this study is to determine the specific identity of the hookworm infecting New Zealand sea lions and to investigate its role in pup mortality. The life cycle of the parasite has to be elucidated on the Auckland Islands. Preliminary data from worm counts from intestines of pups that died during the summers of 1998 to 2002 indicate that the prevalence of the infection for each season was respectively 61.5% (n = 13 autopsied pups), 59.4% (n = 32 pups), 64.3% (n = 14 pups) and 61.9% (n = 84 pups). Moreover, the incidence of the infection showed that the majority of the infected pups had been autopsied by the end of January (68% in 1999-2000, 75% in 2000-01 and 71% in 2001-02). The pattern of the hookworm infection in pups has been investigated by looking at the distribution of the adult parasites within the small intestine (30 -45% in the proximal segment, 44 -50% in the middle segment and 11-19% in the distal segment). However, the burden of the hookworm presented great variations in the number of adults recovered within the same season and between years. Research is ongoing to analyse the data and investigate the differences in infection pressure between years.

STREPTOCOCCUS OF THE BLACK SEA BOTTLENOSE DOLPHIN (*TURSIOPS TRUNCATUS*)

T. E. Denisenko[1, 2]

[1] *109472, Academik Skryabin Street, 23, Moscow, Russia*
[2] *K.I.Skryabin Moscow State Academy of Veterinary Medicine and Biotechnology, Moscow, Russia*

In a captive environment, the death of more than 75% of Black Sea bottlenose was due to purulent-septic diseases caused by staphylococcus and streptococcus. Unfortunately, it is near impossible to diagnose these diseases in cetaceans in the early stages due to the absence of clinical signs, therefore attempts to save diseased animals are generally unsucessful. The development of early diagnostic techniques is necessary to reveal possible etiological roles of streptococcus and streptococcosis appearance in independent diseases. The goal of our work was to study clinical signs of diseases and pathologo-anatomical changes, types of streptococcosis agents, and their localisation in a sick aphaline organism. We also wanted to determine biological features of isolated streptococcus, including a sensitivity spectrum (range) to antibacterial preparations. Streptococcuses were obtained from the upper respiratory tract and inner organs (lungs, spleen and liver). Ten isolated cultures of streptococcus were identified as *S.pyogenes* (30%), *S.pneumoniae* (60%), *S.iniae* (10%). In all cases, streptococcuses were not isolated from control water samples. Isolated streptococcus cultures differed in morphology, cultural and enzymatic qualities. The antibiotico-sensitivity spectrum analysis of streptococcus identified high levels of resistance to infection agents. Quantity, pathogenecity and biological features of streptococcus identified their etiological role in purulent-septic disease origin and course for a small cetacean.

KLEBSIELLA PNEUMONIAE EPIDEMICS IN NEW ZEALAND SEA LIONS. A NATURAL PHENOMENON OR EVIDENCE FOR A CONTAMINATED ENVIRONMENT?

P. J. Duignan[1], A. Castinel[1], A. Grinberg[1], and I. S. Wilkinson[2]

[1]*New Zealand Wildlife Health Centre, IVABS, Massey University, Palmerston North, New Zealand*
[2] *Science and Research, Department of Conservation, 65 Victoria St., Wellington, New Zealand*

During the 2002 and 2003 breeding seasons, New Zealand sea lions (*Phocarctos hookeri*) were subjected to epidemics that claimed over 30% of the pup production. In previous years, the mean mortality at one month of age was 11% with bacterial infection contributing approximately 10%. In contrast, in both 2002 and 2003, bacterial infection contributed to over 50% of the mortalities. In both seasons pup productivity was also decreased (20% in 2002 and 10% in 2003). Necropsies were conducted on most of the pups that died at the Sandy Bay rookery and samples collected for bacteriology. *Klebsiella pneumoniae* was consistently isolated from all pups diagnosed with a bacterial infection but it was not isolated from pups that died during the 1999/2000 and 2000/2001 seasons. In October 2003 an adult male sea lion was found dead on the South Island with a massive pharyngeal abscess from which *K. pneumoniae* was isolated. *K pneumoniae* is primarily a human pathogen and has only rarely been isolated from pinnipeds and has not previously been associated with marine mammal epidemics. Two possible hypotheses are (1) the population is under "stress" allowing a normal commensal bacterium to become pathogenic; (2) this is a novel pathogen in a species not immunologically competent to deal with it, hence, the greater susceptibility of pups. These hypotheses are being tested using pulsed field gel electrophoresis to test whether the isolates from 2002 and 2003 are clonal and whether the sea lion isolates are related to those from hospitals throughout New Zealand. We are also testing clonality by determining MIC patterns for isolates and looking for antibiotic resistant genes in isolates from the sea lions. The latter should not be present in animals not normally exposed to antibiotics but are present in isolates from human hospitals.

MYCOBACTERIUM TUBERCULOSIS SUBSP. PINNIPEDIAE SUBSP. NOV. IN NEW ZEALAND FUR SEALS AND SEA LIONS

C. Dupont[1], P. J. Duignan[1], D. Cousins[2], D. Collins[3], and A. Murray[1]

[1]*New Zealand Wildlife Health Centre, IVABS, Massey University, Palmerston North, New Zealand*
[2] *Australian Reference Laboratory for Bovine Tuberculosis, Dept. of Agriculture, South Perth, WA 6151, USA*
[3] *AgResearch, Wallaceville Animal Research Centre, Upper Hutt, New Zealand*

Tuberculosis is recognised as a cause of pinniped mortality and as a zoonosis in the southern hemisphere. In Australia and South America it is endemic in fur seals and sea lions. Recently, infection was discovered among NZ fur seals (*Arctocephalus forsteri*) and sea lions (*Phocarctos hookeri*). In severe cases granulomatous lesions involve the lungs, pleura, peritoneum and peripheral lymph nodes. This study investigated the relationship between NZ isolates and those from Australia, South America and the U.K. (captive animals from Argentina). Polymerase chain reaction (PCR) was used to amplify the PAN promoter sequence and MPB70 gene fragment from two fur seal isolates confirming that they belong to the *M. tuberculosis* complex. When compared to strains of *M. tuberculosis*, *M. africanum*, *M. microti*, *M. bovis*, '*M. tuberculosis* subsp. canetti' and *M. tuberculosis* subsp. caprae, the seal isolates from NZ, Australia, and South America formed a distinct cluster within the *M. tuberculosis* complex, hence the new subspecific designation. However, DNA fingerprinting showed four distinct spoligogroups with the NZ isolates comprising one of these. The finding of a bovine isolate in NZ indistinguishable from the fur seal isolates, suggests that the seal bacillus is capable of infecting cattle. This fact, combined with its ability to infect humans, guinea pigs, and tapir, suggests the seal bacillus has the potential for an extended host range, beyond that of *M. tuberculosis*, *M. africanum* and *M. microti*.

MONITORING CIRCULATION OF MORBILLIVIRUS IN THE POPULATION OF CASPIAN SEALS

A.A. Durymanova[1], V.A. Evseenko[1], A.V. Epanchinceva[1], Yu. V. Tumanov[1], S.I. Zolotykh[1], A.M. Shestopalov[1], V.V. Kuznetsov[2], and L.S. Khuraskin [2]

[1] *State Research Center of Virology and Biotechnology "Vector", Kol'tsovo, Novosibirsk region, 630559 Russia*
[2] *Caspian Fisheries Research Institute, Astrakhan, Russia*

Morbillivirus disease is widespread among sea mammals and causes them essential harm. In 2000, death of a large amount of Caspian seals was discovered. Osterhaus and his co-authors distinguished viruses from dead seals which were diagnosed as morbillivirus. In the summer and autumn of 2000, we collected samples from dead and sick animals on Maliy Zhemchuzhniy Island on the north of Caspian sea. Then we started the monitoring of morbillivirus disease in the population of Caspian seals. In summer 2000, using DOT-ELISA on morbillivirus antigen, 30 animals were detected. Morbillivirus was diagnosed In 23 animals (76%). In autumn of the same year 50 animals were inspected and in 12 (24%) of them morbillivirus was detected. In summer 2001, the virus was detected in 9 (53%) out of 17 animals, and in summer 2002 the virus was detected in 11 (42%) animals out of 26. Using morbillivirus sensitive animals (ferrets, *Mustela putoris*), isolate was distinguished and gene P (phosphor-protein) was partly sequenced. This isolate is genetically close to the isolate which circulated in the population of Baikal seal. During 2000-2002 we collected 285 samples of serum of Caspian seals: 119 in 2000, 96 in 2001, 70 in 2002. Using ELISA we defined the antibody to morbillivirus in that serum. In 2000, antibody to morbillivirus in sera was not ascertained, but in 2001 the antibody to morbillivirus was ascertained in 64% of sera. In 2002, positive sera were reduced to 23%. Thus, monitoring of morbillivirus disease in Caspian seals in 2000-2002 showed that the virus was actively circulated in the population, as well as identifying the presence of significant immune layers among animals. By molecular-genetic characteristic, the virus is close to the virus which circulated in population of Baikal seals, and is ascribed to Canine Distemper Virus (CDV).

OCCURRENCE OF THE DEGENERATIVE DISEASE SPONDYLOSIS DEFORMANS IN THE VERTEBRAL COLUMN OF WHITE-BEAKED DOLPHINS (*LAGENORHYNCHUS ALBIROSTRIS*) FROM DANISH WATERS

A. Galatius[1] and C.C. Kinze[2]

[1] *Skovvangen 3, DK-2920 Charlottenlund, Denmark*
[2] *CCKonsult, Falkoner Allé 35 1. th., DK-2000 Frederiksberg, Denmark*

The occurrence of osteophytosis in the vertebral column caused by spondylosis deformans was studied in 41 skeletons of the white-beaked dolphin originating from Danish waters and held in the collections of the Zoological Museum, University of Copenhagen. Osteophytosis was evident in 5% (n=19) of the physically immature specimens and 77% of the mature specimens (n=22), complying with the degenerative character of the disease. In most cases the ventral side of the vertebrae was affected. 75% (n=12) of the affected females and 43% (n=9) of the affected males showed fusion of two or more vertebrae. In general, females seemed to be more susceptible, exhibiting a higher number of affected vertebrae and more severe cases of the disease. In females, osteophytosis was predominantly detected in the lumbar and anterior caudal vertebrae, while in males it was uniformly distributed over the entire vertebral column, except the posterior portion of the caudal vertebrae. In the entire sample, osteophytosis posterior to the 24th caudal vertebra was only detected in a single specimen.

MONITORING OF HEALTHY STATUS IN MARINE MAMMALS STRANDED ON BALTIC SEA COAST OF MECKLENBURG-VORPOMMERN, GERMANY

K. Harder[1], P. Wolf[2], U. Siebert[3], and H. Benke[1]

[1] *German Oceanographic Museum, Katharinenberg 14/20, 18439 Stralsund, Germany*
[2]*Landesveterinär-und Lebensmitteluntersuchungsamt Mecklenburg-Vorpommern, 18003 Rostock, Germany*
[3] *Forschungs-und Technologiezentrum Westküste (FTZ), Hafentörn, 25761 Büsum, Germany*

The German Oceanographic Museum has been collecting information on marine mammals from the waters of Mecklenburg-Vorpommern for many decades. It is therefore possible to judge the occurrence and situation of marine mammals for that area. As part of the Environmental Monitoring Program cetaceans and pinnipeds found stranded or by-caught have been investigated for their health status and biological parametres. If the carcasses were fresh enough, a full necropsy was performed including weighing and measuring the animals. Furthermore samples for further investigations including histology, microbiology, parasitology, serology, toxicology, genetics, age determination, reproduction and stomach analyses were preserved. Skeletons were macerated and stored at the German Oceanographic Museum for further research. No indication of epidemics caused by a specific bacterial or viral infection were found. Most of the porpoises examined were subadult. Lesions of those animals were mainly related to the by-catch, parasitic or bacterial infections. Contrary to porpoises most grey seals were adults and determined up to 40 years of age. Some of the older grey seals were showing leiomyomas, occlusion and stenosis of the uterus, loss of bone substance, fibrosis and multifocal calcification of the kidneys and the adrenal glands. These lesions have been commonly observed in a large number of grey and ringed seals from the Baltic Sea and have been summarized as "Baltic Seal Disease" by Swedish scientists. It was suspected that alterations are associated with high levels of endocrine disrupting chemicals such as PCBs and DDT. The investigations on the biology and health status are an important tool/information for the management, especially in the face of the endangered population of harbour porpoises in the Baltic Proper.

ERIKA OIL SPILL IMPACT ON THE GREY SEALS AND OTTERS OF THE FRENCH ATLANTIC COASTS

S. Hassani[1] and L. Lafontaine[2]

[1] *LEMM Oceanopolis, BP 91039, 29200 Brest, France (sami.hassani@oceanopolis.com)*
[2] *SOS Otters Network, GMB, Maison de la Riviere, 29450 Sizun, France*

INTRODUCTION Oil spills can have direct effects on marine mammals (e.g. increased mortality), as well as having an indirect impact on marine mammal populations through the alteration of lower trophic levels or be associated to benign exposure to oil compounds (markers). The effect of the *Erika* oil spill was investigated spatio-temporally comparing mortality and concentrations of vanadium, nickel and porphyrins (bio-markers) in grey seals (*Halichoerus grypus*) and Eurasian otters (*Lutra lutra*) of the French Atlantic coasts. These species might differ in their vulnerability to oil. No increase in mortality was found. Vanadium concentrations in both species were low after the oil spill. There was no significance in the gradual increase of the otter spraint ratio Nickel/Vanadium from control sites to oiled sites. Blood porphyrins concentrations in grey seals were not statistically different. Otter spraint porphyrins indicated an increase of the ratio (proto/copro)-porphyrins after the oil spill for the polluted area suggesting a limited response to contaminants. In conclusion no measurable effect of the *Erika* oil spill was found on seals (blood) although a measurable one has been found on otters (spraint). These investigations allowed the monitoring value of many biological parametres to be assessed.

MATERIALS AND METHODS The levels of oil trace elements (vanadium and nickel) and bio-markers (porphyrins: hem precursor) have been measured in grey seals blood samples (n= 63) and in otter spraints (n=42) in impacted and unimpacted areas or habitats during pre-Erika and post-Erika periods. Vanadium and nickel analysis were carried out using ICP/MS with a detection limit of 2.5 $ng.g^{-1}$dry mass. Faecal and blood porphyrins were measured out by using spectrophotometry and spectrofluorimetry with a detection limit of 30 $nmole.g^{-1}$ dry mass. The ratio of (proto/copro)-porphyrins in otters have been used as a pertinent indicator of physiological trouble. The monitoring of the stranded marine mammals conducted by the regional stranding network group is the source of the mortality of this study.

RESULTS No oiled otters, dead or alive, were found during the oil spill period (2000); similarly, no significant increase in the number of stranded seals (dead or alive) was detected. Spatio-temporal comparisons of the different sub-samples of grey seals show that the individuals collected in the impacted area during the winter following the spill did not display higher levels of porphyrins than those collected previously and subsequently or in other areas ($p>0.01$, Student-Newman-Keuls) (Figure 1). On the other hand the majority of the samples were under the limit of detection for vanadium and nickel. In contrast, otter spraints from oiled sites (e.g. MUL for Mullembourg and SEB for Sebastopol in Noirmoutier Island) displayed higher relative levels (%) of coproporphyrins and lower relative levels of protoporphyrins than spraints collected from estuarine habitats indirectly exposed to oil (ARB, POM and PDA: coastal marshes of Mèsquer, Loire Atlantique) or from control sites (ECT) located further up stream ($p<0.05$) (Figure 2). Unlike the seals samples, nickel and vanadium was detected within the otter samples but no significant evolution of the levels between the different sites was found. A gradual increase between the nickel/vanadium ratio from control sites and impacted sites is perceptible (Figure 3) but this difference is not statistically significant ($p>0.05$).

CONCLUSION No effect of the Erika oil spill could be detected on grey seal through the type of indicators used. In contrast, porphyrins considered as a bio-marker of toxicity suggest a slight effect on coastal otters. This work is in agreement with other studies on the oil spills impacts on marine mammals (Prieur and Hussenot, 1978; Geraci and Williams 1990; Loughlin, 1994; Ridoux *et al*., 2003; Conroy, in press). Indeed, those studies indicate that the otters are more vulnerable to oil spill than seals and, above all, cetaceans, this is certainly due to the restricted home range of this species which limits the ability to avoid extended oil slicks. More generally, this work illustrates the value of long term studies based on stranding and sampling networks, the interesting use of different indicators (markers and bio-markers), and the relevance of porphyrins as previously identified in other studies especially on north-american otters (*Lontra canadensis*) and Steller sea lions (*Eumetopia jubatus*) (Taylor *et al*., 2000; Beckmen *et al*., 2002)

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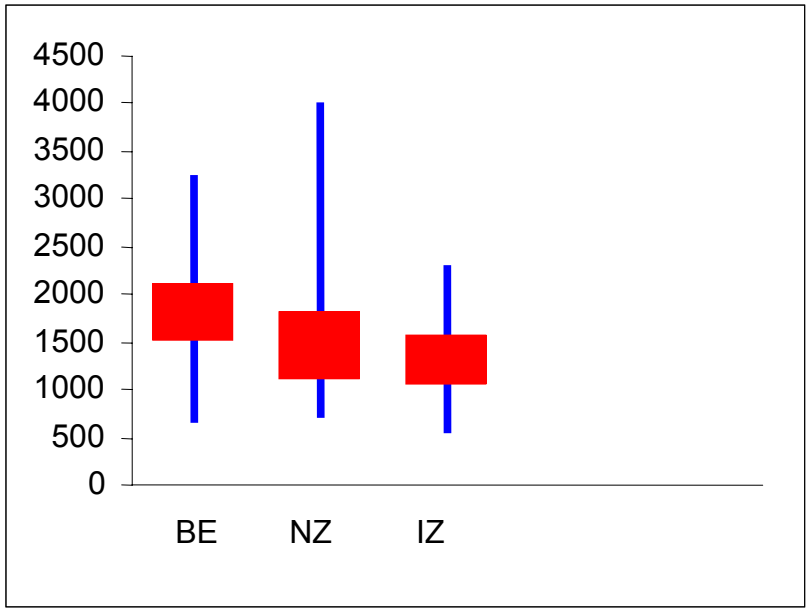

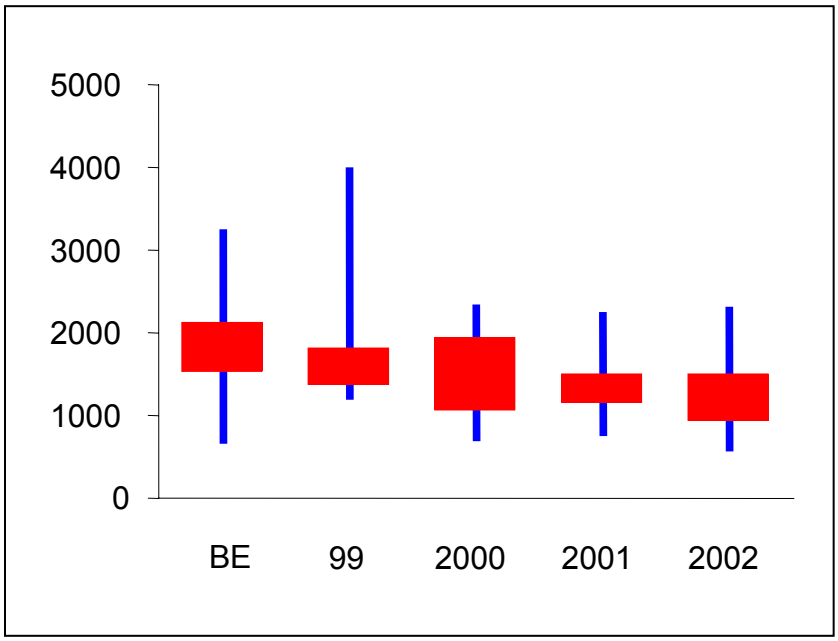

Fig. 1. Concentrations of porphyrins in nmole.g^{-1}in the blood of grey seal compared spatially (top) or temporally (bottom). BE stands for before *Erika*, NZ for north zone and IZ for impacted zone; values are given as inter-quartiles and ranges

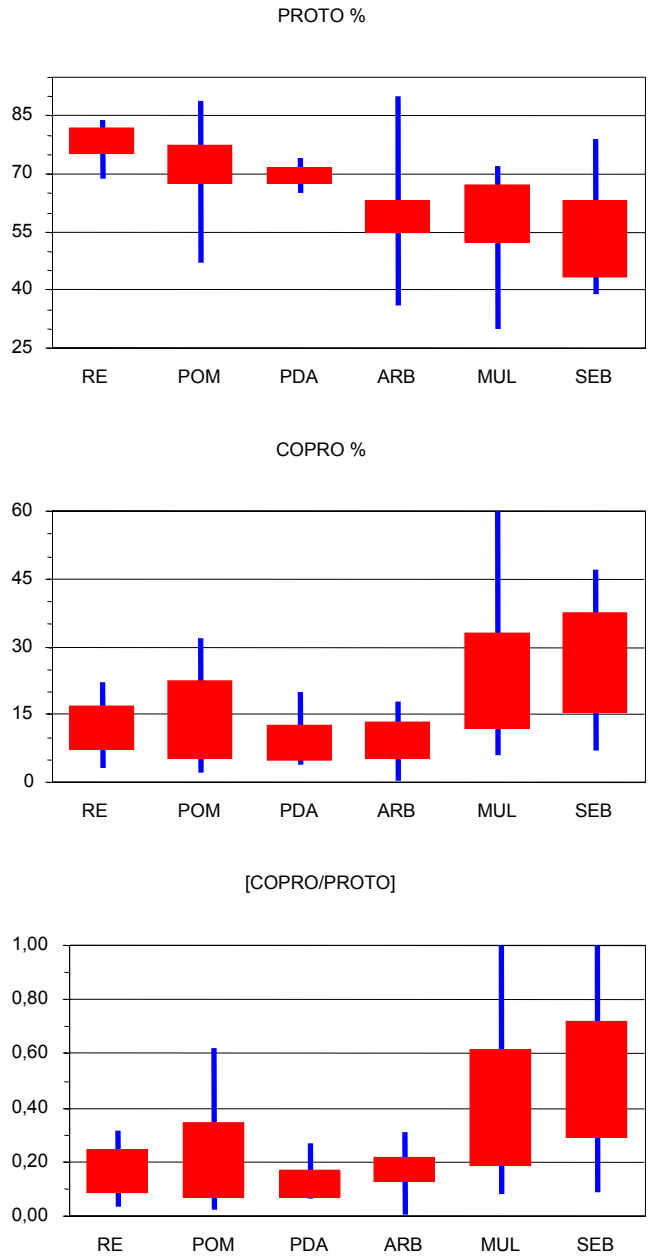

Fig. 2. Relative levels of proto- (top) and coproporphyrins (intermediate) and the copro- /proto porphyrin ratio (bottom) in otters from the Bay of Biscay. RE stands for reference locations up stream; POM, PDA, ARB are three sites in which foraging home ranges include stretches of estuarine habitat; MUL and SEB are two sites in which foraging home ranges include coastline and salt marshes that were directly impacted with oil

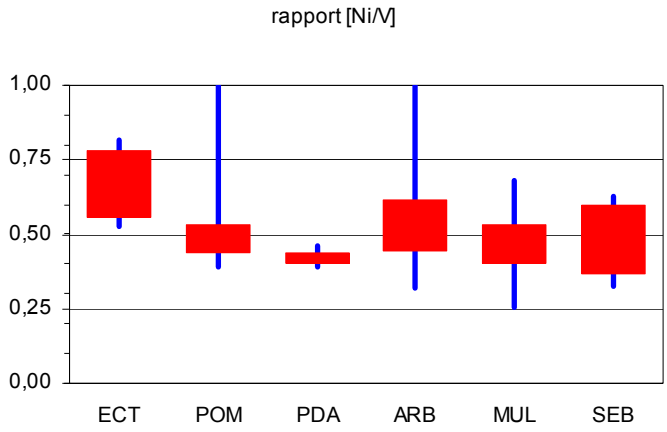

Fig. 3. Ratio nickel/vanadium from control sites to impacted sites in otter spraints

SERUM ELECTROPHORESIS IN HARBOR SEALS (*PHOCA VITULINA*)

Ilka Hasselmeier[1], A Schweiger[2], B Horn[2], and U Siebert[1]

[1]*Research and Technology Center Westcoast, Hafentoern, 25761 Buesum, Germany*
(ihassel@ftz-west.uni-kiel.de)
[2]*Westkuestenklinikum Heide, Esmarchstrasse, 25746 Heide, Germany*

Serum electrophoresis has been used as an immunology status marker in human medicine for a long time. It has also been performed on several marine mammals, including cetaceans and pinnipeds, however, studies on serum electrophoresis in harbour seals are scarce. Three groups of harbour seals were tested in this project: seals held permanently in captivity, rehabilitated seal pups (both at the Rehabilitation Center Friedrichskoog, Germany) and wild seals caught in the Wadden Sea of Schleswig-Holstein. Blood was taken during several years, centrifuged and serum was stored at –20°C before examination. The serum electrophoresis was done in collaboration with Westkuestenklinikum Heide, Germany. The densitograms of the animals held in captivity show very little differences even though the animals are of different ages and sex, whereas in Hall (1998) differences in the serum chemistry of gray seals were clearly related to age and sex. The densitograms of the rehabilitated pups look similar to those of the animals held in captivity. The end of the graphs for both the captive and wild animals showed a distinct peak of a protein that cannot be found in the pups (nor humans or other mammals). It seems that an unknown stationary protein is present at the starting point of the electrophoresis. The analysis of the serum electrophoresis of the wild catches proved to be rather difficult and, with the exception of the first fraction, no distinct peaks were observed. The actual contamination was most likely caused by lipemia, which is a common phenomenon in marine mammals such as harbour seals (Tryland & Brun, 2001). In Davis *et al.* (2001), the high molecular weight of the apoE in pinnipeds, especially in harbour seals, is mentioned. It seems that the wild catches dispose a higher amount of lipoproteins, and therefore apoE. This might interfere with the migration of the other serum proteins and blur the bands on the cellulose acetate. Why only the wild catches show this phenomenon is not clear yet. Ultracentrifugation may help solve this problem.

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FIRST EVIDENCE OF BRUCELLA INFECTION ON A BOTTLENOSE DOLPHIN STRANDED ON THE FRENCH ATLANTIC COAST

C. Hue[1], O. Van Canneyt [2], T. Jauniaux[3], M. Thiébaud[4], J. M. Verger[5], M. Grayon[5], and B. Garin-Bastuji[4]

[1] *Zoo de La Flèche F - 72200 La Flèche*
[2] *Centre de Recherche sur les Mammifères Marins,*
Institut de la Mer et du Littoral, Port des Minimes F-17 000 La Rochelle, France
[3] *MARIN Marine Animals Research & Intervention Network, Dept. Of Pathology,*
Faculty of Veterinary Medicine, Univ. of Liege, Bat. B43, Sart Tilman, B-4000 Liege, Belgium
[4] *Unité Zoonoses Bactériennes, AFSSA, BP 67, F-94703 Maisons-Alfort Cedex, France*
[5] *Laboratoire de Pathologie Iinfectieuse et Immunologie, INRA, F-37380 Nouzilly, France*

On May 25th 1997, a 15 year old female bottlenose dolphin (*Tursiops truncatus*) was found stranded alive on a beach of French Atlantic coastline (Mesquer). The dolphin died after unsuccessful attempts to refloat it. Necropsy and sampling were performed following standardised procedures. No significant gross pathology was observed. Under the microscope, focal interstitial subacute pneumonia and renal calcification were observed. Besides necropsy results, a Brucella strain (ref. 7763/2) was isolated from the frozen spleen using conventional methods. This strain was identified as a Brucella by its colonial and cellular morphology, staining characteristics, biochemical activity, agglutination by monospecific sera, susceptibility to lysis by Brucella bacteriophages and metabolic profile. However, like all the Brucella isolated from marine mammals throughout the world during the last decade, it differed from the six previously recognised members of the genus. It seems to be the first isolation of Brucella in marine mammals in France and, to our knowledge, the first from a wild bottlenose dolphin in the world. The strain was recently proposed as a member of a new Brucella species, Brucella cetaceae. This case underlines the problem of prevention of such a potential zoonosis in the frame of a stranding network, and the lack of information for people who could be in direct contact with wild fauna. Work is ongoing to evaluate the level of Brucella infection amongst the sea mammal populations in France.

SEVERE FUNGAL PNEUMONIA IN HARBOUR PORPOISES STRANDED ON BELGIAN AND FRENCH COASTLINE IN 2003

T. Jauniaux[1], B. Mignon [2], and F. Coignoul[1]

[1]*Department of Pathology, Veterinary College, University of Liege, Sart Tilman B-43, 4000 Liege, Belgium*
[2] *Department of infectious diseases and parasitology, Veterinary College, University of Liege,*
Sart Tilman B-43, 4000 Liege, Belgium

The multidisciplinary research group MARIN (Marine Animals Research and Intervention Network) is in charge of necropsies of marine mammal stranded along the coasts of Belgium and Northern France and the identification of death causes. Between 1998 and 2002, the average annual number of stranded harbour porpoises (*Phocoena phocoena*) was 19.3 while during 2003, more than 50 porpoises were washed ashore. The most common findings were emaciation and broncho-pneumonia secondary to nematode infestation. But, in some cases, large caseous abcesses were found in the lung. Under the microscope, severe acute necrotizing pneumonia was observed and in 2 cases, granulomatous reaction was observed in bronchial and mesenteric lymph nodes. In pulmonary and lymphoid tissues, fungal filaments were observed in the inflammatory reaction and stained positively with periodic Shiff staining while reaction stained negatively with Zielh-Neelsen staining. After culture on Sabouraud media, yeast was isolated from lesions and identified as Candida-like fungus. It appeared to be the first cases of fungal pneumonia in porpoises stranded on the continental coastline of the southern North Sea. Such disease should participate to the high rate of strandings in 2003. In cetaceans, most frequent cases of fungal pneumonia were previously described as being associated with morbillivirus infection.

METAL SENSITIVITY OF MARINE MAMMALS: A CASE STUDY OF A DERMALLY-WOUNDED GREY SEAL TRANSPORTING A PHONE-TAG

A. Kakuschke[1], E. Valentine-Thon[2], A. Prange[1], and U. Siebert[3]

[1] *GKSS-Forschungszentrum, Max-Planck-Strasse 1, 21502 Geesthacht, Germany*
[2] *Laborärztliche Gemeinschaftspraxis Dr.Sandkamp, Köster & Dr.Hiller, Norderoog 2, 28259 Bremen, Germany*
[3] *Forschungs-und Technologiezentrum Westküste (FTZ), Hafentörn, 25761 Büsum, Germany*

Marine mammals appear to be good indicators of accumulated trace elements in the marine environment. Environmental pollution can induce a variety of immunological effects, including delayed-type hypersensitivity. To study this, the MELISAÒ Test (memory lymphocyte immuno-stimulation assay) was employed: isolated lymphocytes were co-cultured for five days with two concentrations of various metals and the proliferation response determined by 3H-thymidine incorporation as well as by a morphological analysis. In a 6-month-old grey seal with a dermal wound near a phone tag carried since birth, lymphocyte responses to Al, Be, Pb, Cd, Cr, Co, Cu, Mo, Ni, Pd, Pt, EtHg, MeHg, HgCl, Sn, and Ti were measured. A positive response was found for Be and Ni. In addition, these and other metals were tested for their presence in the animal's whole blood and plasma. The evaluation of marine animals for metal sensitivity and metal intoxication may, therefore, be a useful monitor of marine pollution.

HISTOLOGY OF SELECTED IMMUNOLOGICAL ORGANS IN POLAR BEARS (*URSUS MARITIMUS*) FROM EAST GREENLAND IN RELATION TO LEVELS OF ORGANOHALOGENS

M. Kirkegaard [1, 2], C. Sonne-Hansen [1, 3], P. S. Leifsson [2], R. Dietz [1], E. W. Born [4], R. Letcher [5], and D. C. G. Muir [6].

[1] *Department of Arctic Environment, National Environmental Research Institute, Frederiksborgvej 399, DK-4000 Roskilde, Denmark*
[2] *Department of Pharmacology and Pathobiology, The Royal Veterinary and Agricultural University, Bülowsvej 17, DK-1870 Denmark*
[3] *Department of Anatomy and Physiology, The Royal Veterinary and Agricultural University, Bülowsvej 17, DK-1870, Denmark*
[4] *Greenland Institute of Natural Resources, P.O. Box 570, DK-3900 Nuuk, Greenland, Denmark*
[5] *Great Lakes Institute for Environmental Research, University of Windsor, Windsor, ON, Canada*
[6] *National Water Research Institute, Environment Canada, Burlington, ON, Canada.*

Samples of lymph nodes (axillary, n = 54 and inguinal, n = 45), spleen (n = 60), thymus (n = 11) and thyroid (n = 5) from a total of 82 polar bears (Ursus maritimus) collected in East Greenland 1999-2002 were examined histologically. The purpose was to detect and possibly relate histopathological observations to levels of organohalogenes (ΣPCBs, ΣDDTs, ΣHCHs, ΣCHLs, ΣHCBs, Dieldrin and ΣPBDEs) determined in adipose tissue (ng/g lw). No histopathological observations were found in thymus or thyroid. In spleen and lymph nodes no histopathological observations were found, and the secondary secondary follicle counts were semi-quantitively divided into four groups (0: few/ absent to 3: high). In the spleen, a high secondary follicle count was found in 21% of the cases (n = 12 out of 60), and this was significantly higher in subadults ($p<0.01$) compared to adult males and adult females. Also in the lymph nodes a high secondary follicle count was found in 20 % of the cases (n = 20 out of 99), and in the axillary lymph nodes changes were significantly higher in subadults ($p<0.05$) compared to adult males and adult females. No significant relation between levels of organohalogens in adipose tissue and the amount of secondary follicles in lymph nodes was found ($p > 0.05$). In spleen, a significant relation between low levels of organohalogens in adipose tissue and few/absent secondary follicles was found for CHLs, HCHs, HCBs and Dieldrin. In conclusion the data suggest that the exposure level of contaminants to polar bears are unlikely to have resulted in adverse effects on the tissues in question, although high levels of ΣCHLs, ΣHCHs, ΣHCBs and Dieldrin in spleen were related to increased secondary follicle counts.

GASTRIC FOREIGN BODIES IN A CAPTIVE HARP SEAL (*PHOCA GROENLANDICA*): GENERAL ANESTHESIA AND SURGICAL REMOVAL

S. Labrut[1], E. Aguado[2], D. Holopherne[2], E. Risi[3], and L. Marescaux[2]

[1]*Service d'Anatomie Pathologique, Ecole Nationale Vétérinaire de Nantes, Atlanpole La Chantrerie, BP 40706, 44307 Nantes cedex 3, France*
[2] *Service de Pathologie Chirurgicale et d'Imagerie Médicale, Ecole Nationale Vétérinaire de Nantes, Atlanpole La Chantrerie, BP 40706, 44307 Nantes cedex 3, France*
[3] *Centre de Soins de la Faune Sauvage, Ecole Nationale Vétérinaire de Nantes, Atlanpole La Chantrerie, BP 40706, 44307 Nantes cedex 3, France*

This report describes anesthesia and gastrotomy caused by gastric foreign bodies in a captive male harp seal (*Phoca groenlandica*) of four years of age. The seal presented dysorexia for four months and a marked delay in growth. Diagnosis was based on clinical signs and radiographic findings (seven metallic objects, and an accumulation of other foreign bodies (as a ring) in the stomach). General anesthesia was one of the challenges, but it was a success with the use of isoflurane by tube (after an intramuscular injection of midazolam at a dosage of 0.2 mg/kg intramuscularly). Gastrotomy allowed the removal of a few metallic objects and many silicone joints. Postoperative cares were based on restarting feeding after 10 days antibiotherapy (cefalexine at a dosage of 20 mg/kg intramuscularly, then PO, and a period of two days with butorphanol (0.1 mg/kg intramuscularly) for analgesia). Now, the challenge is to avoid this seal from eating other foreign bodies.

MOLECULAR CHARACTERISATION OF LUNGWORMS FROM HARBOUR PORPOISE (*PHOCOENA PHOCOENA*) AND HARBOUR SEAL (*PHOCA VITULINA*) FROM GERMAN WATERS: FIRST RESULTS

K. Lehnert[1], S. Fonfara[2], G. Von Samson-Himmelstjerna[3], and U. Siebert[1]

[1] *Forschungs- und Technologiezentrum Westküste der Universität Kiel, Hafentörn, 25761 Büsum, Germany*
[2] *GKSS Forschungszentrum, Max-Planck-Str.1, 21502 Geesthacht, Germany*
[3] *Institut für Parasitologie, Tierärztliche Hochschule Hannover, Bünteweg 17, 30559 Hannover, Germany*

As a part of monitoring programmes in Schleswig-Holstein, harbour porpoises and harbour seals are investigated for their health status and special attention is given to parasites as major infection agent. Porpoises and seals show mixed infections with different species of lung nematodes belonging to the superfamily Metastrongyloidea, which often induce secondary bacterial infections and bronchiopneumonia. To establish a new method to identify and characterize each of the lungworm species, nuclear ribosomal DNA (rDNA) is a useful tool, especially when polymerase chain reaction (PCR) is employed. The species-specific second internal transcribed spacer (ITS-2) region is known to be a variable region that separates the more conserved 5.8S and 28S regions and has been used to investigate the relationship among a variety of species including insects, cestodes and trematodes. Nucleotide sequences of the ITS-2 are compared in most cases. Lungworm specimens were isolated from infected hosts at necropsy. Genomic DNA from individual adult female lungworms was isolated using a QIAamp Tissue Kit (Qiagen) according to the manufacturers protocol. Ribosomal ITS-2 of two lungworm species of individual worms were amplified by PCR using primers designed from the the adjacent conserved 5.8S and 28S regions of Caenorhabditis elegans that are suited for a range of nematode species. Amplified PCR products were prepared for sequencing using enzymatic treatment with exonuclease I and shrimp alkaline phosphatase. Sequencing reactions were performed using DYEnamic ET terminator sequencing chemistry, and reaction products were separated and detected using a MegaBACE 1000 capillary sequencer. Two sequences shall be presented as first results: Partial ITS-2 sequence of Otostrongylus circumlitus from the lung of a harbour seal and partial ITS-2 sequence of Torynurus convolutus from the lung of a harbour porpoise. They show characteristic differences and can be used to differentiate between the two species.

SALMONELLA INFECTION IN SEALS, PIGS AND PEOPLE IN NEW ZEALAND

M. Leyland[1], P. J. Duignan[1], A. Castinel[1], L. Rogers[1], S. Fenwick[2], and C. Nicol[3]

[1] *New Zealand Wildlife Health Centre, IVABS, Massey University, Palmerston North, New Zealand*
[2] *Murdoch University, Perth, Western Australia*
[3] *ESR, Porirua, New Zealand*

Salmonella sp. have the potential to cross between the marine and terrestrial environment and to cause serious zoonotic infection in people in contact with infected animals. In 2001, a wildlife carer in Dunedin became infected with *S. enteriditis* PT1 after attempting to rehabilitate a sick fur seal (*Arctocephalus forsteri*). The isolates from the patient and the dead seal were indistinguishable by phage typing and pulsed-field gel electrophoresis (PFGE). All pinnipeds necropsied at Massey University since 1996 to the present day, whether they were apparently healthy bycatch or moribund stranded animals, were sampled for Salmonella sp. by faecal culture. Subtyping of Salmonella sp. was performed by serotyping, phage-typing, and PFGE. *S. Typhimurium* PT101 was isolated from apparently healthy and from diseased New Zealand fur seals from the mainland and *S. Typhimurium* PT1 from a by-caught seal, while *S. Cerro*, *S. Derby*, *S. Enteritidis* PT4 and PT8, and *S. Newport* were isolated from New Zealand sea lions (*Phocarctos hookeri*) from the Auckland Islands. The sea lion samples were collected during a mass mortality event in 1998 and subsequently from pups found dead on Enderby Island rookeries each breeding season from 1999 to 2003 and including epidemics in 2002 and 2003. Isolates were also cultured from feral pigs on the main Auckland Island. Isolates from sea lions and feral pigs were indistinguishable by PFGE. Salmonella serotypes from NZ pinnipeds were also compared with human and non-human isolates from other countries.

FIRST RECORD MASS STRANDING OF FALSE KILLER WHALE (*PSEUDORCA CRASSIDENS*) IN THE IBERIAN PENISULA

M. Llarena[1], A. Lopez[1], J. M. Ceideira[1], X. Valeiras[1], R. Carril[1], J. A. Díaz[2], L. Laría[3], and J. M. Alonso[1]

[1] *Coordinadora para o Estudio dos Mamíferos Mariños, CEMMA. P.O. Box 15, Gondomar, Pontevedra, Spain (Cemma@arrakis.es)*
[2] *Sociedade Galega de Historia Natural. P.O. Box 356, Coruña, Spain*
[3] *Coordiandora para la Protección y Estudio de los Mamíferos Marinos CEPSMA, Paseo del muelle 3, Luarca, Asturias, Spain*

There are no reports of false killer whale (*Pseudorca crassidens*) mass strandings in the Iberian Peninsula coast, and only a few records of stranded or observed animals have been published. This paper describes the mass stranding of this species that occurred in Burela (Galicia), on the north-west coast of Spain. The animals were first seen on the afternoon of January 7th 2003, when at least 30 specimens were swimming around in a harbour area. During the night, 15 of them repeatedly stranded alive, and refloating operations were initiated. Continuous re-strandings were reported until the morning of January 8th, when a group of 12 individuals finally returned to open sea and 7 animals were found dead and retrieved for post-mortem examination. Necropsy and sampling were immediately carried out in one calf (male) and six females. All individuals were in good nutritive condition except the largest one that presented signs of starvation with important loss of body mass. Intestines of four females were full of gas, and strongly parasitized by plathelmintes that obliterated nearly the whole lumen in some intestinal portions. All animals presented severe pulmonary oedema with abundant exudate in the airways. In one of the adult females, there was evidence signs of a recent gestation and lactation were found. The described signs were particularly noticeable in the largest female. Several fore-stomach ulcerations, gingival and periodontal lesions, broken teeth, presence of nematodes (*Stenurus* sp.) were also found in this individual. During the rescue operations this animal showed a strong and repeated tendency to strand, and was the first to die. These facts suggest the leading role of the largest female, supporting the hypothesis of the importance of social cohesion in these events.

ASSESSING THE POTENTIAL IMPACT OF SOUND ON HARBOUR PORPOISES IN THE NORTH AND BALTIC SEA: A HISTO-PATHOLOGICAL ATTEMPT

S. Prahl[1], U. Gaethke[1], J. O'Malley[2], K. Lucke[1], U. Siebert[1], and D. R. Ketten[2]

[1] *Forschungs- u. Technologiezentrum (FTZ), Hafentoern, 25761 Buesum, Germany*
[2] *Woods Hole Oceanographic Institution (WHOI), 11 School Street, Woods Hole, MA 02543, USA & Harvard Medical School (HMS), 243 Charles Street, Boston, MA 02114, USA*

The anatomy and pathology of ears of harbour porpoises (*Phocoena phocoena*) coming from German and Danish waters of the North and Baltic Seas are being comprehensively investigated in this study for the first time. The harbour porpoise is an endangered species and may be impacted by exposure to anthropogenic sound in the German North and Baltic Sea, including ship traffic, acoustic deterrent pingers and noise from off-shore construction. This is the first broad analysis of pathologies in the ears of North and Baltic Sea harbour porpoises. In order to assess potential impacts, histo-pathological methods for cetacean inner ears (Ketten 1992) were applied for the first time on animals from German waters. The method comprises computerized tomography (CT) of the heads followed by ear extraction, 10% buffered formalin fixation, EDTA decalcification, celloidin embedding, and H and E or cresyl-violet staining. In some cases, to maximize inner ear preservation, the left ear was extracted prior to scanning. During the period of 2002 to 2005 this project will examine heads and ears from 25 fresh by-caught or stranded animals of different sex and age classes. CT scans and histological findings are to compared and complemented to each other. CT scan results and a description of preliminary histological results as well as exam protocols are to be presented.

THE DEATH OF A KILLER WHALE (*ORSINUS ORCA*) CAUSED BY BACTERIAL PNEUMONIA

E. I Rozanova[1], A.V. Abramov[1], Yu. N. Rassadkin [2], Yu.V. Tumanov[2], and A.M. Shestopalov [2]

[1] *Utrish sea station, Moscow, Russia*
[2] *State Research Center of Virology and Biotechnology "Vector", Kol'tsovo, Novosibirsk region, 630559 Russia*

According to the data of the Society for Protection of Whales and Dolphins, 134 killer whales have been caught since 1961. Only 24 animals are alive now. Most animals died of stress and infectious diseases. A female six-year-old killer whale (*Orcinus orca*) was caught on September 26th 2003 in Avachin Bay, Kamchatka, Russia. The animal was brought with signs of weakness. Since October 8th, the following changes in the animal's behavioural reactions were observed: reduced locomotor activity, "hovering" on the surface, dyspnea, and absence of appetite. Treatment with medicaments did not have any effect. The animal died on October 19th, 2003. Post mortem examination revealed great patho-anatomical changes in the lungs. The mucous membrane of trachea had petechial hemorrhages. In its opening, foamy reddish contents with putrefactive smell was found. Pleural cavities had blurred effusion with whitish flakes. The pulmonary tissue section was brown and had a great number of suppurative foci (micro-abscesses). There were also infarction loci of a dark grayish/green colour with diametres of 2–6 mm. Bifurcational, paratracheal and mesenteric lymph nodes are enlarged. ELISE and immunohistochemical analyses did not confirm morbilliviral infection. As a result of microbiological analysis of secretum of the blowhole made on 10.11.03 and that of pulmonary focus made on 10.20.03 was isolated culture and classified under *Pseudomonas* genus. It is known that the typical representative of blue pus bacillus (*Pseudomonas aeruginosa*) is pathogenic for warm-blooded animals and humans. In particular, it causes pneumonia that is practically incurable. Testing the isolated culture for resistance to antibiotics showed that it was resistant to all groups of antibiotics with the exception of loxacin. Thus, abscessed pneumonia caused by one of the representatives of *Pseudomonas* was the cause of the killer whale's death. The isolated microorganism proved to be resistant to practically all groups of antibiotics.

