Symposium

The Role of Marine Mammals in the Ecosystem in the 21st Century

29 September -1 October, 2008
Alderney Landing, Dartmouth, NS, Canada

Convened by:

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Poster

Foreward

In 1995, NAFO and ICES sponsored a successful symposium on the ecological role of marine mammals. This follow-up symposium will present new findings on the syntheses of information over ecosystem components, on biological and physical aspects of the environment, and on new research approaches to understanding the role of marine mammals.

This symposium entitled "*The Role of Marine Mammals in the Ecosystem of the 21st Century*" is sponsored by NAFO, ICES and NAMMCO and organized by the NAFO Secretariat. The Scientific Steering Committee consists of Mike Hammill (Canada), Phil Hammond (Scotland) and Anthony Thompson (NAFO Secretariat)

This booklet contains the Abstracts of papers and posters presented at this symposium. Please note that any subsequent changes will be announced by the co-convenors.

Presented papers and posters are eligible for consideration in the Symposium Proceedings to be published as a special issue of the NAFO *Journal of Northwest Atlantic Fishery Science* (JNAFS) [http://journal.nafo.int].

September, 2008 NAFO Secretariat

Symposium
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Monday, 29 September

0830-0900 Registration, set-up Posters and load presentations

0900-0915 Introduction (Scientific Council Chair, Convenors)

Session 1. **Biological and environmental factors affecting life history traits** (Garry Stenson)

0915-1000 Mark Hindell ***Keynote - Factors affecting Life History Traits***

1000-1020 A. K. Frie, V. Svetochev, G. Stenson and T. Haug Trends in reproductive parameters of female hooded seals *Cystophora cristata* in the Northeast and the Northwest Atlantic

1020-1040 D. Thompson, A. J. Hall, B. J. McConnell, C. D. Duck, P. P. Pomeroy, S. E. W. Moss, and M. E. Lonergan, Patterns of mortality of harbour seal pups from declining and stable populations in Scotland

1040-1110 **Break** (30 min)

1110-1130 P. P. Pomeroy, S. E. W. Moss, S. D. Twiss, S. Smout and R. King. Low and delayed apparent recruitment rates in UK grey seal colonies

1130-1150 P.Brodie , K. Ramirez and M. Haulena Growth rates and age of sexual maturity of Beluga (*Delphinapterus leucas*) from a wild population in Cumberland Sound, Canada, compared to those raised in captivity.

1150-1210 S. Murphy, G. J. Pierce, R. J. Law, M. B. Santos, J. A. Learmonth, M. Addink, W. Dabin, E. Rogan, P. D. Jepson, R. Deaville, A. F. Zuur, P. Bustamante, F. Caurant, V. Lahaye, V. Ridoux, B. N. Zegers, A. Mets, C. Smeenk, T. Jauniaux, A. López, J. M. Alonso Farré, A. F. González, A. Guerra, M. García-Hartmann, S. P. Northridge, R. J. Reid, C. Lockyer, J. P. Boon Assessing the effect of contaminants on reproductive success.

1210-1230 H. Frouin, M. Fournier, M. Lebeuf, R. St.-Louis, E. Pelletier, M. Hammill. Toxic effects of tributyltin and its metabolites on harbor seal (*Phoca vitulina*) immune cells.

1230-1400 **Lunch (1.5 hours)**

Session 2. **Foraging strategies and energetic requirements**(Tore Haug)

1400-1445 Dan Costa ***keynote - Foraging Ecology and Energetics of Pinnipeds: Conservation Implications***

1445-1505 T. Tamura, K. Konishi Foraging Ecology and Energetics of Pinnipeds: Conservation Implications.

1505-1525 G. A. Víkingsson Feeding ecology of common minke whales (*Balaenoptera acutorostrata*) in Icelandic waters.

1525-1555 **Break** (30 min)

1555-1615 T. S. Stevens and J. W. Lawson. Using recent distribution and behavioural data for killer whales (*Orcinus orca*) in Atlantic Canada to assess the influence of predation pressures on the movement and social patterns of minke whales

1615-1645 M. O. Hammill, M. Ryg and D. Chabot. Seasonal Changes in Energy Requirements of Harp Seals.

1700-1830 Reception/Poster Display

Tuesday, 30 September

0900-0920 K. Ono and M. Bertrand. Diving, Movements, and Habitat Preference in Gulf of Maine Harbor Seal Pup (*Phoca vitulina concolor*)

0920-0940 J. M. Andersen, Y. Wiersma and G. Stenson. Habitat Selection By Hooded Seals (*Cystophora cristata*) In A Dynamic Marine Ecosystem.

0940-1000 K.T.A. Davies, C. T. Taggart and K. Smedol. The role of physical oceanography and zooplankton in controlling the spatiotemporal distribution of the North Atlantic right whale.