INVESTIGATIONS ON THE DEVELOPMENT OF THE HEALTH STATUS OF HARBOUR SEALS IN THE YEAR OF THE PDV-SEAL DIE-OFF IN 2002

U. Siebert[1], S. Fonfara[2], I. Hasselmeier[1], K. Das[1, 3], P. Wohlsein[4], and T. Harder

[1] *Forschungs-und Technologiezentrum Westküste (FTZ), Hafentörn, 25761 Büsum, Germany*
[2] *GKSS-Forschungszentrum, Max-Planck-Strasse 1, 21502 Geesthacht, Germany*
[3] *Institut für Veterinär-Pathologie, Tierärztliche Hochschule Hannover, 30559 Hannover, Germany*
[4] *Landeslabor Schleswig-Holstein, Max-Eyth.Strasse, 24537 Neumünster, Germany*

More than 21,500 harbour seals were killed by Phocine Distempter Virus in the North Sea and adjacent waters in 2002. Of those more than 3,340 seals were found dead on the coast of Schleswig-Holstein. After the second seal die-off during the health monitoring, seals were captured alive for a health check and also stranded seals were examined for their health status. Blood status and chemistry tests were performed, microbiological, parasitological, histological, serological and cytological investigations were conducted. During the first catch after the seal die-off animals seemed to be in clinically good condition but the blood pictures showed that the animals were still suffering from viral (leucopenia) and bacterial (leucocytosis) infections. At bacteriological investigations Bordetella bronchisptica was isolated, a bacteria which was exclusively cultured during the seal die-off. At later catches the blood pictures improved and also the normal bacterial flora was cultured. The serological investigations for morbillivirus-specific antibodies revealed positive titers in 100% of the seals. At pathological investigations there was no indication for a continuous morbillivirus infection by both histology and immunocytochemistry. The pathological findings were similar to those before the epizootic including parasitic and bacterial bronchopneumonia, emaciation and dermatitis. Contrary to the first seal die-off in 1988/89 an increased number of large skin wounds on the ventral side and infections of the umbilicus were not seen. This may indicate that the seal population in Schleswig-Holstein was generally in better health at the second seal die-off compared to the first one. The continued investigations will allow a further assessment of the development of the seal population in the Wadden Sea.

HIGH NUMBER OF BY-CATCH AMONG BEACH-CAST HARBOUR PORPOISES, *PHOCOENA PHOCOENA*, IN THE NETHERLANDS

C. Smeenk[1], M. García Hartmann[1, 2], M. J. Addink[1], and L. Fichtel[2]

[1] *National Museum of Natural History, Naturalis, P.O. Box 9517, 2300 RA Leiden, The Netherlands*
[2] *Zoo Duisburg AG, Mühlheimer Straße 273, 47058 Duisburg, Germany*

Over the period 1990-2000, a minimum of 43% of the harbour porpoises stranded and examined on the Dutch coast consisted of by-catches in fishery operations, washed ashore after death. For this study we used a tissue bank containing lung and kidney material of 130 porpoises, stored in 10% neutral buffered formalin. The lung tissue was stained using the Gomorri silver stain. This histological method was previously tested successfully on lung tissue of Atlantic white-sided and common dolphins drowned during fishing operations, and yielded good results in examining lung samples of the harbour porpoises. Additional information for diagnosis was provided by a standard Hematoxilin-Eosine stain of kidney tissue. The reports of the gross post-mortem examination of each specimen were also used in the diagnosis. Based on standardised criteria, the histopathological and gross post-mortem findings were both divided into three main categories: (1) no by-catch, (2) equivocal or possible by-catch and (3) by-catch. For category (2), by-catch could not be proved or disproved. Judging by "blind" histopathological examination, 43% of the examined porpoises were diagnosed as by-catch, against 46.1% based on gross pathology. By histopathology 15.3% were diagnosed as not by-catch, against 24.6% by gross pathology. The category "equivocal" increased from 19.2% by gross pathology to 29.2% by histopathology. By gross pathology and histopathology, 10.1% and 12.5%, respectively, could not be evaluated properly due to constraints in the interpretation of tissue or data; These were excluded from the analysis. We conclude that combining the specialised Gomorri histopathological study with a gross pathological examination of stranded porpoises reduces the uncertainty of the pathological examination alone, since gross pathology often reveals findings that may be rather common in various diseases. Thus, a diagnosis by gross pathology depends more on the experience of the pathologist regarding by-catch pathology than a diagnosis based on histopathology.

TOXOPLASMOSIS IN THE BLACK SEA BOTTLENOSE DOLPHINS (*TURSIOPS TRUNCATUS*)

E. N. Ustinova[1], E. I. Rozanova[2], I. N.Kuvshinova[1], and A. M. Shestopalov[1]

[1] *State Research Center of Virology and Biotechnology "Vector", Kol'tsovo, Novosibirsk region, 630559 Russia*
[2]*Utrish sea Station, Moscow, Russia*

The Black Sea bottlenose dolphin has been entered in the International Red Book, and monitoring of the number of these animals is an important task. The last decades saw a decline in the number of the Black Sea bottlenose dolphins. This may be caused either by ecological factors such as a decrease in the food resources due to uncontrolled fishing or diseases that influence the reproductive ability of the animals. It is known that toxoplasmosis causes fetal pathology, premature birth and still-birth. It is also known that the presence of antibodies to a pathogen is indicative of the circulation of the infection it causes in an animal population. We conducted monitoring of serums of the Black Sea bottlenose dolphins for the presence of toxoplasmosis antibodies with enzymoimmune assay method. Serums of 40 dolphins kept in dolphinariums and serums of 13 wild animals were analysed. Antibodies to toxoplasmosis agent were detected in 42% of bottlenose dolphins living in dolphinariums; there was no dependence on the period of living in a dolphinarium and the age. Pregnancy ended with still-birth in four of the examined females with a high level of toxoplasmosis antibodies. The female that gave birth to a live calf showed a negative reaction for toxoplasmosis. Toxoplasmosis antibodies were detected in 7 of 13 bottlenose dolphins caught in the Taman Bay of the Black Sea, i.e. in 60% of animals. Thus, the circulation of toxoplasms in the population of the Black Sea bottlenose dolphins was revealed for the first time. It has been shown that approximately 60% of animals are carriers of toxoplasmosis antibodies. Taking into account the fatal effect of toxoplasms on the animal's reproductive system, we think that toxoplasmosis is one of the factors that influence the number of the Black Sea bottlenose dolphins.

NEW TECHNIQUES

ELECTROENCEPHALOGRAPHIC STUDY IN DOLPHIN (*TURSIOPS TRUNCATUS*): TECHNICAL ASPECTS

M. Böye[1], J. Vauclair[2], and O. Güntürkün[3]

[1]*Delfinarium Nürnberg, Am Tiergarten 30, D-90480 Nürnberg, Germany*
[2] *Centre PsyCLÉ, Université de Provence, 29 Av. Schuman, 13621 Aix-en-Provence, France*
[3] *Ruhr-Universität Bochum Fakultät für Psychologie, Biopsychologie, D-44780 Bochum, Germany*

Anatomical and histological investigations in the cetacean brain show archaic features typical of primitive mammals. On the other hand, the cetacean nervous central system appears impressively large and its surface highly convoluted. This combination of ancient and modern neurological traits in one brain remain so far unique and lead authors to many conflicting hypothesis concerning how cetacean brain is functionally organised. The recent progress made in brain imagery (functional Magnetic Resonance Imagery, Positron Emission Tomography or ElectroEncephaloGraphy-EEG) outstandingly improved our knowledge concerning "the (human) working brain". These techniques are generally not suited for large marine animals such as dolphins with the exception of EEG. So far record of brain electric activity has been successfully used in marine mammals to build brainstem response audiograms (Popov and Supin, 1990) or study hemispheric sleep (Mukhametov, 1987). We present here an EEG protocol adapted to the study of high order treatment (cognitive activities) in the dolphin brain. The subjects are two adult male bottlenose dolphins (*Tursiops truncatus*) respectively housed in Nürnberg (Germany) and Parc Asterix (France) dolphinaria. In few months our goals were reached. The two animals are able to wear up to 6 electrodes while stationing still up to 3 minutes. The participation of non-restrained dolphins in a non-invasive neuro-physiological experiment has been proved feasible. Its use in different behavioural contexts may lead to interesting observations helping us to better understand how this non-primate highly developed brain works.

REMOTE VIDEO MONITORING OF SEALS: THE EFFECTS OF OFFSHORE WIND FARM CONSTRUCTION

S. Mc. Edrén, J. Teilmann, and R. Dietz

National Environmental Research Institute, Department of Arctic EnvironmentFrederiksborgvej 399, Box 358, DK-4000 Roskilde, Denmark

Rødsand seal sanctuary south of Lolland/Falster, Denmark is the most important haul-out, breeding and moulting site for harbour seals in the Baltic Sea. The area also has the largest population of grey seals in Denmark. Between 2002 and 2003 an offshore wind farm, consisting of 72 wind turbines, were built 4 km southwest of the seal sanctuary. To evaluate the potential effect from the wind farm a range of studies were carried out to study changes in behaviour and number of the seals using Rødsand seal sanctuary before, during and after the construction. One of the methods used is a remote-controlled web-based camera system placed 400m from the seals. The wireless digital camera system powered by solar and wind energy is designed to operate under extreme weather conditions and was manufactured by SeeMore Wildlife. The cameras have fully remote-controlled 360-degree pan, 120-degree tilt, zoom, auto focus, and windshield wiper. Live images and still photos are transmitted 10km to a land station, from where it is streamed to the Internet. Still photos are stored every 5 seconds. After the construction seals are still hauling out in the sanctuary. The maximum number of seals peaks from the end of April through June where the seals are coming to breed and again in August where the seals are moulting. Southerly winds around 4-8 m/s increased the number of seals on land. The construction work on the wind farm had in general little or no effect on the presence of seals. Even two grey seal pups were recorded during the construction period. This is the first time in over 100 years that live grey seal pups have been observed in Denmark.

THE USE OF AD-HOC SELF-ORGANISING NETWORKS TO INVESTIGATE SOCIAL ORGANISATION IN MARINE MAMMALS

B. J. McConnell

Sea Mammal Research Unit, University of St Andrews, St Andrews, KY16 8LB, Scotland

Our primary objective in the design of this proposed novel telemetry system is to estimate the degree of social association (and thus susceptibility to the spread of disease) in marine mammal species initially targeting naive grey seal (*Halichoerus grypus*) pups during their first year. Traditional telemetry systems (Argos, VHF, GSM-mobile phone) are financially and logistically limited to small sample sizes and this limits the power of such population parameter inferences. The flood of current academic and commercial interest in peer-to-peer ad-hoc telemetry networks now makes the development and deployment of very low cost (and thus large sample size) node-tags timely. In essence, these tags will record local 'encounters' (either through RF or ultrasound modality) with other tagged animals. Importantly, they will also swap and store encounter histories. Through data diffusion, the ad-hoc network of node-tags thus slowly accrues segments of the social network encounter data. This information will diffuse ashore through a small sub-sample of node tags having additional GSM functionality (portal tags) and/or via shore-based node-tags trunked to a landline. We demonstrate the feasibility of this approach by simulating node-tag network performance using existing satellite tag track data obtained from 20 grey seal pups. We simulate the network connectivity obtained if 100 similar animals had been fitted with node tags. We also show that the energy in one C cell per tag is sufficient for a year of operation. In parallel with this technical and operational proof of concept, we illustrate the potential biases involved in this radical form of animal-centric data collection and their consequences for bespoke mark-recapture model design. In particular we highlight the importance of portal-tagged animals being randomly selected from the study animals.

HARDWARE AND SOFTWARE TOOLS FOR ACOUSTIC AND VISUAL SURVEYS

G. Pavan

Centro Interdisciplinare di Bioacustica e Ricerche Ambientali, Università di Pavia,
Via Taramelli 24, 27100 Pavia, Italy & Dipartimento di Urbanistica, Università IUAV, Venezia, Italy

A hardware and software package was developed to assist researchers in collecting, storing and plotting data resulting from combined acoustic and visual surveys. The package includes software for 1) recording and analysing sounds received by up to 8 wide band sensors, 2) receiving and distributing NMEA navigation data, 3) assist logging and classifications of acoustic contacts, 4) assist logging visual contacts, 5) sharing data among a network of PCs, 6) plot georeferenced data on a GIS. The system is modular and flexible to be adapted to different contexts and needs. It requires at least one PC dedicated to sound recording and one to GIS and navigation; additional networked PCs can be used to distribute processing and visualization needs. Depending on the chosen acoustic interface and on storage capabilities, 2 to 8 channels with bandwidth up to 100 kHz can be continuously recorded 24 hours/day. Acoustic data is stored in standard wav files, in user defined time cuts; each cut is time- and geo-referenced. Logged data is stored in raw ASCII files to be easily imported in spreadsheets or other analysis programs. Specific VBA modules have been developed to plot georeferenced data on ESRI ArcGis 8.2 either in real-time or in post-processing. A low-cost commercial mapping software can also be used to plot navigation and user data. The package has been estensively tested and progressively upgraded in five Sirena cruises in the Mediterranean Sea (SOLMAR Project). Examples of results will be presented. The research has been carried out within the NATO Saclantcent's SOLMAR Project with ONR Grants N00014-99-1-0709 and N00014-02-1-0333.

3D ADD-ON TO THE DORSAL FIN DATABASES:
A SPECIFIC WAY OF DEVELOPMENT OF THE PHOTO-ID TECHNIQUE

V. Pavlov

Crimean State Medical University, Lenin blvd 5/7, 95006, Simferopol, Ukraine

Use of virtual 3D models of dorsal fin to the photo-identification technique was examined. 3D models of the dorsal fin of bottlenose dolphins were constructed with a CAD program on the basis of fin cross-section measurements and photos from photo-id catalogs. Models were used in identification of individual dolphins with Finscan software. Two main tasks were examined: use of the models in fin identification by the fin outline matching and use of colour marks of the model. It was found that virtual models are suitable in identification of non-planar images of dorsal fins in "difficult" cases when the shot was made at the angle to the operator. Unlike the traditional use of photos, an arbitrary view of virtual model of the fin can be obtained by the rotation about X,Y, and Z-axis. It allowed comparison of the non-planar outline of the identified fin as well as appropriately distorted colour marks with non-planar images of unknown fins. A concept of the new method is proposed. It includes use of a 3D scanner for acquisition of fin geometry and colouring. Data obtained could be added to the existing database in file formats that are standard in 3D applications. Creation of 3D modules as an add-on to the existing photo-id software is proposed. The module is intended to generate arbitrary views of 3D models close to a new image and sort them by similarity. The individual model colouring should facilitate user's choice. Both model geometry and surface colouring can be further updated. A new method could be applied in but not restricted to the following cases: in monitoring of resident or semi-resident schools, when dolphins have been captured sometimes for different purposes; in monitoring of dolphins released from rescue/rehabilitation centers in the wild; in monitoring of dolphins in post-tagging period.

COMPUTER-ASSISTED IDENTIFICATION OF HUMPBACK WHALES VIA WATERSHED SEGMENTATION AND AFFINE INVARIANT MATCHING

E. Ranguelova, M. Huiskes, and E. Pauwels

Center for Mathematics and Computer Science (CWI), Amsterdam, The Netherlands (Elena.Ranguelova@cwi.nl)

INTRODUCTION Individual identification of cetaceans is of great interest to marine biologists and plays an important role in their long-term studies of the population and behavioural patterns of the mammals (Mizroch, 1990; Araabi, 2001; Kehtarnavaz, 2003). The method of photo-identification (ID) hinges on the uniqueness of the natural markings captured by photographing the dorsal fins or flukes. Humpback whales (*Megaptera novaeangliae*) exhibit sufficient variation in their natural markings to allow the identification of individuals based on images of their flukes. As the photographic collections grew, so did the need for more efficient retrieval methods that would allow a researcher to quickly match new photographs against the image database.

There are several approaches to computer-assisted humpback photo-ID available in the literature. In Mizroch (1990) manually generated code is used, based on a set of 38 generic fluke patterns which takes into account the location of blotches/scars. WhaleNet is a graphical user interface (GUI) which allows the user to narrow down the search for matches by visually selecting one of 18 fluke types. Araabi extends a curve-matching technique, developed for the identification of bottlenose dolphins (Araabi, 2000) for the fluke's trailing edge (Araabi, 2001).

The approach proposed in this paper comprises two main steps: the extraction of the tail and the actual matching. Similar ideas have been discussed in Kehtarnavaz (2003), but our method differs in the methodology used. We propose an affine invariant grid that is automatically fitted to the segmented tail. Each grid region is characterised by the relative contribution of dark and light patches. This maps the visual information into a numerical feature vector which can then be compared to the feature vectors obtained from other images.

Fluke patch extraction The proposed matching approach requires an accurate segmentation of the fluke in white and dark patches. Because the photographic material is typically quite challenging we have opted for semi-automatic segmentation based on a marker controlled watershed algorithm (Soille, 2003). The watershed transformation is a powerful mathematical morphology tool for image segmentation (Soille, 2003). Any grey-level image can be considered as a topographical surface. Flooding this surface from its minima partitions the image into catchment basins. This transformation applied to the gradient of an image gives basins corresponding to homogeneous gray-level regions. It is well-known, however, that the transform tends to produce an over-segmentation. A marker controlled transformation is a solution to this problem. The location and support of the minima is given a priori in the form of markers (Soille, 2003). In this way only the most significant gradient edges will contribute to the final segmentation result.

The tail extraction is initialized by the user, who specifies a rough initial contour (marker) within the tail (Fig. 1). The watershed transformation then automatically produces a boundary contour for the tail. The software allows the user to fine-tune the results by interactively introducing additional markers. Finally, the error-prone region at the basis of the tail (due to wave occlusion, water splash, etc.) is removed by clipping the contour (Fig. 2). The user specifies three tail landmarks, visable: the left and right fluke's tips and the central fluke notch. These landmarks have also been used for photo-identification in (Hillman, 2003). Next, we use Otsu's grey-level thresholding (Otsu, 1997) to obtain an initial segmentation into dark and light patches (Fig. 3).

Matching: fitting a coordinate grid Images typically exhibit a large variation in viewing angles distances and fluke inclination. In (Kehtarnavaz, 2003) it is argued that since fluke surfaces are nearly planar with dimensions significantly smaller than the distance to the camera, these variations can be modelled using affine transformations (rotation, translation and scaling). Invariance is an essential property of any method to deal with a single view reconstruction problem (Araabi, 2002)

We propose a coordinate grid that is superimposed on the tail. A triangle *LOR* (Fig. 4) defined via the three pre-selected landmarks is constructed. The base of the triangle *LR* is divided in two equal parts by the point *M*. The symmetrical point of *M* in respect to *O*, i.e. *N* is found. Each fluke is then divided into *n* parts with lines parallel to the median *NM*. Thus, the grid delineates $N_R=4n-2$ (the tips are considered single regions) grid regions. These regions are labelled *1* through N_R by scanning left to right, top to bottom. For the grid on Fig. 4 $n=4$, $N_R=14$. Notice that since the construction is solely based on affine invariant concepts the resulting grid is invariant under affine transformations.

Feature extraction and comparison After the grid has been fitted to the segmented fluke an N_R -dimensional feature vector $\mathbf{f} = (f_1, \mathrm{K}, f_{N_R})$ is computed. Each element f_i equals the ratio of the number of white pixels to the total number of pixels in the *i*-th grid region R_i. The feature vector for each fluke image is computed and stored in a database of features $\mathbf{F} = \{\mathbf{f}_1, \mathrm{K}, \mathbf{f}_N\}$ for all *N* images of the image database. The matching process involves a comparison of the feature vector **q** calculated from a query image against all entries in **F**. This is done by computing the average Euclidean distance per fluke segment

$$d(\mathbf{q}, \mathbf{f}) = \frac{\sqrt{\sum_{i=1}^{N_R} I_i (q_i - f_i)^2}}{\sum_{i=1}^{N_R} I_i},$$

where the variable I_i indicates if the corresponding region of any of the pair of flukes to compare should be considered, i.e.: $I_i = I_i^{\mathbf{q}} I_i^{\mathbf{f}}$. The indicator for each fluke and its corresponding grid has elements equal to *1* for all regions above the clipping line and *0* for the ones which are occluded. Because different regions will be occluded with the different flukes we need to normalise the distance over the number of regions used for the comparison of any pair of flukes. The images in the database are then ranked based on their similarity to the query image.

Adaptive adjustment of the grid The flukes are submerged into the sea up to a different level, therefore the totally or partially occluded grid regions are not directly comparable. There are two ways of dealing with this problem, namely ignoring all affected grid regions (i.e. to set $I_i=0$) or to adapt their relative size. In the first one can lose important information from the partially occluded regions. Alternatively, we propose an adaptive grid adjustment scheme. The area of $\triangle$LNR (Fig. 4) is invariant under affine transformation. If the location of point *N* is below the clipping line *c* || *LR*, the level of occlusion can be defined as the ratio of the heights of the similar triangles as depicted in Fig. 5:

$l = h_c / h$.

When comparing a query image to a potential match from the database, the levels of occlusion may be different, i.e. $l^{\mathbf{q}} \neq l^{\mathbf{f}}$. If the database image has been occluded more than the query, i.e. if $l^{\mathbf{f}} > l^{\mathbf{q}}$, to preserve the area ratio the clipping tail line of the query has to be adjusted to a new height:

$$\tilde{h}_c^{\mathbf{q}} = h_c^{\mathbf{f}} h^{\mathbf{q}} \Big/ h^{\mathbf{f}} = l^{\mathbf{f}} h^{\mathbf{q}}.$$

In this manner, it is possible to use the correct part of the partially occluded regions within triangle *LNR*.

Initial matching is performed as described in Section 3.2. For the partially occluded regions within triangle *LNR* the indicator variable is set to *1*. The query is compared against the whole database. Then the grid adjustment is performed between each pair of images: the query and the candidate within the top 20 from the initial ranking.

RESULTS A database of 69 grey-scale images of humpback whale flukes was available for testing the proposed methodology. The images were of a different resolution and quality. The database has been manually processed by an expert and 32 individuals were identified. For *5* of these individuals there were 3 different images (triple) available and for the rest 27 there were 2 images each (pairs) in the database.

Fluke and patch extraction The watershed segmentation provided an excellent contour of the tail for most of the data at one iteration. The semi-automatic approach showed a very good performance overall and was able to extract the fluke for all images. Figure 6 illustrates the performance of the flukes and patch extraction for a pair of images of the database. It can be seen that the segmentation captured the important markings well.

Grid fitting and matchingn Figure 6 illustrates also the grids ($n=8$, $N_R=30$) fitted to a segmented pair of images. It should be noted that salient markings appear in the correct grid region independently of the viewing angle and tail slant.

Two matching strategies were tested. The first one ignores all completely or partially (i.e. $I_i = 0, \forall i, R_i \mathrm{I}\ c \neq \varnothing$) occluded regions, and no grid adjustment was performed. The second strategy performs grid adjustments within the top 20 matches obtained after an initial ranking as described in Section 3.3. Although the first strategy is faster as it uses the available feature database **F** the second one achieves better retrieval results as summarized in Table 1.

Both strategies reduced the number of images which had to be reviewed by the expert by a factor of 7. All images had their true match ranked amongst the top 10 using the grid adjustment strategy. For more than two-thirds of the

database images the true match(es) were correctly identified as the first (or first and second in case of triples). The more difficult cases are illustrated in Fig. 7 where the true matches of a query from a triple were ranked first and fourth. It can be noted that the "false positives"' are still visually similar to the query image.

DISSCUSSION The work reported in this paper addresses two aspects of the photo-identification problem: the segmentation of relevant image information (fluke, patches) and the feature extraction and matching based on an affine invariant coordinate grid. The segmentation program has been tested by marine biologists during a Europhlukes Project (www.europhlukes.net), EC project-ID EVR1-CT2001-20007) software evaluation test meeting, where it had a very favourable reception.

The performance of the methodology needs to be confirmed on a much larger database. However, it bears pointing out that the methodology is quite generic and can easily be extended to other photo-identification problems where markings are used to distinguish between individuals. Also, our hypothesis is that on a larger database the grid adjustment will achieve more substantial improvement in the retrieval performance.

The current research efforts are focused on improving the grid-based features. We are working on a salient pattern detector. The descriptors of the salient markings in respect to the affine coordinate system, could dramatically improve the recall specificity.

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Table. 1. Percentage of individuals whose true match is ranked among the top *k*

Grid adjustment	*k=10*	*k=3*	*k=1*
No	*94.2*	*81.1*	*60.8*
Yes	*100*	*84*	*66.7*

Fig. 1. Original image and initial rough marker for the tail

Fig. 2. Watershed-based segmentation of fluke (dark contour). The fluke is clipped at its base at a user-supplied point by fitting a line parallel to the line connecting the fluke tips

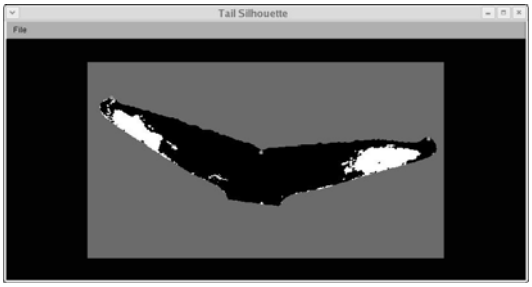

Fig. 3. Final segmentation result divided in black and white patches used for the identification. The three landmark points are indicated as dots

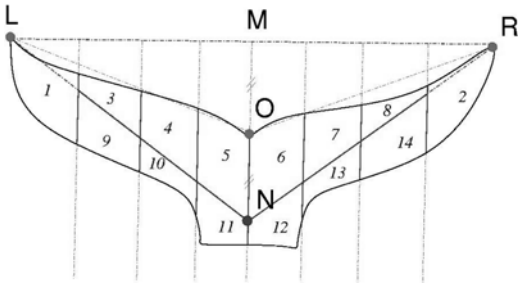

Fig. 4. Affine grid construction

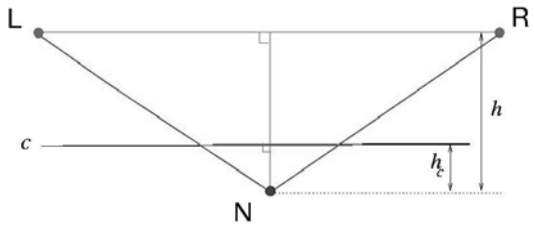

Fig. 5. Adjustment of the coordinate grid to accommodate the different level of occlusion

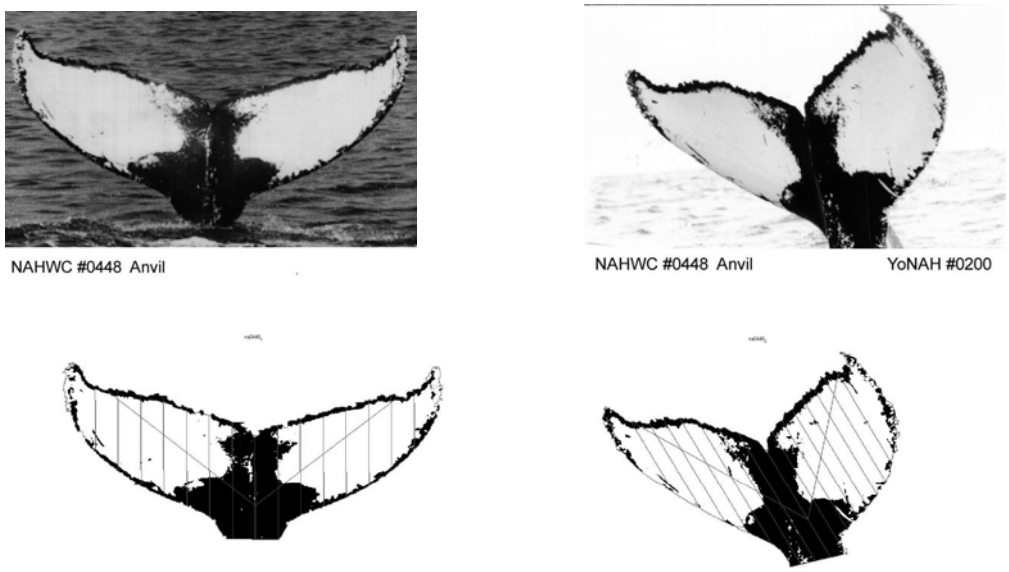

Fig. 6. Segmentation and grid fitting to a pair of images subject to affine transformation

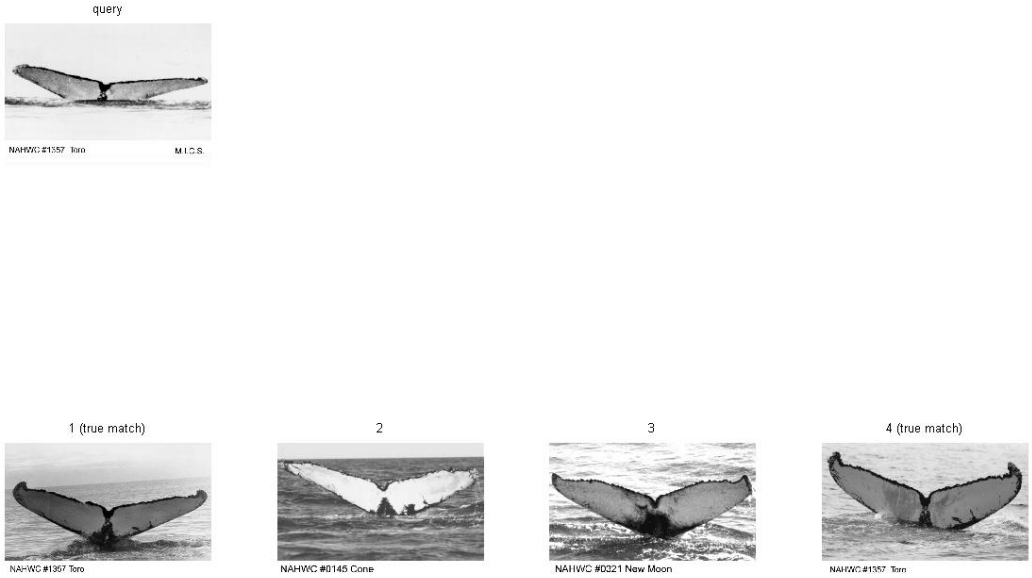

Fig. 7. Query image and first four matches

FATTY ACIDS IN BOTTLENOSE DOLPHIN (*TURSIOPS TRUNCATUS*) MILK DIFFER SIGNIFICANTLY FROM THOSE IN MATERNAL AND CALF BLUBBER: EVIDENCE USING A NOVEL ANALYTICAL APPROACH

J. E. Reynolds III, D. L. Wetzel, and R. S. Wells

Mote Marine Laboratory, 1600 Ken Thompson Parkway, Sarasota, Florida 34236 USA

We tested the hypothesis that fatty acids present in the milk of bottlenose dolphins reflects fatty acids present in the blubber of the lactating females and of their calves. Samples of milk, maternal blubber and calf blubber were collected during routine health examinations from eight mothers and their calves. The sex ratio of the latter was unity. The samples were processed and analysed using a novel, high-resolution chemical approach to fatty acid analysis. The technique involves creation of nitrogen (picolinyl) esters rather than methyl esters, and permits confirmation of virtually all constituents present. The fatty acids present in milk were consistent among the eight samples, and they were more diverse (approximately 86 total fatty acids in each sample) than those found in either calf or maternal blubber (76 fatty acids in each). Rankings of the most prevalent fatty acids in milk, maternal blubber, and calf blubber suggested that the constituents of the blubber samples were similar to each other and were different from those in the milk. Statistical analyses to date (hierarchical clustering; Euclidean and Manhattan distances) of the full set of fatty acid components confirmed that (a) blubber samples of the mothers and their calves were not different, and (b) milk samples were different from both types of blubber. These results were unexpected based on previous studies on other marine mammal species.

THE USE OF PRINCIPAL COMPONENT ANALYSIS (PCA)-BASED MODELLING FOR CONSTRUCTING PREDICTIVE MODELS OF OCCURRENCE FOR LARGE, MOBILE, MARINE ANIMALS

C. M. Schweder[1], G. J. Pierce[2], C. D. MacLeod[2], and T. Gaillard[3]

[1] *PO Box 25-073, St Heliers, Auckland, New Zealand*
[2] *Zoology Department, University of Aberdeen, Aberdeen, AB24 2TZ, UK*
[3] *Hebridean Whale and Dolphin Trust, 28 Main St, Tobermory, Isle of Mull, PA75 6NU, UK*

Traditionally species distribution has been studied using systematic surveys, which are time consuming and expensive to conduct. This study investigated whether a PCA-based modelling technique, originally applied to terrestrial plants, could be adapted and applied to large, mobile, marine animals. The technique applied in this study used a presence-only dataset together with non-dynamic environmental variables to predict the likelihood of occurrence of four cetacean species on the west coast of Scotland. The species were: harbour porpoise (*Phocoena phocoena*), minke whale (*Balaenoptera acutorostrata*), common dolphin (*Delphinus delphis*) and bottlenose dolphin (*Tursiops truncatus*). The presenceonly data were obtained from the Hebridean Whale and Dolphin Trust sightings database. An independent presence-absence dataset was collected using ferry surveys to test the accuracy of the models. Overall accuracy was determined using the Kappa statistic. Of the species-specific models, those for harbour porpoises were found to be the most accurate. In general, sightings occurred according to model predictions and few occurred in areas where animals were predicted to be absent, indicating that the models had high sensitivity. Accuracy of models improved if the testing dataset consisted of multiple surveys of the same area to determine whether animals were truly absent from an area. For species with lower sightings rates, the number of surveys per grid cell needs to be higher than for more frequently sighted species. As an extension of this modelling technique, it was possible to identify the niche width and habitat preferences within this niche in terms of the parameters used to construct a specific model. This modelling technique has the potential for extension from local to ocean-wide distribution models.

AUTOMATED DETECTION OF BEAKED WHALE SONAR

N. J. C. Tregenza[1], M. Johnson[2], and N. Aguilar de Soto[3]

[1] *Beach Cottage, 5 Beach Terrace, Long Rock, Cornwall, TR20 8JE, UK (nick@chelonia.demon.co.uk)*
[2] *Dept. Applied Ocean Physics and Engineering, Woods Hole Oceanographic Inst., Woods Hole, MA 02543, USA.*
[3] *Depto. Biología Marina, Universidad de La Laguna, Islas Canarias, Spain*

INTRODUCTION The detection of beaked whale sonar from boats using near-surface hydrophones has been very difficult. It is widely supposed from anatomical and comparative evidence that these whales use sonar, but do so only rarely at the surface. The characteristics of Cuvier's Beaked Whale, *Ziphius cavirostris,* vocalizations recorded near to the surface were reported by Frantzis *et al* in 2002. This report was used as a specification for the acoustic characteristics of an automated detection system based on the Chelonia 'T-POD', a system for automated monitoring of those cetaceans that produce high-frequency tonal echo-location clicks in trains. The echo-location clicks of Cuvier's beaked whale and Blainville's beaked whale (*Mesoplodon densirostris*) were subsequently recorded in 2003 with suction cup attached digital tags in Liguria and El Hierro (Canaries) respectively (Johnson *et al*, in press).

MATERIALS AND METHODS T-POD record only the times of narrowband acoustic events at pre-determined frequencies, and steps through six different target frequencies each minute. The bandwidth of the events is determined by continuous comparisons of the output of two bandpass filters. Any event that meets user-determined criteria on intensity and filter output ratios is timed to 10 microsecond resolution. Pattern recognition software subsequently detects trains within the recorded times, and classifies these to remove trains that arise from boat sonars or as chance occurrences within clusters of non-cetacean acoustic events.

For this study housing was constructed for use down to 2000m and the T-POD electronics were modified to reduce the frequency range to 7kHz to 21kHz. Tank tests were conducted using synthetic clicks with the features described by Frantzis *et al,* i.e. a narrow energy peak between 13 and 17kHz, duration around 1ms, and interclick intervals 0.40 and 0.50s. These confirmed that the system did detect them appropriately.

The beaked whale T-POD was deployed for 4 hours close to the south coast of El Hierro in the Canary Islands on two successive days in an area in which 2 species of beaked whales were present. The POD was deployed 800m below a drifting buoy with a radio tracking beacon for recovery. The specific location of the POD was not monitored during the deployment but a team of four observers were surveying the general area from a vessel and two more observers from a high point on land, all of them with binoculars. Sea conditions during the deployment were Beaufort scale 3 or less. No cetaceans other than beaked whales were sighted during the deployments.

RESULTS In each deployment several regular trains of narrowband sounds were detected and their spectral characteristics, inter-click intervals and click durations corresponded closely to those sought. Although the data was not inconsistent with the Frantzis report of sequences of 35–105 clicks with short intersequence pauses of 3–10s, these features could not be confirmed because the POD was set to switch frequencies every 10seconds, and click trains were detected strongly only during the times 17kHz was the target frequency. From the mode of operation of the POD this indicates that the clicks show a strong fall in intensity below 17kHz rather than locating the peak spectral intensity. The trains were grouped within encounters spread over 20 minutes or less. Results on the ICI (inter click interval) and frequency range of the click series were coherent to the recordings on suction cup attached digital tags (DTag, Johnson & Tyack, 2002) applied on Blainville's beaked whales in the same area during the same cruise (Johnson *et al*, in press).

DISCUSSION These are encouraging results, particularly in view of the unusual difficulty of studying beaked whales visually or acoustically at the surface. This brief study has given only a very limited view of the range of click rates and intensities that may be detected using this approach. The sensitivity of the system could be enhanced by optimisation of the train pattern recognition algorithm when a sufficiently diverse data set is available, allowing single deployments to give continuous passive acoustic monitoring of fixed locations for many months. Further work to optimise the system is planned in the waters around El Hierro, where there is a high density of beaked whales all year round (Aguilar *et al*, 2004).

CONCLUSION This trial suggests that beaked whales make frequent use of their sonar at depth and that automated monitoring of their acoustic activity over long periods at specific sites is possible.

ACKNOWLEDGMENTS Alessandro Bocconcelli provided invaluable guidance and support on deployment. Ivan Dominguez, Francisca Díaz, Cristina Aparicio, Marta Guerra y Aitziber Hernández, from La Laguna University, undertook the observational field work.

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A GLOBAL ACCESS DATABASE FOR YOUR CETACEAN WORK: AN EFFICIENT WAY TO SAVE TIME

P. Verborgh[1], R. De Stephanis[1], and C. Guinet[2]

[1] *CIRCE, Conservation Information and Research on Cetaceans, C/Cabeza de Manzaneda 3, Algeciras-Pelayo, 11390 Cadiz, Spain*
[2] *Centre d'Études Biologiques de Chizé, CNRS UPR 1934. 79 360 Villiers en Bois, France*

We present the structure of an accesss data-base we developed to manage all of the information collected by CIRCE during our work on cetaceans, seabirds and turtles. This data-base allows a rapid extraction and calculation of the observation effort, species sighting, and information related to acoustic recordings, behavioural data, photo-identified individuals. Antropogenic data such as the number of vessels, vessel type, and underwater noises are also included. This data-base is structured in 4 subdata-bases, totaling 15 different tables. The first sub-database manages all of the information on the observation effort, such as the observation platform, sea and weather conditions. The second one contains the sightings data of the differents animals observed. Related to each sighting, a photo-identification sub-routine manages all of the information contained on each picture taken: quality of the picture, number of individuals present, number of individuals identified and their indentity. Finally, all of the acoustic data contained within the cetacean recordings, noise sampling and of the accoustic signatures of most of the boats present in the Strait (resident boats) are also merged into the data base. This global data-base will allows the relation of all the information available and to visualise them for a given area, time period, species and/or a given individual. The data-base will allow to creation of tables in a data-base IV format which is interfaced with with a GIS (Arc-View 3.2). This Data base is completly compatible with the programs made by the IFAW, like Logger 2000 and Rainbow Click. The data-base was created in ACCESS 2000 to allow new changes, and the creation of new querys to work with other software without any problem and can be adapted according to the individual need. A free version of this data base structure is available on request and condition of use are indicated at www.circe-asso.org

DIETARY INFORMATION FROM BLUBBER: A MINI-REVIEW

M. J. Walton

Sea Mammal Research Unit, Gatty Laboratories, St Andrews, Scotland, KY16 8LB

Knowledge of the diet of marine mammals is important for energetic studies and interpreting conflicts with the fishing industry. The best method currently available to do this is by analysing otoliths from faeces or stomach contents, but this method has several well-known biases. In 1993 Iverson proposed that fatty acid signature analysis FASA had the potential to overcome some of these biases, but until now (Ecological Monographs 2004) has not described the methodology (known as QFASA) required for quantitative analysis. Meanwhile she, and others, have shown the usefulness of FASA, together with multivariate statistical procedures, for qualitative dietary studies to detect the occurrence of spatial and temporal changes, different foraging strategies between sexes, to identify stocks etc. Although many marine mammal researchers have heard about FASA there is a lot of confusion and misconceptions about what has been done, what is possible or how it can be achieved. It is often wrongly assumed that methodologies used qualitatively are also appropriate for quantitative studies. In an attempt to clear up some of the confusions I will firstly review qualitative FASA and then go on to briefly describe how quantitative information can be obtained, the data required and some limitations. The QFASA model of Iverson involves a best fit procedure using distance measures between prey items and predator profiles, using Fortran and S-plus routines. Using the procedures described in the paper I have produced a stand-alone Windows version. For the model to work one also needs a library of prey profiles and importantly a set of correction factors since predator profiles and are not exact copies of prey profiles and this must be corrected for. These factors are obtained from feeding studies on captive animals, and are probably species specific. These requirements could limit which species can be studied.

PHYSIOLOGY AND ANATOMY

SOME COMPARATIVE OBSERVATIONS ON THE PERSISTENCE OF SCARS IN THE OVARIES OF HARBOUR PORPOISE (*PHOCOENA PHOCOENA*)

M. Addink[1], W. Dabin [2], J. A. Learmonth[3], S. Murphy[4], V. Ridoux[2], E. Rogan[4], A. Lopez[5], M. B. Santos[3], and G. J. Pierce[3]

[1]*National Museum of Natural History, Darwinweg 2, 2300 RA, Leiden, The Netherlands*
[2]*Centre de Recherche sur les Mammifères Marins and Laboratoire de Biologie et Environment Marins, Université de la Rochelle, Avenue de Lazaret, 17042, La Rochelle, France*
[3]*Department of Zoology, School of Biological Sciences, University of Aberdeen, Tillydrone Avenue, AB24 2TZ, Aberdeen, UK*
[4] *Department of Zoology and Animal Ecology, University College, National University of Ireland, Cork, Lee Maltings, Prospect Row, Cork, Ireland*
[5] *Coordinadora para o Estudio dos Mamíferos Mariños, P.O.Box15, 36380 Gondomar (Pontevedra) Galicia, Spain*

Ovarian scars of ovulation and pregnancy in cetaceans are generally assumed to be permanent, which implies that information on life-time reproductive success may be gained from examination of ovaries. However, recent work on *Delphinus delphis* and *Tursiops truncatus* suggests that for some species this may not be so. Harbour porpoises from Scotland, the Netherlands, Ireland, France and Spain have been studied over the past three years under an EC-funded study (BIOCET) of the relation between pollutant burden, health and reproductive success of several cetacean species. Part of this research involved the study of the reproductive organs of female porpoises, including recent and historical material. In general, all activity was located in the left ovary, with pregnancies in the left uterus and a corresponding corpus luteum (CL) in that ovary. However, presence of scars in the right ovary was also recorded, e.g. around 10% of the females in the Netherlands also show scars in the right ovary, with two animals showing a CL of pregnancy, with the foetus in the right uterus horn. The harbour porpoise generally starts breeding at 3-5 years of age and most individuals are dead by 12 years. High numbers of scars (up to 20) observed in ovaries of some individuals could thus indicate that individuals show different rates of (multiple) ovulation, or perhaps different rates of resorption. Harbour porpoises from some areas studied show no relationship between age and the number of ovarian scars whereas data from other areas suggested persistence of scars, with no resorption during pregnancy.

IMAGING EXAMINATION OF THE SMALL CETACEAN URINARY TRACT

J. M. Alonso[1] and E. Degollada[2]

[1] *Coordinadora para o Estudio dos Mamíferos Mariños, CEMMA. P.O. Box 15, Gondomar, Pontevedra, Spain & Laboratori d'Aplicacions Bioacústiques, Universitat Politècnica de Catalunya, Avda. Víctor Balaguer s/n, 08800 Vilanova i la Geltrú, Barcelona, Spain (jmalonso@iim.csic.es)*
[2] *Departament Anatomia i Embriologia, Facultat de Veterinària, Universitat Autònoma de Barcelona, Campus de Bellaterra (Barcelona), Spain (Eduard.Degollada@uab.es*)

Some urinary tract focal lesions have been described post-mortem in marine mammals, including tumours, abscesses, calculi, cysts, and parasites. These lesions could be detected by imaging techniques, therefore, Magnetic Resonance (MR), Computerized Tomography (CT) and ultrasound examination could be considered as useful diagnostic tools. This presentation describes the two-dimensional topographic location of the kidney and urinary bladder of small cetaceans, as well as their normal ultrasonographic, MR and CT images. For this purpose, five fresh carcasses of dolphins were frozen and parallel sliced in transversal, sagittal and coronal sections. Moreover, thrirty-five animals, both dead and live dolphins belonging to five different species were ultrasonically examined using a 3'5 MHZ real-time transducer. MR and CT of the entire body were also performed in three dead dolphins. The multi-lobular cetacean kidney could be visualized at the level of the dorsal fin, placed on the roof of abdominal cavity. However, significant differences in the location related with external landmarks (dorsal fin, genital slit) between young and adult animals were observed. Ultrasonically, the kidney renules appeared as a group of anechogenic circular structures with hyperechoic boundaries. If the urinary bladder had enough urine inside, it could be easily identified by its smooth hyperechogenic boundary (wall) and an anechoic lumen (urine). Other urinary tract structures such as renal medullae or pelvis, ureters or renal veins couldn't be identified, due to the multiple interfaces produced by the multi-lobular structure of the kidney and the similar echogenicity of these tissues with surrounding structures. The description of the dolphin body sections related to the kidney and urinary bladder becomes a very helpful tool to interpret CT, MR and ultrasound images of these organs. Nowadays, ultrasound examination has to be taken into account in "in vivo" routine diagnostic procedures when focal urinary tract diseases are suspected in a dolphin.