1000-1050 **Break** (50 min)

1050-1110 K. Konishi, T. Tamura, T. Isoda, R.Okamoto, K. Matsuoka, T. Hakamada. Prey consumptions and feeding strategies of three baleen whale species around the Kuroshio-current extension.

1110-1130 P. Brodie and G.Vikingson Observations of the feeding mechanics of the Sei whale (*Balaenoptera borealis*), based on the examination of hunted specimens off Nova Scotia and Iceland.

1130-1150 A. I. Mackay and P. C. Stephenson. An assessment of the foraging behaviour of bottlenose dolphins interacting with a bottom trawl fishery.

1150-1320 **Lunch (1.5 hours)**

Session 3. **Marine mammal – fisheries interactions** (Gisli Vikingsson)

1320-1405 John Harwood, J. Matthiopoulos and S. Smout ***keynote - Quantifying marine mammal-fisheries interactions***

1405-1425 C. D. Orphanides Comparison of Methods for Estimating the Bycatch of Protected Species: Estimating the Bycatch of Harbor Porpoise (*Phocoena phocoena*) in U.S. Gillnet Fisheries in the Northwest Atlantic

1425-1445 M.-Y. Lee. Whale-watching and Herring Fishing: Joint or Independent?

1445-1505 S. Goetz, G. Hernandez-Milian; C. Varela-Dopico, J. Rodriguez-Gutierrez, J. Romón, J. R. Fuertes-Gamundi, E. Ulloa, N. J. C. Tregenza, A. Smerdon, M. G. Otero, V. Tato, J. Wang, M. B. Santos, A. López, R. Lago, J. Portela, G. J. Pierce, Results of a Short Study of Interactions of Cetaceans and Longline Fisheries in Atlantic Waters: Environmental Correlates of Catches and Depradation Events

1505-1525 I. Payá and P. Brickle Changes of fishing gear design for reducing whale interference: Impacts on stock assessment and management of toothfish off Falkland Islands.

1525-1605 **Break** (30 min)

1605-1625 T. Aho, A. Gårdmark, K. Lundström and J. Pönni Effects of grey seals on the herring population in the Baltic Sea area.

1625-1645 S. Gunnar Lunneryd, S. Königson and K. Lundström The grey seal- fishermen cod competition in the Baltic Sea.

1645-1705 C. Lenky and B. Sjare Interactions between harp seals and salmon in coastal habitats of Newfoundland and Labrador.

1705-1725 F. L. Read, J. Martínez-Cedeira, Á. F. González, A. López, B. S. and G. J. Pierce Understanding marine mammal and fisheries interactions in Galicia, north-west Spain: Past, present and future.

1725-1745 J.W. Lawson and J.-F. Gosselin Don't Ignore The Whales: Cetacean Biomass Consumption Estimates Based On The Recent TNASS Aerial Survey of Atlantic Canada

Wednesday, 1 October

Session 4. **Theoretical considerations on apex predators and multispecies models** (Mike Hammill)

0900-0945 Andrew Trites ***keynote Marine Mammals and the Theoretical Considerations Associated with Apex Predators and Multi-Species Models***

0945-1005 U. Lindstrøm, K.T. Nilssen, L.M.S. Pettersen and T. Haug Use and selection of prey by harp seals in the northern Barents Sea.

1005-1025 A. D. Buren, M. M. Koen-Alonso, G. B. Stenson. Reconstructing diet composition using a multinomial regression approach

1025-1055 **Break (30 minutes)**

1055-1115 L. Morissette, K. Kaschner, J. L. Melgo and L. Gerber Declining fish stocks: are whales the culprits?

1115-1135 T. A. Øigård, T. Haug, K. T. Nilssen and A.-B. Salberg Reducing uncertainty in estimated harp and hooded seal pup production using Generalized Additive methods: Results from aerial surveys in the Greenland Sea in 2007.

1135-1155 T. J. Lavery and J. G. M. Mitchell. Marine Mammals Stir the Ocean.

1155-1325 **Lunch (1.5 hours)**

1325-1345 M. Mauritzen, E. Johannesen, P. Fauchald, A. Bjørge, E. Olsen and N. Øien Large-Scaled Distribution Of Baleen Whales In The Barents Sea: The Role Of Competitive And Trophic Inteactions With Pelagic Fish.

1345-1405 S. Egorov, V. Zabavnikov, and S. Zyryanov.Marine Mammals Status in the Barents Sea in Modern Stage as Element of its Ecosystem and Climatic Changes.

1405-1425 A. D. Buren, M. Koen-Alonso, K. S. Dwyer and G. B Stenson. Is there room for competition among fish top predators and harp seals in the Northwest Atlantic (NAFO Div. 2J3KL)?

1425- **General Discussion**

How have we improved our understanding in the past 13 years?

What is our current understanding of the role of marine mammals?