BODY WATER AND BODY COMPOSITION OF FREE-RANGING WALRUSES (*ODOBENUS ROSMARUS ROSMARUS L.*) STUDIED BY ISOTOPE DILUTION

M. Acquarone[1], and E. Born[2]

[1] *The Royal Veterinary and Agricultural University, DK-1870 Frederiksberg, Denmark*
[2] *Greenland Institute of Natural Resources, c/o Danish Polar Center, Strandgade 100H, DK-1401 Copenhagen, Denmark*

Knowledge of body water pool dynamics is important for the derivation of physiological parameters useful for ecological research. Deuterium oxide was used to measure isotope dilution space on 11 occasions in seven individual free-living, male, adult walruses (*Odobenus rosmarus rosmarus L.*) (930-1597 kg), in NE Greenland. Equilibration of the intravenously injected isotope was complete after 2-3 hours. The application of a general correction factor for all pinniped species allowed the estimation of total body water content to 56.8% (range: 36.6-73.3 %) of total body mass (TBM). Water turnover averaged 44.5 g/kg*day. For one animal it was possible to estimate water influx to 4.8 g/kg*day and water efflux to 21.8 g/kg*day. The estimates of body fat and body protein averaged 24.7% and 18.4 % of TBM respectively. Similarly for an average walrus weighing 1300 kg, body ash was calculated to average 26 kg and body gross energy to 18300 MJ. The assessment of body fat by isotope dilution does not differ significantly from the estimates of blubber content obtained from the dissection of walruses in the wild. This work demonstrates the feasibility of estimating body composition of free-ranging walrus by hydrogen isotope dilution.

BACK TO BASICS: SIMPLE DIVE RECORDS REVEAL PHYSIOLOGICAL CONSEQUENCES OF INDIVIDUAL VARIATIONS IN THE FORAGING ECOLOGY OF ELEPHANT SEALS

M. Biuw, M. Fedak, B. McConnell, and H. Burton

NERC Sea Mammal Research Unit, Gatty Marine Laboratory, University of St. Andrews, FifeKY16 8LB, Scotland, UK

The movements and diving behaviour of several marine mammals have been successfully studied using data loggers and satellite telemetry, but these devices have mainly been used for general descriptive purposes. Here, we show how detailed analyses of simple time-depth records can be used in conjunction with point estimates of body size and composition to describe the spatial and temporal patterns of resource assimilation of marine mammals foraging at sea. We use this technique to test specific hypotheses about how individual variations in maternal resources delivered to southern elephant seal pups affect the the development of foraging behaviour in space and time during their first independent foraging excursions, and the effects this has on their early body composition. We have developed a mechanistic model that predicts relative body composition using body morphometrics and density, as calculated from vertical rates of descent/ascent during passive drifting. While previous studies have suggested that weaned elephant seal pups from Macquarie Island spend much time in waters between the Polar Front (PF) and the southern boundary of the Antarctic Circumpolar Circulation (sbACC) during autumn/early winter, detailed analysis of so-called drift dives indicate well-defined "hotspots" where increases in relative lipid content suggest that seals are in positive energy balance. These hotspots are not stationary, but move slowly eastward throughout the season, and appear to be associated with steep gradients in sea surface height and low sea surface temperatures. The body condition of seals returning to land is positively correlated to the amount of time spent in these hotspots, but negatively correlated to total trip duration. These results suggest that pups spending less time in transit from their natal beaches and encounter profitable prey patches early in the trip, will obtain sufficient resources within a relatively short time, and will return to land in good body condition.

BREATH-RELATED CARDIAC ACTIVITY CHANGES IN KILLER WHALES (*ORCINUS ORCA*)

S. Brando[1], and M. Tocchetti[2].

[1] *Animalconcepts, 17 Bvd Bijou plage, 06160 Juan les pins, France*
[2] *Via Nurra 82, 09046 Quartu SE, Italy*

Preliminary observation of R-R interval and its variability (indirect measure of sympatho-vagal balance) in relation to respiratory acts was analysed in 3 specimens (2 wild born, 1 captive born) of both sexes of killer whales (*Orcinus orca*), housed at "Marineland-Antibes", France, during surface activity. Experimental sessions were performed on animals previously trained to wear a digital ECG recorder and station in front of the trainer, having the head above water surface. Average respiratory rates and R-R interval were calculated during a 10 min period. R-R interval variability was estimated by means of the standard deviation of the mean R-R interval (SD) and the root mean square of successive differences in R-R interval (rMSSD).A respiratory act consisted of the rapid sequence of both an exhalation and an inhalation. Average breathing times between acts observed was of 68.3 ± 4.0 s, standard error. After every respiratory act, mean R-R interval, SD and rMSSD significantly decreased, for a time that represented the 27.8 ± 2.9 % of the whole breathing interval. Past this period all parametres increased to preceding levels. Each respiratory act would effect on the normal cardiac activity in a temporary tachycardic phase. Decrease of RR interval and its variability following breathing would be connected to the shifting of the autonomic-nervous-system balance towards the sympathetic component. Presumably, oscillations in haematic respiratory gas tensions were involved in this mechanism. Changes in heart frequency were not to be connected to any diving activity nor mechanical or thermal stimulation, but entirely to the breathing pattern.

RESPIRATION AT DIFFERENT ACTIVITY LEVELS IN A CAPTIVE HARBOUR PORPOISE

L. Buholzer[1,2], G. Desportes[1], and F. B. Jensen [2]

[1] *Fjord&Bælt, DK-5300 Kerteminde, Denmark*
[2] *Institute of Biology, University of Southern Denmark, Odense, Denmark*

Blood taken from two adult harbour porpoises (*Phocoena phocoena*) was analysed for O_2 and CO_2 binding properties and acid-base status, and then compared to data obtained from terrestrial mammals. The two porpoises were rescued from Danish pound nets and have been kept in a semi-natural outdoor enclosure (natural environmental conditions, sea water, tidal currents, fauna) at the Fjord and Bælt centre, Denmark since 1997. The blood was equilibrated in Eschweiler tonometres at 37ºC to 1, 5 and 9% CO_2 with air (oxygenated blood) or N_2 (deoxygenated blood) as the balance gas. Following equilibration, O_2 equilibrium curves were constructed using the mixing method, and the total CO_2 and pH was measured in true plasma. Acid-base data was also obtained on a separate plasma. The P50 values were 15.8, 24.8 and 32.4mmHg at 1, 5 and 9% CO_2. The Hill coefficient was close to 3. Blood pH was 7.99 ± 0.02, 7.60 ± 0.02 and 7.40 ± 2.02 at 1, 5 and 9% CO_2, which was higher than the levels measured in terrestrial mammals. The Bohr factor (Dlog P50/pH) was – 0.53. In line with the significant Bohr effect, the total CO_2 was higher in deoxygenated than oxygenated blood (Haldane effect). The non-bicarbonate buffer value (bNB = -d[HCO3-]/dpH) of harbour porpoises true plasma was similar to other diving mammals.

MAPPING OF PRIMARY AUDITORY CORTEX (PAC) IN THE LA PLATA DOLPHIN (*PONTOPORIA BLAINVILLEI*)

C. Fung[1], A. Schleicher[2], T. Kowalski[2], and H. Oelschläger[1]

[1] *Department of Anatomy (III), Johann Wolfgang Goethe University, Theodor Stern Kai 7, D-60590 Frankfurt a. Main, Germany*
[2] *C. and O. Vogt Institut for Brain Research, Heinrich Heine University, Universitätsstr. 1, D-40225 Düsseldorf, Germany*

The localisation of cortical areas in mammalian brains is often performed by means of electrophysiological methods. In toothed whales, only a few such studies have been carried out and most occurred in the 1970's (e.g., Sokolov *et al.*, 1972, Supin *et al*., 2001). Knowing that the PAC is located in the suprasylvian gyrus we tried to locate the borders separating this area from the visual and secondary auditory cortices. The stereological, observer-independent procedure used here is based on changes in the volume density of cell bodies at the boundary between two neighbouring cortical areas (Schleicher et al., 2000). We analysed the brain of a La Plata dolphin which had been fixed in formalin, embedded in paraffin, cut at sections of 20µm thickness and stained with cresyl violet. From a total of 150 equidistant sections we used sections 30 to 115, thus excluding the frontal and occipital parts from the analysis. When applied to the dolphin brain, the stereological method could discriminate adjacent functional areas even in the poorly laminated dolphin cortex due its high sensitivity to changes in volume density. The cortex was extremely thin sometimes falling below 1mm in thickness and an extremely dense folding of the cortical surface and numerous tangential sections proved challenging. In the latter, the laminar pattern of the cortex is often considerably distorted, resulting in a false positive detection of borders. Analysis of two trials with different spatial resolutions and the rejection of all false positive borders however, resulted in one continuous border at the bottom of the suprasylvian sulcus and an additional one at the bottom of the ectosylvian sulcus, thus separating the primary auditory from the visual and secondary auditory cortices. This first 3D-reconstruction of the PAC was processed using the AMIRA 3.0 Graphics software package comparing the main primary gyri in the histological sections with the coronal MRI scans of another Pontoporia brain.

ALLOMETRY IN HARBOUR PORPOISES (*PHOCOENA PHOCOENA RELICTA*) FROM THE SEA OF AZOV AND THE BLACK SEA

P. E. Gol'din

Dept. of Zoology, V. I. Vernadsky Taurida National University, 4, Vernadsky Avenue, 95007 Simferopol, Crimea, Ukraine

The harbour porpoise in the Black Sea basin is one of the smallest cetaceans in the world, so the study of its body proportions is the subject of particular interest. External measurements were taken from 125 harbour porpoises stranded or by-caught at the coast of the Sea of Azov and the Black Sea between 1997 and 2003. The age of specimens was determined on GLGs in dentine. Allometric growth of body parts during the postnatal ontogenesis of harbour porpoise differs substantially in four body sectors, which correspond to the skull and the thoracic, lumbar and caudal departments of the vertebral column. The anterior body region and fins are characterised by negative allometry, and many of their measurements do not correlate with the total body size. The highest rates of allometric growth are observed in the thoracic and caudal departments. The anterior, posterior and partially overlapping middle body parts are interconnected by a ratio of proportions expressed by allometry equations and that are not dependent on the sex. The middle part of the body demonstrates the maximum rates of allometry in both sexes. The two-stage growth of the organism is considered to be determined by the periodicity of growth of the caudal department. Sexual dimorphism of the absolute body size is determined by the body parts, which exhibit positive allometry or isometry in both sexes. Sexual differences in growth rates are observed in the lumbar department but the differences of absolute length values concern only the anus-genital distance.

HIGH-RESOLUTION 3-D MRI ATLAS OF A COMMON DOLPHIN BRAIN

M. Haas-Rioth[1], M. Knauth[2], S. Jung[2], and H. H. A. Oelschläger[1]

[1]Department of Anatomy (Dr. Senckenbergische Anatomie, Institut III), J. W. Goethe-University, D-60590 Frankfurt a. Main, Germany
[2] Department of Neuroradiology, Georg-August-University, 37075 Göttingen, Germany

Magnetic resonance imaging (MRI) is a powerful technique for the non-invasive and non-destructive research on rare and preserved museum specimens like cetacean brains. Moreover, conventional anatomical methods can be avoided. A high-resolution isotropic MR dataset of an adult formalin-fixed brain of a common dolphin was acquired by Siemens Trio with the following imaging parameters: field strength 3 Tesla; isotropic voxel size 0.5mm; proton density weighted 3D gradient echo sequence. A series of high-resolution scans in the coronal, sagittal and horizontal planes was used for three-dimensional (3-D) macroscopic brain reconstructions which included major brain parts (telencephalon, diencephalon, mesencephalon, cerebellum, brainstem and the ventricular system) as well as more detailed neuroanatomical features as, e.g., corpus callosum, thalamus, hypothalamus, optic nerve and tract, facial nerve and nucleus, inferior olive. Digital 3-D reconstructions with AMIRA 3.0 Graphics software package resulted in detailed virtual replices of neuroanatomical structures. In addition, quantitative analysis of brain components (surface areas, volumes) were carried out. An integral part of the presentation will be an animated short video demonstration of the reconstructed brain and brain parts.

GROWTH AND BODY CONDITION OF HARBOUR PORPOISE (*PHOCOENA PHOCOENA*)

M. Iversen [1,2], C. Lockyer [3], and G. Desportes [4]

[1] Department of Marine Ecology and Aquaculture, Danish Institute for Fisheries Research, Kavalergården 6,DK-2920 Charlottenlund, Denmark
[2] Department of Marine Ecology, Aarhus University, Finlandsgade 14, DK-8200 Aarhus N. Denmark
[3] Age Dynamics, Huldbergs Alle 42, DK 2920 Kongens Lyngby, Denmark
[4] Fjord and Bælt, Margrethes Plads 1, DK- 5300 Kerteminde, Denmark

The two harbour porpoises (*Phocoena phocoena*) that have been held at Fjord and Belt in a semi-natural penned-off area of Kerteminde Fjord for a period of approximately six years have shown marked seasonal fluctuations in their body weight. The seasonal weight fluctuations were mirrored in the girth and blubber thickness and correlated with the food intake of the animals and sea temperature. We hypothesise that similar weight fluctuations would occur in the wild and that they could also be correlated with water temperature and reproduction. To address this hypothesis the monthly or seasonal weight and growth variations were investigated in detail and compared with factors such as body condition measurements and girth. Furthermore, the energy budget of the porpoise was investigated to estimate if the weight fluctuations were likely to be caused by differences in prey, increased/decreased energy density or by allocation of energy. This may give an idea of the porpoise physiology and their food preferences and possible food limitations. This study has been done mainly on the basis of standardised dissections of by-caught or directly caught porpoises in Danish waters. This includes age determination and diet investigations. The results show that the seasonal and monthly fluctuations in weight, blubber weight and thickness in both genders are observed in the wild. These fluctuations are seen as low body weight, blubber weight and blubber thickness in the summer period and as higher weights and blubber thickness in the winter. The largest decreases in weight are seen around April/May and the maximum increase around October. Stomach analyses show differences in diet during the seasons. The conclusion is that the investigated data show consistency with the hypothesis.

COMPUTER TOMOGRAPHY (CT) OF THE INDUS RIVER DOLPHIN EAR (*PLATANISTA MINOR*)

L. S. Kossatz[1], M. Drieske[2], J. Winckler[1], T. J. Vogl[2], and H. H. A. Oelschläger[1]

[1] *Dr. Senckenbergische Anatomie (III), Johann Wolfgang Goethe-University, Theodor Stern-Kai 7, D-60590 Frankfurt a.M., Germany (E-mail: kossatz@em.uni-frankfurt.de)*
[2] *Department of Diagnostic and Interventional Radiology, Johann Wolfgang Goethe-University, Theodor Stern-Kai 7, D-60590 Frankfurt a.M., Germany*

INTRODUCTION This paper shows the morphology of the labyrinth in the Indus river dolphin (*Platanista minor*) as part of our investigation of the whole ear region in this species. The head of this juvenile specimen (Pilleri Collection; Research Institute and Natural History Museum Senckenberg, Frankfurt a. M., Germany), fixed and stored in 4% formaldehyde, was scanned with a Siemens Somatom Plus 4 Volume Zoom CT in the coronal plane. Detailed and overlapping images were obtained with the following protocol settings (InnerEarSpi 0.75 U30u: slice thickness 0,75mm, image size 512*512, KVP: 120, Exposure time 1000, X-ray tube current: 250, convolution kernel U30u). The CT dataset with a total of 232 images (Voxel size: 0.2887x0.2887x0.2165mm3) was segmented manually to perform realistic surface reconstruction of all the components of the bony labyrinth using the Amira® Graphics software package.

RESULTS The following pictures show the inner ear from different points of view. Due to the high resolution of the scans, this reconstruction shows the size and proportions of the cochlea and the vestibular organ including the semicircular canals.

Figure 1 shows the cochlea, seen from below. It has one and a half turns. The mean length is 28.32mm with a standard deviation of 2.23mm. At the basis of the cochlea, the cross-section is ovoid with a mean diameter length of 4.45mm (+/- 0.42mm) and a mean short diametre of 1.99mm (+/- 0.13mm).

Figure 2 gives an overview of the facial nerve in this area. It is well developed and has a mean diametre of 1.45mm (+/- 0.45mm).

Figures 3 and 4 show a reconstruction of the bony semicircular canals (SC).

CONCLUSION Our data shows that the cochlea has one and half turns which could apply to the whole superfamily Platanistoidea; the Amazon river dolphin (*Inia geoffrensis*) has the same number of turns (Ketten *et al.*, 1990). In the Indus river dolphin the vestibular organ with the three thin semicircular canals is miniaturized with respect to cochlear size as in other toothed whales but should be an active system. The facial nerve could be followed along its course throughout the periotic. In comparison with other smaller toothed whales, the facial nerve seems to be rather thin, in accordance with the literature (*Inia geoffrensis*). Whether this is characteristic for river dolphins, in general, has to be substantiated by further studies.

ACKNOWLEDGEMENT We thank Dr. Gerhard Storch (Research Institute and Natural History Museum Senckenberg, Frankfurt a. M., Germany) for allowing us the scanning of this extremely valuable specimen.

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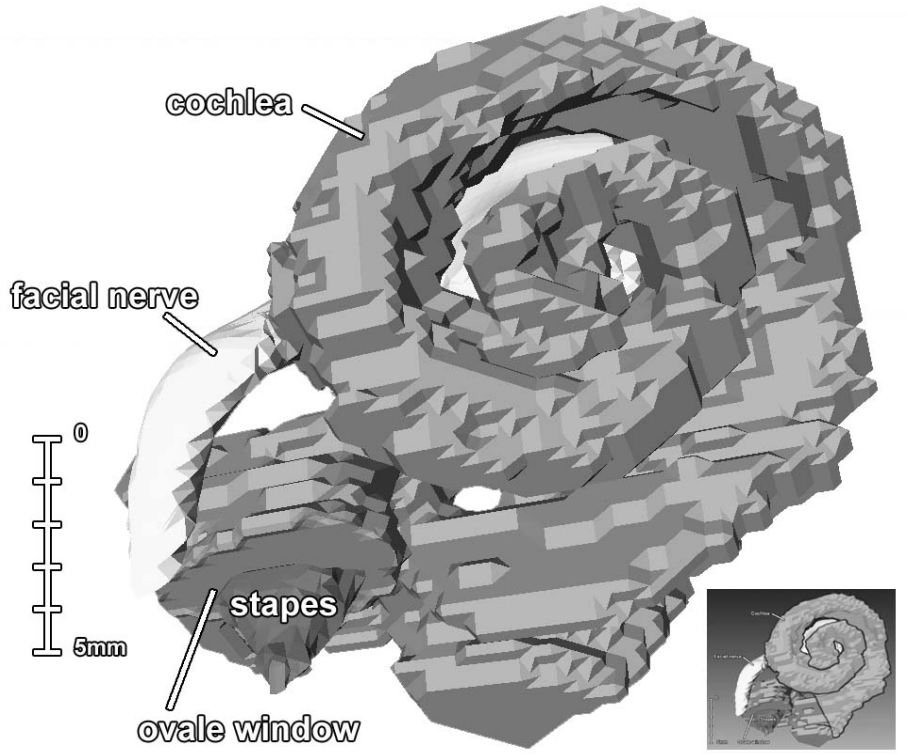


Fig. 1. The cochlea, seen from below. It has one and a half turns. The mean of its length is 28.32mm with a standard deviation of 2.23mm. At the basis of the cochlea, the cross-section is ovoid with a mean long diameter of 4.45mm (+/- 0.42mm) and a mean short diameter of 1.99mm (+/- 0.13mm)

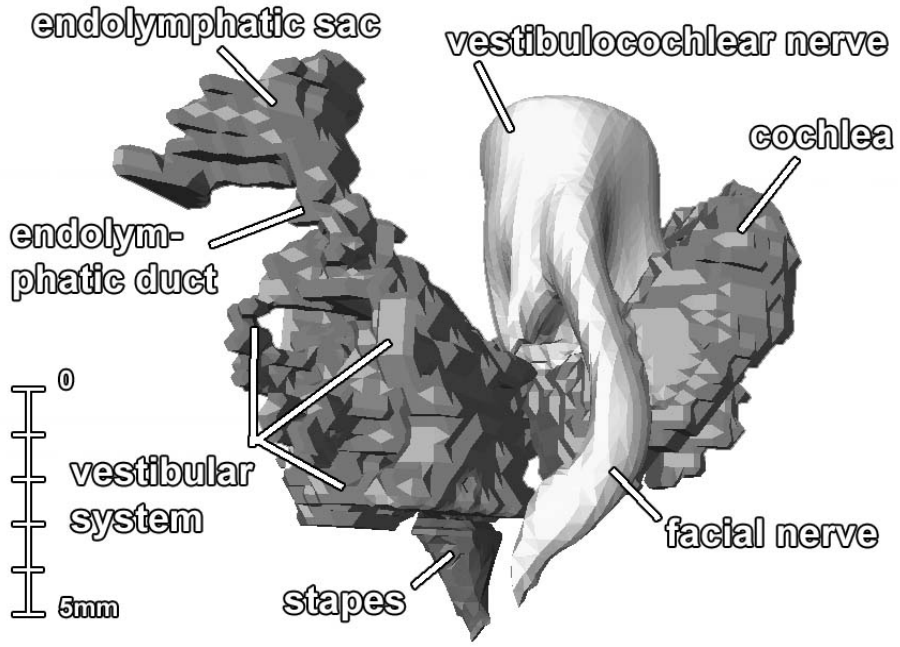


Fig. 2. An overview of the facial nerve in this area.
It is well developed and has a mean diameter of 1,45mm (+/- 0,45mm)

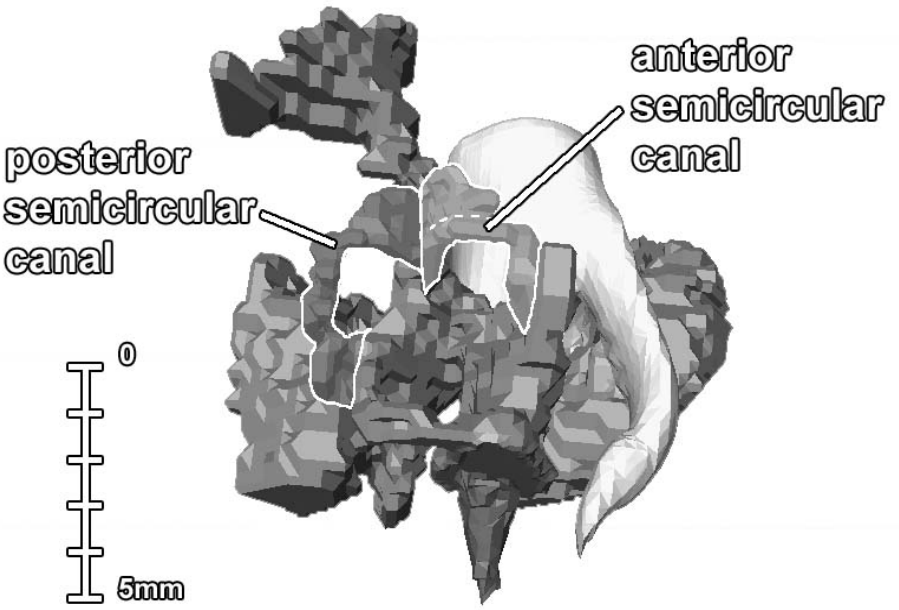
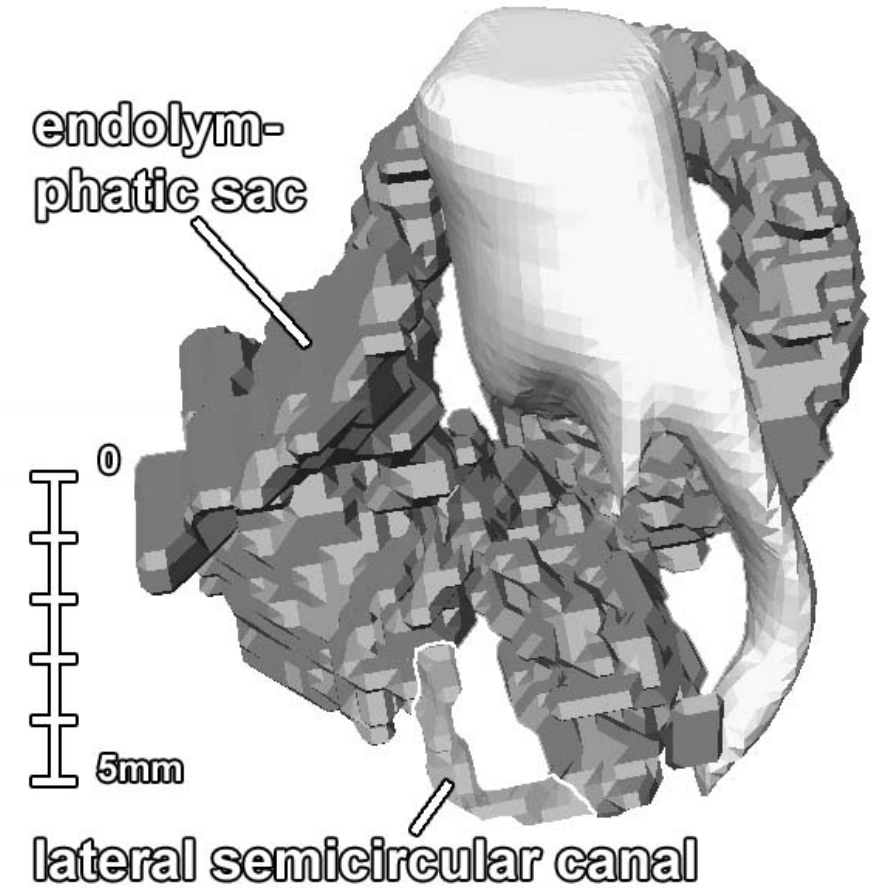


Fig. 3. A reconstruction of the bony semicircular canals (SC)



Diameter of	Mean	Standard deviation
Anterior SC	0.77mm	0.16mm
Posterior SC	0.71mm	0.17mm
Lateral SC	0.80mm	0.08mm

Fig. 4. A reconstruction of the bony semicircular canals (SC)

AGE – HOW IS IT DETERMINED AND VALIDATED IN MARINE MAMMALS?

C. Lockyer

Age Dynamics, Huldbergs Allé 42, DK-2800, Denmark. (e-mail: agedynamics@mail.dk)

INTRODUCTION There are many different methods of age determination that have been tested and employed, and new methods that are as yet not fully evaluated for determining accurate age in marine mammals. This review focuses on tissues that demonstrate Growth Layer Groups (GLGs), where continued deposition of tissue is possible throughout life. Hard tissues, especially teeth, that have Growth Layer Groups (GLGs) in dentine and cementum (Fig. 1a), and ear plugs of baleen whales (Fig. 1b) are well established materials for age determination (Perrin and Myrick, 1980). This review examines the known reliability of GLG-based methods for a variety of species with reference to important validation methods of using 1) known age or known history animals either in human care or free-living, 2) reference to other methods of ageing e.g. female ovulation/pregnancy records, and 3) tetracycline antibiotic administration that provides permanent marks in hard tissues of animals both in human care and free-living. Consideration is also given to the possibility of using tooth GLGs for interpolating life history events such as weaning, age at sexual maturation/parturition, and possible episodes of impoverished nutrition and environmental stress. In conclusion, a ranking of methods that may be of use for age determination is presented and an indication of where new techniques and research must be sought.

METHODS

Direct methods of age determination –

1. Monitor the life history of the animal:

- Maintain the animal in captivity from birth until death.
- Record repeat sightings of the free-living animal using natural marks, freeze brands, various tags from birth until death; in practice this is difficult and may only represent partial known life history.

Indirect methods of age determination –

1. Use incremental growth layers – Growth Layer Groups (GLG):

- In baleen whales, count incremental layers in tissues of epidermal origin e.g. ear plugs (Lockyer, 1984), baleen plates (Ruud, 1940); ovarian corpora counts for relative age (Laws, 1961).
- Use hard tissues such as mandible (Laws, 1960) and tympanic bulla (Christensen, 1981; 1992; 1995) for incremental growth layers in baleen whales.
- In toothed mammals, count incremental growth layers in hard tissues (Klevezal and Kleinenberg, 1967) e.g. teeth (Perrin and Myrick, 1980), jaw bones (Laws, 1960).
- In clawed mammals, examine incremental layers in claws and nails e.g. some seal species (Riedman, 1990).

2. Use chemical and physical analytical methods:

- Examine eye lens weight, opacity e.g. baleen whale species (Nishiwaki, 1950).
- Examine aspartic acid racemisation in teeth (Bada *et al*., 1983), eye lens e.g. humans, some baleen whale species (Bada *et al*., 1980, George *et al*., 1999).
- Examine stable isotopes in tissues.
- Examine blubber fatty acid profiles (Møller, 1999; Olsen *et al*., 2002).

Problems associated with various indirect methods

- Baleen plates have incremental growth lines, but they wear away at the tip; therefore they are only useful in young animals
- Claws and nails also wear away at the distal edge
- Bony tissues e.g. jaws, often suffer from tissue resorption, so that growth layers are difficult to interpret
- Teeth sometimes wear down at the crown or even fall out with extreme age
- All chemical analyses e.g. aspartic acid racemisation, isotope analyses, usually require baseline data for calibration purposes, which may be unavailable
- Most indirect methods require the animal to be dead for the samples to be available, e.g. ear plugs, teeth, baleen, bones, eye lens, etc.

Some advantages associated with various indirect methods

- Ear plugs have incremental growth lines that persist throughout life; age at sexual maturity can also be determined from the transition zone where widely-spaced GLGs become narrower

- Teeth continue growing throughout life and have both dentine and cementum – either or both of which can be used for incremental growth lines; they can be removed from living animals sometimes

Ear plugs in baleen whales Age from GLGs ear plugs have long been recognised as useful means for age determination in baleen whales (Purves and Mountford, 1959, Lockyer, 1984), especially balaenopterid whales (Fig. 1b). Validation of fin whale, *Balaenoptera physalus*, GLGs in ear plugs indicated an annual deposition rate (Roe, 1967); similarly in the sei whale, *B. borealis* (Lockyer, 1974). Doubt remains over the deposition rate of GLGs in humpback whale, *Megaptera novaeangliae*, ear plugs, where Chittleborough (1960) proposed 2 GLGs per year. The age at sexual maturity has been interpreted from the transition phase in ear plugs of fin and sei whales (Lockyer, 1972; 1974). This has been a useful technique for other species e.g. minke whale, *B. acutorostrata bonaerensis* (Kato, 1984), and can detect trends in maturity over time in populations (Thomsen *et al*., 1999).

Tooth structure in marine mammals Typically, marine mammal teeth are similar to those of terrestrial mammals (Fig. 2). The teeth continue growing throughout life with a characteristic incremental growth rate of GLG formation in dentine (Figs 3b, d and e). The neonatal line appears immediately after birth and is the baseline reference point of age zero (Fig. 3e). The crown may wear down during life, removing early forming GLGs (Fig. 4). Cementum builds up from the gum tissue and also continues growing at a set rate during life with GLGs (Figs 3a and c).

Methods of validating age and incremental deposition rate GLG counts in dentine or cement of teeth from known-age or known history animals, usually from captive-held animals (Fig. 4), teeth may also be collected from monitored free-living animals (Hohn *et al*., 1989). Treatment of animals with tetracycline antibiotics to time mark the teeth, usually in captive-held animals (Fig. 5), requires the retrieval of teeth at death or in the future during life (Lockyer, 1993, Myrick *et al.,*1984) to monitor growth over time and compare size to anticipated length at a given age with GLGs in teeth. These results should be cross referenced with relative methods of age determination such as number of ovulations/pregnancies (counting ovarian corpora) to estimate age at first ovulation (Lockyer, 1972; 1974, Olsen, 2002).

Teeth may contain ultra-structural anomalies that provide clues as to stock structure and life history events Cetacean teeth frequently exhibit anomalies such as pulp stones, marker lines, accessory lines and so on (Perrin and Myrick, 1980; Lockyer, 1995) (see Figs 3d and e). These have been analysed in detail in harbour porpoise, *Phocoena phocoena*, (Lockyer, 1995; 1999) long-finned pilot whale, *Globicephala melas*, and short-finned pilot whale, *G.macrocephalus* (Lockyer, 1993) and beluga, *Delphinapterus leucas* (Benjamins, 1999). In porpoises, these have been associated with population structure (Lockyer, 1999). Similarly, Akin (1988) reported geographic differences in the tooth structure of spinner dolphins, *Stenella longirostris*. Suckling lines have been identified in some species such as Antarctic fur seals, *Arctocephalus gazella* (Bengtson, 1988), in addition to the formation of an accessory line at weaning (Fig. 4). In pilot whales they have been correlated with reproductive events and nutritional crises (Lockyer, 1993). In dusky dolphin, *Lagenorhynchus obscurus*, off Peru, poorly calcified GLGs have been correlated with reproductive status and dietary problems associated with El Niño (Manzanilla, 1989). Parturition events have been detected in *Stenella spp.* teeth (Klevezal and Myrick, 1984). In beluga there appear to be no particular associations (Lockyer *et al*., 1999).

CONCLUSIONS The most appropriate and reliable method: Baleen whales Ear plugs in most balaenopterid whales show GLGs; however, minke whales in the N.Atlantic cannot be aged by this method. Other methods such as bullae, mandibular GLGs are not ideal (Olsen, 2002). Other possibilities include aspartic acid racemisation of eye lens (Olsen and Sunde, 2002). This method is still experimental, and is expensive. It has also been applied to balaenid whales (George *et al*., 1999). Bullae and baleen are generally not recommended.

Odontocete whales Hard tissues such as teeth show that GLGs are the most accepted method. The dentinal GLGs are usually the clearest. Treatment of the teeth varies. Teeth can be halved and acid-etched in large whales e.g. the sperm whale, throwing the GLGs into relief of ridges and troughs. In other species, e.g. the beluga (white whale), a thin section (ca 100 μm) without treatment is often best. Narwhals still present problems. Dolphin and porpoise teeth that are small are best decalcified, thin-sectioned (ca 20 μm) and stained (e.g. haematoxylin stains, toluidine blue) to highlight the GLGs. Beaked whales have unusual shaped teeth that present a challenge for age determination (Kasuya, 1977, Herman *et al.,* 1994). However, most when thin-sectioned contain GLGs. Orientation of the tooth for sectioning may be problematic because of the unusual shape.

Pinnipeds Teeth are generally the best tissue (incisors or post-canines). However, cemental GLGs are more often used here. Either thin untreated or decalcified stained sections can be appropriate, depending on species. The site chosen for GLG counting may be critical, i.e. root or side. There are many species e.g. monk seals, for which methods are presently unreliable. Validation of deposition rates is often lacking. Walrus teeth become worn flat with age but

the root cemental GLGs are very useable for age determination in either untreated or decalcified stained sections (Fig. 5) (Garlich-Miller *et al.* 1992). Note that the tusks are not used in this way.

Sirenians Teeth, especially incisors, and tusks in male dugongs, are suitable for dentinal GLGs (Kasuya and Nishiwaki, 1978, Marsh, 1980, Mitchell, 1978). They appear internally similar in structure to sperm whale teeth.

Fissipeds In polar bears and otters, teeth (either incisors, or small post-canines/premolars) are most suitable (Bodkin *et al.,* 1997). The cement in the root has GLGs, visible in either untreated or decalcified stained sections. Readability depends on the geographic region and population.

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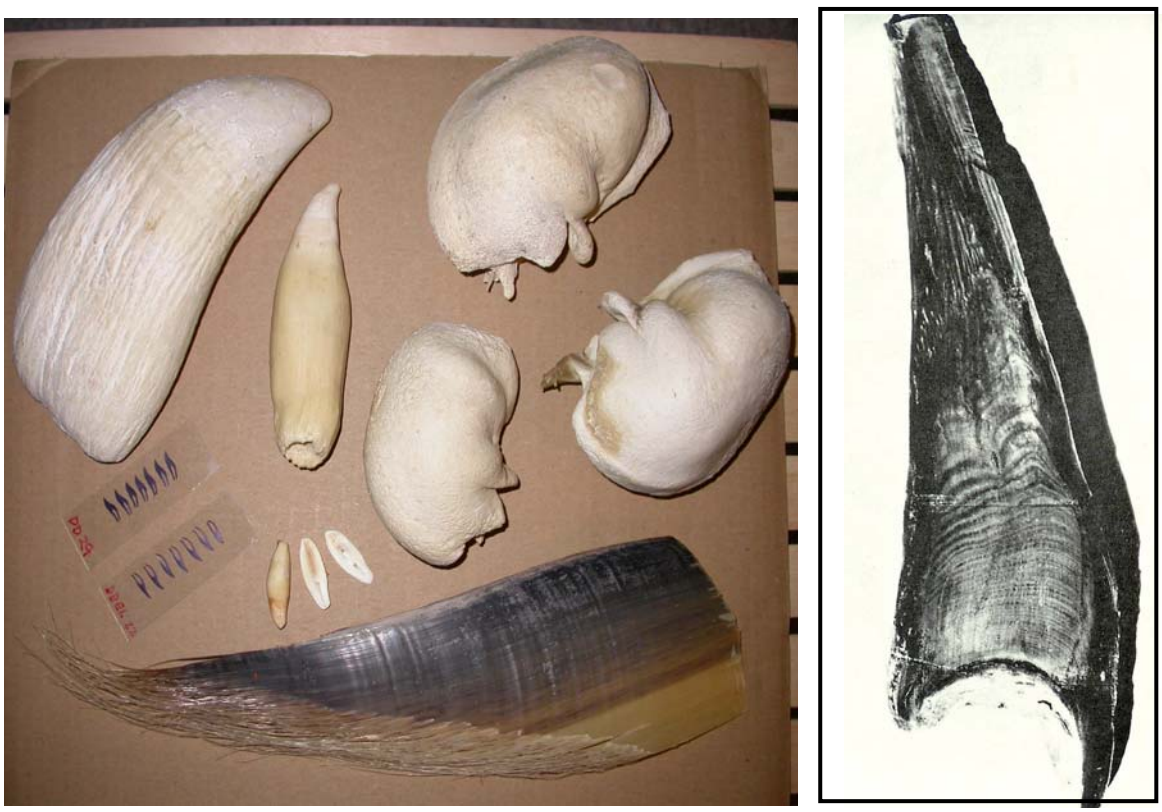

Fig. 1. Examples of various hard tissues used for age determination. **a.** Anti-clockwise from top right, are seen: tympanic bullae from fin and minke whales, sperm and killer whale teeth, whole and sectioned pilot whale teeth, decalcified thin-sectioned and stained common dolphin teeth, and fin whale baleen (bottom). **b.** Cut fin whale ear plug showing Growth Layer groups (GLGs)

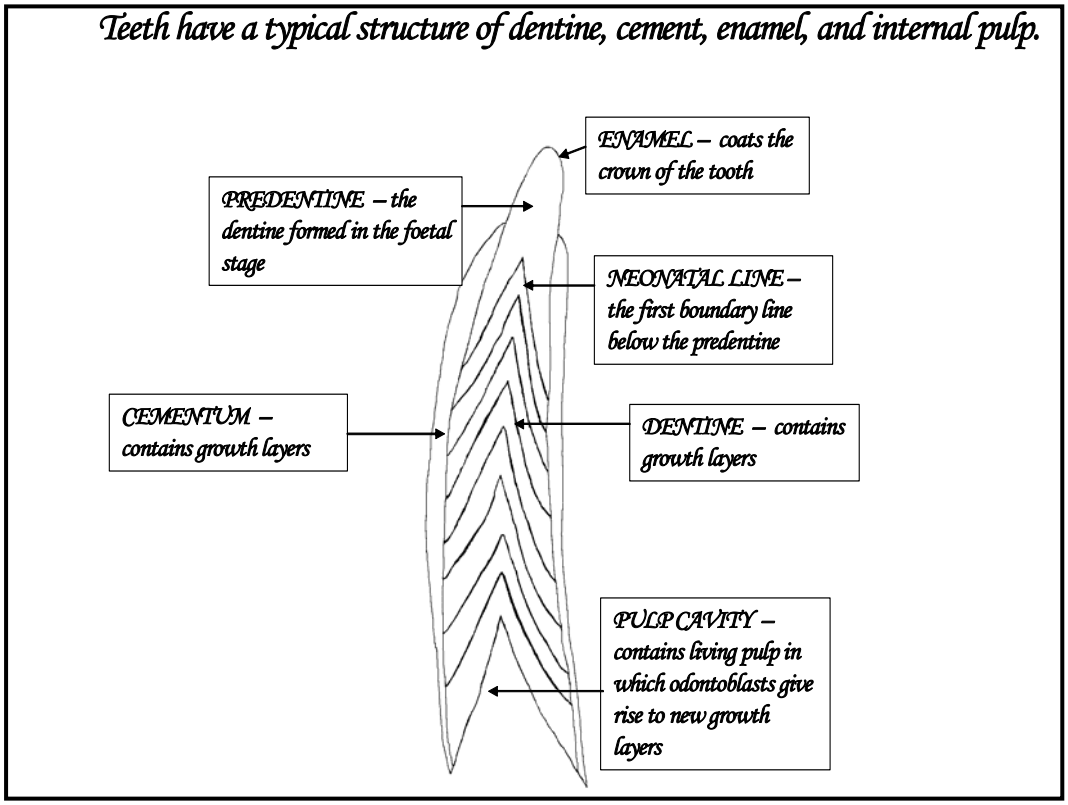

Fig. 2. A schematic marine mammal tooth illustrating various structural features

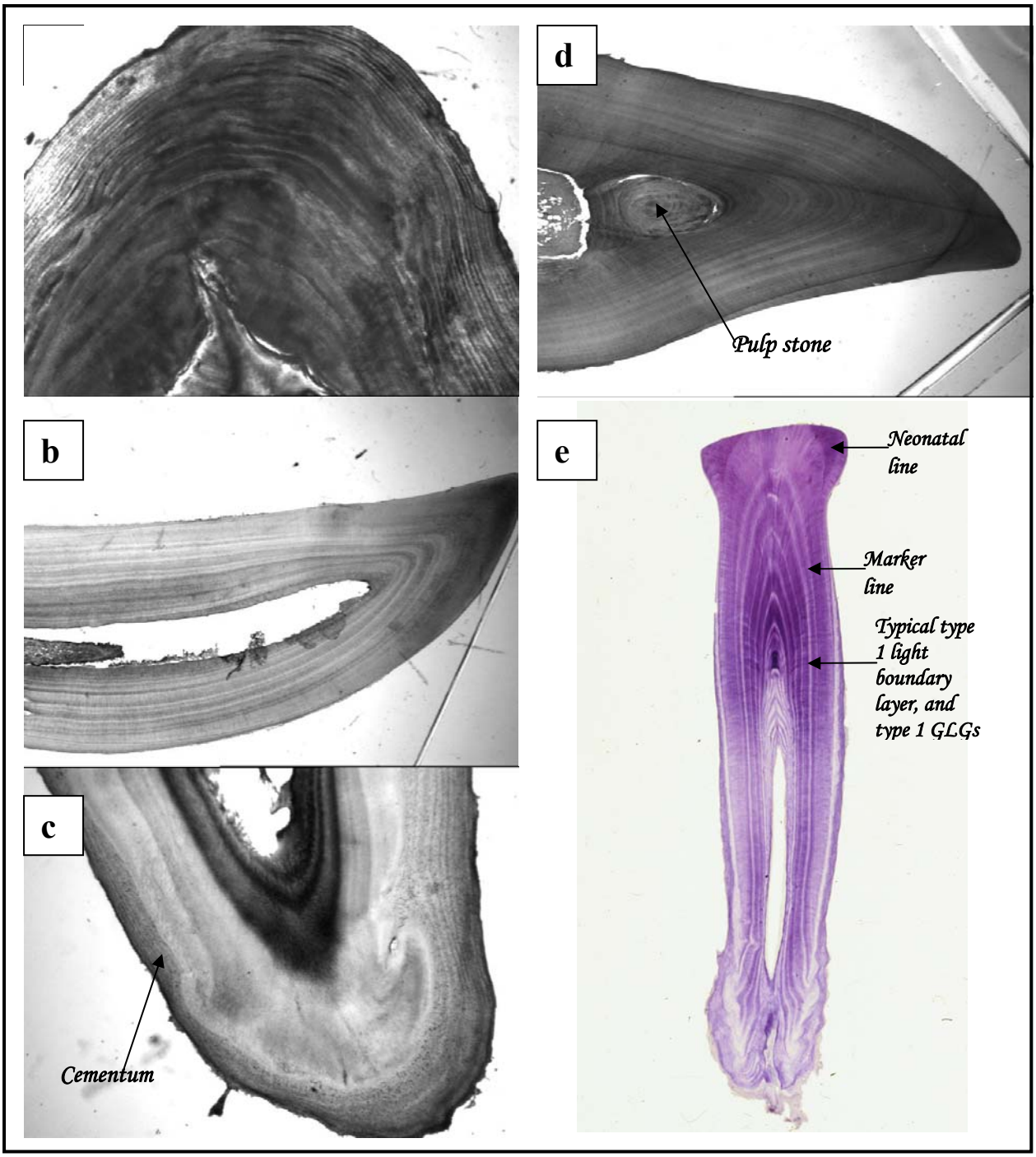

Fig. 3. Various examples of tooth Growth Layer Groups (GLGs): **a.** Walrus - *Odobenus rosmarus,* with 29 cemental GLGs (courtesy of Erik Born, Greenland Institute of Natural Resources, Nuuk); **b.** and **c.** Ringed seal - *Phoca hispida*, with 7 dentinal GLGs and 7 cemental GLGs in root (courtesy of Greenland Institute of Natural Resources, Nuuk) ; **d.** Pilot whale - *Globicephala macrocephalus,* with 18 dentinal GLGs (courtesy of John Heyning, Los Angeles County Natural History Museum); **e.** Harbour porpoise – *Phocoena phocoena*, with 17 GLGs (courtesy of Aleta Hohn, NOAA, Beaufort NC, USA)

Fig. 4. The tooth above is severely worn down with loss of the neonatal line and probably some GLGs. The animal was juvenile when first captured. The beluga, *Delphinapterus leucas*, is a good example of an animal where validation of age determination from GLGs in tooth dentine has not yet been achieved. Currently it is believed that 2 GLGs form annually but there is controversy that perhaps – like other cetaceans – only one GLG forms annually. The problems hindering validation include:

- Teeth wear down at the crown so that total age cannot be counted
- Multiple accessory lines exist within GLGs, so that confusion arises as to what constitutes a boundary layer between GLGs
- Many teeth contain multiple pulp stones and other mineralization anomalies making it difficult to count GLGs
- The pulp cavity becomes narrow and filled out in older age so that the most recently formed GLGs are difficult to distinguish from each other.

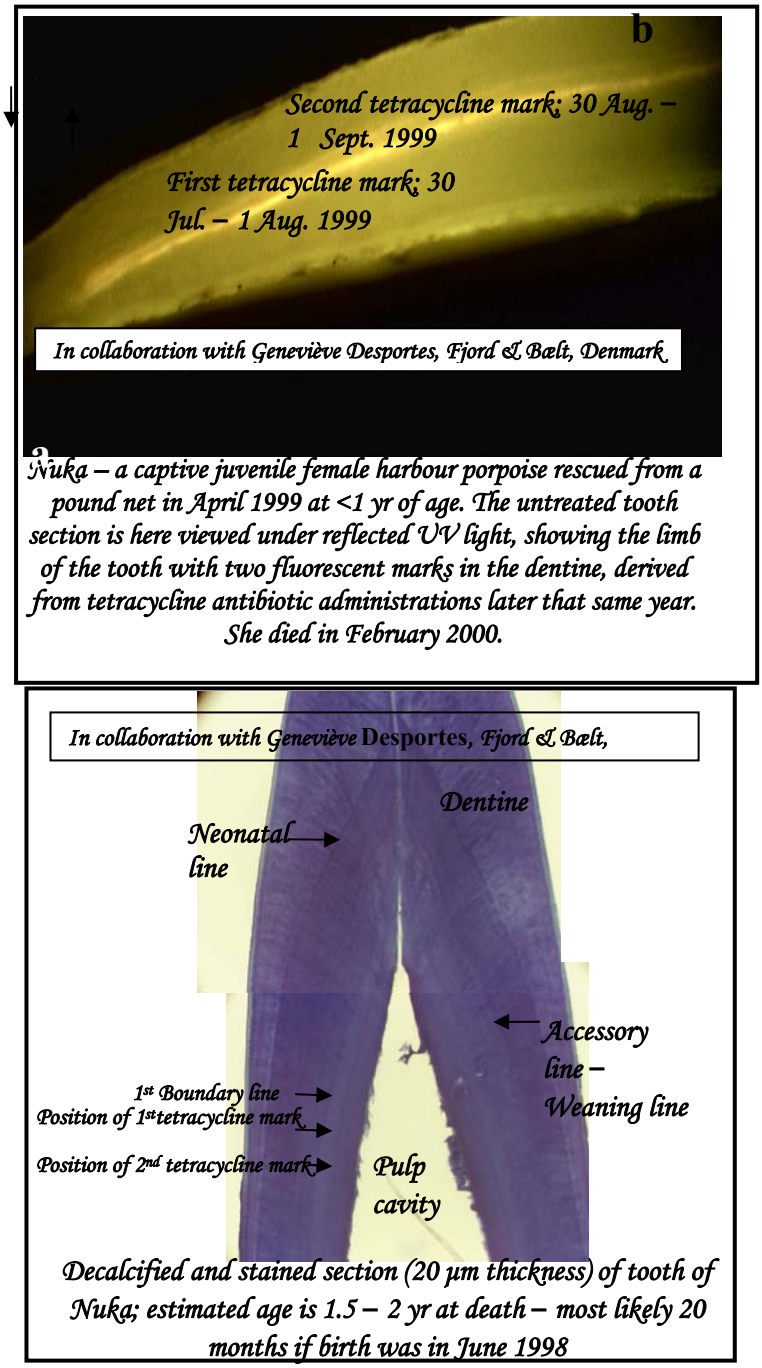

Fig. 5. Validation of GLGs using tetracycline antibiotic time-marking. This is a harbour porpoise tooth, *Phocoena phocoena*. **a.** Untreated thin section (100 µm thickness) under reflected UV light; the tetracycline marks fluoresce. **b.** A decalcified thin-stained (haematoxylin) section (20 µm thickness) of the same tooth, under transmitted ordinary light. The study was undertaken in cooperation with Fjord & Bælt, Kerteminde, Denmark.

ASSESSING THE MATING SYSTEM OF THE SHORT-BEAKED COMMON DOLPHIN (*DELPHINUS DELPHIS*) IN THE NORTH-EAST ATLANTIC USING SAMPLES OBTAINED FROM POST MORTEM EXAMINATIONS

S. Murphy[1], E. Rogan[1], A. Collet[2], and M. Addink[3]

[1] *Department of Zoology, Ecology and Plant Science, University College, Cork, Ireland*
[2] *CIRCE, BP3053, 17031 La Rochelle cedex 01, France*
[3] *Nationaal Natuurhistorisch Museum of Leiden, The Netherlands*

The relationship between relative testes size and sexual dimorphism are commonly used as indicators of mating systems within the Cetacea. To assess the mating system in the common dolphin we investigated not only male reproduction and sexual dimorphism, but also age, growth and female reproduction. Samples were obtained from both the Irish and French strandings and bycatch programmes. Age was estimated for 297 individuals and sexual dimorphism was investigated by analysing 25 external body measurements taken from 189 individuals. Gross and histological examinations of gonadal material from female (n = 69) and male (n = 209) common dolphins were also undertaken. Sexual size dimorphism was evident with a ratio of 1.06. Males were significantly larger than females in overall length and in 20 external body measurements. Sexual shape dimorphism was lacking except for the presence of a prominent postanal hump in mature males. Reproductive seasonality was found to occur as the mating and calving periods were estimated to take place during the months June to September. In female common dolphins there was no linear correlation found between the number of corpora scars with body length or with age. Furthermore, pregnant females had a significantly lower number of corpora scars compared to resting mature females. In males, reproductive seasonality places limits on peak reproductive activity, evidenced by marked seasonal changes in both testes mass and cellular activity in males outside the mating period. Combined testes mass for mature male dolphins ranged from 0.45–5kg, relatively large considering the overall size of the dolphin. Moderate sexual dimorphism and large testes suggest sperm competition and a promiscuous mating system, with female common dolphins mating with multiple mates.

DOES "FREE-RIDING" BEHAVIOR ENHANCE SWIMMING EFFICIENCY AND REDUCE LOCOMOTOR COSTS OF DOLPHIN CALVES? IMPLICATIONS FOR DEPLETED DOLPHIN STOCKS IN THE EASTERN TROPICAL PACIFIC

S. Noren[1], E. Edwards[1], W. Hurley[2], and G. Biedenbach[2]

[1] *Southwest Fisheries Science Center, 8604 La Jolla Shores Dr., La Jolla, CA 92037, USA*
[2] *Dolphin Quest Hawaii, 69-425 Waikoloa Beach Drive, Waikoloa, HI 96738, USA*

Although dolphin calves have a small proportion of locomotor muscle and low aerobic capacity they must swim immediately at birth. Theoretically calves "free-ride" to compensate by moving close to their mothers' lateral flank ("echelon position"). Hypothetically this position reduces locomotor costs since the calves are carried in the mothers' pressure wave. Empirical evidence for this energetic savings has yet to be provided. This study explores the swimming kinematics of mother-calf dolphin pairs to determine empirically the extent to which echelon position reduces the locomotor costs of calves. Several bottlenose dolphin (*Tursiops truncatus*) mother-calf pairs housed at Dolphin Quest, Hawaii are being studied throughout the first two years postpartum. Mother-calf pairs are trained to swim alone and together in a straight line between two points at various swim speeds while being video taped with an underwater digital camcorder. Anatomical points (dorsal fin, fluke hinge, fluke tip) are manually digitised and the swimming kinematics are analysed by a motion-analysis system (Peak Performance Technologies, Inc. Englewood, CO, USA). Speed, stroke amplitude, stroke frequency, and distance travelled while stroking or gliding are determined. The effects of swim speed and swim behaviour (alone versus echelon position) on swimming kinematics are examined. Stroke amplitude, frequency and the proportion of time spent gliding provides an index of swimming energetics; greater stroke amplitude and frequency, and reduced time spent gliding implies greater locomotor effort. The impact of chases associated with the yellow fin tuna purse-seine in the Eastern tropical Pacific (ETP) makes the study of calf swimming kinematics a priority, as calves may be incapable of maintaining position with their mothers given the speed and level of maneuvering required during the chase. If calves are unable to sustain these speeds, the calves may become separated from the pod and may ultimately die.

NUMERICAL VARIABILITY OF DIFFERENT CORTICAL AREAS IN WHALES AND DOLPHINS

H. Oelschläger[1], O. Güntürkün[2], S. Ridgway[3], and C. Fung[1]

[1] *Department of Anatomy (III), Johann Wolfgang Goethe University, Theodor Stern Kai 7, D-60590 Frankfurt a. Main, Germany*
[2] *Department of Biopsychology, Ruhr University Bochum, D-44780 Bochum, Germany*
[3] *University of San Diego, CA, USA*

The cetacean neocortex has often been subject to various histological investigations, and yet most studies do not provide precise data about neuron density in given volumes of cortex. This study not only compares neuron density in different cortical areas of individuals but also in different species of whales and dolphins with respect to their brain mass and total body mass. We studied formalin-fixed brains of six adult specimens of dolphins and other toothed whales (*Delphinus delphis*, *Kogia breviceps*, *Tursiops truncatus*, *Globicephala macrorhynchus*, *Pseudorca crassidens*, and *Orcinus orca*). Cortex samples from the auditory, visual and somatosensory cortex- and from both hemispheres- were photographed, subjected to paraffin histology (sectional thickness: 35 µm) and stained for cresyl violet. Counts of nucleoli were made in a frame extending from the pial surface of the cortex to the white matter and 150µm wide. This procedure made sure, that no neuron was counted twice. If we arrange the brains according to their brain weight in an ascending series and define the smallest brain mass as 1, we get the following results: *Delphinus delphis* = 1 (834g), *Kogia breviceps* = 1,2 (1000g), *Tursiops truncatus* = 1,56 (1302g), *Globicephala sieboldii* = 3,28 (2733g), *Pseudorca crassidens* = 5,16 (4307g), *Orcinus orca* = 7,26 (6052g). This ascending series of increasing brain mass correlates well with decreasing neuron density in all the investigated cortical areas. Thus the amount of neurons per volume unit shows in invers proportion to the size of the accessory brain but does not give any information about the total number of neurons. Kogia breviceps is the only exception within this ascending series. With regard to neuron density, there are no significant differences between the cortical areas investigated.

THERMAL BIOLOGY OF DELPHINID CETACEANS: INSIGHTS FROM ANATOMY, AND CAPTIVE AND WILD ANIMAL STUDIES

D.A Pabst

Biological Sciences, UNCW, Wilmington, NC 28403, USA

Delphinid cetaceans possess vascular adaptations for both the whole body and reproductive system thermoregulation. Within their appendages, delphinids possess countercurrent heat exchangers (CCHE) that function to conserve body heat, and a parallel superficial venous systems that dissipates excess body heat. Delphinids also possess a specialised reproductive CCHE that functions to regulate the temperature of the intra-abdominal testes in males and the developing fetus in females. This reproductive CCHE co-opts venous blood returning from the superficial surfaces of the dorsal fin and flukes to cool the arterial supply of reproductive tissues. The discovery of the reproductive CCHE relied upon systematic dissections of delphinid specimens that permitted identification of vascular connections between superficial and deep tissues. Physiological studies of the reproductive CCHE relied upon controlled experiments using captive bottlenose dolphins (*Tursiops truncatus*). These studies permitted direct measurements of deep body temperatures, and the development of novel methodologies to measure both heat flux and skin surface temperatures of stationary and free-swimming animals. These techniques have subsequently been employed on wild bottlenose dolphins in Sarasota, FL to describe the ontogeny of reproductive CCHE function, and how dolphins respond to environmental temperature change. These techniques were also employed on wild spotted dolphins (*Stenella attenuata*) to assess their thermal response to chase and capture in the Eastern Tropical Pacific tuna purse seine fishery. Our understanding of delphinid thermal biology has, thus, relied upon both the (1) integration of anatomical and physiological data, and (2) use of captive dolphins to develop appropriate and safe thermal measurement techniques for wild animals. These studies have yielded information that is pertinent to the management and conservation of these protected species.

ANATOMIC LINES THAT RULE OVER THE GROWTH IN *DELPHINUS DELPHIS*

U. Pena[1], M. Aldir [2], and A. Palanca[3]

Animal Anatomy Laboratory, Science Biology Faculty, Apdo.874 36200 Vigo,Spain
([1] ursula_pena@correo.uvigo.es [2] marialdir@correo.uvigo.es [3]apalanca@uvigo.es)

Several *Delphinus delphis* skulls of diverse sizes stranded in the NE Atlantic in the nineties have been studied with the purpose of characterizing the anatomic lines that rule over their growth. Three big cranial areas, uncorrelated among themselves in size and form, grow independently to generate different kinds of morphometric that might have great importance from both an evolutionary and functional point of view. The results are represented graphically in a poster comparing those with the ones obtained from dormouse (*Eliomys quercinus*) studies.

EAT NOW PAY LATER: DO GREY SEALS DEFER THE HEAT INCREMENT OF FEEDING TO MAXIMIZE DIVE DURATION?

C. E. Sparling[1], J. Y. Georges[2], K. L. Brookes[1], D. Thompson[1], and M. A. Fedak[1]

[1]*Sea Mammal Research Unit, Gatty Marine Laboratory, University of St Andrews, St Andrews, Fife, Scotland, UK.*
[2]*Centre National de la Recherche Scientifique, Centre d'Ecologie et Physiologie Energétiques, CEPE CNRS UPR 9010, 23 rue Becquerel, 67087 Strasbourg, France*
**(ces6@st-and.ac.uk)*

INTRODUCTION Air breathing divers are faced with a trade off between obtaining oxygen at the surface and exploiting a food resource underwater. Optimal foraging theory predicts they should evolve a variety of characteristics that enable them to minimise energy expenditure and to maximise energy gain while searching for prey underwater. According to these theories, divers should adopt strategies that maximise the proportion of time spent at the foraging site by minimising the proportion of time spent travelling and/or recovering at the surface (Kramer, 1988; Houston and Carbone, 1992). Although decisions on when to return to the surface may be influenced by other factors, they are ultimately constrained by oxygen balance. When exploiting a good quality patch, divers should be diving to their physiological limits. There are two things that determine how long a seal can remain submerged and still be metabolising aerobically. One is the amount of oxygen stored within the body and the other is the rate at which this store is used up. The former is fixed at the onset of a dive; to get more oxygen on board the animal has to return to the surface. The latter is variable, the faster an animal uses this store the quicker it has to return to the surface Therefore anything which increases the rate of oxygen consumption during diving should decrease the ADL. Sparling and Fedak (2004) have recently shown that increased swimming activity during dives results in higher DMR and shorter dive durations.

Feeding causes a subsequent increase in metabolic rate. Most investigations into this effect in marine mammals have referred to this cost as HIF so for consistency the same term will be used here. The metabolic cost of HIF can be separated into a mechanical component that is due to physical processing and movement of food through the gut (Tandler and Beamish, 1979). The remainder of the cost is thought to be of a biochemical nature, most likely related to the biochemical costs of nitrogen excretion (Kleiber, 1975). HIF is not a fixed amount, and is partly dictated by the size and composition of the meal. In terrestrial mammals, feeding typically elevates metabolism 6-40% over resting rates, depending on the meal composition. Expressed in terms of the energy content of the food consumed, HIF is about 6% for carbohydrates, 13% for fats and 30% for proteins (Blaxter, 1989).

HIF has been investigated extensively in terrestrial mammals (Kleiber, 1975; Webster, 1983) but has been measured in only a few marine mammal species to date. These include sea otters (Costa and Kooyman, 1984), harp seals (Gallivan and Ronald, 1981), harbour seals (Markussen *et al.*, 1994) and Steller sea lions (Rosen and Trites, 1997). When harbour seals were fed herring, metabolic rate increased within 30 minutes of feeding, maximal increase was up to 1.7 times the postabsorptive rate depending on amount of energy intake. Metabolic rate also remained elevated above baseline values in this species for up to 12 hours (Markussen *et al.*, 1994). Rosen and Trites (1997) demonstrated an increase in metabolism of 2.13 times baseline levels after Steller sea lions had been fed 4kg of herring and an increase of 1.76 times baseline after a 2kg meal. The effects peaked at 3.7 hours after feeding for the larger meal and 2.8hr for the smaller meal. These studies show that the increase in metabolic rate after feeding in seals can be quite considerable; if this effect is similar in wild animals then similar increases in metabolic rate may occur during extended periods of foraging. An increase in metabolism of this magnitude during diving is likely to have a significant effect on the amount of time a seal can stay submerged. We examined the effect of simulated foraging and feeding during diving on diving metabolic rate (DMR) and on subsequent dive behaviour, testing the hypotheses that feeding during diving should increase DMR and decrease the duration of subsequent dives due to a reduced ADL.

MATERIALS AND METHODS This study was carried out at the captive animal facility of the Sea Mammal Research Unit in St Andrews. Three female grey seals, two adults (L and Q) and one juvenile (R), were used in this study. All seals were caught in the wild, from local haul-out sites and taken by boat to the captive facility of the SMRU, in St Andrews. Seals were released back into the wild after a maximum period of one year. All handling conformed to the UK's Animals (Scientific Procedures) Act 1986.

During foraging trials seals were trained to swim between a breathing box and an underwater feeding device. Nets were used in the pool to increase the distance which the seals had to swim to get to the feeder. Trials were carried out with the feeder 40, 80 and 120 metres away from the breathing box. The feeder consisted of a moving belt which presented prey items to the seals underwater. The frequency at which fish were placed on the belt could be manipulated in order to vary the rate at which fish were delivered and thus provide the seal with food "patches" of different density. Prey density varied between 0 and 12 fish per minute. Prey densities were randomly allocated among

dives so that prey encounter rates were constant within dives but varied randomly between dives. An underwater camera was positioned above the feeder and was linked to a television and video so that observations of feeding behaviour could be recorded. Seals were fasted overnight before trials. The subject was placed into the experimental pool one hour before the feeding experiment started and the panels closed off so that the respirometry breathing chamber was the only place they could breathe, and they stayed within the set-up for another hour after completion of the feeding experiment. Dives continued until the seals' daily allowance of fish was used up, with a session lasting approximately 1 to 2 hours. Seals were also fitted with time-depth-recorders (Mk 8 TDR, Wildlife Computers), attached to the head of the animals, in order to provide an independent measure of velocity, the duration of travelling time an the duration of dive and surface periods.

RESULTS Changes in diving metabolic rate over time while foraging and feeding DMR is affected by both the duration of the dive and the extent of swimming activity during the dive (Sparling and Fedak 2004). Therefore, when looking for changes in DMR over time we need to ensure that any trend in DMR is not simply a result of variation in activity, especially since PER varied between dives as PER has a large effect on the behaviour of a seal during a given dive. In order to control for any changes in behaviour over the experimental period we first calculated the expected DMR of each dive, using the model developed by Sparling and Fedak (2004), we then plotted the ratio of observed to expected DMR over time since the start of feeding. Since the effect of dive duration and swim speed on DMR is thus completely controlled for, we can be assured that any trend seen in this ratio is due to factors other than behaviour. While diving to the feeder 40 metres away from the breathing box all 3 seals exhibited a non-linear increase in metabolic rate over the feeding period, with the asymptote occurring approximately 30-50 minutes after the onset of feeding (Figure 1). Actual DMR increased to approximately 1.5 times the predicted levels. While diving to the feeder 80 metres away from the breathing box, again all 3 animals exhibited an increase in DMR above predicted levels, occurring at the same time-scale as at 40m, although the patterns are not as clear as at 40m. While diving to the feeder 120m metres away from the breathing box the ratio of observed to predicted DMR did not change with feeding. In this case the ratio of actual to predicted DMR was not significantly different from 1.

Changes in dive duration over time while foraging and feeding Again, because higher PER's resulted in longer dive durations, it is necessary to control for the effect of PER when looking for changes in dive duration that are due to changes in DMR. We did this by first modelling the effect of PER on dive duration and then examining the trends in the residuals from that model. We did this separately for each animal and depth. At 40m, there was a significant non-linear decrease in residual dive duration over the course of the feeding trials for all three seals (Figure 2). There were no trends in residual dive duration over time at either 80 or 120 metres.

DISCUSSION Our data suggest that during deeper (and consequently longer) dives, seals may be deferring the heat increment of feeding in order to maximise dive duration. This suggests that the strategy of deferring HIF is a flexible one which can be invoked when the need arises to maximize dive duration and minimize energetic costs, such as when exploiting prey at deep depths. It may be that while diving to deep depths, they are diving closer to their limits, so there simply isn't the scope for the seals to increase their metabolism and still be able to exploit prey effectively at that depth, due to the increased traveling cost.

The exact mechanism whereby seals achieve this deferment is unclear at present, but may involve a simple cessation of digestion due to the redistribution of blood flow away from the digestive organs during these periods. Previous studies have shown that blood flow is markedly reduced to the intestines during forced dives in Weddell seals (Zapol *et al.*, 1979). Crocker *et al.* (1997) suggested a trade off between the metabolic demands of maintaining the gastro intestinal tract and processing food and locomotion during diving. Rather than try to meet demands of both, they suggested that northern elephant seals may reduce locomotor costs by drifting when increased energy is needed for processing food. Handrich *et al.* (1997) suggested that the decreased abdominal temperatures of foraging king penguins may be a result of a local metabolic depression, associated with a slowing down of digestion, which may serve to reduce the penguins' own energy expenditure during foraging and to accumulate food in their stomach for their chicks.

We do not know how closely our artificial foraging situation resembles the feeding habits of grey seals in the wild. If ingestion of multiple small prey items is spread out over a long time then each item or small meal may not cause a discernable effect and the HIF may never reach a level where it constrains behaviour. But if seals are exploiting rich patches of dense prey rather than sparsely distributed single items it is more likely that there is the potential for HIF to impact upon ADL. Advances in telemetry have enabled us to gain a clearer picture of the diving behaviour and movements of seals at sea (e.g. McConnell *et al.*, 1999) and techniques such as faecal analysis, fatty acid analysis and stable isotopes are providing us with information on diet composition (e.g. Iverson *et al.*, 1997; Rau *et al.*, 1992; Hammond *et al.*, 1994). However, we are still lacking good information on the actual feeding behaviour of wild seals. Recent studies using cameras mounted on seals (e.g. Davis *et al.*, 1999; Hooker *et al.*, 2002; Bowen *et al.*, 2002) have begun to provide some information on a few species. However logistical problems associated with this technique

limits its use (i.e. recovery of the device, battery size, memory size and cost). Further manipulative experiments on animals in captivity of this type, combined with investigations into the feeding habits of wild seals are required to fully understand how the outcomes of the complex interplay between food intake, behaviour and physiology in free-living diving and foraging grey seals.

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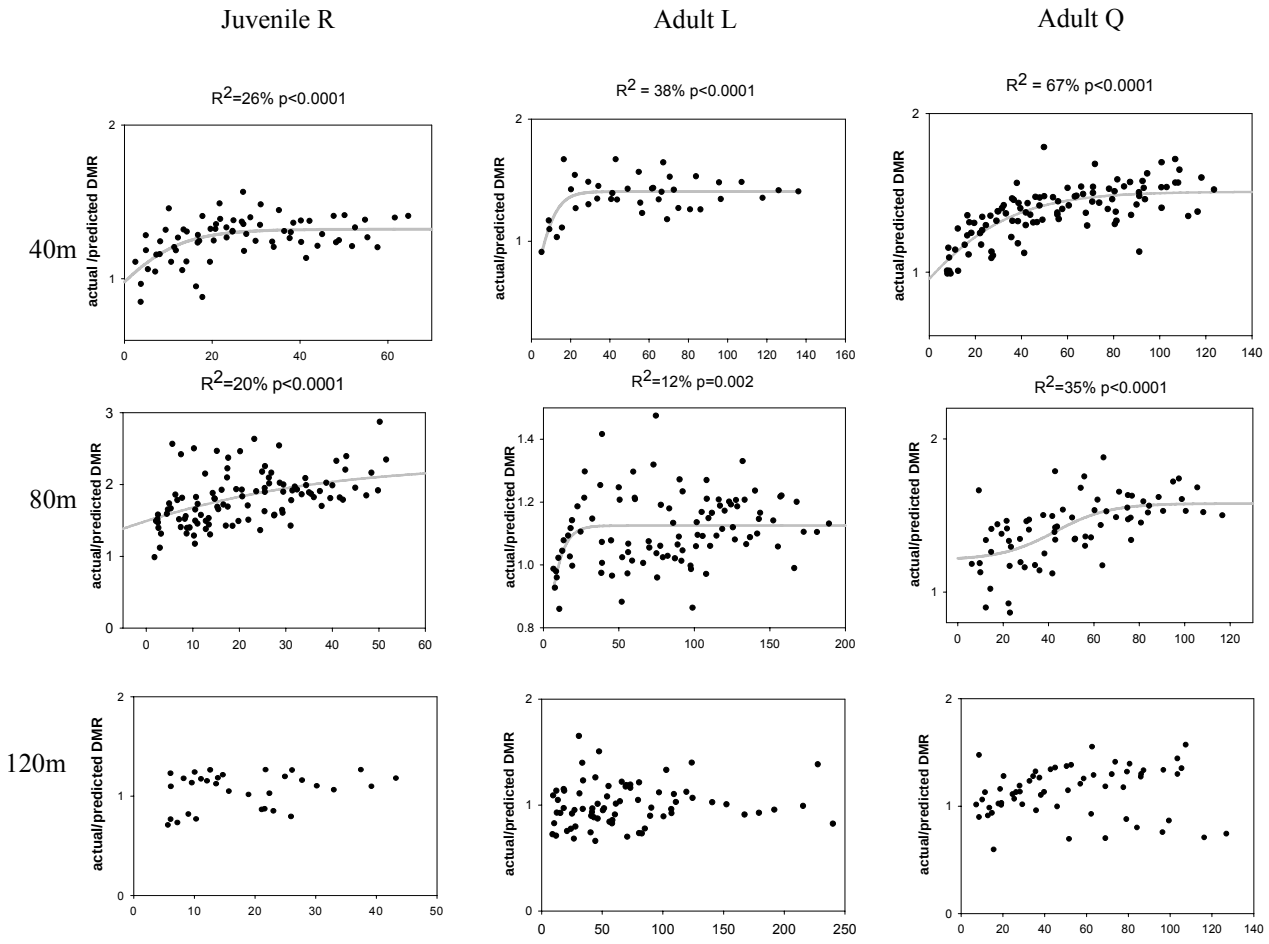

Fig. 1. Changes in the ratio of actual DMR to predicted DMR over experimental foraging periods for 3 female grey seals, diving to feed at a prey 'patch' 40, 80 or 120 metres away from the surface. Lines are non-linear regression fits, where $p<0.05$, associated R^2 values are shown on each graph

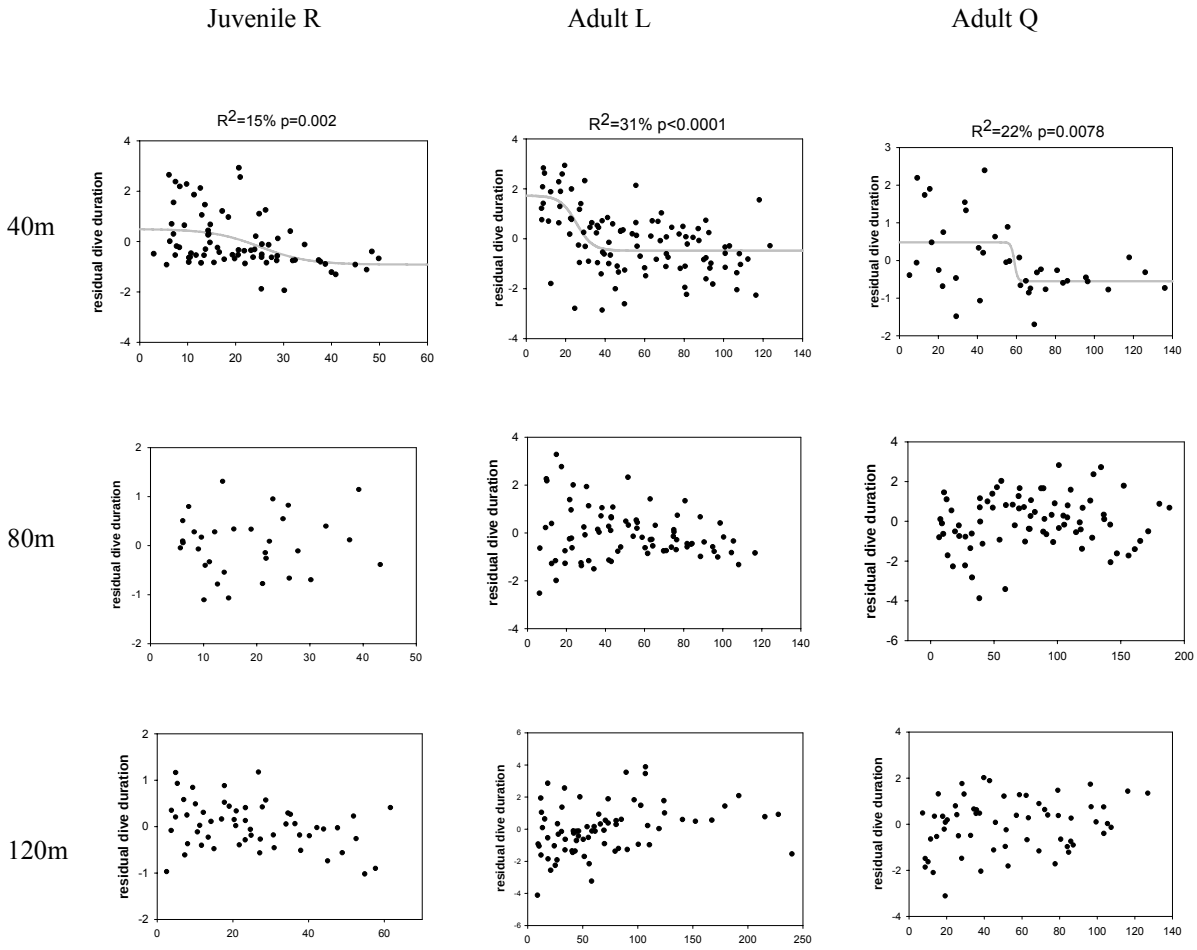

Fig. 2. Changes in residual dive duration (residuals of a model describing the effect of prey density on dive duration) over experimental foraging periods for 3 female grey seals, diving to feed at a prey 'patch' 40, 80 or 120 metres away from the surface. Lines are non-linear regression fits, where $p<0.05$, associated R^2 values are shown on each graph

CARDIAC AND RESPIRATORY MONITORING DURING ARTIFICIAL ACOUSTIC STIMULATION IN THE BOTTLENOSE DOLPHIN (*TURSIOPS TRUNCATUS*)

M. Tocchetti, G. Cansella, I. Tomassini Barbarossa, and A. M. Angioy

Sezione di Fisiologia Generale, Dip. Biologia Sperimentale, Università degli Studi di Cagliari, 09042 Monserrato (CA), Italy

Cardiac activity revealed itself as a focal physiologic tool to monitor behavioural variations, including responses to external sensory stimulation. Changes in respiratory rates, R-R interval and its variability (indirect measurements of sympatho-vagal control) during normal activity and following acoustic stimulation were analysed in a 5-year-old female bottlenose dolphin (*Tursiops truncatus*), housed at the "Acquario di Genova", Italy. Nine experimental sessions at two different times of the day (8.30 am and 4.30 pm) were performed on the animal previously trained to wear and freely swim with a digital ECG recorder. Average respiratory rates were calculated in a 10 minute period before and after an artificial acoustic stimulation. Mean R-R interval (RR) was measured in consecutive 30 second periods before and after stimulation. R-R interval variability was estimated by means of the standard deviation of the RR (SD) and the root mean square of successive differences in R-R intervals (rMSSD).Breathing times did not significantly differ in the two different times of the day, nor following stimulation. In the first 6 experiments, RR measured in the period following stimulation showed a significantly lower value than the period before, increasing to its original value in the subsequent 30 second period. On the other hand in last 3 experiments, RR showed no significant variation among the different periods considered. Absence of respiratory rate differences should allow exclusion of any effects of respiratory arrhythmia on heart activity. Increase of heart rate together with the decrease of SD and rMSSD indicated an improved sympathetic tone and a lower parasympathetic antagonism following the artificial acoustic stimulation used. Response progressively decreased in intensity and duration, until it completely disappeared. Furthermore, RR before the stimulation, was significantly lower in the morning than in the afternoon, possibly reflecting a circadian variation in cardiac activity.

POST-MORTEM CHANGES OF RETINOID CONCENTRATIONS IN THE BLUBBER OF BY-CAUGHT HARBOUR PORPOISES (*PHOCOENA PHOCOENA*)

V. Tornero[1], A. Borrell[1], H. Koopman[2], A. Read[3], P. J. H. Reijnders[4], and A. Aguilar[1]

[1]*Faculty of Biology, University of Barcelona, Diagonal 645, Barcelona, Spain (victoriatornero@ub.edu)*
[2]*Woods Hole Oceanographic Institution, MS No 36, Woods Hole, MA, 02543, USA*
[3]*Nicholas School of the Environment and Earth Sciences, Marine Laboratory, Duke University, 135 Duke Marine Lab Road, Beaufort, NC, 28516, USA*
[4]*Alterra - Marine and Coastal Zone Research, P.O. Box 167, 1790 AD Den Burg, The Netherlands*

INTRODUCTION Retinoids (Vitamin A) are non-endogenous molecules essential for many physiological functions in mammals (Blomhoff *et al*., 1992). Since the metabolism and tissue concentrations of retinoids are affected by exposure to organochlorine compounds, retinoids have been proposed as biomarkers of the impact of this group of pollutants (Borrell *et al*., 2002). Retinoids are largely stored in the liver; therefore, body retinoid status is commonly assessed in mammals through the hepatic concentrations. However, retinoids are lipophilic and can also accumulate in fatty tissues, such as the blubber of marine mammals.

Retinoids are sensitive to light, oxygen, and excessive heat (Barua and Furr, 1998). In field conditions, a long interval of time between death of the individual and sample collection is often inevitable and, during this period, variation in retinoid levels may potentially occur.

In this work we calibrate the effect of post-mortem time on retinoid concentrations in the blubber of harbour porpoises (*Phocoena phocoena*), with the aim of assessing the reliability of samples collected from by-catches. We also investigate whether blubber constitutes a reliable alternative for monitoring retinoid status in this species.

MATERIAL AND METHODS The fieldwork was conducted in the Bay of Fundy during the summer of 2001. A blubber sample was collected at the moment of death from 6 by-caught harbour porpoises. After death, and to mimic natural conditions, animals were placed at a depth of 2 metres underwater and suspended beside the dock; blubber was then periodically re-sampled at 3, 9, 24 and 48 hours. A liver sample was also collected at 48 hours. Water and carcass temperatures were monitored throughout the holding period. After excision, samples were immediately wrapped in aluminium foil and stored at -20ºC. Samples were analysed for retinoids by triplicate by high-performance liquid chromatography (HPLC).

In order to compensate for the undesired variability among individuals, the analytical results from each porpoise were standardised by calculating the proportion that the concentration at each time point (mean of the 3 replicates) represented in relation to the mean concentration of all time points (mean of the 15 replicates: 3 replicates*5 time points). The proportions obtained were the values used in the statistical comparisons.

Differences in retinoid levels were established by an analysis of variance (ANOVA) followed by the Tukey t-test to identify different sample pairs at $p<0.05$. The correlation between retinoid concentrations in liver and blubber was investigated by regression analysis. All calculations were carried out using the SPSS-x statistical package.

RESULTS AND DISCUSSION Table 1 shows the retinoid concentrations found in the various tissue samples. Liver concentrations were approximately 5-6 times higher than those found in the blubber. Concentrations in both tissues were significantly and positively correlated (Figure 1; $p<0.05$, $r^2=0.80$), suggesting that retinoid deposition in blubber and liver is subject to similar processes.

Figure 2 shows the variation of the mean temperature of carcasses and seawater, and the mean relative retinoid blubber concentrations at different time points during the 48 hours post-mortem period. Mean holding water temperature was 12.9ºC. Carcass temperatures decreased drastically from the moment of death to the 48 hours time point. We did not find significant differences in concentrations of retinoids over the study period ($p>0.05$), indicating that the potential degradation agents (oxygen, ultraviolet rays and heat) had no sensible effect on blubber retinoid levels. Before necropsy, the skin cover provided a barrier to ultraviolet penetration in the carcass. From the moment of tissue collection to that of analysis at the laboratory, samples were protected from light by wrapping with aluminum foil and deep freezing, thus avoiding potential degradation by UV rays. On the other hand, the temperature of seawater appeared to be sufficiently low to ensure the stability of retinoids during the study period. Moreover, retinoid loss depends on both the nature of the retinoids and that of the other compounds (e.g. molecular oxygen, tocopherols, ascorbic acid, lipids) present in the tissue. The proteins bound to retinoids, the high lipid content of blubber of cetaceans, and its richness in natural antioxidants are also likely factors to have contributed to the stability of retinoids.

CONCLUSIONS Since blubber retinoid concentrations correlated to those in liver, both tissues appear equally reliable for the purpose of monitoring retinoid status.

1) Blubber can easily be sampled using non-destructive biopsy techniques and its chemical composition is likely to contribute to ensure retinoid stability. Therefore, blubber constitutes a more practical alternative than liver for monitoring retinoid status in porpoises.

2) In the conditions of this study, retinoids remained stable during a 48 hours port-mortem period. As a consequence, blubber is considered reliable for the assessment of retinoid status of unpreserved specimens kept in conditions similar to those of the study. This conclusion should not be extended to stranded individuals, which usually are over 48 hours post-mortem and their retinoid status may be altered by disease or impoverished nutritive condition.

ACKNOWLEDGEMENTS This study was carried out under the International Whaling Commission POLLUTION 2000+ program. Samples were supplied by the BMA Environmental Tissue Bank created with the support of the Pew Fellows Program in Marine Conservation and Earthtrust.

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Table. 1. Sex, body length, blubber retinoid concentrations (0, 3, 9, 24 and 48 hours post-mortem replicates: mean ± SD) and liver retinoid concentrations (48h post-mortem replicates: mean ± SD) of the harbour porpoises studied.

harbour porpoise	sex	body lenght (cm)	n	blubber (mg/Kg)	n	liver (mg/Kg)
69	male	139	15	140.04 ± 41.12	3	877.83 ± 88.82
84	male	119	15	74.23 ± 15.98	3	575.91 ± 118.95
85	male	126	12	103.10 ± 26.00	3	170.98 ± 25.27
184	male	109	15	42.60 ± 10.46	3	252.21 ± 10.57
191	male	129	15	224.03 ± 42.64	3	1679.46 ± 643.92
199	female	150	14	88.26 ± 19.70	3	131.24 ± 52.59

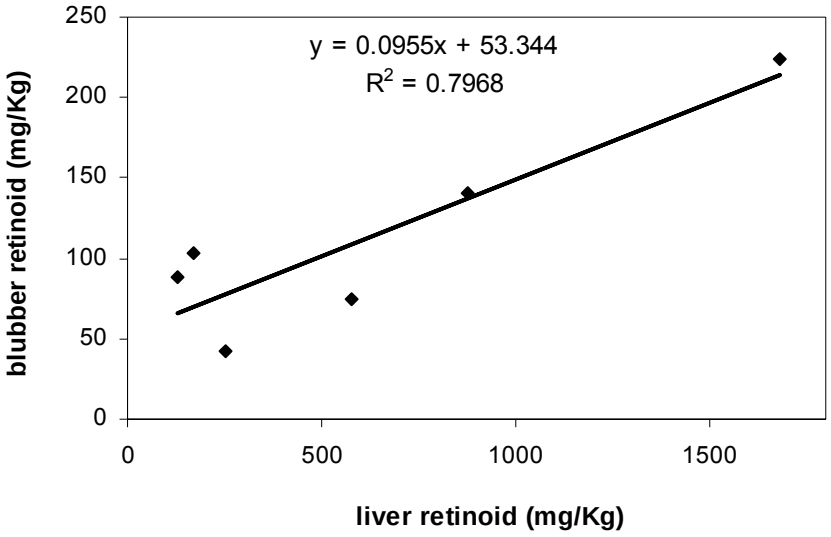

Fig. 1. Correlation between liver and blubber retinoid concentrations

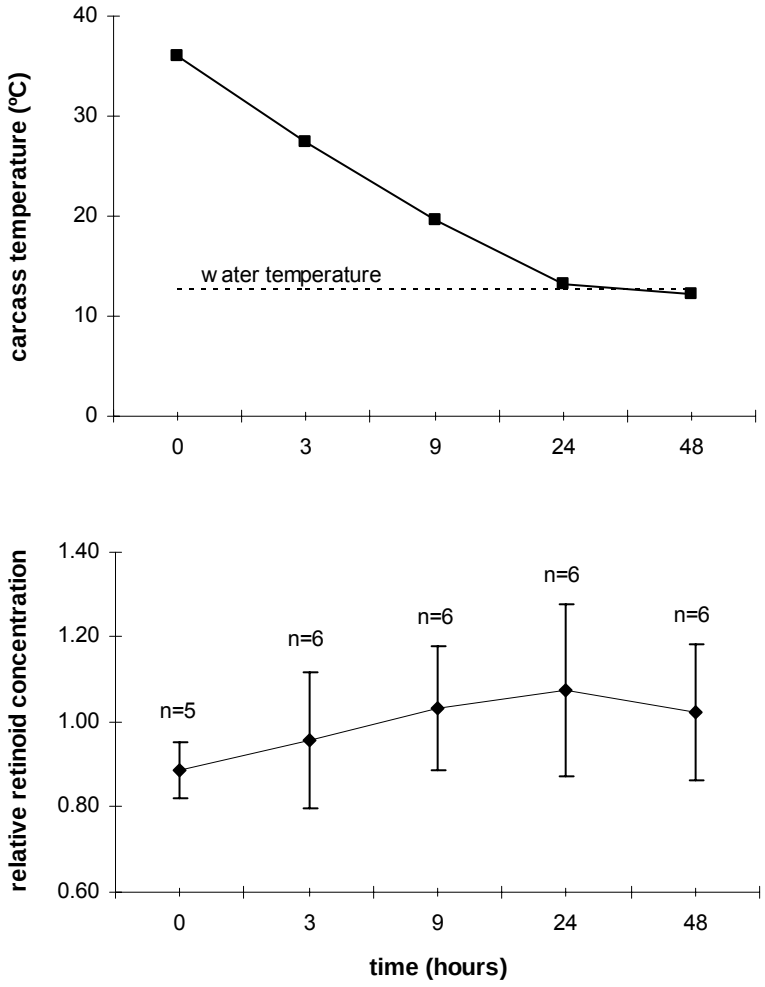

Fig. 2. Means of seawater and carcass temperatures, and of blubber relative retinoid concentrations at each time point: 0, 3, 9, 24 and 48 hr

STOCK IDENTITY AND DISTRIBUTION

COMPARISON OF TWO COMPUTER ASSISTED PHOTO-IDENTIFICATION METHODS APPLIED TO SPERM WHALES

B. W. P. M. Beekmans[1], H. Whitehead[2], R. Huele[1], L. Steiner[3], and A. G. Steenbeek[4]

[1] *Institute of Environmental Sciences, P.O. Box 9518, 2300 RA Leiden,The Netherlands*
[2] *Department of Biology, Dalhousie University, Halifax, Nova Scotia, Canada B3H 4J1*
[3] *Whale Watch Azores, 5 Old Parr Close, Banbury,Oxon OX16 5HY, UK*
[4] *Centre for Mathematics and Computer Science, P.O. Box 94079, 1090 GB Amsterdam,The Netherlands*

The performances of two computer assisted photo-identification methods for sperm whales, namely the Highlight method (as described by Whitehead 1990) and the Europhlukes method, were compared with each other. Performance was measured in terms of speed and accuracy. A test set was constructed containing 592 photos, representing 296 matched pairs of 296 different individuals. The test set was divided into three classes of photographic quality, namely Q3, Q4 and Q5 photos (see Arnbom 1987) and three classes of fluke distinctiveness, measured by the number of marks. Mean extraction time for the Europhlukes method was 90.1 seconds (s = 61.2), compared to 72.4 seconds (s = 15.8) for the Highlight method. Both methods met requirements for fast matching. For the whole test set, as well as the different classes of photographic quality and distinctiveness, no significant difference was found between the the Highlight method and the Europhlukes method with respect to accuracy. The test showed that accuracy improved when using photos of a higher photographic quality or photos representing more distinctive flukes. Still, by using only Q4 and Q5 photos for the test, 12.4% of the matches were not included in the top 9 of the list for the Highlight method, compared to 14.0% for the Europhlukes method. Using both methods together resulted in a much higher accuracy: only 3.3% of the matches could not be found in the top 9. For improved matching, it is therefore recommended that both methods should be used in tandem (although this requires a larger time investment) and that an integrated program, which combines the two methods, should be developed. Furthermore, because only one user performed the test, the influence of user dependence on matching could not be assessed. Because performance of the two methods will probably differ depending on the user, the experiment should be conducted with several users.