What needs to be done next to improve our understanding?

Posters

Session 1

P. Miller, Y. Watanabe, P. Robinson, M. Biuw and M. Fedak Establishing the costs and benefits of reproductive strategies in seals.

V. Zabavnikov. Correlation Between Harp Seal Distribution On Whelping Patches In The White Sea And Ice Conditions

M. Hammill and G. B. Stenson. Impact of ice mortality on harp seal population dynamics.

Session 2

D. Pappas, K. Ono and M. Sweezy. Molecular methods for differentiating gray seal (*Halichoerus grypus*) and harbor seal (*Phoca vitulina*) scat with a note on summer diet of gray seals in outer Penobscot Bay, Maine.

E. S. Nordøy, A. S. Blix & L. P. Folkow. Development of diving ability and foraging range of hooded seals during early life

B. H. Witteveen and K. M. Wynne. Consumption and prey removals by humpback whales (*Megaptera novaeangliae*) near Kodiak Island, Alaska: A revision of previous estimates.

Session 3

M. Rossman. Estimated Bycatch of Small Cetaceans in Northeast U.S. Bottom Trawl Fishing Gear During 2000-2005

G. Pierce, S. Lens, U. Pena, S. Goetz, M. Laporta, J. L. del Río, J. Portela, S. Iglesias. Observer programmes to record marine mammal and seabird distribution and interactions with fishing operations in Southwest Atlantic waters.

D. Belden, G. T. Waring, J. R. Gilbert, A. Williams and D. L. Palka. Characteristics of phocid seal bycatch in New England fisheries.

A. Caskenette, S. Crawford, and D. Duplisea. Evaluating the interaction between the southern Gulf of St Lawrence Atlantic cod (*Gadus morhua*) stock and the Northwest Atlantic grey seal (*Halichoerus grypus*).

W. Ledwell, S. Benjamins, J. Huntington and C. Hood. Incidental entrapments of large whales in Newfoundland Region from 1999-2007

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Session 4

H. Murase, T. Kitakado, K. Matsuoka, T. Hakamada, S. Nishiwaki and M. Naganobu Predator-prey relationship in spatial context -Is the distribution pattern of krill the determinant factor of the distribution pattern of Antarctic minke whale?

T. J. Lavery and J. G. M. Mitchell. Marine Mammals Fertilise the Ocean

S. Lens, M. B. Santos, D. Oñate, A. Miranda., G. Casas, A. Cañadas, J. M. Cabanas, M. Iglesias, R. Fernández and J. A. Vázquez. Distribution of fin whales and krill aggregations off the Galician coasts observed during the CODA-IEO survey.

C.C.A. Martins, P. Lamontagne, L. Parrott, J. A. Landry,D. Marceau, C. Chion, S. Turgeon, R. Michaud, N. Menard, S. Dionne, and G. Cantin. Conceptualizing an individual-based model to simulate marine mammal behaviour in the Saint Lawrence Estuary, Canada

S. Ignatyev. Long-Term Observations Over Mammals On Ukrainian Antarctic Station Academic Vernadsky (Antarctic Peninsula)

The Role of Marine Mammals in the Ecosystem in the 21st Century
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Theme Session 1.

Biological and environmental factors affecting life history traits

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Monday, 0915-1000 ***Keynote*** Mark Hindell **Biological and environmental factors affecting life history traits of marine mammals**

Life history traits broadly refer to those decisions that individuals make to maximize their life-time reproductive output. In this paper, I examine the complex interplay between phylogenetic history and environmental factors in shaping life history traits in marine mammals. For example, body size is a fundamental characteristic of all marine mammals, which influences a variety of other traits, such as fasting ability (which in turn influences migratory patterns and reproductive strategies), but this works in concert with aspects of the marine environment to determine the particular reproductive strategy of a species. Marine mammals can broadly be divided into capitol breeders, which utilize their large body size and energy reserves to enable short efficient periods of maternal care, and income breeders where mothers need to routinely leave their pups to renew their energy reserves. Another example of this interplay between phylogeny and environment is in the foraging ability. In this case, body size influences breath-hold ability and therefore foraging ability. However the kinds of foraging strategies that a species adopts are also affected by the fine-scale distribution of prey ultimately determined by physical aspects of the environment. The degree of plasticity in these traits is also important, and equally under selection pressure. Species that occupy inherently variable and unpredictable habitats are like to be more adaptable in the face of a changing marine environment.

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The Role of Marine Mammals in the Ecosystem in the 21st Century
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Monday, 1000-1020 Anne Kirstine Frie, Vladislav Svetochev, Garry Stenson and Tore Haug. **Trends in reproductive parameters of female hooded seals *Cystophora cristata* in the Northeast and the Northwest Atlantic**

Monitoring reproductive parameters of hooded seals is important for reliable population and harvest modelling. In addition, information on reproductive rates from different areas and over time can give insights on population structure and habitat quality. Traditionally hooded seals breeding in the Northeast Atlantic (NEA) and the Northwest Atlantic (NWA) have been managed as separate stocks based on assumptions of demographic independence which is supported by conventional tagging and satellite telemetry data. Recent genetic studies have, however, not been able to distinguish between areas.