A FIRST DESCRIPTION OF CETACEAN SIGHTINGS IN THE COMOROS ARCHIPELAGO (MOZAMBIQUE CHANNEL, INDIAN OCEAN), WITH A SPECIAL REFERENCE TO HUMPBACK WHALES (*MEGAPTERA NOVAEANGLIAE*)

O. Breysse[1], J. Kiszka[1], K. Boinalli [2], and M. Vély[1]

[1] *MEGAPTERA Océan Indien, c/o Marine Mammal Observatory, Direction de l'Agriculture et de la Forêt, BP 103, Mamoudzou, Mayotte (Email: jeremy.kiszka@wanadoo.fr)*
[2]*Parc Marin de Mohéli, Nioumachoua, île de Mohéli, Comores*

INTRODUCTION Few studies on cetacean populations have been made in the islands of the western Indian Ocean Sanctuary (see for example Balance *et al.*, 2001 for the Maldives area; Keller *et al.*, 1982 for the Seychelles; Avolio *et al.*, 2002 for the island of Mayotte, eastern Comoros), and none have been made in the Comoros archipelago (islands of the Islamic Federal Republic of the Comoros). The Comoros are situated in the northern Mozambique Channel, in the western tropical Indian Ocean. The archipelago comprises four main islands, and many surrounding small islets. The islands of *Mohéli*, *Anjouan,* and *Grande Comore* constitute volcanic islands where the marine biodiversity is important. Cetaceans have never been studied in this area, and dedicated small boat surveys were conducted in 2002 and 2003 in order to assess cetacean diversity, distribution, and frequency in the Comoros, with a special attention to humpback whales (*Megaptera novaeangliae*). Preliminary results of these surveys and of opportunistic sightings are presented in this paper.

MATERIALS AND METHODS Two data sources will be considered in this study: (1) Sighting data (species, position, group size, behaviour) collected by two to four permanent observers, onboard small motorized boats (5-7 metres long, 25 to 40 PH engine), around the three main islands of the Comoros (*Anjouan, Mohéli, Grande Comore*), during dedicated closing mode surveys conducted during August and September 2002; (2) Occasional sighting data recorded by experienced observers during trips dedicated to whale filming (n=7 days off *Mohéli*, September-October 2003), and records from the databases of the *Parc Marin de Mohéli,* and the NGO *MEGAPTERA* Océan Indien.

RESULTS Species composition From 2002 to 2003, a total of fourteen marine mammal species, including the dugong (*Dugong dugon,* n=1 sighting) have been recorded in the Comoros (n=151 sightings), *i.e.*: the humpback whale (n=98), the sperm whale (*Physeter macrocephalus*, n=1), spinner (*Stenella longirostris*, n=21), pantropical spotted (*Stenella attenuata*, n=7), Fraser's (*Lagenodelphis hosei*, n=1), both bottlenose (*T. truncatus*, n=3) and presumed Indo-Pacific bottlenose dolphins (*T. aduncus*, n=3), Risso's dolphin (*Grampus griseus*, n=1) melon-headed (*peponocephala electra*, n=2), pygmy killer (*Feresa attenuata*, n=8), short-finned pilot whales (*Globicephala macrorhynchus*, n=3), but also Blainville's (*Mesoplodon densirostris*, n=2), and Longman's beaked whales (*Indopacetus pacificus*, n=1).

Humpback whale distribution and group composition In 2002, a total of 117 hours were spent at sea, during the austral winter (July-October), to undertake cetacean closing mode surveys. Observation effort was concentrated off the south-western part of the island of *Anjouan*, off the southern coast of *Mohéli*, and off the east and northern coasts of *Grande Comore.* The humpback whale was by far the most encountered species during the field season (71.5%), followed by the spinner dolphin (15.3%), other delphinids (including "blackfishes") and beaked whales. A total of 13 groups were encountered in *Anjouan*, 27 off *Grande Comore*, and 23 off *Mohéli* (with 25, 57, and 23 individuals observed, respectively). The species was encountered throughout the study area, with an average occurrence of 0.42 groups/hour of effort off *Anjouan*, vs. 0.56 off *Mohéli*, and 0.60 off *Grande Comore.*

Humpback whale group composition was heterogeneous, with the presence of both mother and calf pairs (48.6%), active groups (14.3%), mother-calf pairs and escorts (20%), and single individuals and singers (17.1%). A photo-ID catalogue has been set-up during the surveys, but no sightings between years have been recorded. However, site fidelity between-days, was observed in three individuals in Mohéli. At least one individual was a female.

DISCUSSION AND CONCLUSIONS Many species of marine mammals can be found in the Comoros waters. The diversity is high, and several poorly known species have been observed. Recent observations seem to confirm the presence of a resident pygmy killer whale population, probably doing offshore to inshore movements off the island of *Grande Comore*. Sightings of spinner dolphins and pantropical spotted dolphins were underestimated in the occasional sighting record database. Indeed, they were not systematically recorded due to their very high frequency. We suspect these species are resident. However, the residency and population size of small delphinids also needs to be assessed. Presumed Indo-Pacific bottlenose dolphins seem to occur close to the shores of both islands. Conversely to the French

island of Mayotte, eastern Comoros, the Indian Ocean humpbacked dolphin (*Sousa plumbea*) has been not recorded in the other islands of the Comoros (Avolio *et al.*, 2002).

The humpback whale is the most common species during the austral winter (July to October), the reproductive period. This population (C2 population, Avolio *et al.*, 2002) is actually unknown in terms of abundance and habitat utilization. Its genetic identity, in the context of the south-western Indian Ocean, also needs to be confirmed. It is probably linked with the humpback whales occurring off the island of Mayotte. The high proportion of mother-calf pairs indicates that the waters off the Comoros play a major role as a nursery ground even if competitive groups and singers have been observed. In Mayotte, humpback whales groups are also mainly mother-calf pairs (Avolio *et al.*, 2002).

Further studies on the spatial/temporal distribution, abundance, inter-island movements, and vocal repertoire of humpback whales are planned, as well as research on toothed cetaceans, especially on pygmy killer whales. The conservation status of marine mammal populations is currently unknown, but cetaceans seem to be preserved because of the very low concentration of coastal and marine human activities.

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THE POPULATION STRUCTURE OF THE WHITE SEA BELUGAS IN THE ONEGA BAY

A. D. Chernetsky, and M. Bel'kovichv

Shirshov Institute of Oceanology RAS, 36 Nakhimovsky av., 117997, Moscow, Russia

According to our earlier studies, the White Sea population of belugas is composed of several local herds with each herd developing a reproductive gathering (RG) during summer time. The development of reproductive gatherings is a very important period for the entire population. The distribution range is shrinking down to several distinct territories, where belugas give birth, copulate and establish hierarchical and social relationships. As a result of our ship and aerial surveys, carried out between 1999–2002, we have described at least four beluga local herds in the White Sea Onega Bay (Soolovetsky, Zhizhginsky, Myagostrov and Southern herds). We aimed at comprehensive characterization of the spatial distribution as well as an estimation of how anthropogenic and natural forces influence the utilization of certain regions by belugas. In 2003, we carried out our observations from four coastal observation points (Solovetzky Island, Myagostrov Island, Lesnaya Osinka Island, and Cape Gluboky) and two sail-motor boats. The boats were rigged with special acoustical equipment allowing detection and recording of underwater signals. At favorable weather conditions, our equipment allowed us to locate beluga individuals for up to 5 km. As a result of our studies, we obtained new data on the population dynamics, distribution and behaviour of beluga whales. Observations near Myagostrov Island and Cape Gluboky confirmed the presence of two local herds in the south part of Onega Bay. We determined the locales of RGs of the Myagostrov and Southern herds and refined data on their distribution limits. According to our studies, the reproductive gatherings of belugas in the various parts of the sea are distinct in terms of their localisation, range of feeding grounds and usage dynamics of reproductive areas. These features are closely related to biological, natural and anthropogenic factors. We determined the critical habitats (RG), which require close attention and protection.

SUMMER SPATIAL DISTRIBUTION OF CETACEANS IN THE STRAIT OF GIBRALTAR IN RELATION TO THE OCEANOGRAPHIC CONTEXT

R. De Stephanis[1,2], N. Pérez Gimeno[1,2], J. M. S. Sierra[1], and C. Guinet[3]

[1] CIRCE, Conservation Information and Research on Cetaceans, C/Cabeza de Manzaneda 3, Algeciras-Pelayo, 11390 Cadiz, Spain
[2] Laboratorio de Acústica y Vibraciones de la Universidad de Cádiz, CASEM, Polígono Río san Pedro s/n Puerto Real Cádiz, Spain
3 Centre d'Études Biologiques de Chizé, CNRS UPR 1934. 79 360 Villiers en Bois, France

The Strait of Gibraltar, the only natural passage between the Mediterranean Sea and the Atlantic Ocean, characterised by a surface inflow of Atlantic waters and a deep outflow of dense Mediterranean waters, is inhabited by a large number of cetacean species. The present study focuses on the occurrence and the spatial distribution of cetacean species within the Strait in relation to oceanographic features. Boat surveys were conducted during the summers 2001 and 2002, covering 3 396km. A total of 399 sightings of 7 cetaceans species were recorded. The spatial distribution of 6 odontocete species: common dolphins (*Delphinus delphis*), striped dolphins (*Stenella coeruleoalba*), long-finned pilot whales (*Globicephala melas*), bottlenose dolphins (*Tursiops truncatus*), sperm whales (*Physeter macrocephalus*), and killer whales (*Orcinus orca*) was examined with respect to the depth, slope, latitude and longitude. These analyses indicate that these species could be ordered into three groups. The first group, with a northward tendency, is composed by common and striped dolphins assumed to be feeding on mesopelagic fishes or squids associated with the surface Atlantic waters due to its at sea-location and feeding habits. The second group, comprising bottlenose dolphins, long-finned pilot whales and sperm whales is mainly found over the deep waters of the central part of the Strait. While the foraging ecology of bottlenose dolphins is still unclear, both sperm whales and pilot whales are most likely to be feeding on squids occurring in the deep Mediterranean waters. The third group, formed by killer whales (*Orcinus orca*) was always associated with blue fin tuna (*Thunnus thynnus*) fisheries occurring in the southwestern part of the Strait.

SEASONAL AND INTER-ANNUAL DISTRIBUTION OF HARBOUR PORPOISES (*PHOCOENA PHOCOENA*) IN A HIGH DENSITY AREA IN THE GERMAN BIGHT WITH SPECIAL EMPHASIS ON MOTHER-CALF PAIRS

A. Gilles, M. Scheidat, and U. Siebert

Forschungs- und Technologiezentrum Westkueste der Christian-Albrechts-Universitaet zu Kiel, Hafentoern, 25761 Buesum, Germany (gilles@ftz-west.uni-kiel.de)

In the German North Sea, the area "Amrum Aussengrund" is frequently used by harbour porpoises. Aerial surveys conducted in 2002 and 2003 revealed harbour porpoises visit this area approximately ten times more often than other areas in the German Bight. The aim of this study was to describe the seasonal distribution and density of harbour porpoises with a special emphasis on the occurrence of mother-calf pairs. The hypothesis that these pairs use a different habitat than other social groups was tested. In the study area (5,085 km^2) eight transects were surveyed, using the standard line-transect method, five times in 2002 (393.4 km^2) and six times in 2003 (344.9 km^2). GIS-analysis (ArcGIS 8.2) was applied dividing the study area into a grid of 64 cells (10x10 km). In 2002 (May to October) a total of 490 porpoises (including 14 calves) were sighted. The highest density, with 3.07 animals per km^2, was calculated in May 2002. Between February and October 2003, a total of 640 porpoises (including 40 calves) were sighted. The highest density, with 3.31 animals per km^2, was calculated in June 2003. Density of harbour porpoises showed a highly seasonal variation in both years, with the highest values recorded in the early summer and the lowest in the late autumn and winter months. The overall distribution of porpoises was seasonally different: aggregations of up to 60 animals, observed in the centre of the area, were detected in early spring whereas the distribution in summer was more even. It was not possible to detect clear differences in habitat use by mother-calf pairs. The results may be biased due to limited number of mother-calf pairs detected and/or the possibility that the analysed area was too small to detect gradients in mother-calf pair distribution. In future, more surveys should be conducted in winter months to enhance the knowledge of seasonal distribution.

DISTRIBUTION OF CETACEANS IN RELATION WITH ENVIRONMENTAL FACTORS IN CENTRAL SPANISH MEDITERRANEAN WATERS

A. Gomez De Segura[1], P. S. Hammond[2], and J. A. Raga[1]

[1] *Departmento de Zoología, Universidad de Valencia, P.O. Box 22085, E-46071, Valencia, Spain*
[2] *Gatty Marine Laboratory, University of St Andrews, Fife KY16 8LB, St Andrews, UK*

Seasonal aerial surveys were conducted in the waters of Valencia and Murcia (Spain) between 2000 and 2002 using line transect methodology to obtain data about the distribution of cetacean species in this area. The primary influence over cetacean distribution is probably the aggregation of prey species, but this information is typically very difficult to obtain. However, some environmental parametres play an important role in the distribution of prey species, and may thus provide an indirect explanation of cetacean distribution. We recorded information on the following parametres in the study area: depth, slope, distance to the coastline and standard deviation of sea surface temperatures among months (a measure of variation in water temperature). We divided the survey tracks into 5-mile segments, then characterised each segment by the mean of each environmental parametre and the presence or absence of each cetacean species. The data for the three most common species, striped dolphin (182 sightings), bottlenose dolphin (29 sightings) and Risso's dolphin (15 sightings), were analysed using Generalised Linear Models (GLMs) with the presence/absence of each cetacean species as the response variable and the environmental parametres as covariates. For bottlenose dolphins, no significant relationship was found with any covariate, including depth, even though no bottlenose dolphin was observed in waters greater than 1000m, as also seen in other studies in the Mediterranean. The distribution of both striped and Risso's dolphin was significantly related to a quadratic function of depth ($p<0.05$). The striped dolphin was observed in waters between 100 and 2600m, preferring areas between 900 and 1500m in depth. Risso's dolphin was sighted in depths between 500 and 2600m, preferring waters between 1700 and 2300m in depth. In both cases, depth alone explained a large extent of the distribution of animals observed in the area.

THE HARBOUR PORPOISE (*PHOCOENA PHOCOENA*) IN THE SOUTHERN NORTH SEA: A COME-BACK IN NORTHERN FRENCH AND BELGIAN WATERS?

J. Haelters[1], J. Kiszka[3, 4], T. Jauniaux[2], and J. Tavernier[1]

[1] *Royal Belgian Institute of Natural Sciences (RBINS), Management Unit of the North Sea Mathematical Models (MUMM), 3e en 23e Linieregimentsplein, B-8400 Oostende, Belgium*
[2] *Pathology Department of the Veterinary College, University of Liège, B43 Sart Tilman, B-4000 Liège, Belgium*
[3] *Coordination Mammalogique du Nord de la France, Marine Mammal Section, c/o 140, rue Marcel Sailly, F-59123 Bray-Dunes, France (Email: jeremy.kiszka@wanadoo.fr)*
[4] *Groupe Ornithologique et Naturaliste du Nord-Pas-de-Calais, c/o 140, rue Marcel Sailly,F-59123 Bray-Dunes, France*

INTRODUCTION The harbour porpoise (*Phocoena phocoena*) is the most abundant cetacean in the North Sea (Hammond *et al.*, 1995). However, during the twentieth century, it declined drastically in many regions, particularly in the southern North Sea (Smeenk, 1987; Camphuysen and Leopold, 1993; Camphuysen, 1994). The factors of this decline seem to be related to human activities, such as overfishing, incidental catch in fishing gear, pollution, and habitat degradation (Hammond *et al.*, 1995). Here we present an analysis of stranding records of harbour porpoises along the northern French and Belgian coasts from 1990 to 2002. Since the late 90's, trends of stranding records seem to underline a come-back of the harbour porpoise in the southern bight of the North Sea. Possible factors of the increased number of harbour porpoise strandings are discussed.

MATERIALS AND METHODS Stranding data were collected by correspondents of the French Stranding Network (*RNE,* co-ordinated by the *Centre de Recherche sur les Mammifères Marins*, la Rochelle, France), and by the Belgian group *Marine Animals Research and Intervention Network* (MARIN, co-ordinated by the Royal Belgian Institute of Natural Sciences, Management Unit of the North Sea Mathematical Models (MUMM). To investigate the status of the harbour porpoise, we analysed the inter– and intra-annual distribution of strandings, their composition (sex and age-ratios), and the causes of death of most of the stranded individuals. Necropsies were performed at the University of Liège, Belgium (Department of General Pathology).

RESULTS Between 1990 and 2002, 155 harbour porpoises stranded along the northern French (n=56) and Belgian (n=99) coasts. From 1990 to 1996, the mean annual stranding number was low in both areas (mean annual number=5.3; SD=1.8; min=3; max=9; n=33). However, it increased significantly from 1997 to 2002 (*Pearson, p*=0.001; mean=22.6; SD=22.6; min=11; max=36) (Fig. 1). The sex-ratio was normal and all age classes were represented (Fig. 2), with a higher presence of immatures. In the late 1990's, we observed a re-emergence of stranded newborn individuals, and recorded for the first time a pregnant female (in 2001,on the Belgian coast), probably reflecting calving in northern French and Belgian waters. A clear seasonality occurred with more strandings occuring during late winter and early spring (Fig. 3). Post mortem investigations revealed that 20% of the animals presented evidence of by-catch in fishing gear. The main macroscopic lesions were emaciation, parasitosis, and pneumonia. Microscopic lesions were acute pneumonia, pulmonary oedema, enteritis, and hepatitis. Encephalitis was observed on a few individuals.

DISCUSSION AND CONCLUSIONS Similar to the Dutch coast, the harbour porpoise seems to have made a come-back in the southern bight of the North Sea, however this has occurred somewhat later than observed in the Netherlands (Camphuysen and Leopold, 1993; Camphuysen, 1994). The increasing number of harbour porpoise strandings along the southern North Sea coast may be related to an increase in mortality, due to natural diseases or human activities (such as by-catch). However, *post mortem* investigations did not show any sign of epizooty, or other potential factors of highest mortality. In conclusion, we suspect an increase in the size of the southern North Sea porpoise population. The growing number of harbour porpoise strandings these last years along the northern French and Belgian coasts coincides with an increase of sightings in coastal waters (like off the Dutch coast), especially during the spring months (MUMM & CMNF, unpublished data).

Movements of other populations (from the northern or eastern North Sea) to the southern North Sea sector may have affected the abundance of the species, this may be the result of changes in prey availability and/or environmental changes in the southern North Sea and/or in other areas of the North Sea. The increase of herring (*Clupea harengus*) stocks in the southern North Sea in the late 1990's may have provoked the come-back of the harbour porpoise in this area (IFREMER, *pers. comm*.). During the same period, herring stocks declined in the northern North Sea (IFREMER, *pers. comm*.). However, preliminary investigations of the diet of harbour porpoises from the southern North Sea (individuals from the Netherlands) confirmed a low presence of herring and other clupeid fishes (Addink, pers. com.).

Consequently, more investigations on the ecology, habitat, distribution and abundance of the harbour porpoise in the southern North Sea are clearly needed to better understand its current status.

ACKNOWLEDGEMENTS The work of the intervention network would not be possible without the support and dedication of a large number of collaborators, volunteers, institutes and authorities. We would especially like to thank André Lastavel, Nathalie Maytas, Sylvain Pezeril, Jean-Michel Charpentier, Jacky Karpouzopoulos, Perrine Prinzivalli and all other members of the French Stranding Network (co-ordinated by the Marine Mammal Research Center of la Rochelle, France), Jan Tavernier, Dr. John van Gompel, and Sea Life Blankenberge.

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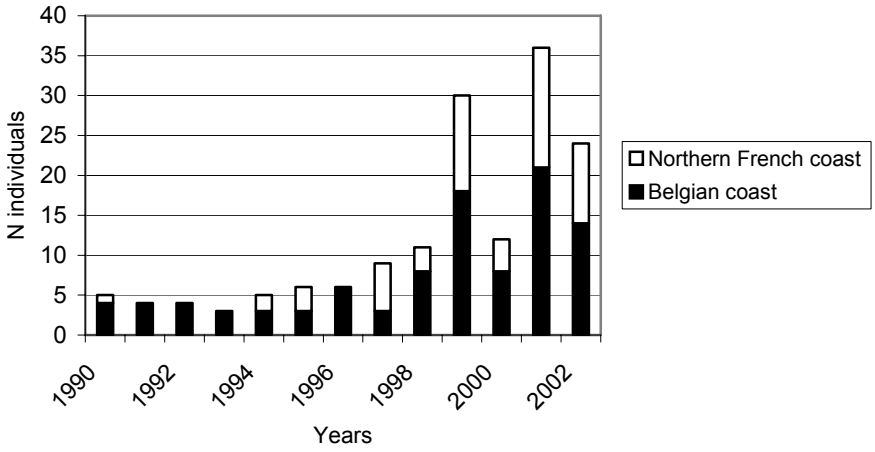

Fig. 1. Inter-annual distribution of harbour porpoise strandings along the northern French and Belgian coasts from 1990 to 2002

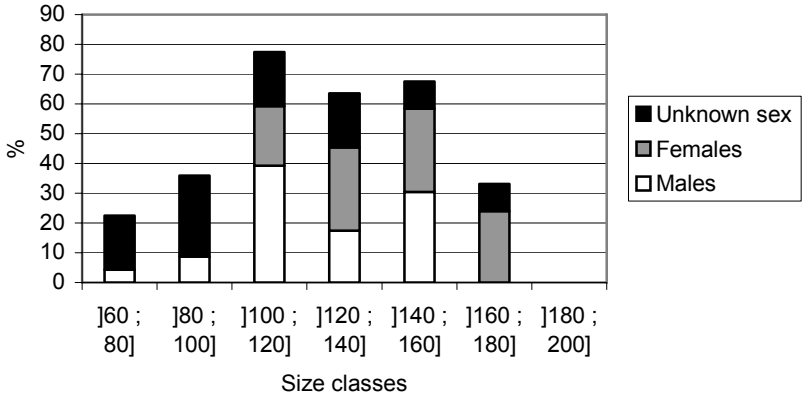

Fig. 2. Size and sex distribution of harbour porpoises stranded along the northern French and Belgian coasts from 1990 to 2002

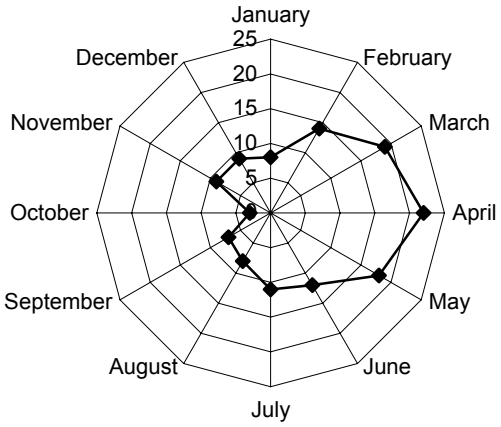

Fig. 3. Monthly distribution of harbour porpoise strandings along the northern French and Belgian coasts from 1990 to 2002

INCREASING RECORDS OF BALAENOPTERID WHALES IN THE OUTER BALTIC SEA DURING 1994-2003: RISE IN EFFORT OR NEW FAUNISTIC PHENOMENON?

C.C. Kinze[1], T. Jensen[2], U. Siebert[3], and G. Schulze[4]

[1]*CCKonsult, Falkoner Alle 35 1th, DK-2000 Frederiksberg, Denmark*
[2] *Fisheries and Maritime Museum, Tarphagevej 2, DK 6710 Esbjerg V, Denmark*
[3] *Forschungs- und Technologiezentrum Westkueste, Hafentoern, D-25761 Buesum, Germany*
[4] *Deutsches Meeremuseum, Katharinenberg 14/20, D-18439 Stralsund, Germany*

During the last decade four species of balaenopterids have been documented from the Kattegat, Belt Sea and western Baltic Sea. The minke whale (*Balaenoptera acutorostrata*) was the most frequently encountered species with sightings or strandings in 1995, and annually from 1999 through 2003. The fin whale (*Balaenoptera physalus*) was sighted during 1997 and 2003 while the humpback whale (*Megaptera novaeangliae*) was encountered in 1995, 2002 and 2003, respectively. In addition, a single record of the Bryde's whale (*Balaenoptera brydei*) was documented in 2000. Facultative coastal and ecological flexible balaenopterids (minke, fin and humpback) outnumber the strictly oceanic species (blue, sei and Bryde's) by a factor of 15. Compared to the average number of records during earlier decades (1904-1993), an increase in their numbers of more than five fold has seemingly occurred, this in part is due to an increase in observer's effort. We further offer two explanations for the eight fold increase in the number of minke whale sightings recorded during the most recent decade: either the records reflect the natural background occurrence or they provide evidence for a growing population in the North Atlantic. For the fin whale an increase of 1,7 may solely mirror the natural fluctuations while the occurrence of humpback whales and oceanic species may be governed by hydrographical phenomena.

PHOTO-IDENTIFICATION OF BOTTLENOSE DOLPHINS IN THE CARDIGAN BAY CANDIDATE SPECIAL AREA OF CONSERVATION

P. Lastra[1, 2], and F. Ugarte[1, 3]

[1] *Cardigan Bay Marine Wildlife Centre. New Quay, Ceredigion SA45 9PS Wales-UK*
[2] *Universidad de Las Palmas de Gran Canaria, Spain*
[3] *Sea Watch Foundation, UK*

Our study area is the Cardigan Bay candidate Special Area of Conservation (cSAC), Wales. The area was named a cSAC in order to protect the local population of bottlenose dolphins, a target-species of "community interest" under the European Community's Habitats Directive. Boat-based surveys for bottlenose dolphins were carried out from May to September 2003 from a 10m motor vessel. Photographs of natural markings on the dorsal fin were taken in order to identify individual animals. In each encounter, group size, structure, group composition and behaviour were recorded. In order to look for potential preferred areas and possible seasonal movements, the locations (lat-long) of identified animals were plotted onto a chart using MapInfo software. Photographs were matched, classified, and catalogued based on irregularities in the dorsal fin. A total of 134 dolphin groups were photographed. To date (November 2003), 41 encounters have been analysed and 64 "well marked" individuals (i.e. animals with irregular fins that can be recognised from pictures from either side) have been recognised. An average of 70% of the dolphins are well marked (SD=29, n=30 group counts). The results of a discovery curve suggest that we have identified a considerable proportion of the "well marked" individuals using the area during the period analysed. 60% of the identified dolphins have been re-sighted at least once (and some up to 7 times), indicating a high degree of residency in the population during the study period. The distribution pattern of individual dolphins over the summer period indicates that some animals have preferred areas, whilst others are highly mobile within the cSAC. Comparisons with earlier catalogues show that some animals have been regularly seen in the study area for more than a decade. This study provides evidence that a small population of bottlenose dolphins occurs regularly in the Cardigan Bay cSAC during summer.

CETACEAN POPULATION IN COAST OF THE BASQUE COUNTRY: A FIRST APPROACH

E. Marcos-Ipiña[1, 2], J. M. Salazar-Sierra[1, 2], and R. De Stephanis[2]

[1] *E.I.B.E. C/ Baserritar Etorbidea 6 3ºD 20280 Hondarribia, SPAIN.*
(enara@eibeh.org / juanma@eibeh.org)
[2] *CIRCE Spain, Cabeza de Manzaneda 3, Pelayo 11390, Algeciras, SPAIN. (renaud@teleline.es)*

INTRODUCTION The Bay of Biscay is a zone of interest for cetacean populations, several studies showed a high diversity in this area, in which a total of 23 cetacean species were identified (Brereton *et al.,* 2001). In this frame, a preliminary study has been done to determine the diversity and distribution of cetaceans during the summer in the adjacent waters of the geographic territory of The Basque Country, the south-eastern part of the Bay of Biscay. This survey, supported by EIBE, has been carried out along the coast of the Basque Country, between April 2003 and September 2003. The aim of this study is to provide baseline information on the diversity, and distribution of cetaceans in this area. (Fig. 1)

MATERIALS AND METHODS A total of 2,004.34 kilometres have been sailed along the Basque coast, between April 2003 and September 2003, totalling an average of 77.09 km per survey day. All these transects were carried out on board a 15 metre long boat, covering 7.532,32 km^2. Data regarding effort of observation, as well as environmental and sighting data was recorded onboard, following the methodological protocols of the Spanish Cetaceans Society (SEC 1999).(Fig. 2.) Only data recorded where the sea state was 3 or less in the Douglas scale, was taken into account for the data analysis. Data were analysed using GIS software (Arc View GIS 3.2), with its extension animal movement (Hooge and Eichenlaub, 2000); and the Statistics program SPSS 1.1, to estimate the spatial distribution of the species according to the depth. The survey area was divided in 4 depth classes. The nautical miles sailed were calculated in each depth class to normalise the distribution of the species in the area. Once the miles were calculated and the sightings normalised, the encounter rate of cetaceans in each depth class was obtained.

RESULTS AND DISCUSSION Ten different species were encountered in a total of 31 sightings. The most frequent species observed during the season was the bottlenose dolphin (*Tursiops truncatus*) with 9 sightings (29%), striped dolphin (*Stenella coeruleoalba*) with 6 (19%), common dolphin (*Delphinus delphis*) with 5 (16%), non identified Ziphiidae, 3 (10%), Cuvier´s beaked whale (*Ziphius cavirostris*), 2 (6%) long-finned pilot whale (*Globicephala melas*), 2 sightings (6%), short-finned pilot whale (*Globicephala macrorynchus*), 1 (3%), Risso´s dolphin (*Grampus griseus*), 1(3%), sperm whale (*Physeter macrocephalus*), 1 (3%), and minke whale (*Balaenoptera acutorostrata*), with only one sighting (3%) (Fig. 3). The unusual sighting of a short-finned pilot whale seems to confirm the possibility that the limit of the geographical range of this species is the Bay of Biscay (Nores and Pérez, 1988).

The map shows the presence of bottlenose dolphins in the continental platform and in the deepest areas of the Canyon of CapBreton, a higher diversity of cetaceans is appreciated in deep waters (1,201-2,000 metres). Only bottlenose dolphins and a single sighting of minke whale have been recorded on the continental platform (Fig. 4).

From the data collected, the distribution of all the species with respect to the depth was examined. Significant differences were observed between encounter rates in relation to the effort and depth. A greater number of cetaceans were observed in deep water. A 55% rate of encounter was observed in the deepest zone of the canyon of Capreton where waters range from 1,201 – 2,000 m, whereas 29% of the total encounters were recorded in the continental slope at depths between 601 and 1,200 m, 11 % between 200 and 600 m, and 5% in the continental platform where the only cetacean present was the bottlenose dolphin (Fig. 5).

CONCLUSSION Ten different species were encountered, with an unusual sighting of short-finned pilot whale that was not registered in the area before. A greater presence in depths from 1,200 -2,000 m is shown, located mainly in the zone of the canyon of CapBreton.

ACKNOWLEDGEMENTS We wish to express our gratitude to Circe; Renaud de Stephanis, Cristhophe Guinet, Neus Perez, and Philippe Verborgh. Special thanks to the numerous field assistants who have helped us (Antonio Villar, Txurru, Ane, Silvia, Willy, Agurtzane, Txema, Adriana, Paula, Antonio, Iñigo, Sonia, Monica, Manolo, Patricia, Evix, Eva, Zaida). Thanks also to SEC and to Azti; to Raul Castro, Ainhize Uriarte and Diego Mendiola. Finally, thanks to the nautical club of Hondarribia, to the fishermen of Hondarribia, to all the members of EIBE (Hilario, Marcela, Igor, Telmo, Beñat), and to these fantastic animals.

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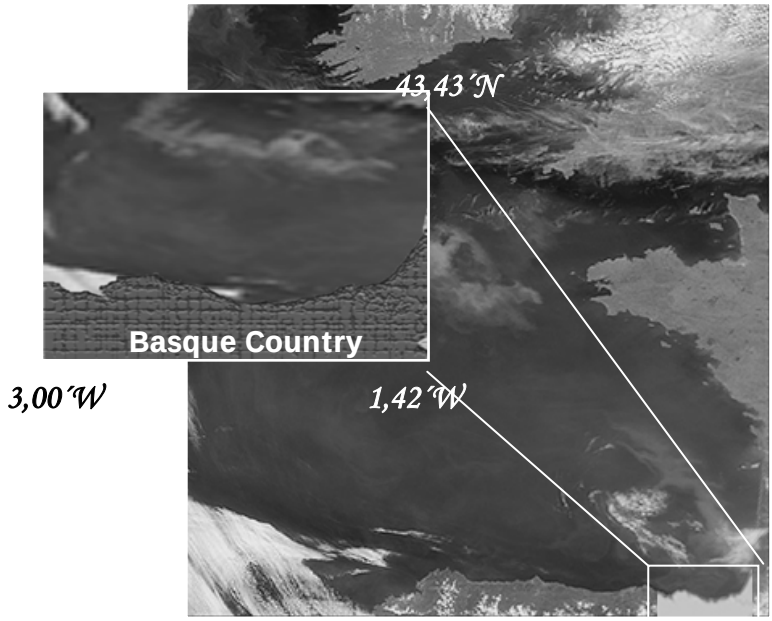

Fig. 1. Geographical situation of the area of study

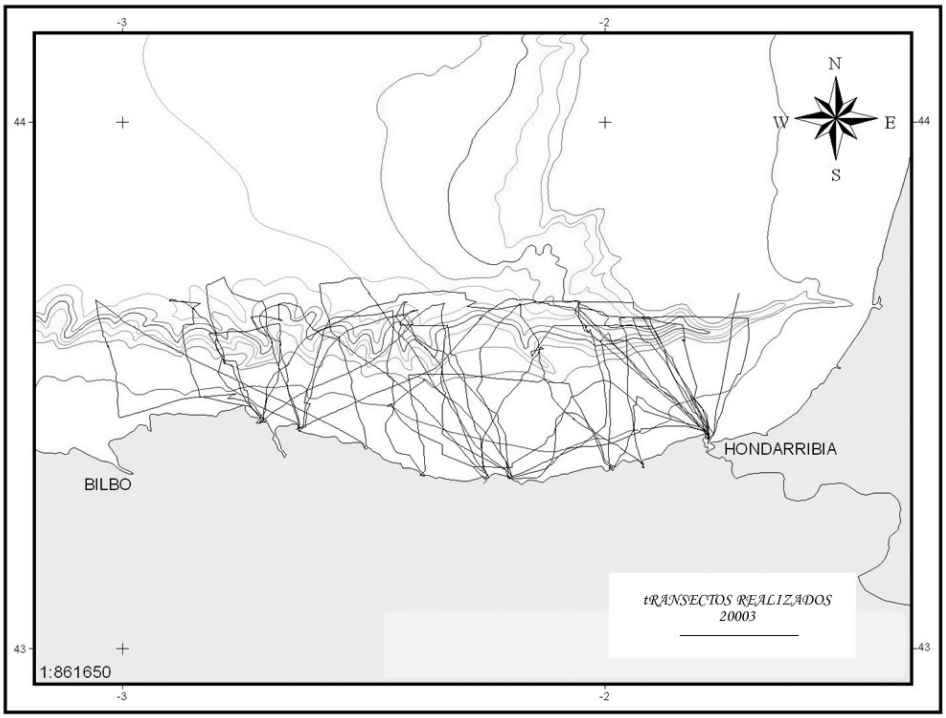

Fig. 2. Map showing the shipboard transects.

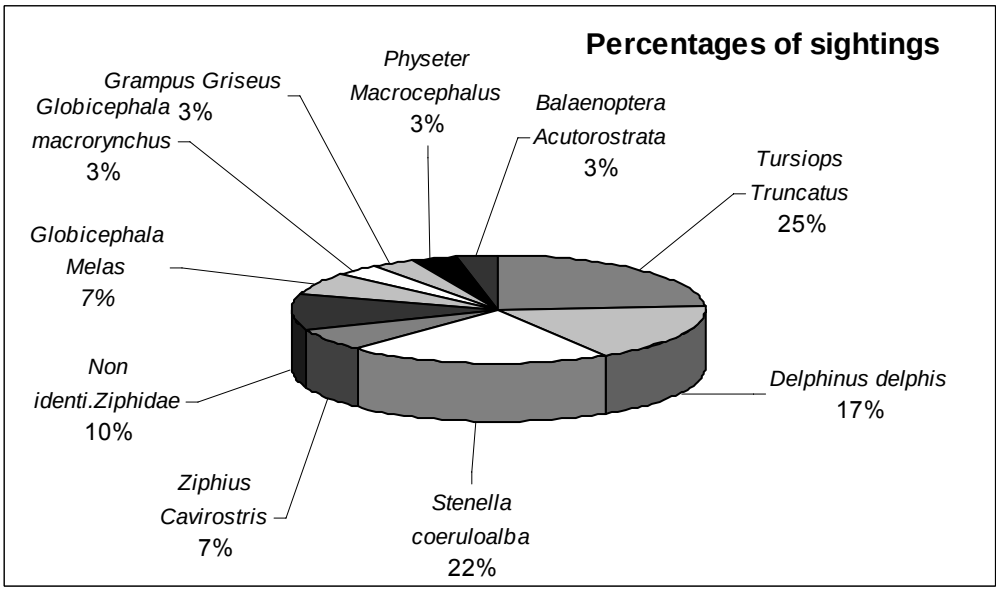

Fig. 3. Percentages of sightings per species

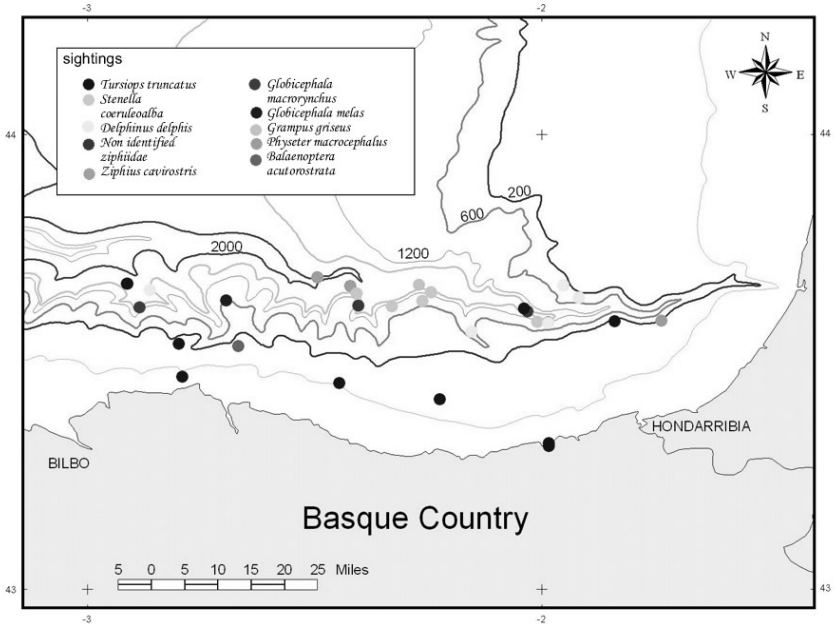

Fig. 4. Sightings survey 2003

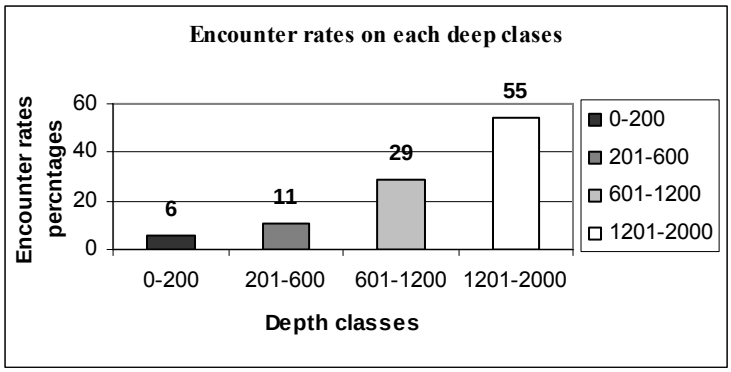

Fig. 5. Encounter rates percentages on each depth classes

SPRING DISTRIBUTION PATTERN AND SITE FIDELITY OF STRIPED DOLPHINS, *STENELLA COERULEOALBA*, OFF NICE (NW MEDITERRANEAN SEA)

A.M. Meissner[1, 3], A. Gannier[1, 2], V. Ridoux[3], S. Bourreau[1, 2], S. Laran[1, 2], and B. Lombrail[1]

[1] *Centre de Recherche sur les Cétacés-Marineland, 306 avenue Mozart, 06600 Antibes, France (crc@marineland.fr)*
[2] *Groupe de Recherche sur les Cétacés, 741 chemin des moyennes Bréguières, villa 13, 06600 Antibes, France (assgrec@wanadoo.fr)*
[3] *Laboratoire de Biologie et d'Environnements Marins, Port des Minimes, 17000 La Rochelle, France (vincent.ridoux@univ-lr.fr)*

INTRODUCTION The striped dolphin (*Stenella coeruleoalba*) is the most abundant cetacean in the Western Mediterranean Sea (Forcada *et al*., 1995) and is present all year round (Gannier, 1995). In order to better describe the habitat use of this species, we studied coastal schools of striped dolphins in spring 2003.

MATERIALS AND METHODS The observation protocol was divided in two parts. The first one aimed at locating the dolphins. The survey was a zigzag leg, travelled at 7 knots, between Cap Ferrat and Cap Roux (A1 to A19) extending to 10km offshore (Figure 1). The way to A1 and from A19 was made with an average speed of 12 knots. Surveys were conducted only with good environmental conditions (equal or lower than Beaufort 3). Three observers searched the 180° frontal sector with naked eyes at 3m above sea level using binoculars for the collection of sightings data collection. Additionally, acoustic sampling (1-2 minutes of headphone listening and recording) was performed every 3.7 km completed by a record of environmental parametres. The second part consisted of distant tracking. Once sighted, dolphins were approached at about 200m and followed in order to estimate the size and composition of the group and determine its activity (socialising, feeding, resting, travelling). A photo-identification attempt was finally undertaken: dolphins were approached closer (30m) to be photographed.

RESULTS Ten surveys were undertaken between February and June 2003, representing an effective effort of approximately 67h and 668km. The first four surveys put the definitive protocol survey into place (Figure 1) and the next six surveys allowed the following dolphins, representing an observation effective effort of 21h.

Activity spectrum from GREC/CRC data base Previous summer surveys undertaken by the GREC and the CRC-Marineland between 1988 and 2002 allowed us to describe a general activity pattern for striped dolphins observed up to 20km (Figure 2). Proportions of groups engaged in each activity change within a day. A Chi-squared test was done to analyse this distribution. Dolphins show the same activity pattern before 10am and after 6pm and a different one between 10am and 6pm. Foraging seems therefore to be the principal activity until 10am and after 6pm (82% and 53% of groups sighted before 8am and 10am were foraging as were 73% and 40% of groups sighted after 6pm and 8pm). Resting and socialising appear to be predominant in the middle of the day (17 to 34% of sighted groups between 10am and 18pm were socialising and 13 to 35% were resting). This suggests an activity pattern with feeding occurring from the evening to the morning (and during the night time). Previous studies evidenced nocturnal feeding behaviour of striped dolphins (Gannier, 1999) probably related to prey vertical migration (Gannier and David, 1997). Morning time would therefore coincide with the end of nocturnal feeding activity and evening with its beginning. Socialising and resting takes place during the middle of the day, as previously shown by Gannier and Laran (1999).

From survey in spring 2003 Two types of sightings were distinguished (Figure 3): the first ones, before 10am, were of short duration because animals were rapidly lost visually (observations of 10 to 40 minutes, except for one observation of 3h40). They generally concerned small groups of adults or sub-adults with a mean school size of μ_1=16,2 ind/group (N=5, SD=24,7). In the morning, dolphins displayed a feeding behaviour (jump, furtive apparition), sometimes revealed by acoustic listening. The second type of observations, after 10am, concerned larger schools whose mean size was μ_2=41,0 ind/group (N=10, SD=27,6), consequence of the aggregation of several groups. Observations of these groups, often comprised of calves and juveniles, could last from a few hours upto 5 hours. The end of sightings was always decided by the crew. The mean school sizes μ_1 and μ_2 wouldn't be significantly different when compared with a Mann and Whitney test (p-value =0,079). This trend is however supported by previous studies (Gannier and Laran, 1999). In the afternoon, schools rather rest or socialise. This scheme fits with the general summer pattern described above.

Dolphins movement in the study area Dolphins seem to show horizontal diel movements: an inshore to offshore movement has clearly been observed for surveys 5 to 8. Schools followed (during 3 hours in average, SD=1h20) travelled at a speed of about 3 knots heading South East out of the Var Canyon. This movement pattern is in

agreement with the main trend observed in previous studies (Gannier and David, 1997; Gannier, 1999; Gannier and Laran, 1999).

Photo Identification Striped dolphins show a high variability of colour patterns. The spinal blaze seems to be one of the most variable (Acquarone and Notarbartolo Di Sciara, 1992). Photographing a single part of the body proved to be quite difficult on small and rapid cetaceans, consequently all parts of the animal were used for analysis. A total of 763 photographs were taken during the six surveys. A hundred and seventy four potentially different dolphins were identified (using all the pictures available). One dolphin was seen during three surveys between April and June 2003 (Figures 4, 5, 6). Another dolphin was identified twice in the area on May 31st 2003 and June 3rd 2003 (9th survey). Moreover, new surveys undertaken between January and March 2004 allowed us to re-identify three other dolphins previously seen in June 2003 on several occasions (e.g. Figures 7 and 8). First, these new results support the idea of site fidelity for these dolphins in this coastal area. Secondly, marks and scars seem permanent enough to be used reliably over long periods of time (at least 7 months) for individual identification of this species.

CONCLUSION AND DISCUSSION This study provides interesting results on the habitat use of this species in a coastal area, assumed to be a nocturnal feeding ground. Striped dolphins are present year round off Nice and undertake the same offshore movement pattern already described in the summer. More over, recapture of some dolphins over several months supports the idea of coastal residency in striped dolphin, a truly pelagic species. More investigations, however, are needed to better understand their behaviour. Finally, this study encourages photo identification work on small and rapid cetacean species like the striped dolphin.

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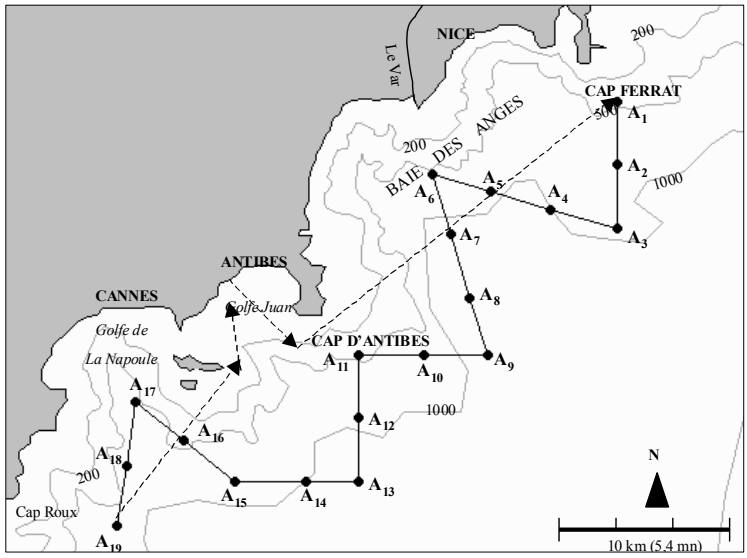

Fig. 1. Transect survey (-•-) undertaken in spring 2003, way to and from the transect (·····▶)

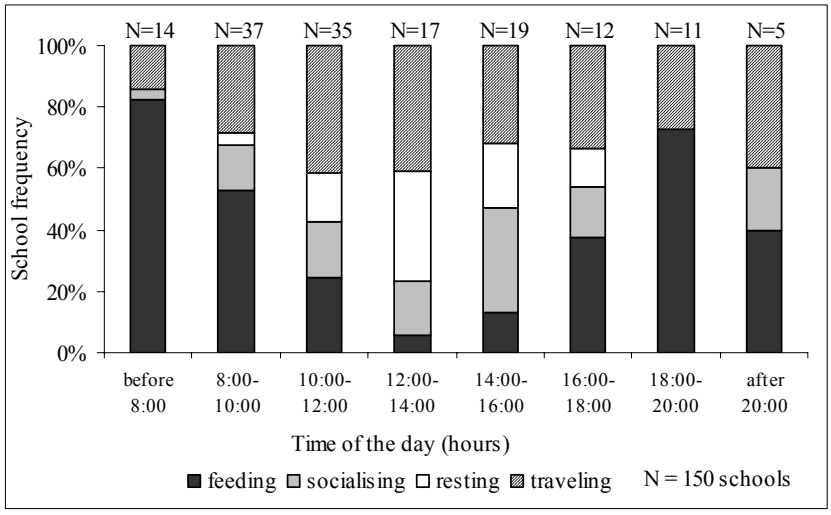

Fig. 2. Activity spectrum of dolphins

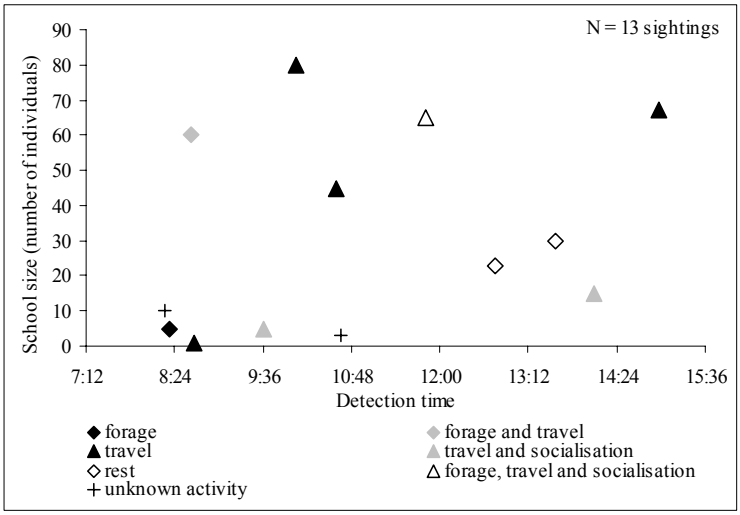

Fig. 3. Activities of schools sighted in spring 2003

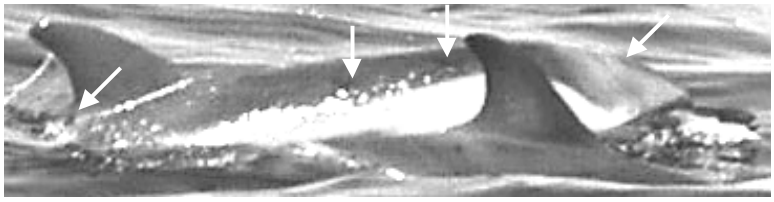

Fig. 4. #Sc1 on April 17th 2003 (5th survey)

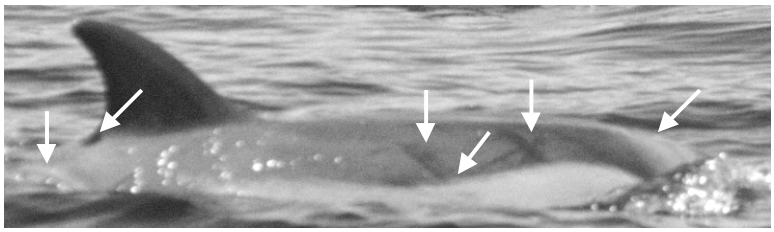

Fig. 5. #Sc1 on May 23th 2003 (8th survey)

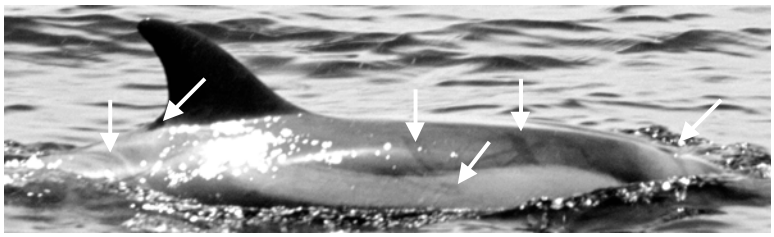

Fig. 6. #Sc1 on June 3rd 2003 (9th survey)

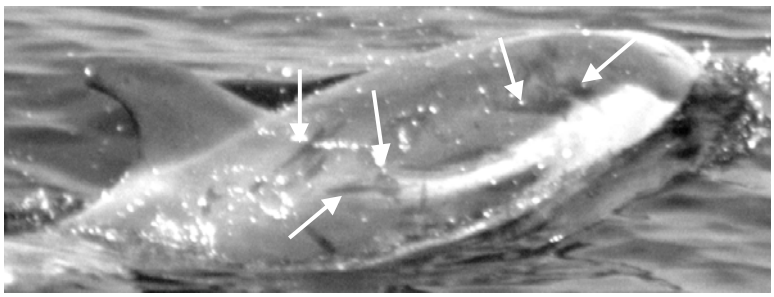

Fig. 7. #Sc4 on June 3rd 2003 (9th survey)

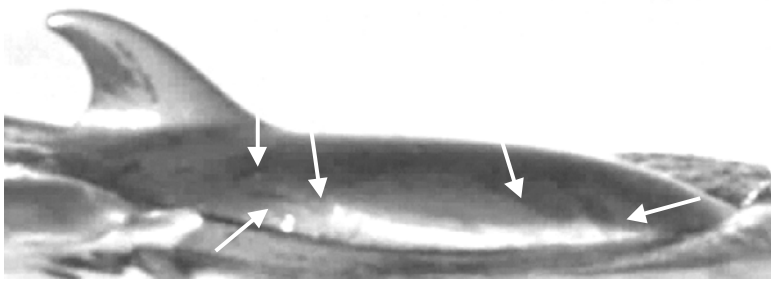

Fig. 8. #Sc4 January 6th 2004 (11th survey)

REGIONAL DIFFERENCES IN FATTY ACID COMPOSITION IN COMMON MINKE WHALES (*BALAENOPTERA ACUTOROSTRATA*) FROM THE NORTH ATLANTIC

P. Møller[1], E. W. Born[2], R. Dietz[1], T. Haug[3], D. A. Ruzzante[4], and N. Øien[5]

[1] *National Environmental Research Institute, Frederiksborgvej 399, DK-4000 Roskilde, Denmark*
[2] *Greenland Institute of Natural Resources, P.O. Box 358, DK-3900 Nuuk, Greenland*
[3] *Institute of Marine Research, P.O. Box 6404, N-9294 Tromsó, Norway*
[4] *Dalhousie University, Halifax, Nova Scotia B3H4J1, Canada*
[5] *Institute of Marine Research, P.O. Box 1870, N-5817 Bergen, Norway*

Variation in fatty acid (FA) composition of blubber collected in 1998 from 170 common minke whales (*Balaenoptera acutorostrata*) was used to study population structure in the North Atlantic. Samples from seven IWC management units were analysed: West Greenland ('WG', n = 69); East Greenland ('CG', n = 3); Jan Mayen ('CM', n = 24); Svalbard ('ES', n = 16); the Barents Sea ('EB', n = 30); Vestfjorden/Lofoten ('EC', n = 7); and the North Sea ('EN', n = 21). FA analyses were conducted on both deep and superficial blubber with a one-step extraction and esterification method followed by gas-chromatography. The 43 FAs identified comprised 93-99% of total FAs. CART and MANOVA analyses on FA signatures in both blubber sections suggested a '3-geographic Regions model' where the regions were Greenland (WG, CG), the Northeast Atlantic (CM, ES, EB, EC) and the North Sea (EN). This is in general agreement with a genetic study on the same samples and suggests that differences in FA signatures can be used for studying population structure in minke whales. Potential variation in FA signatures caused by internal and environmental factors needs to be better understood. It is recommended that future studies of blubber FA signatures in minke whales include samples from their entire North Atlantic range (including Canadian and Icelandic waters). Samples should be collected from a pre-specified body site to rule out possible internal variation and during a narrow time-window in the same year to rule out seasonal exchange between areas.

POPULATION DIFFERENTIATION AMONG BOTTLENOSE DOLPHINS (*TURSIOPS TRUNCATUS*) IN THE BLACK SEA, MEDITERRANEAN SEA AND EASTERN NORTH ATLANTIC

A. Natoli[1], A. Birkun[2], A. Aguilar[3], A. Lopez[4], L. Marsili[5], C. Fortuna [6], and A. Hoelzel[1]

[1] *Dep. Biological Sciences, University of Durham, South Road, DH1 3LE Durham, UK*
[2] *Laboratory of Ecology and Experimental Pathology, S.I. Georgievsky Crimean State Medical University, Lenin Boulevard 5/7, Simferopol, Crimea 95006, Ukraine*
[3] *Universitad de Barcelona, Departamento de Biologia animal, Facultad de Biologia, Diagonal 645, 08071 Barcelona, Spain*
[4] *CEMMA Ap. 15 E36380 Gondomar, Spain*
[5] *Università di Siena, Dipartimento di Scienze Ambientali, Via Mattioli 4, 53100 Siena, Italy*
[6] *Blue World, Plavi Svijet, Zad Bone 11, 51551 Veli Losinj, Croatia*

This study assesses population structure among contiguous populations from the Black Sea to Scotland, and investigates the mechanisms for the evolution of structure over this geographic range. In marine mammal species the factors involved in population differentiation are not fully understood. Bottlenose dolphins are widely distributed and a high degree of differentiation among populations inhabiting different geographic regions has been reported. However, genetically isolated sympatric populations have also been found, suggesting that factors other than geography may play a role in the population differentiation of this species. We analysed 145 samples from the Black Sea, Mediterranean Sea and eastern North Atlantic using mtDNA and microsatellite DNA markers and found fine-scale geographic structure among five putative populations (initially identified using a Baysian inference model): the Black Sea, the eastern Mediterranean, the western Mediterranean, the eastern North Atlantic, and Scotland. The Black Sea and Scottish putative populations showed the lowest level of genetic diversity, and may represent local founder events. Estimates of directional gene flow using a coalescent likelihood method and sex-biased dispersal based on assignment likelihoods suggested a similar level of dispersal for males and females, with some evidence for a directional bias in dispersal for females from the Black Sea and Scottish populations. Taken together these data support the management of these local populations as separate management units, and based on the apparent philopatry of both sexes, we suggest that social behaviour may be important in the structuring of bottlenose dolphin populations over this geographic range.

DO BOTTLENOSE DOLPHINS (*TURSIOPS TRUNCATUS*) FOLLOW ANY SEASONAL MOVEMENT PATTERN IN THE STRAIT OF GIBRALTAR?

N. Pérez Gimeno[1, 2, 3], R. De Stephanis[1, 2, 3], J. M. Salazar Sierra[1, 3], P. Verborgh[1], A. Cañadas[3, 4], and C. Guinet[5]

[1] *CIRCE, Conservation Information and Research on Cetaceans, C/Cabeza de Manzaneda 3, Algeciras-Pelayo, 11390 Cadiz, Spain*
[2] *Laboratorio de Acústica y Vibraciones de la Universidad de Cádiz. CASEM, Polígono Río san Pedro s/n Puerto Real Cádiz, Spain*
[3] *Sociedad Española de Cetáceos C/Nalon 16, La Berzosa, Madrid, Spain*
[4] *Alnitak C/Nalon 16, La Berzosa, Madrid, Spain*
[5] *Centre d'Études Biologiques de Chizé, CNRS UPR 1934. 79 360 Villiers en Bois, France*

The Strait of Gibraltar is the only natural passage between the Atlantic Ocean and the Mediterranean Sea. It is characterised by a high diversity of cetacean species with seven species numbered, some of them transiting in and out of the Mediterranean Sea. Sightings of bottlenose dolphins (*Tursiops truncatus*) have been reported in the study area since 1998. They are found in the deeper waters of the central channel of the Strait of Gibraltar. However, little is known about the social structure and migration patterns of this species in the region. The present study focuses on the possible seasonal movements of bottlenose dolphins in the Strait. Boat-based survey transects were conducted during 2001 and 2002, covering 6,307.25 km. A total of 69 sightings of bottlenose dolphins were analysed, in which the estimated group size ranged from 1 to 200. The analyses indicate that this species was more abundant during late autumn, winter and spring (encounter rates of 0.130, 0.125 and 0.132 sighting per km respectively) than during summer, (encounter rate of 0.091 sighting per km). Furthermore, the larger group sizes occurred mainly during winter time (mean = 43.8) and spring (36.6), with the minimum averages in summer (20.5) and autumn (19.1). Therefore, the number of individuals per km was maximum during the winter (5.49), while in the summer it was 1.88, being the minimum for all seasons. Further work is being carried out, through photo-identification, to determine if the lower numbers of dolphins in the Strait of Gibraltar during the summer is due to seasonal movements into the Alboran Sea, the Atlantic contiguous waters or the Moroccan waters.

EVIDENCES OF EXCHANGES OF FIN WHALES THROUGH THE STRAIT OF GIBRALTAR

J. Salazar Sierra[1], R. De Stephanis[1], A. Cañadas[2], P. Verborgh[1], N. Perez-Gimeno[1], R. Sagarminaga[2], and C. Guinet[3]

[1] *CIRCE Conservation, Information and Research on Cetaceans, Apart. 93, 29080 Algeciras, Cádiz, Spain*
[2] *ALNITAK - Universidad Autónoma de Madrid. C/Nalon 16 Hoyo de Manzanares, Madrid, Spain*
[3] *Centre d'Études Biologiques de Chizé, CNRS UPR 1934. 79 360 Villiers en Bois, France*

Sightings of fin whales have been reported all over the Mediterranean Sea, highlighting the Ligurian Sea as an important feeding area for this species during the summer. Very little is known about possible migration patterns of this species within and out of the Mediterranean Sea, and about the wintering grounds. The only passage for possible migrations between the Mediterranean and the Atlantic Sea is the Strait of Gibraltar. To test this hypothesis, research on this species started in 1998 by researchers of CIRCE in co-operation with ALNITAK, which has been recording sightings of fin whales in the eastern section of the Alboran Sea since 1994. A total of 28736 nautical miles have been sailed on effort in the Alboran Sea, the Strait of Gibraltar and the Gulf of Cadiz between 1992 and 2003. A total of 156 fin whales were sighted in a total of 103 encounters in the whole area. The direction of swimming of the animals could be recorded in 87.37% of the encounters. The data was stratified by seasons. In autumn-winter, 77.8 % of the groups or individuals encountered were moving eastwards, towards the Mediterranean Sea, while during the spring and summer months, 95.5 % of the sightings were moving westwards towards the Atlantic Ocean. These data suggest the existence of a seasonal movement of fin whales between the Atlantic Ocean and the Mediterranean Sea (at least in its westernmost basin).

FIRST SIGHTING OF FREE-RANGING FALSE KILLER WHALE (*PSEUDORCA CRASSIDENS* OWEN 1846) IN EASTERNMOST MEDITERRANEAN SEA

A. Scheinin

Tirat Shalom, P.B. 1356, Nes-Ziona 74052, Israel

False killer whales are globally distributed in warm temperate and tropical seas. They are typically pelagic, most often found over steep-sloped areas of the continental shelf, venturing into coastal waters around oceanic islands. In the Mediterranean Sea they are considered a rare species, with sightings and strandings off Spain, Morocco, Algeria, France, Italy, Greece, Turkey and Egypt. No authenticated sightings occurred east of longitude 300º. On March 28th, 2003, at 07:20, a pod of approximately 20 false killer whales were sighted 70 nautical miles west of the Israeli coastline (33º 18'N 033º 44'E). Bottom depth at the sighting point was 1,800 metres. Skies were clear and sea was very calm (Beaufort 0-1). The observation lasted an hour and 40 minutes, during which time the pod exhibited two behavioural modes, resting and dive-traveling. During the former, some individuals approached the boat to bow-ride. During the dive-travel mode, one individual preformed wake- and keel-riding for 5 minutes at an average speed of 6.4 knots. Cetacean sightings in this area are always suspect of evidence for Lessepsian migration (i.e *Sousa chinensis*), false killer whale being common in the Red Sea. Further surveys in this area are crucial in order to clarify the status of this and of other cetacean species in the Easternmost Mediterranean Sea.

SEASONAL MOVEMENT OF FIN WHALE (*BALAENOPTERA PHYSALUS*) IN THE BAY OF BISCAY

J. Simi, A. Williams, and T. Brereton

Biscay Dolphin Research Programme, 6 Manor Way, Lee on the Solent, Hampshire PO13 9JH, UK

The fin whale, *Balaenoptera physalus*, accounted for approximately 70% of all baleen whales recorded by Biscay Dolphin Research Programme (BDRP) during systematic year round surveys undertaken between 1996 and 2000. The distribution of fin whales occurred in a relatively narrow band. The single most important habitat appeared to be along the 4000m depth contour where approximately 44% of individuals were concentrated. The majority of sightings occurred during summer and autumn. At this time, the distribution was widest in a north-south direction. August and October accounted for 53 % of all observations. In winter (December to February) only three sightings were made in total during the five years analysed, and these were all in the southern part of the bay. Distribution did not change distinctively with sea surface temperature. Fin whales appeared to aggregate along the 4000m depth contour in the eastern part of the abyssal plain, and the position of these concentrations of individuals changed with season. Therefore, northerly movement in summer and southerly movement in autumn within the Bay of Biscay is hypothesized. The mean school size was 2-3 and this did not change significantly through the five-year period or between months. During the summer months, groups of up to 16 fin whales were observed feeding together. The study of *Balaenoptera physalus* in the Bay of Biscay confirmed the importance of the area for this species, especially as seasonal feeding and weaning ground.

SITE FIDELITY OF SPERM WHALES IN THE AZORES, WITH NOTES ON SOME LONG RANGE PHOTO-IDENTIFICATION MATCHES

L. Steiner[1], J. Gordon[2], T. Lewis[3], E. Lettevall[4], and B. Beekmans[5]

[1] *Whale Watch Azores, 5 Old Parr Close, Banbury. OX16 5HY, UK*
[2] *Ecologic, 7 Beechwood Terrace West, Newport on Tay, Fife, DD6 8JH, UK*
[3] *"Song of the Whale" Research Team, International Fund for Animal Welfare, 87-90 Albert Embankment, London, SE1 7UD, UK*
[4] *Göteborg University, Dept of Zoology/Animal Ecology, Box 463, SE 405 30, Göteborg, Sweden*
[5] *Institute of Environmental Sciences, PO Box 9518, 2300 RA Leiden, the Netherlands*

For the past 17 years, photo-identification work has been conducted on sperm whales in the Azores mainly by the International Fund for Animal Welfare and Whale Watch Azores. Although the archipelago spans 300nm and includes 9 islands, most of the sightings were made around the central group of 5 islands. Whales were usually located using hydrophones but in the last 2 years there was some additional input from local land-based lookouts. Matching within and between the resulting large catalogues was facilitated by using the newly developed Europhlukes sperm whale matching algorithm. Out of more than 1110 individuals identified, 93 have now been seen in more than one year. One whale has been seen in 8 different years over a 15-year period and 15 whales have been seen in four or more different years. Using 32 individuals that have been seen in more than two years, we investigated site fidelity of sperm whales around the Azores. Results show that there does not appear to be any strong site fidelity within this area. Sightings are distributed over a wide area, both between and within years. Although the level of sperm whale photo-identification effort is much lower in other parts of the North Atlantic, a few long-range photo-identification matches have been made between whales in the Azores and those in the Canaries, Madeira, and Norway. In conclusion, with the increasing number of images being contributed to the Europhlukes and NAMSC catalogues from the archipelago and the wider North Atlantic, more matches of individuals are likely to be found and further insights gained into movement patterns as well as life histories and association patterns in addition to site fidelity of sperm whales.

GEOGRAPHIC VARIATION OF ATLANTIC AND MEDITERRANEAN POPULATION OF *STENELLA COERULEOALBA* INVESTIGATED THROUGH 3D- GEOMETRIC MORPHOMETRICS

A. Tamburelli[1], R. Carlini[1,2], A. Loy[3], and G. Lauriano[3]

[1] *Via U.Aldrovandi 18, 00197 Rome, Italy*
[2] *Dipartimento STAT, università degli Studi del Molise, V.Mazzini 8, 86170 Isernia, Italy*
[3] *I.C.R.A.M. Via di Casalotti 300, 00100 Rome, Italy*

Recent molecular data recorded on Mediterranean and Atlantic populations of *Stenella coeruloalba* showed a high level of isolation of the Mediterranean populations, suggesting an interruption of gene flow within the Atlantic pool. Following this evidence we evaluated whether genetic differention is also reflected in morphological differentiation in the shape of the skull through the analysis of the 3D shape variation of 89 skulls belonging to collections from several Atlantic and Mediterranean areas. Geometric morphometrics is a shape based approach to the analysis of morphological variation developed in the last 10 years. Coordinates of points in 3 dimensions are analysed through various geometric and statistical algorithms in order to visualise variation of shape in a multidimsional space. The analyses are independent of size which is evaluated as an independent scalar factor. Results show significant differentiation between Atlantic and Mediterranean populations in the skull's shape, particularly in the rostrum and in the hind region. Otherwise the Atlantic French population appears to be more similar to the Mediterranean sample than to the rest of the Atlantic group, and adaptative convergence is hypothesised to explain this pattern of variation.

A JOURNEY OF A MINKE WHALE FROM DENMARK TO THE MEDITERRANEAN

J. Teilmann and R. Dietz

National Environmental Research Institute, Department of Arctic EnvironmentFrederiksborgvej 399, Box 358, DK-4000 Roskilde, Denmark

Minke whales are widely distributed in most of the North Atlantic. Due to the exploitation of minke whales in past and present days, the population structure has been investigated in several studies, but still population boundaries remain unclear. For management purposes, the International Whaling Commission has assigned the North Sea and waters west of the British Isles and south to the Bay of Biscay as one management unit. However, little is known about their movements as no whales have been tracked in this area before. On the 5th June 2003, a 5m long subadult minke whale was caught in a pound net at Skagen, the northern point of Denmark. The whale was able to swim calmly around in the net until it was released. In co-operation with local fishermen, the whale was held in the net while two researchers attached a satellite transmitter to the dorsal fin. The whale was calm during the operation and swam away apparently unaffected when released. Contact remained for almost three months. Within a few days the whale swam north of the British Isles and south along the continental shelf and continued south visiting the islands of Cap Verde, Azores and Gran Canary. Finally it entered the Mediterranean where contact was lost near Mallorca. This surprising journey shows that minke whales may move over large distances within a short time and demonstrates that the North Sea population may extend further south than previously believed.

FIRST REPORT ON MELON-HEADED WHALES (*PEPONOCEPHALA ELECTRA*) STRANDED ALIVE ON THE EUROPEAN COAST

O. Van Canneyt[1], J. Spitz[1], G. Dorémus[1], W. Dabin[1], G. Anselme[2], J.R. Meslin[3], C. Brenez[4], and V. Ridoux[1]

[1] *Centre de Recherche sur les Mammifères Marins, Port des Minimes, 17000 La Rochelle, France*
[2] *BP 34, 17840 La Brée les Bains, France*
[3] *JRM Production, chemin des Eridolles, 17580 Le Bois Plage en Ré, France*
[4] *Department of pathology, Veterinary College, University of Liège, 40000 Liège, Belgium*

On the 27th August 2003, two melon-headed whales, *Peponocephala electra*, stranded alive on the beach of Oléron Island, located on the middle French Atlantic coast (46°00'N x 01°30'W). Both animals were helped back to the sea with the assistance of local firemen, but two days later one of them was found dead on a nearby beach. The dead specimen, an adult male, measured 2.43m and weighed 123kg (the other measured approximately the same length). A necropsy showed the animal to be in a medium physical condition with no severe pathological lesions. Only some parasites were observed in the genital area and stomach. The complete skeleton has been preserved. Age and reproductive status were determined. The stomach content was analysed and some remains of cuttlefish, squid, blue whiting and hake were identified. This observation comes from an exceptionally high latitude for this species and represents the first record for the coast of France and the first live sighting in European waters. The only other record for Europe involves a skull which was found in September 1949 near Charlestown, Cornwall, England. The biology and ecology of this species is poorly documented, the investigations of the dead specimen could contribute to the knowledge of the melon-headed whale.

IDENTIFYING AREAS OF SPECIAL INTEREST FOR CUVIER´S BEAKED WHALE (*ZIPHIUS CAVIROSTRIS*) IN THE SOUTHERN PART OF THE BAY OF BISCAY

J.A Vázquez[1], P. Cermeño[1], A Williams[2], C. Martin[2], O. Lazkano[1], L. Ruiz[1], A. Basañez[1], and I. Guzman. [1]

[1]*AMBAR,C/ Blas de Otero, 18, 5 iz. 48014. Bilbao. Spain*
[2]*Biscay Dolphin Research Programme,6 Manor Way, Lee on the Solent, Hampshire PO13 9JH, UK*

Beaked whales are one of the least known group of cetaceans. Recent studies in Spain highlighted the existence of areas of high relative density of these species: Canary Islands, Bay of Biscay and South of Almería (Alboran Sea). Due to the vulnerability of this species to human activities, as highlighted by the massive standing in the Canary Islands as a result of military sonar exercises, it is important to identify areas of special interest in order to provide appropriate management guidelines to help promote their favourable conservation status. Since 2001, AMBAR (Association for the study and the conservation of the marine fauna) has worked in collaboration with BDRP (Biscay Dolphin Research Programme) in a monitoring project of cetaceans inhabiting the Bay of Biscay and English Channel. Data collected by these two organisations identified the southern part of Bay Biscay as an area of high relative density for Cuvier´s beaked whales (*Ziphius cavirostris*). During the summers of 2002 and 2003, dedicated boat surveys were also carried out in the deep waters of the Cap Breton Canyon. Most sightings of this species were recorded in the eastern part of the Canyon: 80.3% of total number of sightings (n=33). The encounter rate (0.20 animals per hour on effort), the group sizes (42.4% $\geq$ 3 animals) and the sighting duration (33.3% $\geq$10 minutes) registered in this work, together with the low level of recapture derived from photo-id analysis stresses the importance of this area for further research on the ecology of this species and for conservation purposes.

KAGOSHIMA SPECIMEN OF LONGMAN'S BEAKED WHALE

T. K. Yamada[1], T. Kakuda[2], N. Kubo[3] and M. L. Dalebout[4]

[1] *Department of Zoology, National Science Museum, 3-23-1 Hyakunin-cho, Shinjuku-ku, Tokyo, 169-0073, Japan*
[2] *Graduate School of Science, Kanagawa University, 2946, Tsuchiya, Hiratsuka-shi, Kanagawa, 259-1293, Japan*
[3] *Kagoshima City Aquarium, 3-1, Honkou Shinmachi, Kagoshima-shi, 892-0814, Kagoshima Japan*
[4] *Biology Department, Dalhousie University, Halifax, Nova Scotia B3H 4J1 Canada*

A 6.5m unidentified female beaked whale was found stranded in Kagoshima-ken, south-west Japan, on the 26th of July 2002. Finally the whale was identified as a Longman's beaked whale (*Indopacetus pacificus*) based on skull morphology and mitochondrial DNA sequences. Both skull and postcranial skeletons were investigated to depict the character of the species. Validity of the Genus Indopacetus (Moore 1968) was discussed by Dalebout, *et al.* (2003), however, further considerations both on morphology and molecular biology of the species will be necessary, especially analyses taking relative growth into account as some of the characters are size dependent. Findings on the two adult female Longman's beaked whale collected in the Maldives and Kagoshima indicate that these specimens are strikingly similar to the type specimen (Longman, 1926). Although Moore (1968) hypothesized the holotype as a male, the type specimen could be a female, considering often prominent sexual dimorphism in Ziphiidae.

SURVEYS AND ABUNDANCE

NEW EVIDENCE OF POPULATION DECLINE: THE HARBOUR PORPOISE (*PHOCOENA PHOCOENA*) REMAINS THE LEAST ABUNDANT CETACEAN SPECIES IN THE NORTHERN BLACK SEA

A.A. Jr. Birkun[1], S.V. Krivokhizhin[2], D.M. Glazov[3], O.V. Shpak[3], A.V. Zanin[4], and L.M. Mukhametov[3]

[1] *Crimean State Medical University, Lenin Blvd. 5/7, 95006 Simferopol, Ukraine*
[2] *Brema Laboratory, Gagarin Str. 9a, 95026 Simferopol, Ukraine*
[3] *Institute of Ecology and Evolution, Leninsky Ave. 33, 117071 Moscow, Russia*
[4] *Karadag Nature Reserve, Kurortnoye, 98188 Feodosia, Ukraine*

Before the end of 20th century, the harbour porpoise (*Phocoena phocoena*) was the ominant cetacean species in the coastal waters of the northern, northwestern and northeastern Black Sea. In the late 1990s, the ratio between relative abundance indices of harbour porpoises and another inshore cetaceans – bottlenose dolphins (*Tursiops truncatus*) – changed radically towards the prevalence of latter species. However, until now there have been no tolerable estimates of absolute abundance in the area of concern. Two shipboard line transect surveys were carried out in September and October 2003 to estimate the abundance of harbour porpoises, bottlenose dolphins, and short-beaked common dolphins (*Delphinus delphis*) in the Ukrainian and Russian territorial waters (12 nautical miles) of the Black Sea. Those cruises extended between the Danube Delta in the west and Sochi in the east (a total of 2230km of observation effort along 79 zigzag tracklines). The third series of boat surveys was conducted in August 2003 in the Russian and Ukrainian Kerch Strait (310km of the effort including 35 transects). The analysis of results was performed with the help of the 'Distance 3.5' program package. The absolute abundance is estimated as follows: 54.0 ± 45.7 harbour porpoises and 127.0 ± 41.3 bottlenose dolphins in the Kerch Strait; 1157.0 ± 601.7 harbour porpoises, 4193.0 ± 1089.9 bottlenose dolphins, and 5376.0 ± 1718.2 common dolphins in the Black Sea study area. According to these figures, *P.phocoena* is the least abundant cetacean species in the Ukrainian and Russian Black Sea. Annual mass mortality of harbour porpoises in bottom-set gill nets was recognised as the principal cause of their population decline. The riparian states should provide special measures for the conservation of this species. The extermination of illegal fishing for Black Sea turbot and sturgeon (both fisheries are dangerous to harbour porpoises) should be at the centre of attention.

MODEL-BASED ABUNDANCE ESTIMATES FOR BOTTLENOSE DOLPHINS (*TURSIOPS TRUNCATUS*) OFF SOUTHERN SPAIN

A. Cañadas[1], R. Sagarminaga[2], and P. S. Hammond[3]

[1] *ALNITAK, Nalón 16. E-28240 Hoyo de Manzanares, Madrid, Spain*
[2] *SEC – Spanish Cetacean Society, Nalón 16. E-28240 Hoyo de Manzanares, Madrid, Spain*
[3] *Sea Mammal Research Unit, University of St. Andrews, St. Andrews, Fife KY16 8LB, UK*

An EU-funded LIFE project was initiated off southern Spain in 2002, with the main objective of developing a Conservation Plan for bottlenose dolphins in the area. As part of this process, it is of fundamental importance to have baseline information on population abundance and distribution. Long-term follow-up of information on abundance and distribution is needed to determine if the conservation objectives are being accomplished. In this context, 10023km of non-systematic line transects were conducted from 2000 to 2002 and analysed (57 sightings; research area = 14201km^2). These transects were divided into 3627 small segments (average 2.8km) with similar values for sightability conditions and environmental variables. A detection function was obtained using the multiple-covariate distance sampling method. The effective area searched was calculated from the effective strip width for each segment, using the covariates of the detection function. Spatial modelling using GAMs was applied to the data using the effective area searched of each segment as an offset, producing a map of predicted abundance and distribution. The point estimate was 1005 dolphins. After 400 bootstrap resamplings, the mean abundance estimate was 1076 (CV = 0.187, 95% CI = 820–1266). The same method was applied to estimate the trend in abundance since 1996 in the eastern section of the research area, where most dolphins were concentrated (5780 km^2, 17191 km of transects, 5810 segments, 139 sightings), stratifying by three groups of years. Point estimates were 396 dolphins for 1996-1997, 1020 for 1998-1999 and 932 for 2000-2002. The increase in abundance between 1997 and 1998 corresponded with the arrival of an "immigrant" group of dolphins. The model-based method appears to be a good approach to simultaneously estimate abundance and describe distribution, both for establishing a baseline and for following-up trends in the populations.

AERIAL AND SURFACE CETACEAN SURVEY: AN EFFICIENCY COMPARISON DURING A SEASONAL WHALE-WATCHING ACTIVITY IN THE MEDITERRANEAN SEA

R. Gobbo[1], M. Manghi[2], and R. Trucchi[3]

[1] *University of Padova, Biology Department, Italy (rudi.gobbo@tin.it)*
[2] *Centro Interdisciplinare di Bioacustica e Ricerche Ambientali, Università di Pavia, Via Taramelli 24, 27100 Pavia, Italy (mmanghi@cibra.unipv.it)*
[3] *WWF Italia - Sezione Liguria, Italy (r.trucchi@mclink.it)*

INTRODUCTION Given that one of the problems of the tourist whale-watching, from an organisers point of view, is granting customer satisfaction. Expensive new efforts have been made to gain a higher success rate in spotting animals at sea, among these, the support of a reconnaissance aircraft could be a great help. Statistical analysis has been carried out to test the improvement of sightings given by the plane, and to compare the efficiency of aerial and surface methods. Further analysis has been done to identify any differences in the observers' performance (from the surface) when the plane was known to be flying overhead.

MATERIALS AND METHODS Data was collected during the whale-watching campaign from June to September 2003, in the area out of Savona and Imperia, Ligurian Sea, Italy (Fig. 1). All the days in which the plane took off with good sea state (sea state lower than Beaufort 2) were considered. All other environmental parameters were not considered as it was assumed to equally affect both platforms.

The whale-watching boat (La Superba) is a motor-ship for passenger transport (length 27.7 m. width 7.1 m.) with two Caterpillar engines 3412 DITA 1350 hp that reaches a maximum speed of 28 knots. During this campaign the ship never exceeded 20 knots during transfers and 8 knots during observations. Two expert observers and two inexperienced observers were always on board. These have been theoretically considered as a total of three observers. Even if of different models, the employed planes have the same relatively poor visibility characteristics with low wings and no transparent floor. One was a Piper PA-28 161 (length 7.27 m. width 10.67 m.), the other was a SIAI 205-20R (length 8 m. width 10.86 m.). Two pilots and one or two dedicated observers were on board for a theoretical total of two or three observers, considering that the pilots were also involved in aircraft conduction. The observations from the plane started at take-off (see Table. 1 for take-off and landing times) and ended with the landing, so the whole flight time was considered. For the boat, the time was corrected subtracting the time spent in harbours picking up passengers and the time spent for lunch break.

The data collected by GPS Garmin 12 on altitude and position were directly recorded into a Powerbook G4 12" using a serial/USB Keyspan adapter and plotted by OziExplorer software running on WindowsXP under VirtualPC environment. Details about sightings, weather conditions and sea state were noted on paper for a later insertion.

The plane followed a straight track both when reaching the boat's position and back to the airport. When it was above the area surrounding the boat, the plane followed random circular tracks, according to approximate directions given by the observers on the boat. A circular over-flight was often needed after an aerial sighting to double check the sighting and to identify the species. This made it easier, for the observers on the boat, to locate the area where a sighting happened and it allowed the aerial observers not to loose sight of the fastest cetaceans. The cruise altitude was between 600 and 1,000 feet (190–350 m) during transfers and about 500 feet (150 m) during observations with short periods at higher altitude for communications with the airport. The speed, maintained almost constantly, was approximately 100 knots. Analysis of the efficiency at different altitudes will be carried out as soon as further data for statistical treatment has been collected (Fig. 2).

The boat always followed random tracks except when going to an area with animals, indicated from the plane by radio.

The efficiency of sightings per outing was calculated by dividing the number of sightings by the minutes of observation, corrected for the number of observers if needed. Spatial basis comparison was not possible because of technical problems in recording GPS data and tracks on the boat. Analysis of the percentages of different species sightings was carried out considering all the sightings that the observers on the boat made independently.

This preliminary study was completed with the intention of designing a protocol for further campaigns. The financial dependence of the whale-watching activity prevented free use of the plane making it difficult to follow pre-designed routes. In addition the plane was required to stay above the animals for longer periods of time to allow the boat to reach the sighting. This last limitation introduced a big bias on the time the plane spent searching for new animals with a consequential underestimation of the searching capabilities of the plane. It could have been corrected if the observer had

measured the time dedicated to a particular school after sighting. As well, the opportunistic nature of this research prevents the use of DISTANCE or other distribution analysis software, as such analysis requires a strong protocol in data collection, not compatible with a tourist activity.

A potential bias that should be controlled in future is the variability of the aircrafts. Even if quite similar, the wing position and distribution of transparent surfaces differed from plane to plane. Unfortunately, the support of a small flying club did not allow using the same plane for all the flights.

All the observers on the plane had great experience in sighting marine mammals from boats however only one was an experienced observer from the air. Observation from above requires a change in the *research image* and a training period is needed to re-tune this image. It remains difficult to estimate performance improvement during the campaign and personal skills in sighting.

RESULTS AND CONCLUSIONS To better understand the definitions of efficiency, please consider what follows:
- Boat alone without aerial support: refers to the period of a day in which the plane took-off but when the plane was not flying.
- Boat with over-flying plane and aerial support: refers to the period in which the plane was flying and boat sightings included those passed from the observers on the plane.
- Boat with over flying plane excluding aerial support: refers to the period in which the plane was flying but the boat sightings included only those sightings the observers on the boat made by themselves.

Comparisons were carried out with statistical analysis software InStat3 (GraphPad InStat version 3.0a for Macintosh, GraphPad Software).

Aerial support gave an extremely significant increase to the boat's efficiency of 226% compared to when it was out alone (two-tailed unpaired t-test with Welch correction P=0.0006; Kolmogorov and Smirnov test for normality passed; equal variances not assumed). This is probably an overestimation of the real effect of the plane because data come from observations performed in different times of the day. The improvement could also result from the hypothetical easiness in spotting cetaceans during meridian hours or from variability in observers' performance (see below). A better comparison could have been made considering the same time window in the days in which the plane didn't fly. Unfortunately, the data collected in those days are very poor and biased by bad weather and rough sea conditions. Even the use of previous years' data has been useless because of poor accuracy in their collection (Table. 2).

The comparison between La Superba's efficiency with aerial support and its efficiency excluding aerial support in the same hours of the day and with the same light, revealed a 65% improvement. Statistically, this is not of sufficient significance (two-tailed unpaired t-test P=0.0674; Kolmogorov and Smirnov test for normality passed; equal variances assumed due to F test P=0.7626). This increase is probably the best estimator of the advantage which was obtained thanks to the use of a plane (Table. 2). However, the difference between the boat efficiency when it was alone and its efficiency while the plane was flying, but excluding aerial support, seems to show improved performances independently on the aerial support (97.6% improvement). Statistically, this is not of sufficient significance (two-tailed unpaired t-test with Welch correction P=0.0768; Kolmogorov and Smirnov test for normality passed; equal variances not assumed) (Table. 2). It may be possible that the observers on the boat paid more attention when they knew the plane was flying. They probably thought "OK, now it's really time to watch", or they were spurred by the competitiveness with the plane observers. Or, simply, meridian hours are really the best time for observation.

To compare the aerial observation efficiency with the ship's observation efficiency we considered all the minutes the plane was flying then multiplied them by the number of observers on board of plane and boat. This way the resulting efficiency will be "per observer". The approximation of considering inexperienced observers as half of an expert and the two pilots counting for one expert is obviously rough, but it was used to somehow balance the different number of observers on the plane and on the boat. However, the overall result shows an underestimation of the power of the aerial method. Just consider the fact that an even bigger difference is obtained if a correction is made by taking into account expert observers only. Aerial surveys are 2.64 times more efficient than surface survey, on a time basis (two-tailed unpaired t-test with Welch correction P=0.0025; Kolmogorov and Smirnov test for normality passed; equal variances not assumed). (Tab. 3)

Percentages qualitative analysis of different species' sightings did not show consistent differences between aerial and surface method except for: Fin whale (*Balenoptera physalus*) (6% *vs* 0%; maybe easier to spot from the plane); Long-finned pilot whale (*Globicephala melas*) (0% *vs* 3%; maybe easier to spot from the surface); and Cuvier's beaked whale (*Ziphius cavirostris*) (6% *vs* 14%; maybe easier to spot from the surface because of lack of research image for aerial observers) (Fig. 3).

These considerations don't have, however, a sufficient statistical significance since the Chi-squared test for associations would only make sense if all expected values were more than one and at least 20% of them were more than five. The exact Fisher's test between dolphin frequency (common dolphin *Delphinus delphis*, bottlenose dolphin *Tursiops truncatus* and striped dolphin *Stenella coeruleoalba*) and the sum of all other categories is the only correct one that could be carried out. The result reveals there is no meaningful difference in the frequency of sightings of the two categories from the boat and from the plane (P=0.7980). Further campaigns will provide sufficient data for a better statistical analysis.

AKNOWLEDGEMENTS Special thanks to Antonella Arcangeli, Bruce Brown, Roberto Crosti, Andrea Drusini, Laura Fortunato, Nadia Minicuci and Elena Valsecchi for their scientific opinion; Carla Benoldi, Sonia Fragonara and Fabrizio Signorelli for their hospitality, Luca Gobbo, Federica Ravani and Serena Rocco for their graphical and computer support; Silvia Catanese for her translation help, Valerio La Piana and my parents for their patience; the WWF volunteers and the CIBRA collaborators; the Cooperativa Battellieri del porto di Genova, Aeroclub Genova and, last but not the least, the pilots: Ernesto Serpetta, Marco Cheratite, Filippo Berardi and Raffaele Bevestrello.

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Table. 1. Observation plane flight schedule

Date (yy/mm/dd)	Take-off local time	Landing local time	On flight duration (minutes)
030614	14:03	15:49	106
030621	14:35	16:09	94
030705	14:38	16:52	134
030712	14:13	16:02	109
030721	14:18	16:17	119
030807	14:36	16:31	115
030812	14:05	16:20	135
030814	13:55	15:54	119
030821	14:40	16:17	97
030822	14:13	16:15	122
030825	14:19	16:28	129
030906	14:17	16:33	136
030913	14:07	15:32	85
030920	13:52	16:00	128
030927	14:10	15:54	104

Table. 2. Sightings and sighting efficiency

	Time (minutes)		Sightings			Efficiency (sightings/minute)		
Date (yy/mm/dd)	Boat alone	Boat with plane	Boat alone	Boat with over flying plane and support	Boat with over flying plane excluding support	Boat alone	Boat with over flying plane and support	Boat with over flying plane excluding support
030614	464	106	0	2	1	0,0000	0,0189	0,0094
030621	416	94	1	2	0	0,0024	0,0213	0,0000
030705	376	134	0	1	1	0,0000	0,0075	0,0075
030712	401	109	1	3	2	0,0025	0,0275	0,0183
030721	361	119	2	1	0	0,0055	0,0084	0,0000
030807	455	115	0	2	1	0,0000	0,0174	0,0087
030812	420	135	2	2	2	0,0048	0,0148	0,0148
030814	436	119	4	1	1	0,0092	0,0084	0,0084
030821	413	97	3	0	0	0,0073	0,0000	0,0000
030822	303	122	0	2	2	0,0000	0,0164	0,0164
030825	381	129	2	1	0	0,0052	0,0078	0,0000
030906	374	136	1	2	1	0,0027	0,0147	0,0074
030913	395	85	1	2	2	0,0025	0,0235	0,0235
030920	232	128	3	0	0	0,0129	0,0000	0,0000
030927	376	104	3	2	1	0,0080	0,0192	0,0096
					Mean (SE)	0,0042 (0,00099)	0,0137 (0,00210)	0,0083 (0,00194)

Table. 3. Sighting efficiency of plane and surface observations

		Observators		Correction factor		Corrected time (minutes)		Sightings		Efficiency (sightings/minute)	
Date (yy/mm/dd)	Time (minutes)	Boat	Plane	Boat	Plane	Boat	Plane	Boat	Plane	Boat	Plane
030614	106	2+2	2+2	3	3	318	318	1	3	0.0031	0.0094
030621	94	2+2	2+2	3	3	282	282	0	4	0.0000	0.0142
030705	134	2+2	2+2	3	3	402	402	1	2	0.0025	0.0050
030712	109	2+2	2+2	3	3	327	327	2	3	0.0061	0.0092
030721	119	2+2	2+2	3	3	357	357	0	2	0.0000	0.0056
030807	115	2+2	2+2	3	3	345	345	1	1	0.0029	0.0029
030812	135	2+2	2+1	3	2	405	270	2	3	0.0049	0.0111
030814	119	2+2	2+1	3	2	357	238	1	2	0.0028	0.0084
030821	97	2+2	2+1	3	2	291	194	0	0	0.0000	0.0000
030822	122	2+2	2+1	3	2	366	244	2	2	0.0055	0.0082
030825	129	2+2	2+1	3	2	387	258	0	1	0.0000	0.0039
030906	136	2+2	2+1	3	2	408	272	1	2	0.0025	0.0074
030913	85	2+2	2+1	3	2	255	170	2	0	0.0078	0.0000
030920	128	2+2	2+1	3	2	384	256	0	4	0.0000	0.0156
030927	104	2+2	2+1	3	2	312	208	1	2	0.0032	0.0096
									Mean (SE)	0,0028 (0,00064)	0,0074 (0,00118)

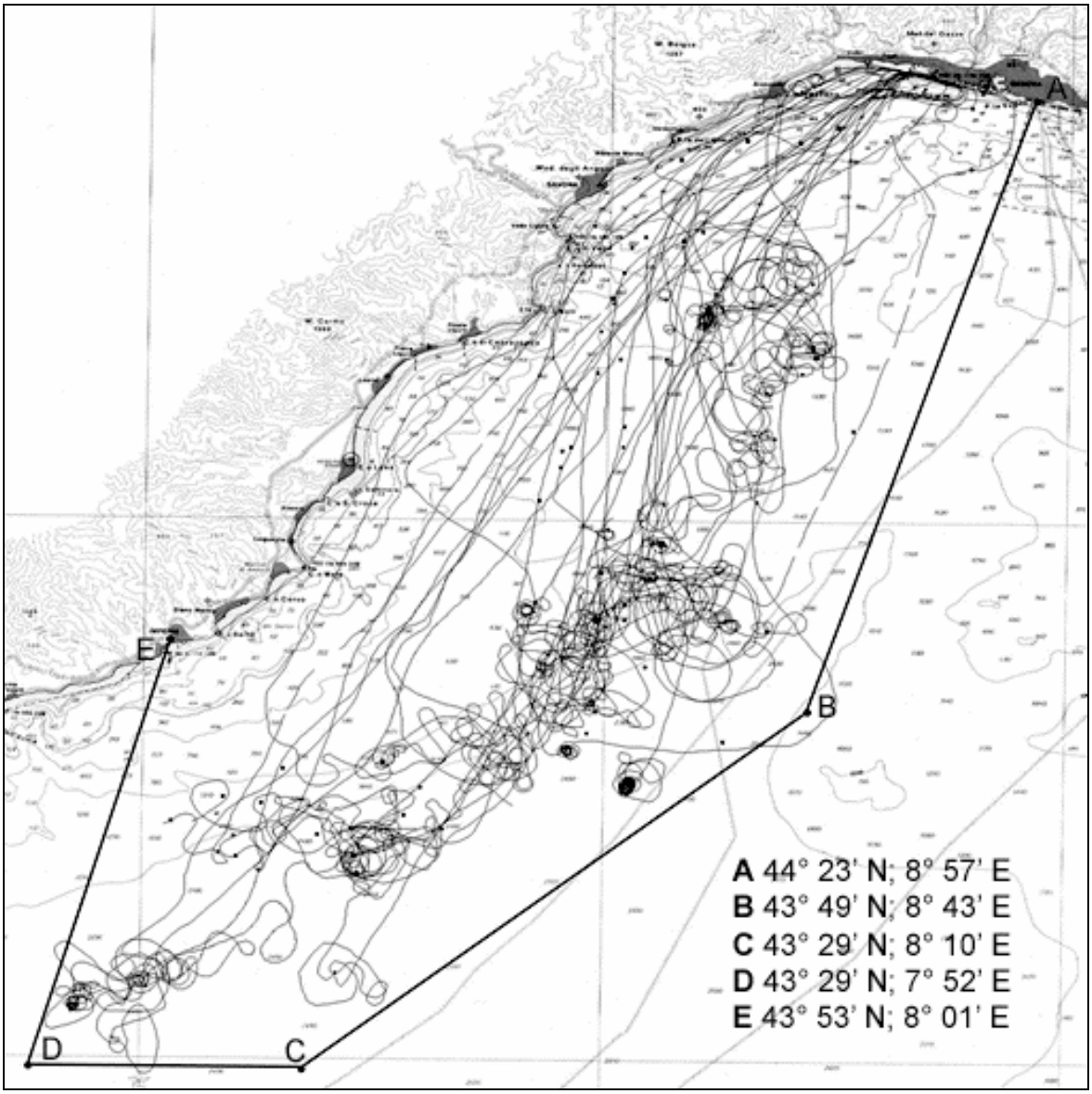

Fig. 1. Study area, Ligurian Sea, Italy

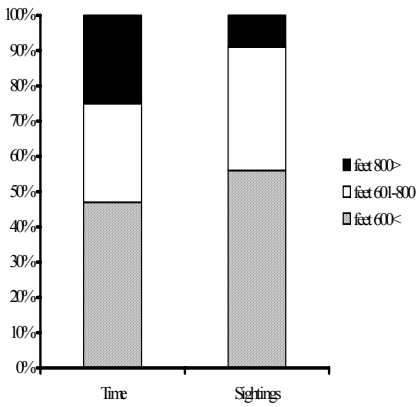

Fig. 2. Percentage of sightings recorded at different altitudes

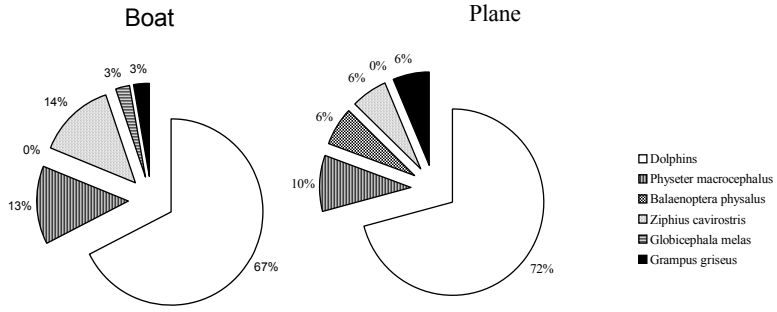

Fig. 3. Comparison between plane and surface sightings of species

PHOTO-IDENTIFICATION OF BOTTLENOSE DOLPHINS *(TURSIOPS TRUNCATUS)* IN THE BALEARIC ISLANDS

J. Gonzalvo and A. Aguilar

GRUMM ,Department of Animal Biology, Faculty of Biology,University of Barcelona, Diagonal, 645, 08028. Barcelona, Spain (j.gonzalvo@ub.edu alexa@bio.ub.es)

The bottlenose dolphin *(Tursiops truncatus,* Montagu 1821) has a worldwide distribution and it is the most common cetacean species over the Mediterranean Sea shelf. Despite its original abundance, in recent decades numbers have declined and the distribution of the coastal groups appears to be increasingly scattered and have fragmented into small units. Individuals can range from coastal to offshore and deep waters, depending on food availability. The Habitats Directive (EU) and the Bern Convention acknowledges the need for species protection, and it is catalogued by the IUCN Red Book of Mediterranean Vertebrate species as *Data Deficient.* In summer 2002, GRUMM (Group of Study and Conservation of Marine Mammals) initiated a study to assess population structure, conservation problems, and movements of bottlenose dolphins in the waters of the Balearic Islands, North-western Mediterranean. The present study takes place within the framework of the LIFE 2000/NAT/E/7303 project aimed to develop seventeen protected areas in the Balearic Archipelago.

The first fieldwork season took place during the months of June, July and the first two weeks of September 2002; the second one lasted from middle of March to the middle of July 2003. Surveys were conducted *ad libitum* from a 6.80 metre long inflatable boat with a fibreglass keel (Sacs-680 *Ghost)* equipped with a Yamaha 115 HP four strokes engine travelling at an average speed of 17 knots with at least, two observers scanning the sea surface. The survey coverage between these two years totalled 8036.08 km (Figure 1).

Photo-identification Individual photo-identification was performed consistently, based on long-term natural marks such as notches and nicks in the dolphins' dorsal fins. Photographs were obtained using an AF reflex camera Canon EOS-30 equipped with Canon EF 70-200 mm f/2.8 L USM zoom lens, and Kodak *Ektachrome* 100 ASA slide film. Of the 58 sightings of bottlenose dolphins observed during the survey, only 49 groups were found in sea state conditions permitting photo-identification. A total of 83 hours were spent following the dolphins under photo-identification effort. More than 3700 pictures were taken during this time and after the bad/poor quality frames were deleted, 3066 slides were catalogued. The analysis has resulted on the identification of 173 individuals. 41 dolphins have been recaptured (seen more than once), 19 of them in different years. This constitutes the baseline for the first bottlenose dolphin photo-ID catalogue in the region. The analysis of these slides indicates that the composition of schools changes frequently, as indicated by the change in the group sizes of the different sightings corresponding to the recaptures done in year 2003 with respect to the identified individuals in year 2002 (Figure 2). This suggests a fission-fusion model is characteristic of this population. Furthermore, there is evidence of relatively high site fidelity, although some individuals have moved between different islands (Figure 3). Group sizes were estimated independently by at least two people at each sighting and the mean number recorded. The best field estimates of group size were corrected *a posteriori* whenever the photo-identification analysis provided additional information. The average group size of the sightings recorded was 7.33 (n= 58, SD 6.07). 57% (33) of groups contained calves. The average group size of sightings with calves (10.36, SD 6.20) was significantly higher (t-student, $p<0.005$) than schools without calves (3.32, SD 2.59).

Interactions with trawlers During the survey, whenever a bottom trawler was detected (40 occasions) we approached in search of dolphins. The presence of dolphins was then evaluated by stopping the boat at approximately 200 m from its stern, and then carefully scanning the sea surface for a minimum of five minutes. On 12 different occasions (21% of sightings) bottlenose dolphins were detected following trawling boats, a total of 58 individuals were photo-identified at least once while doing so. The average group size of these groups was 8.42 (SD 4.21). 8 (66%) of them included calves. The group composition was constant while the fishing boats were trawling. However, only a fraction of the group approached the boat when the net was hauled and during the discarding of non-commercial fish. Therefore, because of the risk of underestimating their actual size, these 8 sightings were not included in the analysis of group size patterns.

CONCLUSIONS The composition of groups is not fixed, indicating that the population structures follow a fission-fusion model. Individuals showed substantial site fidelity, although some were recorded moving between islands within the archipelago. Dolphins frequently associate to trawling boats, suggesting this operation is significant for feeding. Future research should give information about the strength of this interaction and the proportion of the population involved. Schools sighted with calves were significantly larger than those composed only of adults. This

may be indicative that larger groups increase survival of offspring. Management plans in protected areas or neighbouring waters should take into account the above information to ensure adequate protection of the species.

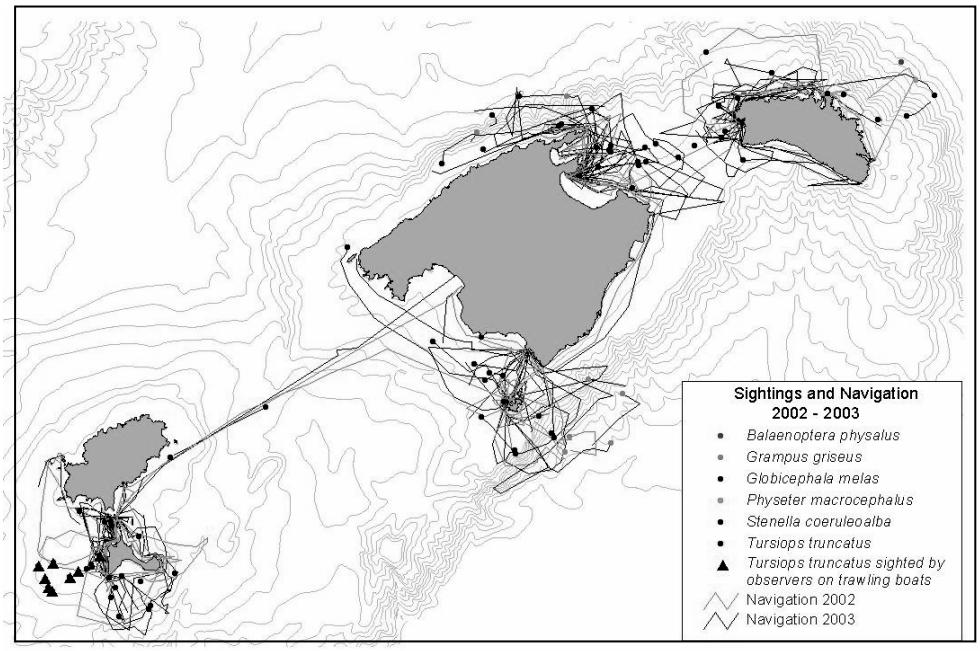

Fig. 1. Survey effort and sightings 2002-2003

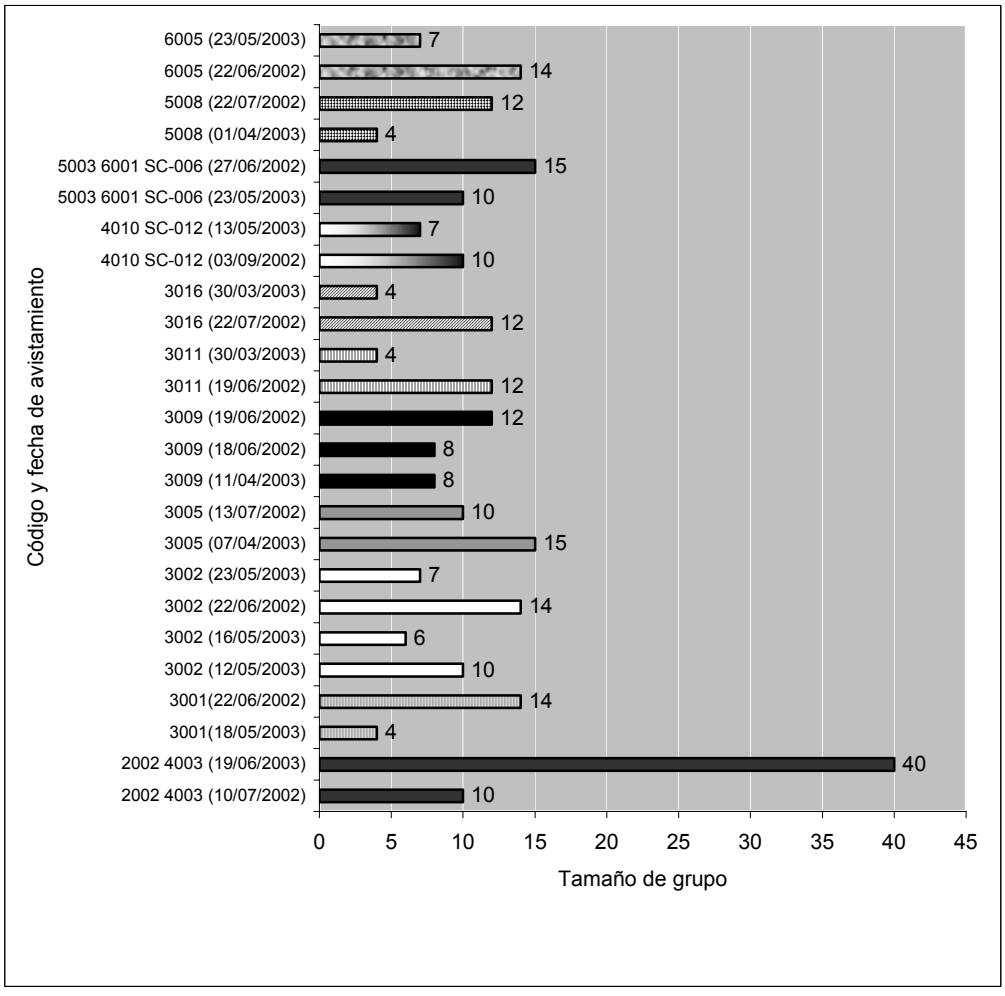

Fig. 2. Distribution of the recaptures 2002-2003

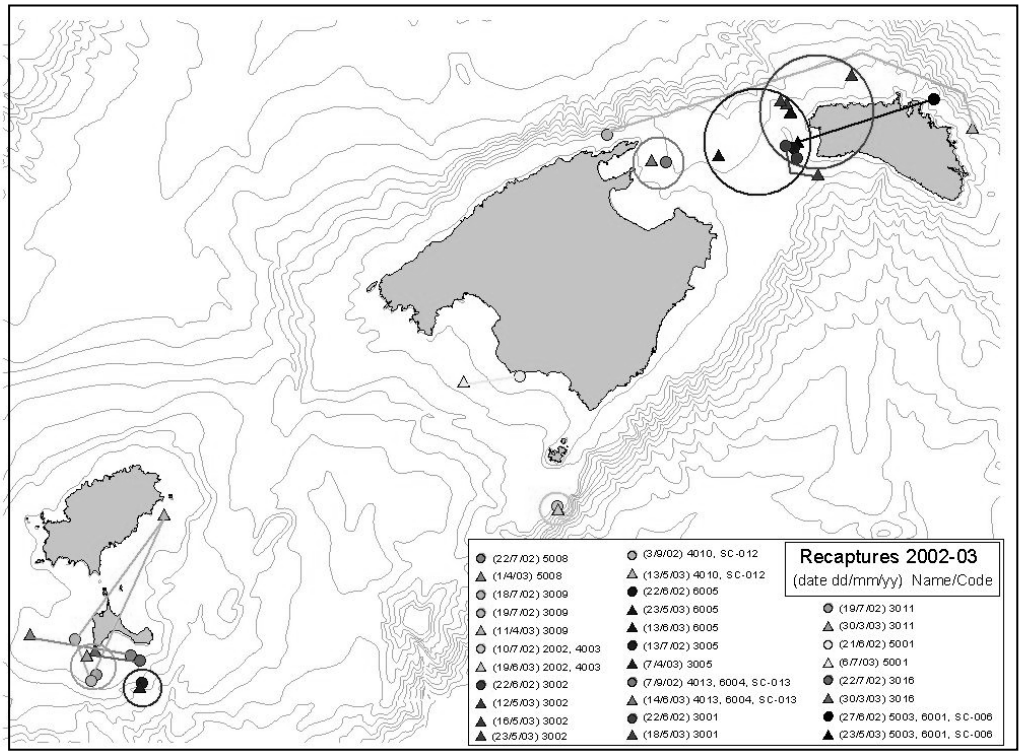

Fig. 3. Distribution of the recaptures 2002-2003

CETACEANS IN WATERS OF MARTINIQUE (FWI), LESSER ANTILLES: RESULT FROM A SMALL BOAT DEDICATED ACOUSTIC AND VISUAL SURVEY (MARCH-APRIL 2003)

S. Jérémie[1, 2], S. Bourreau[2, 3], A. Gannier[2, 3], and J-C Nicolas[1]

[1] *SEPANMAR , 140 Cité Saint-George, 92233 Schoelcher, Martinique (FWI)*
[2] *GREC, BP715, 06633 Antibes, France*
[3] *Centre de Recherche sur les Cétacés, Marineland, 306 avenue Mozart, Antibes, France*

For the first time, a dedicated survey was carried out in Martinique (Lesser Antilles, 14°30'N and 61°W) with a small boat between the 14th March to the 4th April 2003 to assess cetacean biodiversity, relative abundance, distribution and behaviour. The survey was performed with three observers responsible for visual searching and passive acoustic sampling (every 2 nautical mile) using a towed hydrophone. A global effective effort of 1315km was carried out between the coast line and 10-15 nautical miles offshore. The survey area was divided into four distinct regions to estimate an acoustic abundance index and a visual relative abundance (expressed as individuals sighted per kilometre of effort, only for delphinids). Twenty-two days at sea permitted detection of at least 12 species (plus 2 probable species) from thirty-three sightings (including mixed species groups): *Tursiops truncatus* (n=4 groups detected), *Stenella attenuata* (n=5), *Stenella frontalis* (n=1), *Lagenodelphis hosei* (n=2), *Grampus griseus* (n=2), *Pseudorca crassidens* (n=3), *Feresa attenuata* (n=1, probable) and *Stenella clymene* (n=3, probable), *Globicephala macrorhynchus* (n=3), *Megaptera novaeangliae* (n=3), *Ziphius cavirostris* (n=1), *Mesoplodon sp*. (n=1), *Kogia simus* (n=3) and *Physeter macrocephalus* (n=2). Nearly one thousand (N=955) cetaceans were encountered during this early spring survey, and both sighting rates and a visual abundance index were estimated for two periods: the relative abundance was shown to increase between the beginning (0.155 delphinids/km; CV= 43.0%) and the end of the survey (0.381 delphinids/km; CV%=56.4). These results suggest a significant difference (T-test: $p<0.05$; $T=-3.531$, $p\sim0.001$) that could be linked to a variation in water masses observed during the survey. On the other hand, acoustic research revealed a distinctive pattern of distribution for species like *M.novaeanglie* (present in 58.8 % of the acoustic samples) and the sperm whale (only detected off the leeward side of Martinique).

DISTRIBUTION, RELATIVE ABUNDANCE, AND BATHYMETRIC PREFERENCES OF TOOTHED CETACEANS IN THE ENGLISH CHANNEL AND BAY OF BISCAY

J. Kiszka [1, 2], K. MacLeod [1,3], O. Van Canneyt [2], and V. Ridoux [2, 4]

[1] *Organisation Cetacea (ORCA), 9 Prospect Row, St. Neots, Cambs. PE19 1JS, UK.*
[2] *Centre de Recherche sur les Mammifères Marins, Institut de la Mer et du Littoral, Port des Minimes, 17 000 la Rochelle, France (Email: jeremy.kiszka@wanadoo.fr).*
[3] *Sea Mammal Research Unit, Gatty Marine Laboratory, University of St. Andrews, Fife, Royaume Uni.*
[4] *Université de la Rochelle, Laboratoire de Biologie et d'Environnement Marin, Institut de la Mer et du Littoral, Port des Minimes, 17 000 la Rochelle, France.*

Data on habitat utilization by pelagic/oceanic cetaceans are generally difficult to collect. Such information is beneficial for most conservation and management purposes. Data collected during ferry-based cetacean surveys in the English Channel and Bay of Biscay between 1998-2002 were analysed to investigate the spatio-temporal distribution, relative abundance and bathymetric preferences of odontocetes in these waters. Most of the observation effort was concentrated during the summer months. A total of 17,873 nautical miles were surveyed and 1,008 encounters of identified species, comprising 20,481 individuals, were recorded. Thirteen species were observed, i.e. the common dolphin (*Delphinus delphis*, n=329 sightings), the striped dolphin (*Stenella coeruleoalba*, n=187), the harbour porpoise (*Phocoena phocoena*, n=114), the bottlenose dolphin (*Tursiops truncatus*, n=110), the long-finned pilot whale (*Globicephala melas*, n=134), the Cuvier's beaked whale (*Ziphius cavirostris*, n=60), the sperm whale (*Physeter macrocephalus*, n=42), the Risso's dolphin (*Grampus griseus*, n=14), the northern bottlenose whale (*Hyperoodon ampullatus*, n=9), the killer whale (*Orcinus orca*, n=5), the false killer whale (*Pseudorca crassidens*, n=2), the Sowerby's beaked whale (*Mesoplodon bidens*, n=1), and the True's beaked whale (*Mesoplodon mirus*, n=1).

The common dolphin was by far the most frequently encountered and had the highest relative abundance of all species; followed in decreasing relative abundance by striped and bottlenose dolphins, the long-finned pilot whale, harbour porpoise, Cuvier's beaked whale and sperm whales. The Risso's dolphin, the false killer whale, the killer whale and other beaked whales (*Mesoplodon sp*. and *H. ampullatus*) were rarely encountered. The harbour porpoise was essentially encountered in the western English Channel as well as in the northern Bay of Biscay. The species was clearly associated with neritic areas (mean depth=109m.; SD=19). The common dolphin and the bottlenose dolphin were mainly observed in the northern Bay of Biscay, but were regularly encountered in the western English Channel and in the southern bay. Both were associated with shelf waters, although encounters occur along the shelf edge and oceanic areas (mean depth=1,315-m *vs* 714m; SD = 1,347 *vs* 967, respectively). The striped dolphin and the long-finned pilot whale were observed essentially in the central and southern bay (few records in the western English Channel). These oceanic species were clearly associated with deep oceanic waters (mean depth=3,171m *vs* 2,367m; SD=1,024 *vs* 1,309, for the striped dolphin and the long-finned pilot whale, respectively). The largest odontocetes, i.e. the Cuvier's beaked whale and the sperm whale occurred only in deep waters of the southern Bay of Biscay (mean depth=3,147 m *vs* 3,168; SD=747 *vs* 774, respectively). These two species also showed an important affinity to the Santander Canyon, in northern Spain.

These preliminary elements showed the main features of the habitats used by odontocetes in the English Channel and Bay of Biscay. This area concentrates a wide diversity of toothed cetaceans, from typically neritic species like the harbour porpoise, to deep oceanic ones like beaked and sperm whales. Further investigations are clearly needed in order to assess habitat preference of these various cetacean species, notably related with physiographical, physical, and biological variables.

ABUNDANCE AND HABITAT USE OF HARBOUR PORPOISES IN A GERMAN WHALE SANCTUARY IN THE SOUTHEASTERN NORTH SEA, USING VISUAL AND ACOUSTIC METHODS

S. Ludwig[1], S. Werner[2], D. Risch[2], and U. Siebert[1]

[1] *Forschungs- und Technologiezentrum Westkueste, 25761 Buesum, Germany*
[2] *Humboldt-Universitaet Berlin, 10099 Berlin, Germany*

Ship-based and aerial surveys were conducted simultaneously to investigate the relative abundance of harbour porpoises in the German whale sanctuary off the islands of Sylt and Amrum in the southeastern North Sea. The surveys followed the line transect design. A further goal of this study was to compare data obtained from ship-based and aerial sighting cruises. Acoustic porpoise detectors (PODs), were used to determine habitat use of harbour porpoises in the area during and outside the calving and mating season. The estimated transect strip width during ship-based surveys was 177m to each side. A maximum number of 29 porpoises was observed during ship-based surveys. Group sizes varied between one and three animals (mean 1.23). The calculated number of harbour porpoises in the area (1,724km²) obtained from the ship-based counts was 270 animals (confidence interval = 115-636). This number is a first attempt and seems to be low compared to previous raw estimates. However, more censuses need to be included to verify the number of harbour porpoises in the sanctuary. During simultaneously conducted aerial surveys, a maximum of 37 porpoises were observed, with group sizes of up to three animals (mean 1.12). Sightings per kilometre and the number of porpoises per kilometre were higher in aerial surveys. Acoustic devices (PODs) were employed to record the presence of harbour porpoises throughout the year. Porpoises occurred continuously in the area. There were no significant differences in "harbour porpoise positive hours" between February-April and the breeding season May-August ($p < 0.05$). Presence of porpoises varied between 2 and 20 hours per day. Porpoise encounters were recorded throughout the whole day, without preferences for day or night time or low and high tide. The study points out the importance of the area for harbour porpoises due to their continuous presence.

HIGHLIGHTING POTENTIAL COMMON DOLPHIN-FISHERIES INTERACTIONS THROUGH SEASONAL RELATIVE ABUNDANCE DATA IN THE WESTERN CHANNEL AND BAY OF BISCAY

K. Macleod [1, 2] and D. Walker [1, 3]

[1] *Organisation Cetacea (ORCA), 9 Prospects Row, St. Neots, Cambridgeshire, England, UK (www.orcaweb.org.uk)*
[2] *Sea Mammal Research Unit, St Andrews, Fife, Scotland, UK (km53@st-andrews.ac.uk)*
[3] *The Company of Whales, Longhill, Maywick, Shetland Islands, Scotland, UK*

INTRODUCTION Winter mass strandings of common dolphins, *Delphinus delphis*, on the southwest coast of the UK and Atlantic coast of France have highlighted a bycatch issue in the western Channel and Bay of Biscay. Pelagic trawls incidentally capture cetaceans (Morizur *et al*., 1999) and are thought to be the most likely cause of bycatch in the western English Channel and Bay of Biscay. Limited fishery observation programmes have shown that fisheries, including those for seabass (Northridge 2003), horse mackerel, hake and tuna (Tregenza and Collet, 1998; Morizur *et al*., 1999) are sources of bycatch in this region. Information on the abundance of common dolphins in the English Channel and Bay of Biscay is limited to two surveys: SCANS (Hammond *et al*., 2002) and MICA (Goujon *et al*., 1993). Both were conducted during summer and may not necessarily reflect winter abundance. Brereton *et al*. (1999) studied the seasonal distribution of common dolphin sightings in the Bay of Biscay between 1995-1998, but information on seasonal relative abundance was not given. In this study, seasonal changes in distribution and relative abundance of common dolphins are presented using data collected onboard two ferries passing through the Bay of Biscay and western English Channel between 1998-2002. Where high densities of dolphins coincide with certain fisheries, bycatch is assumed likely. The aim was to compare seasonal distribution and relative abundance of dolphins with information (from the literature) concerning seasonal distribution of fisheries. It may help to focus further monitoring or the establishment of monitoring schemes to investigate bycatch in certain areas.

METHODS AND MATERIALS Surveys were conducted on the Pride of Bilboa and Val De Loire ferries. During each survey, observers recorded survey effort, environmental and sightings data on pre-prepared datasheets. Effort and environmental data (e.g. sea state, cloud cover) were recorded at the start and end of each survey period and at least hourly when conditions changed. Position, species and certainty of identification, group size and behavioural information were recorded for each sighting. In recent years, ORCA has encouraged surveyors to record distance sampling information but there is currently insufficient data for analysis to estimate density. Consequently, an index of relative abundance (number of encounters per km surveyed, n/L) was calculated by ¼ ICES grid square (15' latitude x 30' longitude) throughout the survey region. The data were also stratified by season; winter (Jan-March), spring (April-June), summer (July-September) and autumn (October-December). Seasonal relative abundance was mapped on a background of ICES fishing areas using ArcView 3.2. Relative abundance per day of survey effort was estimated to investigate differences in relative abundance between years, seasons and ICES fishing areas (Kriskal-Wallis, α = 0.05). Only common dolphin sightings observed whilst on effort in sea states ≤5 and during good visibility, were used.

RESULTS 435 encounters with 15,537 animals were recorded between 1998 and 2002. Of these, 362 were common dolphins (species ID was definite for 95.6%) and 73 were common/striped dolphin. The mean group size ($\hat{s}$) for just common dolphins was 37.7 (SD = 70.8) but varied seasonally (p = 0.000); winter, $\hat{s}$ = 16.9 SD = 34.7, spring $\hat{s}$ = 45.9 sd = 106.8, summer $\hat{s}$ = 39.9 SD = 66.6, autumn $\hat{s}$ = 78.2 SD = 159.6. Mixed groups of common dolphins with other species were recorded on several occasions: striped dolphins (n = 6), pilot whale (n = 2), fin whale (n = 1) and tuna fish (n = 1).

Annual relative abundance peaked in the year 2000 (n/L = 0.013, SD = 0.016) and there appeared to be an increasing trend over years (Fig.1). For all of the years combined, relative abundance peaked during winter (n/L = 0.035, SD = 0.042) and differences were significant between seasons (KW, p = 0.012) (Fig. 2). Winter appears to be the season when bycatch of common dolphins is particularly acute. During winter, relative abundance was greatest on the continental shelf (<200 m deep), west of the Brittany coast (ICES area VIIIa) but was also relatively high in the western channel (VIIe) (Figs. 3 and 5). However, between years, there was considerable variation in the areas of the highest common dolphin relative abundance (Fig. 4).

Survey effort during spring was relatively low. No encounters were recorded in the English Channel (Fig. 5) and relative abundance was low off the Brittany coast, compared to previous winter months. The highest relative abundance was recorded beyond the continental shelf edge. Survey effort and coverage peaked during summer but the distribution of common dolphins was focused on the continental shelf edge of the northern Bay (Fig. 5). Variation in relative abundance throughout the Bay was small, with the exception of a small area on the northwest corner of the survey area. Coverage during autumn was low, especially in the Channel where no dolphins were recorded. Peak relative abundances occurred on and off the continental shelf in the northern Bay.

CONCLUSIONS The results highlight the variability in common dolphin relative abundance, both temporarily and spatially, although further work is needed to increase sample size and coverage outside the summer season. Common dolphins were distributed widely during the summer but relative abundance was low. Throughout the area, relative abundance varied between years but revealed a seasonal pattern, being consistently higher during the winter months. This may be due to an increased abundance throughout the Bay or due to large-scale movements of animals from offshore into shelf waters at this time.

Over all years, winter relative abundance was highest in the northwestern corner of ICES and VIIIa off the Brittany coast. Winter peaks of strandings have been recorded in France; for example, over 300 cetaceans (mostly common dolphins) stranded south of Brittany over a period of 10 days in January 2002 (Ross, 2003). Independent observer schemes on winter fisheries in this area have been few. Winter fisheries known to have bycatch in the northeast Atlantic and are conducted in ICES are VIIIa include pelagic trawls for horse mackerel, mackerel, hake, and seabass. Catch records (FSTAT, 2002) indicate that the UK, France, Ireland, the Netherlands and Denmark had large catches of some of these species in area VIIIa during 2001. None of these fisheries are currently monitored in this area and warrant monitoring effort.

The Sea Mammal Research Unit, UK, is monitoring and testing mitigation methods in the Scottish seabass fishery in the Channel (VIIe) and bycatch has been documented (Northridge, 2003). Monitoring has also occurred in the UK mackerel, pilchard, blue whiting and anchovy fisheries but no bycatch was recorded (SGFEN, 2002). However, the seabass fishery is unlikely to be the sole cause of bycatch in this area, particularly given that peaks in fishing effort arise later (Northridge, 2003) than observed peaks in numbers of stranded dolphins that have been bycaught. Post mortem examinations of stomach contents of animals stranded, and showing clear signs of having been bycaught, on the coast of Devon and Cornwall, suggested that they may have died in pelagic fisheries for mackerel or pilchard which operate between October and March (Kuiken *et al*., 1994).

Given that relative abundance of common dolphins appears to be irregular between years, it is likely that only long-term monitoring programmes of fisheries will be able to confirm the true scale of bycatch and appropriate mitigation measures to be introduced. Similarly, the data would caution against "emergency" measures, such as closure of fisheries, based on the results of monitoring in a single season. This variability, spatially and temporally, of common dolphin distribution and relative abundance (and of course that of the fisheries) also influences the choice of mitigation measures that will be effective every year.

Monitoring methods onboard vessels of opportunity that allow estimation of relative abundance can be a useful source of seasonal data. However, they are often restricted in the spatial coverage (to ferry routes, as is the case in this study) and inevitably, more data is available during summer when weather is optimal. Datasets within this region should be pooled to form a joint database and analysed with fisheries data, perhaps in a spatial modelling framework, to fully elucidate the patterns and sustainability of bycatch and ensure the correct levels and means of mitigation are enforced.

ACKNOWLEDGEMENTS ORCA wishes to thank all observers and contributors to the ORCA database over the past five years and their continuing support. Thanks also to P&O, Brittany ferries and WDCS for survey support.

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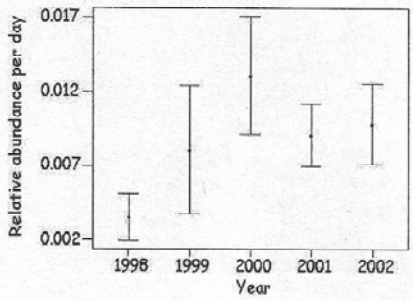

Fig. 1. Mean and standard error of annual relative abundance of common dolphin.

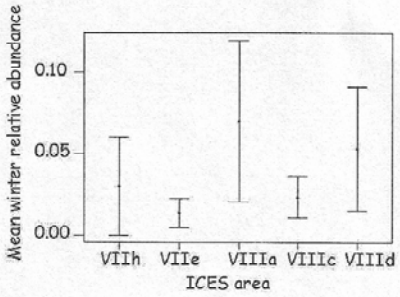

Fig. 3. Mean and standard error of the seasonal relative abundance of common dolphins (1998-2002).

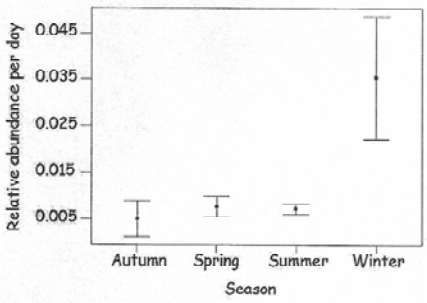

Fig. 2. Mean and standard error of common dolphin relative abundance during winter (1998-

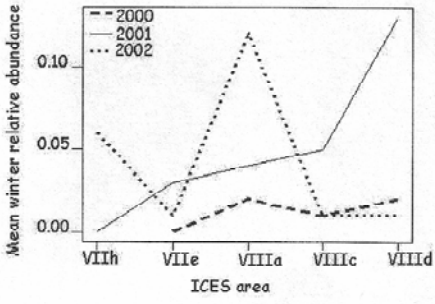

Fig. 4. Mean winter relative abundance of common dolphin by ICES fishing area and year.

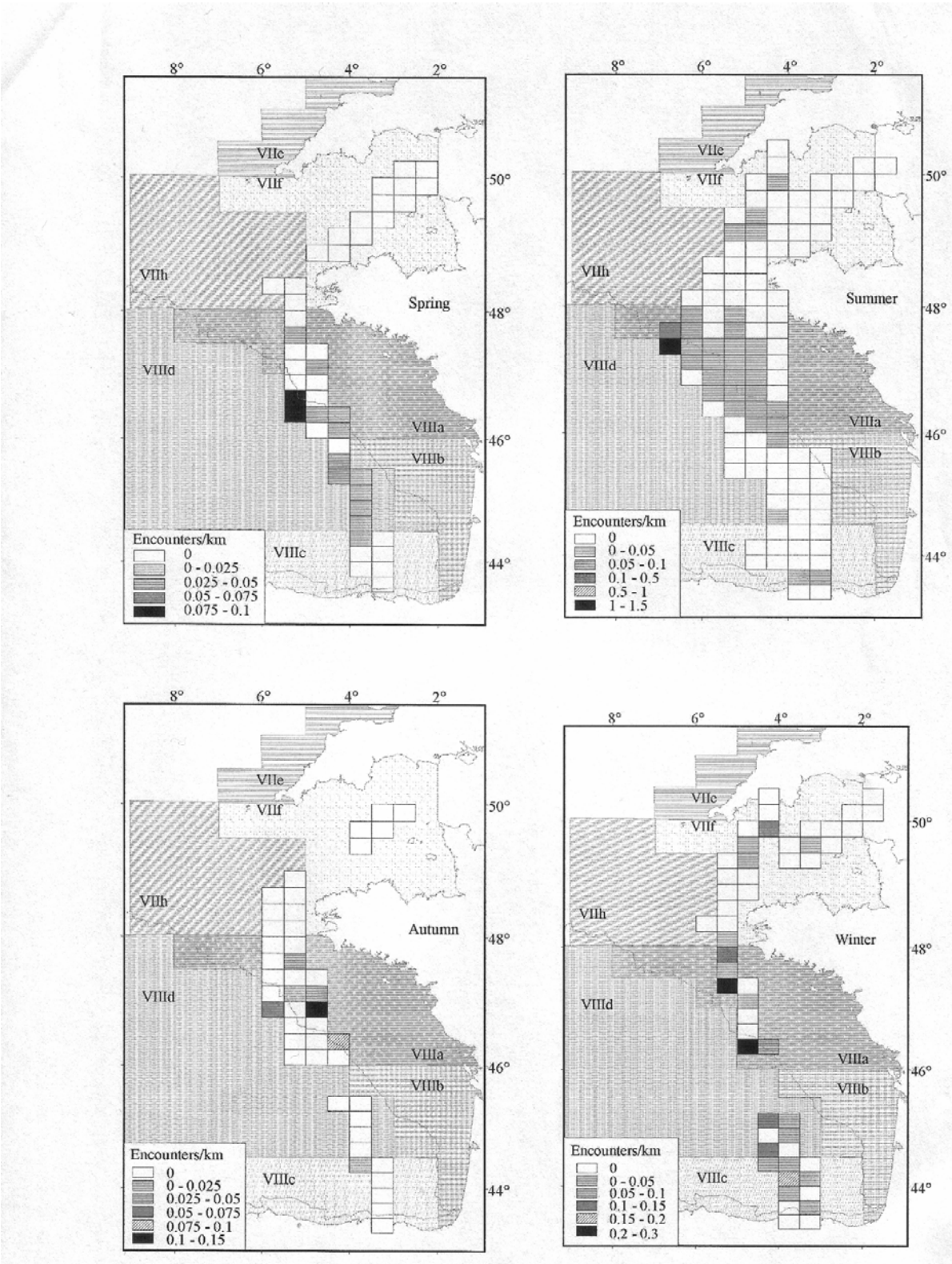

Fig. 5. Seasonal relative abundance and distribution of common dolphins 1998-2002.

SYNOPTIC DISTRIBUTION AND ABUNDANCE OF FIN, HUMPBACK AND SPERM WHALES IN THE NORTHEASTERN ATLANTIC

N. Øien

Institute of Marine Research, P.O.Box 1870 Nordnes, N-5817 Bergen, Norway

Shipboard sighting surveys targeting minke whales have been conducted in Norwegian and adjacent waters during the summer seasons around July since the mid-1980s. In 1995 a synoptic survey covering a large part of the Northeast Atlantic and the North, Norwegian, Greenland and Barents Seas was conducted over the period 5 July to 8 August. The surveyed area was divided into 18 survey blocks which were covered by 11 vessels. All vessels were equipped with two platforms operating independently. The survey was conducted in "passing mode" which hampered species identification. Data analysis was carried out using standard line transect methods. Because of grouping of distances and angles in the data, smearing was applied before fitting detection functions. Estimates have been produced based on both platforms separately as well as a combination of them. During the 1995 survey, a total of 25,000km of primary transects were conducted, covering a total area of approximately 2,827,000km^2. There were approximately 600 records of large whale sightings, of which 40% were classified as fin whales, 20% as sperm whales, 8% as humpback whales, and the rest as other species or unidentified large whales. Most sightings of fin whales were made in the Svalbard area, along the continental slope from Bear Island and northwards to the northwest of Spitsbergen. The sightings of humpback whales were nearly exclusively made in the Bear Island shelf area, which is known to be an important habitat for humpbacks in summer time. Most sperm whales were sighted in the Norwegian Sea off the continental slope west of northern Norway. The total estimates from the combined platforms were 5,395 fin whales (cv 0.20), 1,210 humpback whales (c.v. 0.255), and 4,319 sperm whales (c.v. 0.199).

TRENDS IN THE OBSERVED DISTRIBUTION AND ABUNDANCE OF WHALES IN THE CENTRAL NORTH ATLANTIC

D. G. Pike[1], T. Gunnlaugsson[2], G. A. Víkingsson[2], G. Desportes[3], D. Bloch[4], and B. Mikkelsen[4]

[1] *North Atlantic Marine Mammal Commission, Polar Environmental Centre, N-9296 Tromsø, Norway*
[2] *Marine Research Institute, P.O. Box 1390, IS-121 Reykjavik, Iceland*
[3] *Fjord&Belt, Margrethes Plads 1, Dk-5300 Kerteminde, Denmark*
[4] *Faroese Museum of Natural History, Fútalág 40, FR-100 Tórshavn, Faroe Islands*

The North Atlantic Sightings Surveys (NASS) are a series of international cetacean line transect surveys that have been conducted in 1987, 1989, 1995 and 2001. NASS have covered a very large area of the central North Atlantic, from East Greenland east to coastal Norway, and from Svalbard south to the Iberian peninsula. Coverage has been reduced in recent surveys, but the central area around Iceland and the Faroes has been covered in all surveys. The surveys used ships and aircraft as survey platforms. Target species were minke, fin and pilot whales, but all species encountered were registered. The abundance of fin whales have increased greatly over the period in the Icelandic/Faroese survey area, from an estimated 5,500 (cv 0.18) in 1987 to 25,400 (cv 0.127) in 2001. Humpback whales increased from an estimated 1,800 (cv 0.18) in 1987 to 14,600 (cv 0.49) in 1995, and have shown a mean annual increase rate of 11.4% (cv 0.18) over the period 1986-2001. The abundance of minke whales in the Icelandic coastal area has been stable or shown a moderate increase over the period. All estimates are negatively biased. The observed trends are consistent with increases in abundance following the cessation of whaling in this area, but this cannot account for the large increases in fin and humpback whales. Other factors, including immigration from other areas, changes in carrying capacity due to fisheries, the near extirpation of some other cetacean species, and operational factors in the surveys themselves, may be involved.

A STUDY ON THE WINTER DISTRIBUTION AND ABUNDANCE OF HARBOUR PORPOISES (*PHOCOENA PHOCOENA*) IN THE GERMAN BIGHT USING AERIAL AND SHIPBOARD SURVEYS

W. Piper[1], V. Brock[1], M. Laczny[1], and F. Thomsen[1, 2]

[1] *Biologisch-landschaftsökologische Arbeitsgemeinschaft, Gotenstraße 4, D-20097 Hamburg, Germany*
[2] *Zoologisches Institut und Museum, Universität Hamburg, Martin-Luther-King-Platz 3, D-20146 Hamburg, Germany*

Detailed information on year-round distribution and seasonal abundance of a given population is essential for any conservation study, but for most odontocetes this knowledge is limited. Previous studies have shown an uneven distribution of harbour porpoises (*Phocoena phocoena*) within the German Bight with a relatively high abundance in the offshore waters of Sylt. However, these studies have been mostly conducted in spring and summer. Only limited information exists on the whereabouts of porpoises during wintertime. In this study, we investigated the distribution and abundance of harbour porpoises in the German Bight between December and February of 2001/2002 and 2002/2003 using aerial and shipboard surveys. The study area extended from the coastal waters off Eastern-Frisia over the central German Bight to the offshore waters north off Sylt with a coverage of 8,000 km^2. A total of 7 aerial and 35 shipboard surveys with 8,500 km of trackline were undertaken. For each survey we calculated relative abundance (porpoises per km effort). For surveys with a sufficient sample, absolute abundances were calculated using the software program DISTANCE 4.0. A total of 198 sightings (329 individuals) were recorded. Porpoises were not evenly distributed within the study area. In the offshore area north off Sylt abundance was generally low throughout both winters. In the area off Eastern–Frisia and in the central German Bight we found a relatively high number of porpoises, especially during February 2003. This study provides evidence for a seasonal divergence in the distribution of harbour porpoises within the German Bight. Whether this represents a seasonal migration or indicates a division into sub-populations is unknown, since animals could not be individually identified. Further studies using satellite telemetry might be of great importance to help shed light on the seasonal use of certain areas by harbour porpoises in the German Bight.

DENSITY AND DISTRIBUTION OF HARBOUR PORPOISES (*PHOCOENA PHOCOENA*) IN GERMAN WATERS

M. Scheidat, A. Gilles, and U. Siebert

Forschungs- und Technologiezentrum Westkueste der Christian-Albrechts-Universitaet zu Kiel, Hafentoern, 25761 Buesum, Germany

Current plans to utilise German offshore waters as sites for wind turbine parks as well as ongoing investigation of potential areas to implement Natura 2000 have led to an increased research effort on local marine mammal populations. The aim of our study was to determine the spatial distribution and density of harbour porpoises and other cetaceans in the German part of the North Sea. From May 27th 2002 to October 19th 2003 (40 flight days) aerial surveys were conducted in the German EEZ (exclusive economic zone) in the North Sea. The study area was separated in four substrata. The surveys followed standard line-transect distance sampling methodology flying at a height of 600 feet with a speed of 100 knots. The plane used was a Partenavia with bubble windows allowing a good view of the trackline. A complete coverage of all four strata was attempted in two-month surveys in summer, autumn and winter 2002 as well as in spring, summer and autumn 2003. To estimate g(0) and the effective strip width for the aerial surveys a circling procedure was used. The resulting density, sightings rate, percentage of calves and average group size was compared between the years and seasons. The data was tested for both inter- and intra-annual changes in abundance. The surveys will continue in the next years to provide a baseline database for harbour porpoise abundance and distribution in German waters.

WHERE WERE THE SEALS? ARGOS SATELLITE TELEMETRY POSITIONS AND GRID BASED SURVEYS

J. Tougaard

National Environmental ResearchInstitute, Department of Arctic Environment, Frederiksborgvej 399, 4000 Roskilde, Denmark

Satellite telemetry is widely used to obtain information on movement and distribution of marine mammals. Animals equipped with a Service Argos transmitter are positioned by satellites in sun-synchroneous polar orbits. In general, the more uplinks received during a satellite's pass across the sky, the more accurate the position calculated. However, the precision of positions received from diving marine mammals is poor (most are location classes A and B), due to the limited number of uplinks transmitted per satellite pass. Even with appropriate filtering which removes unrealistic positions based on previous and subsequent positions, the accuracy of A and B positions are low, in the order of several to tens of kilometres. In connection with collection and compilation of data for the Danish Atlasof Mammals, a new method for analysis of Argos positions was developed. Basis for the atlas is an UTM-grid of 10x10 kilometre squares. For each species, it is noted which squares contain at least one recent observation. Given the low accuracy of most Argos positions at sea, it is problematic simply to register which squares contain positions and which does not. Instead, a likelihood is calculated for each square based on all positions registered within the square as well as adjacent squares. This number expresses the probability that at least one true position belongs within the square. This probability is calculated based on knowledge of the mean errors for the different location classes, assuming that errors in positioning are distributed according to the bivariate normal distribution. Analysis of data collected from harbour seals tagged with Argos transmitters confirms the usefulness of the method for this type of grid based surveys. The method may also prove useful for evaluating the presence or absence of tagged animals in very small areas, such as off-shore wind turbine parks.

PRESENT AND FUTURE ABUNDANCE ESTIMATION OF MARINE MAMMALS IN THE CARDIGAN BAY CANDIDATE SPECIAL AREA OF CONSERVATION (CSAC) FROM LINE TRANSECT SURVEYS USING A SMALL BOAT

F. Ugarte[1, 3], P. Lastra[1, 2], P.G.H. Evans[1, 3], S. Hartley[1, 4], and S. Laing[1, 5]

[1]*Cardigan Bay Marine Wildlife Centre, New Quay, Ceredigion SA45 9PS Wales, UK*
[2] *Universidad de Las Palmas de Gran Canaria, Spain*
[3] *Sea Watch Foundation, 11 Jersey Road, Oxford 0X1 3PS, UK*

Data was collected during line transect surveys of the Cardigan Bay cSAC, Wales, conducted between May and September 2003 using a 10m vessel. Distance sampling methodology was used to estimate the numbers of marine mammals using the area. An estimated 219 bottlenose dolphins (95%CI=101-476), 221 harbour porpoises (95%CI=138-355) and 100 grey seals (95%CI=47-212) used the area (ca. 1000km2). For monitoring populations over time, accurate abundance estimation is essential. This requires large sample sizes, which are usually achieved by targeting large populations and surveying over large areas from expensive platforms. Here, small populations were surveyed, over a small area, from a relatively inexpensive platform. Therefore, in order to maximise sample size, a grid of systematically spaced lines was superimposed on the cSAC and as many randomly chosen lines as possible were covered during the season. Further to this, for future surveys, bottlenose dolphin data were used to determine how much extra effort would be required to improve confidence intervals in order to detect any significant changes over time. One critical assumption of distance sampling is that all animals on the line and close to the line are always detected by the main observer(s). Here, two main observers maintained dedicated watch from the roof, and a third independent observer searched ahead of the boat to check this assumption. The main observers did not detect all the porpoises and seals close to the line; so we are probably presenting underestimates of the actual numbers of these two species. The efficiency of line transect surveys for monitoring populations of marine mammals in SACs is influenced by the time that can be spent on the water and the movement of the animals in and out of the area being surveyed, since many of the animals will be encountered more than once during the season.

POPULATION STRUCTURE, SPATIAL DISTRIBUTION AND ASSOCIATION OF BOTTLENOSE DOLPHINS (*TURSIOPS TRUNCATUS*) OFF THE WEST COAST OF TENERIFE

A. Virjee[1] and D. Scott[2]

[1] *Department of Zoology, University of Aberdeen, Tillydrone Avenue, Aberdeen, AB9 2TN, UK*
[2]*Department of Biological Sciences, University of Brighton,Cockcroft Building, Moulsecoom, Brighton, BN2 4GJ, UK*

Population structure, spatial distribution and association of bottlenose dolphins (*Tursiops truncatus*) off the West coast of Tenerife was assessed during a total of 108 photographic surveys conducted between 1998 and 2001 in the months of July, August and September. 71 dolphins were individually identified. The majority of sightings were of resident individuals, but non-resident individuals were also sighted throughout the study period, and were suspected to be transient. Reasons for these high residency patterns are discussed. Three different techniques were used to determine if the population size was stable over the four years. The Baileys triple catch method and the total count of individuals showed a similar pattern in the fluctuation of population size over the four years, whereas the annual catch per unit effort results displayed a greater level of consistency throughout the duration of the study. The dolphins were found in small pods (mean size of 8.25), which was similar to mean pod size from other bottlenose dolphin studies around the world. Seven frequently sighted dolphins inhabited home ranges that varied in size and position. Core areas of intense use within their home ranges were found to be of similar size to those recorded in other studies. Association within the population was investigated, and three main pods were identified, each containing subgroups. Certain pairs of individuals were strongly associated with one another, while others displayed a low level of association that is thought to be typical of a "fission-fusion" society such as a bottlenose dolphin population.

RELATIVE ABUNDANCE OF HARBOUR PORPOISES (*PHOCOENA PHOCOENA*) AND ITS SEASONAL VARIATION IN THE GERMAN BALTIC SEA MONITORED WITH PORPOISE DETECTORS (T-PODS)

U.K. Verfuss[1], C. Honnef[1], A. Kilian[2], and H. Benke[1]

[1] *German Oceanographic Museum, Katharinenberg 14/20, 18439 Stralsund, Germany*
[2] *Nürnberg Zoo, Am Tiergarten 30, 90480 Nürnberg, Germany*

Since August 2002, the relative abundance and habitat use of harbour porpoises (*Phocoena phocoena*) in the German Baltic Sea has been investigated. Porpoise detectors (T-PODs), registering porpoise echolocation click trains, were tested, calibrated and deployed on 24 measuring points in the German Baltic. This acoustic method allows full time and long-term monitoring of the presence of porpoises in the areas around measuring points. To interpret T-POD field data, the echolocation behaviour of porpoises during various behavioural tasks was registered by T-PODs in the Fjord&Bælt in Kerteminde, Denmark, where two harbour porpoises are held in a semi-natural outdoor enclosure. For comparability of data obtained from different T-PODs, all T-PODs were calibrated before deployment. Field data were checked for quality, and false alarms caused by e.g. boat sonar/engines were excluded from data analysis. The results show an eastward decrease in porpoise registration: During summer and autumn, porpoises were registered nearly every day in the Fehmarnbelt; in the Kadet channel, we had registrations on 2/3 of the monitored days. East of the Darss ridge, registrations were rare. In winter, days with porpoise registrations dropped to a minimum in the Fehmarnbelt as well as in the Kadet channel, and raised again in spring and summer, respectively. T-PODs proved to be valuable devices for investigating the relative abundance of harbour porpoises and for assessing seasonal changes in habitat use of monitored areas. This study is financed by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety and the German Agency for Nature Conservation.

THE SOUTHERN OUTER MORAY FIRTH IN NE SCOTLAND AS A POTENTIAL "SAFE AREA" CANDIDATE FOR THE HARBOUR PORPOISE (*PHOCOENA PHOCOENA* L.)

A R. Whaley and K.P. Robinson

Cetacean Research & Rescue Unit, P.O Box 11307, Banff, AB45 3WB, Scotland, UK (mailbox@crru.org.uk)

INTRODUCTION Throughout its range, the distribution of the harbour porpoise (*Phocoena phocoena* L.) has contracted significantly over the last century, particularly in the North Sea. Reasons for this decline have been primarily attributed to detrimental anthropogenic activities, but the current lack of data on the species has been noted as the foremost reason for the apparent complacency with which the UK and EC governments have regarded it to date.

In areas where shore sightings are known to be prevalent, fine scale data on the distribution and abundance of the species will be fundamental to population estimates, and therefore particularly significant to management plans and conservation policies for the protection of these small cetaceans. In fact, the conservation of ecologically important sites for coastal species such as the harbour porpoise that exclusively use particular habitats makes the monitoring of small inshore populations a necessity.

Along the southern coastline of the outer Moray Firth in NE Scotland (57º40´N, 3º30´W), the harbour porpoise is found in significant numbers during the summer months (Robinson, 2003). The aim of the present study was to determine the general distribution and abundance of the animals using this northern coastal location during the summer months and to identify potential "hotspots" used by the species in these productive inshore waters.

METHODS Data were collected between May and October 2003 using boat-based surveys along an 82km stretch of the southern coastline of the outer Moray Firth. The surveys were conducted using a 5.4 m Avon Searider rigid inflatable boat fitted with a 90 hp Johnston Evinrude outboard engine at speeds of 8 to 12 km per hour whilst searching for animals. Trips were made on as many days as possible throughout the study period at sea states of Beaufort 3 or less and during optimal light conditions. If the sea state increased to Beaufort 4 or above or if heavy or continuous rain occurred during the course of a survey, the trip was either stopped temporarily or aborted. Throughout the study, a total survey area of 550 km^2 was systematically covered using four parallel transect routes divided further into 3 sub routes falling between the ports of Portknockie and Fraserburgh (Fig. 1).

For each boat survey, a *Trip Log* was used to detail the trip information which included the route covered, survey start and finish times, GPS start and finish positions, and the sea state/environmental conditions. When animals were sighted, the boat was slowed to minimise disturbance and details of the number of adults and calves sighted, their direction of travel and the behavioural activity of the individuals present was recorded. Since multiple encounters could be made during a single survey trip, the recording procedure was repeated for each individual encounter made. Once the required data had been collected, the encounter was terminated and the end time and end GPS positions recorded accordingly. Back on the shore, the details from each encounter were subsequently entered into a spreadsheet from which the GPS coordinates could be plotted onto a scale map using the graph function.

Indices for abundance of animals were determined by sightings rates and expressed as animals per square kilometre. Plots could then accordingly be made by sightings and effort variables over required time scales.

RESULTS Between the dates of 23 May and 30 September 2003 a total of 44 surveys were carried out on 42 days, producing a total survey effort of 122.87 survey hours and covering a distance of approximately 1,200 km. 77.78% of the surveys were carried out at sea state 2 or less, with a further 20% being undertaken in sea state 3. A total of 131 encounters were recorded on the 42 survey days, producing a cumulative count of 415 animals. Group sizes were found to range from 1 to 17 individuals with a mean of 2.64 ± 1.18 animals (Table 1). Single animals and pairs of animals were recorded most frequently, with single animals accounting for 29.85% of the total encounters recorded. However, the size of groups showed a significant increase (P=0.017) with progression throughout the season, the largest group of 17 animals being recorded in September 2003.

12.68% of all the groups encountered contained calves, accounting for 4.79% of the total cumulative number of animals recorded. During the months of May and June 2003, over 70% of animals were engaged in feeding or foraging activities (Fig. 2). However, this activity dropped to nearly half during the following 3 months, when the animals encountered were more often recorded travelling in typically larger group sizes

Two areas of high usage were identified for the species: Area A, in Aberdour Bay, to the east of the survey area; and Area B, adjacent to Whitehills, in the middle of the survey area (Fig. 3). A total of 71.85% of all encounters made

were recorded within these two areas, 41.48% in Area A and 30.37% in Area B. Only 3 encounters were made at depths of 100-metres, the majority of animals being recorded close to the 20-metre depth line. Using ARCGIS 8, potential harbour porpoise "hotspots" were identified in 5 locations: 2 within Aberdour Bay in Area A, and 3 in Area B, adjacent to and to the west of Whitehills.

The relative abundance for animals throughout the entire study area was calculated as 0.75 animals per square kilometre.

DISCUSSION To date, there have been few fine-scale studies of the harbour porpoise in UK coastal waters and no previously published work for the Moray Firth. The only survey to take this area of Scotland into account was the SCANS survey of 1994, which included a section of the outer Moray Firth along with other regions of northeast Scotland and adjacent areas of the North Sea, classified as Block D. Population estimates for this area are given as 37,144 animals by Hammond *et al.* (1995).

In the present study area, representing just 1.14% of the SCANS Block D area, a cumulative total of 415 animals were recorded from just 44 surveys carried out from May to September over a survey area of approximately 1,200 km. In comparison, Pierpoint (2001) logged 254 animals during survey work in southwest Wales over a distance of 1,287 km, whilst Leopold *et al.* (1992) recorded 251 animals over 270km in southwest Ireland. In addition, Weir *et al.* (2001) compiled sightings from the west and north coast of Scotland over 19 years, between 1979 and 1998, and recorded only 1,318 animals from 650 sightings. These initial figures would suggest that the coastline of the outer southern Moray Firth might represent a significant coastal habitat for this species during the summer months.

This is further supported by the estimation of abundance made for the present study area. The calculated figure of 0.752 animals per square km compares well with other data from around the country. For example, Hammond *et al.* quote a figure for block D in SCANS of 0.363 animals per km, less then half of the estimate made in the present study. The estimates made by Pierpoint range from 0.14 to 0.72 animals per km in southwest Wales. The SCANS survey for the Celtic sea (Block A) provided estimations of 0.57 animals per km, although Leopold *et al.* (1992) found a density of 0.77 per km for a smaller, coastal area. Block F, the central North Sea, is the area that had the highest density in the SCANS survey of 0.776 animals per km. Interestingly, this figure is only slightly above that determined for the present study area.

Virtually all the encounters recorded in the study area occurred either on or near the bathymetric slopes where nutrient upwellings are most likely to occur (Harding-Hill, 1993). Harbour porpoise have been noted to use such upwellings previously (Pierpoint, 1993), where they can often be observed feeding alongside minke whales (*Balaenoptera acutorostrata* Lacépède) (pers. obs.). The porpoises were rarely recorded close to the shoreline and were never observed in the presence of bottlenose dolphins, which typically use the rocky areas and bays close in to the shore (Eisfeld, 2003).

Two main areas were identified as potential "hot-spots", defined as zones of critical habitat supporting aggregations of animals by Pierpoint (2001): one adjacent to Whitehills harbour, and the other within the confines of the more secluded Aberdour Bay. These two areas contained between them 71.85% of all sightings. Both hot-spot areas appear to be clustered along the 20-metre shelf line. Apart from this, the two areas appear to have little in common. Whilst Zone A lies adjacent to a busy marina, Zone B is a quiet bay with little boat traffic. However, since both areas are found adjacent to areas where upwellings may occur, the clumped distribution of animals at these two sites is likely to be related to the presence of prey; the water mixing in these areas resulting in high levels of primary production near the surface (Tynan, 1997). Further studies using newly available techniques such as remote sensing might be useful to correlate such biotic and oceanographic factors with the presence and/or absence of these animals in this location.

Whilst two potential sites of high usage were identified in the present investigation, further study would be desirable to establish whether or not these sites also provide important calving/nursery areas for porpoises. The results suggest that the coastline of the southern outer Moray Firth constitutes a potential "safe area" candidate for the species. To this end, the preliminary study provides a useful foundation supporting further investigation of this population, and additional studies may prove crucial to the designation of protected areas for harbour porpoise populations not only in this area of the North Sea, but in other coastal destinations throughout the UK as a whole.

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Table. 1. Showing the mean and range of harbour porpoise group sizes by month from May to Sep 2003

Survey month	Total no. of encounters	Mean group size encountered	Range		No. single animals encountered
			Min	Max	
May	14	1.79 ± 0.89	1	4	6
Jun	4	1.00 ± 0.00	1	1	4
Jul	45	3.29 ± 2.92	1	13	15
Aug	36	3.47 ± 1.89	1	9	6
Sep	32	3.66 ± 3.17	1	17	7
Total Period	131	2.64 ± 1.18	1	17	38

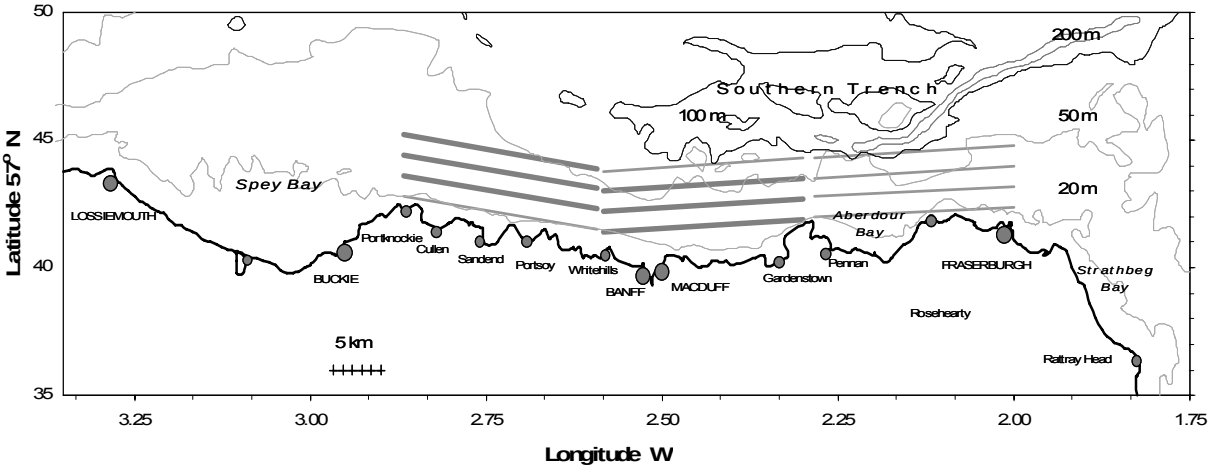


Fig. 1. Map showing the coastline of the southern outer Moray Firth and the line transect survey routes undertaken in the present study between the ports of Portknockie and Fraserburgh. The transects were divided into 4 longitudinal routes, each approximately 45 minutes apart in latitude (depicted by parallel lines running adjacent to the shoreline, above) broken into 3 respective sub routes

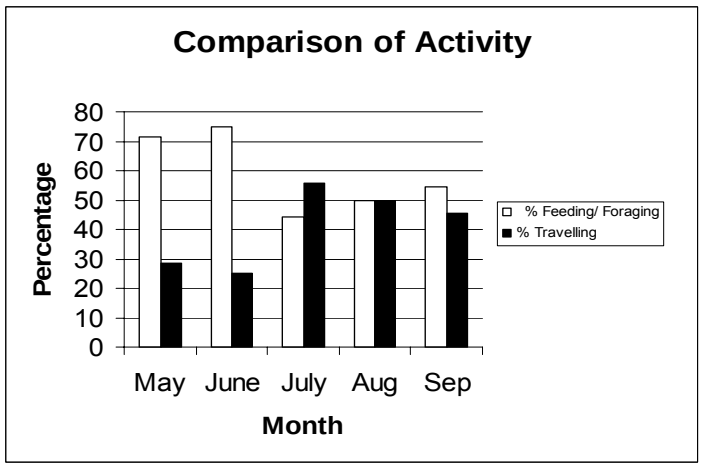
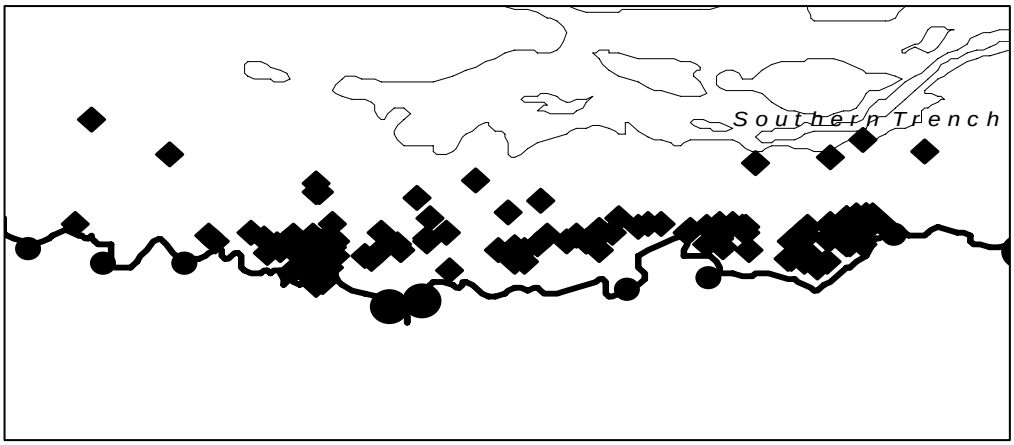


Fig. 2. Histogram showing the activity of harbour porpoise groups recorded during encounters from May to September 2003

(i)



(ii)

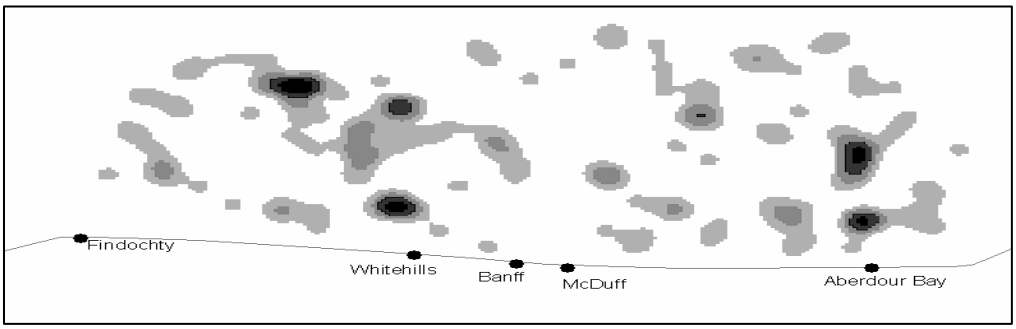


Fig. 3. Distribution maps for the harbour porpoise showing: (i) sightings plotted by individual encounter (n=134); and (ii) abundance throughout the study area in the form of a density map (not to actual scale with map 3a)

SEVENTEENTH ANNUAL REPORT OF EUROPEAN CETACEAN SOCIETY: 2003

Paid-up members of the European Cetacean Society for the year 2003 numbered 523 with 37 countries represented. The highest representation came from United Kingdom (97), Spain (72), Italy (54), Germany (51), France (34), USA (31), Portugal (27), Denmark (18), Belgium (15), Greece, Ireland, the Netherlands and Switzerland (all with 12), and Canada (11)

Countries with ten members or less include Algeria, Argentina, Australia, Austria, Canada, China, Croatia, Finland, Israel, Japan, Malta, Mexico, Monaco, New Zealand, Norway, Poland, Russia, Slovenia, South Africa, Sweden, Taiwan, Turkey and Ukraine, and United Arab Emirates.

The Membership list of the Society continues to be run from the German Oceanographic Museum in Stralsund, which also takes care of the mailing of material including Proceedings. The Society is very grateful to its director Harald Benke, and to Ines Westphal who is responsible for these tasks.

The European Cetacean Society Annual Conference in March 2003 was held in the University of Las Palmas, Gran Canaria, and was attended by 510 people. The theme was 'Marine Mammals and Sound'.

The conference was organised by Michel André. Abstracts were reviewed by a team of reviewers organised by Greg Donovan. Awards were judged by a team led by Thierry Jauniaux.

A total of 56 talks and 416 posters were presented at the conference; there was a student meeting and six workshops:

- Cetaceans and Active Sonar
- POD technologies and use
- The Phocine Distemper Epidemic in 2002
- Maximising Ships of Opportunity for cetacean research
- Whale watching issues
- Research in the Bay of Biscay

The Proceedings of the Rome Conference has been produced, edited by Peter Evans, with help from Ellen O'Boyle. A Special Newsletter Issue from the Workshop on Controlled Exposure Experiments was published, edited by Jonathan Gordon, Peter Tyack, and Dave Thompson.

The Society web page has been significantly developed by Jan-Willem Broekema with help from Ursula Verfuß, and the mailing lists entirely over-hauled.

In accordance with the AGM decision, a statement of concern was prepared on Marine Mammals and Sound.

THE SOCIETY HAS CONTINUED TO PROVIDE INFORMATION OR ADVICE TO GOVERNMENT DEPARTMENTS AND NON-GOVERNMENTAL ORGANISATIONS IN EUROPEAN COUNTRIES, WITH REPRESENTATION AT ASCOBANS AND ACCOBAMS.

The Society is grateful to members and others who have assisted with conferences and in other ways. Particular thanks are due to Roland Lick for all his work on the finances of the society.

FLORENCE CAURANT
Secretary

FINANCIAL REPORT FOR THE YEAR UP TO 1 MARCH 2004

	Irish account EURO	German account EURO	British account GBP
Balance as of 1 March 2003	22,277.66	60,944.29	5,095.30
INCOME			
ECS account savings from 20002/03	22,277.66	60,944.29	5,095.30
Membership fee during the year 2000/2001		10,367.10	
Profit, Conference Gran Canaria 2003		23,323.58	
Other payments (Sale of Proceedings, T-Shirts, etc)		1,282.47	
Interest on Savings account, 2003	16.34	1,208.11	6.08
Total Income	**22,294.00**	**97,125.55**	**5,101.38**

EXPENSES		German account DM	British account GBP
Travel expenses board meeting 2003		3,015.19	114.12
ASCOBANS Meeting			312.53
ECS Newsletters (printing)		5,802.06	
Editorial Expenses			300.00
Postage (Newsletters, Proceedings, E-mail subscription, etc)		2,388.38	198.35
Bank account and credit card expenses		1,514.42	
Total Expenses	**0.00**	**12,720.05**	**925.00**

Balance as of 1 March 2004	**22,294.00**	**84,405.50**	**4,176.38**
	Overall balance	**EURO**	

Roland Lick
Treasurer

EUROPEAN CETACEAN SOCIETY – 2004

The **European Cetacean Society** was formed in January 1987 at a meeting of eighty marine mammal scientists from ten European countries. A need was felt for a society that brought together people from European countries studying cetaceans in the wild, allowing collaborative projects with international funding. Although named a cetacean society, the ECS extends its interests to all marine mammals.

AIMS (1) to promote and co-ordinate the scientific study and conservation of cetaceans;
(2) to gather and disseminate information to members of the society and the general public.

ACTIVITIES The Society set up seven international working groups concerned with the following subject areas: sightings schemes; strandings schemes; cetacean pathology; by-catches of cetaceans in fishing gear; computer data bases that are compatible between countries; the harbour porpoise (a species in apparent decline in Europe, and at present causing serious concern); and ASCOBANS, a regional agreement for the protection of small cetaceans in Europe (in co-operation with the United Nations Environment Program/Convention on the Conservation of Migratory Species of Wild Animals, Secretariat in Bonn, Germany). Some of these have been disbanded now, having served their purpose, and other groups (such as one specifically addressing seals and another on research in the Bay of Biscay) have been established. The names and addresses of contact persons for existing working groups are given below.

Contact persons have been set up in each European member country, where appropriate, to facilitate the dissemination of ECS material to members, sometimes carrying out translations into the language of that country. Their names & addresses are given below.

Special issues of a newsletter are produced at intervals for members. Otherwise, news regarding conservation issues, notable cetacean information from Europe, information on legislation & regional agreements, and reports and notices from Council are posted on ECS e-mailing lists and, where appropriate, the ECS website as topics arise.

There is an annual conference with talks and posters, and at which the annual general meeting is held. The results are published as annual proceedings, under the title *European Research on Cetaceans*. They have been published for conferences held in Hirtshals (Denmark) in 1987, Tróia (Portugal) in 1988, La Rochelle (France) in 1989, Palma de Mallorca (Spain) in 1990, Sandefjord (Norway) in 1991, San Remo (Italy) in 1992, Inverness (Scotland) in 1993, Montpellier (France) in 1994, Lugano (Switzerland) in 1995, Lisbon (Portugal) in 1996, Stralsund (Germany) in 1997, Monaco in 1998 (in conjunction with the Society of Marine Mammalogy, as the 1st World Marine Mammal Science Conference), Valencia (Spain) in 1999, Cork (Ireland) in 2000, Rome (Italy) in 2001, Liège (Belgium) in 2002, and Las Palmas (Canary Islands, Spain) in 2003.

At intervals, workshops are held on particular topics, and the results published as special newsletter issues: no. 6 - a workshop on the harbour porpoise, held in Cambridge (England), 1988; no. 10 - a sightings workshop, held in Palma de Mallorca (Spain), 1990; no. 17 - a workshop to standardise techniques used in pathology of cetaceans, held in Leiden (Netherlands), 1991; no. 23 - a workshop to review methods for the field study of bottlenose dolphins, held in Montpellier (France), 1994; no. 26 - a workshop for the diagnosis of by-catches in cetaceans, held in Lugano (Switzerland), 1995; no. 37 – a workshop on Lung Pathology, held in Lisbon (Portugal), 1996; no. 38 – a workshop on Protected Areas for Cetaceans, held in Valencia (Spain) in 1999; no. 40 – a workshop on Collisions between Cetaceans and Vessels, held in Rome (Italy), 2001; no. 41 – a workshop on the Use of Controlled Exposure Experiments to investigate the Effects of Noise on Marine Mammals, held in Rome (Italy), 2001; no. 42 – a workshop on Active Sonar and Cetaceans, held in Las Palmas (Gran Canaria, Spain), 2003; and no. 43 – a workshop on Research in the Bay of Biscay, held in Las Palmas (Gran Canaria, Spain), 2003.

Membership is open to *anyone* with an interest in cetaceans. The annual subscription is **39 Euros** for full members; **77 Euros** for institutional members and **23 Euros** for student members. For members outside of Europe, an additional **15 Euros** will be charged for higher postage costs. Payment may be made at the Annual Conference in Euro or the currency of the host country. During the year, membership fees can be paid by **credit card** or **transferred directly** to the following ECS-account: Dr Roland Lick, ECS, Postbank Hamburg, Germany, *national bank transfer*: Account No. 789-584-205, Bank Code 200 100 20, *international bank transfer*: Account-No.: IBAN DE21 2001 0020 0789 5842 05, BIC (SWIFT-Code): PBNKDEFF (giving your name and calendar year for membership fee.) Payment in excess of the membership fee will be gratefully received as a donation to the Society.

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Chairman:
Michel Andre,
Laboratori d'Aplicacions Bioacústiques, Universitat Politècnica de Catalunya (UPC)
Centre Tecnològic de Vilanova i la Geltrú, Avda. Rambla Exposició, s/n, 08800 Vilanova i la Geltrú
Barcelona, Spain
(Tel: +34 93 896 7227/ 00; fax: +34 - 93 896 7201; e-mail michel.andre@upc.edu,

Secretary:
Florence Caurant,
Laboratoire de Biologie et Environnement Marins, Université de La Rochelle, Institut de la Mer et du Littoral, Port des Minimes, 17000 La Rochelle, France
(Tel. +33 546 500291; e-mail f.caurant@univ-lr.fr)

Treasurer:
Roland Lick,
Kaiserstrasse 27 B, D-24143 Kiel, Germany (Tel. +49 431 738942; e-mail rlick2059@aol.com)

Editor:
Peter Evans,
Sea Watch Foundation, 11 Jersey Road, Oxford 0X4 4RT, UK
(Tel./fax +44 1865 717276; e-mail peter.evans@zoology.ox.ac.uk)

Other Members of Council:

Jan Willem Broekema,
Brikkenwal 20, 2317 GT Leiden, The Netherlands
(Tel. +31 71 5212076; e-mail j.w.broekema@inter.nl.net)

Thierry Jauniaux,
Dept of Pathology, Veterinary College, University of Liege, Belgium
Tel: +32 4 3664075; fax: +32 4 3664565; e-mail: T.Jauniaux@ulg.ac.be

Iwona Kuklik,
Hel Marine Station, University of Gdansk, P.O. Box 2, 84-150 Hel, Poland
(Tel. +48 58 6751 316; fax. +48 58 6750 420; e-mail: oceik@univ.gda.pl)

Simone Panigada,
Tethys Research Institute, Viale G.B. Gadio, 2, I-20121 Milan, Italy
(E-mail: panigada@inwind.it)

Ursula Verfuß,
c/o Deutsches Meeresmuseum, Katharinenberg 14-20, 18439 Stralsund, Germany
(Tel. +49 3831 2650 390; fax +49 3831 2650 209; e-mail: ursula.verfuss@meeresmuseum.de)

Cristina Beans (Student Member),
Laboratoire d'Oceanologie, Université de Liège, B-6 Sart Tilman, B-4000 Liège, Belgium
(Tel: +32 4 366 3740/ +32 486.730158; e-mail cristinabeans@yahoo.com)

Working Group Contact Persons:

Computer & E-mail Support Group:
Jan Willem Broekema
Brikkenwal 20, 2317 GT Leiden, The Netherlands
(Tel. +31 71 5212076; e-mail j.w.broekema@inter.nl.net)

Pathology:
Manuel García Hartmann
Duisburg Zoo, Mülheimer Str. 273, 47058 Duisburg, Germany
(Tel +49 203 3055900; fax +49 203 3055922; e-mail ha005ha@unidui.uni-duisburg.de)

Beaked Whales:
Colin D. MacLeod, Flat 2/2, 13 Kennoway Drive, Glasgow G11 7UA, Scotland
(Tel: +44 141 337 2209; e-mail: macleod_c@colloquium.co.uk)

Andy Williams, Biscay Dolphin Research Programme, 6 Manor Way, Lee on the Solent, Hampshire PO13 9JH, UK
(Tel/fax: +44 1705 552631; e-mail: Andy.Williams@Biscay-Dolphin.org.uk)

Seals:
Stephen Westcott, 2 Higher Penrose Cottages, Penrose, Helston, Cornwall TR13 0RB
(Tel: 01326-565759/07967-702552; e-mail: stephen@cornwt.demon.co.uk)
in collaboration with Yvan Larondelle (E-mail: larondelle@brut.ucl.ac.be) and Jeny Androukaki (E-mail: rescue@mom.gr)

ECS on Internet:

The ECS can be reached on the internet at www.broekemaweb.nl/ecs. The ECS supports several discussion lists to which cetacean-related discussions, remarks or requests can be sent, some of which are open to free subscription even to non-members.

ECS-talk@jiscmail.ac.uk (the generic open discussion list)

ECS-student@jiscmail.ac.uk (the open discussion list for students)

ECS-members@jiscmail.ac.uk (closed discussion list for ECS members only)

ECS-council@jiscmail.ac.uk (messages to the ECS Council members)

ECS-all-request@jiscmail.ac.uk (to reach the ECS Internet Support Group)

To become a member of ECS-TALK or ECS-STUDENTS, please visit http://www.jiscmail.ac.uk or www.broekemaweb.nl/ecs and search for ecs-talk (or any other list) and follow instructions.

For enquiries about the other membership information (address, telephone, fax and email), and copies of ECS publications, please contact:

Ursula Verfuß, Deutsches Meeresmuseum, Katharinenberg 14-20, 18439 Stralsund, Germany (E-mail: ursula.verfuss@meeresmuseum.de)

NATIONAL CONTACT PERSONS

Algeria Zitouni Boutiba, Institut des Sciences de la Nature, Laboratoire de Biologie et Pollution Marines, University of Oran, Es-Senia, 31000 Oran (Tel. +213 6 337048; fax +213 6 410078)

Belgium Thierry Jauniaux,, Dept of Pathology, Veterinary College, University of Liege, Belgium (Tel: +32 4 3664075; fax: +32 4 3664565; e-mail: T.Jauniaux@ulg.ac.be)

Croatia Danijela Miokovic, Rebar 145, 10000 Zagreb (Fax 385-1-210 361; e-mail: miokovic@Cim.Irb.Hr)

Denmark Anders Galatius, Dansk Havpattedyrforening, Zoological Museum, University of Copenhagen, Universitetsparken 15, DK-2100 Copenhagen Ø, Denmark (Tel. +45 28710372; e-mail agjorgensen@zmuc.ku.dk)

Faroe Islands Dorete Bloch, Museum of Natural History, Fútalág 40, F0-100 Tórshavn (Tel. +298 31 8588; fax +298 31 8589; e-mail doreteb@ngs.fo)

France Florence Caurant, Laboratoire de Biologie et Environnement Marins, Université de La Rochelle, Institut de la Mer et du Littoral, Port des Minimes, 17000 La Rochelle, France (Tel. +33 546 500291; e-mail florence.caurant@univ-lr.fr)

Germany Ursula Siebert, Forschungs- und Technologiezentrum Westküste, Universität Kiel, Werftstr. 6, D-25761 Büsum (Tel. +49 4834 604280; fax +49 4834 6772; e-mail usiebert@ftz-west.uni-kiel.de)

Greece Alexandros Frantzis, Institute of Marine Biological Resources, National Centre for Marine Research, Agios Kosmas, GR-166 04 Hellenikon (Tel: +301 8962730; fax: +301 8960108; e-mail afrantzis@mail.otenet.gr)

Hungary Hajnalka Elekes, 2800 Tataba'nya II, Erdèsz u 9, 1/4 (e-mail helekes@freemail.hu)

Iceland Jóhann Sigurjónsson, Marine Research Institute, Skúlagata 4, P.O. Box 1390, IS-121 Reykjavík (Tel. +354 1 20240; fax +354 1 623790; e-mail johann@hafro.is)

Iceland Gisli Vikingsson, Marine Research Institute, Skúlagata 4, P.O. Box 1390, IS-121 Reykjavík (Tel. +354 55 20240; fax +354 56 23790; e-mail gisli@hafro.is)

Israel Aviad Scheinin, Israel Marine Mammal Research & Assistance Center (MMRAC), P.O. Box 1066, Mikhmoret 40297 (e-mail: aviad.scheinin@013.net.il)

Italy Sabina Airoldi, Tethys Research Institute, Viale G.B. Gadio, 2, I-20121 Milan, Italy (Tel: +39 0184 261027; e-mail: sabina.airoldi@iol.it)

Luxemburg Pierre Gallego, 37 rue du Nord, L-4260 Esch-sur-Alzette, G-D of Luxembourg (Tel: +32 485715924; +34 630 364725; e-mail pierregallego@yahoo.com)

Malta Adriana Vella, Department of Biology, University of Malta, Msida (Fax: +356 32903049; e-mail avel@cis.um.edu.mt)

Morocco Abddellatif Bayed, Unité de Recherche OCEMAR, Université Mohammed V – Agdal, Institut Scientifique, Avenue Ibn Battota, B.P. 703, Agdal, 10106 Rabat (Tel.: +212 37 77 45 48 / 49 / 50; fax: +212 37 77 45 40; e-mail bayed@israbat.ac.ma.uob_isr@yahoo.com>)

The Netherlands Richard Witte, National Institute for Coastal and Marine Management, P.O. Box 8039, 4330 EA Middelburg (Tel: +31 118 672 351; fax: +31 118 651046 e-mail R.H.Witte@rikz.rws.minvenw.nl)

Norway Arne Bjørge, Norsk Institut for Naturforskning – Institute of Marine Research, University of Oslo, PO Box 736, Sentrum, N-0105 Oslo (Tel. +47 22 85 73 15; fax +47 22 85 47 26; e-mail arne.bjorge@imr.no)

Poland Iwona Kuklik, Hel Marine Station, University of Gdansk, P.O. Box 2, 84-150 Hel,
(Tel. +48 58 6751 316; fax +48 58 6750 420; e-mail oceik@univ.gda.pl)

Portugal Marina Loewenstein de Sequeira, Instituto de Conservaçáo da Natureza, Rua Filipe Folque 38-4º D, P-1050-159 Lisboa (Tel. +351 21 316 05 20; fax +351 1 21 352 04 74; e-mail marinasequeira7@yahoo.com)

Slowenia Darja Ribaric, Slovenia Museum of Natural History, Presernova 20, 1000 Ljubljana (Tel. +386 61 1258 472; fax +386 61 218846; e-mail darja.ribaric@guest.arnes.si)

Russia Tatiana Denisenko, K.I. Skryabin Moscow Sate Academy of Veterinary Medicine and Biotechnology, 109472 Akademik Skryabin Street, 23 Moscow (Tel. +7(095) 377 3333; e-mail: tedolphin@mail.ru / tedolphin@list.ru)

Slovenia Tilen Genov, MORIGENOS, Marine Mammals Research and Conservation Society, Jarska Cesta 36/a, 1000 Ljubljana (Tel. +386 1541 0745; fax +386 70 943 266; e-mail tilen.genov@gmail.com)
Spain Juan Antonio Raga, Departamento de Biologia Animal, Universitat de Valencia, Dr. Moliner 50, E-46100 Burjasot, Valencia, Spain (Tel. +34 96 3864375; fax: +34 96 3864372; e-mail toni.raga@uv.es)

Sweden Anna Roos, Environmental Research Group, Swedish Museum of Natural History, P.O. Box 50007, SE-104 05 Stockholm (Tel: +46-8-5195 4223; fax: +46-8-5195 4256; e-mail anna.roos@nrm.se)

Switzerland Beatrice Jann, Via Nolgio 3, CH-6900 Massagno (Tel/fax +41 91 9660953; e-mail jann@dial.eunet.ch)

Turkey Horun Güclüsoy, Dokuz Eylul University, Institute of Marine Sciences and Technology, Baku Blv. 32, 35340 Inciralti, Izmir (e-mail horun.guclusoy@deu.edu.tr)

Ukraine Alexei Birkun, BREMA Laboratory, R. Luxembourg Str. 27-2a, Simferopol, Crimea, 333720 (Tel./fax +380 652 253503; e-mail alexei@birkun.crimea.ua)

United Kingdom Nick Tregenza, Beach Cottage, Long Rock, Penzance, Cornwall TR20 8JE (Tel +44 (0)1736 711783; e-mail nick@chelonia.demon.co.uk)

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Members of the European Cetacean Society are invited to submit summaries of their talk or poster for publication in the Society's Conference Proceedings. They can be half-page abstracts as submitted before the conference, or fuller papers up to five pages in length. These are reviewed by two independent persons. Please use the format given below.

(1) Keep the text, references, and figures/tables to a total of no more than five pages (single-spaced). For those to whom English is not their native language, please ask an English speaker to check the entire text. Unless stated otherwise below, please use Times New Roman font, size 10 throughout.

(2) Prepare all tables and figures in their final form (in black and white NOT colour), and provide the originals for camera-ready printing. Number every table and figure for cross-reference to the text. Place tables, then figures, in chronological order, separate from the text. DO NOT INCLUDE THEM WITHIN THE MAIN BODY OF THE TEXT. Re-size so they occupy as little space as possible whilst still being legible. Place Figure captions underneath each figure, and Table captions above each Table, with Fig. 1, Table 1, etc. in bold type, lower case, and the caption itself in ordinary type, lower case and centred.

(3) Centre the title of your contribution, in capitals and bold type (latin names in the title should be in capitals and italics); one line below place a list of authors in lower case ordinary type (with their initials/first names BEFORE the surname, and a space between initials); one line under this, use ascending numbers (Times New Roman font size 10, at 5-point position superscript) for the addresses of the respective authors.

(4) Place the main text two lines below the authors' addresses. Do not indent the first line but include one line space between paragraphs. Please use double-spacing for two of the three hard copies of the text.

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(6) Sub-headings such as **INTRODUCTION**, **MATERIALS AND METHODS**, **RESULTS**, **CONCLUSIONS**, and **ACKNOWLEDGEMENTS** should be in the body of the text, at the left edge, but **REFERENCES** should be centred above. There is no need for an abstract of any five-page contribution.

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Aguilar, A. and Jover, L. 1982. DDT and PCB residues in the fin whale, *Balaenoptera physalus*, of the North Atlantic. *Rep. int. Whal. Commn*, 32: 299-301.

Sequeira, M.L. 1990. On the occurrence of Ziphiidae in Portuguese waters. Pp. 91-93. In: *European Research on Cetaceans - 4*. Proc. 4th Ann. Conf. ECS, Mallorca, 2-4 March, 1990 (Eds. P.G.H. Evans, A. Aguilar & C. Smeenk). European Cetacean Society, Cambridge, England. 140pp.

Stewart, B.S. and Leatherwood, S. 1985. Minke whale *Balaenoptera acutorostrata* Lacépède, 1804. Pp. 91-136. In *Handbook of marine mammals,* vol. 3. (Eds. S.H. Ridgway and R.J. Harrison). Academic Press, London. 430pp.

(8) Please provide either half-page abstracts or longer five-page contributions both as hard copies and on CD, using Microsoft Word, and Times New Roman font, size 10 throughout (except references which are size 9 pt). **Do not send by e-mail**. Include three copies of the longer contributions (two of which will go to independent referees).

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Dr Peter Evans, Sea Watch Foundation, 11 Jersey Road, Oxford 0X4 4RT, UK (Tel. 44-1865-717276; e-mail peter.evans@zoology.ox.ac.uk).

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