In this study we analysed Norwegian, Russian and Canadian reproductive data from NEA and NWA hooded seals to evaluate temporal and spatial trends in mean age at primiparity (MAP). MAP was determined as the arithmetic mean age of females with one corpus albicans in the ovaries.

In the NWA, MAP ranged from 4.4 years to 4.9 years in samples from 1956-60 (n=52), 1971-76 (n=78), 1978 (n=60) and 1979 (n=49). In the NEA, MAP ranged from 5.7 years to 6.3 years in samples from 1958-62 (n=21), 1978-82(n=98), 1984-1990(n=75), 1986-92 (n=139) and 1999(n=35). There were no significant differences between samples within areas (ANOVA, $P>0.05$), but estimates of MAP were consistently higher in the NEA stock than in the NWA stock and significantly so in the period 1978-1982 (t-test, $P<0.0001$). This supports the assumption of demographic independence between areas and thus, continued recognition of separate management units.

During the study period, hooded seal abundance has been estimated at 450 000- 500 000 animals in the NWA. The NEA stock has likely declined from about 760000 animals to about 80000 animals from 1950 to 1980 and has so far not shown any sign of recovery. The higher 1978-82 value of MAP in the NEA may suggest more marginal habitat conditions for hooded seals in the NEA than in the NWA.

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The Role of Marine Mammals in the Ecosystem in the 21st Century
29 September -1 October, 2008
Alderney Landing, Dartmouth, NS, Canada

Monday, 1020-1040 Thompson, D., Hall,A.J., McConnell,B.J., Duck,C.D., Pomeroy,P.P., Moss,S.E.W. & Lonergan,M.E. **Patterns of mortality of harbour seal pups from declining and stable populations in Scotland**

Harbour seal populations in north and east Scotland have declined by >50% in the last decade. Ultimate causes are unknown but such a reduction must result from reduced fecundity and/or survival. Post-weaning mortality may be high in phocid seals and is thought to be due to failure to develop effective foraging patterns. Food limitation, in terms of quality, quantity or accessibility early in life may have profound effects on overall survival rates.

We used satellite telemetry to investigate relative pup survival rates in areas with declining (Orkney) and stable (Lismore) populations. We tagged 24 female pups, between 3 and 20 days old, with Wildlife Computers SPOT tags at each location. A power analysis indicated that we should be able to identify a difference of 10% or more in survival rates with these sample sizes.

No pre-weaning mortality was detected at either site suggesting the tagging did not disrupt the maternal bond. The mortality pattern in Orkney pups can be closely approximated by a simple exponential decline from the time of weaning, but no simple population survival model fits the trajectory of the Lismore pups.

Up to 150 days of age, mortality in Orkney was double that in Lismore, apparently consistent with the different dynamics of the two populations. The monthly survival probabilities were 0.941 on Lismore (95% CI 0.887-0.970) and 0.866 on Orkney (95% CI 0.788 – 0.918). However, a rapid loss of pups in the Lismore group over the following month meant that the overall survival rates in the two locations had converged by late winter. We present relative survival rate estimates based on simple mark recapture models and show that temporal patterns of mortality in both populations are closely correlated with local sea surface temperatures. While not likely to be a direct causal relationship, this clearly indicates a strong environmental component to the causes of mortality.

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The Role of Marine Mammals in the Ecosystem in the 21st Century
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1110-1130 Pomeroy P.P., Moss S.E.W., Twiss S.D. , Smout S. and King R. **Low and delayed apparent recruitment rates in UK grey seal colonies**

Previously we have shown that adult female grey seals in the UK are faithful to pupping sites and also tend to be philopatric. Individual breeding colonies of grey seals have shown very different pup production trajectories, typified by the decline at North Rona (NR, NW Scotland) and increase then stabilisation at the Isle of May (IoM, E. Scotland) over the last few decades. These changes cannot be attributed to adult mortality alone and here we examine resighting and recruitment of flipper-tagged female pups in certain cohorts born between 1959 and 1997 at these 2 breeding colonies. The total number of female pups tagged was 996 and 1003 at NR and IoM respectively.

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The Role of Marine Mammals in the Ecosystem in the 21st Century
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Monday, 1130-1150 P.Brodie , K. Ramirez and M. Haulena **Growth rates and age of sexual maturity of Beluga (*Delphinapterus leucas*) from a wild population in Cumberland Sound, Canada, compared to those raised in captivity**

The beluga (*Delphinapterus leucas*) is one of the few, highly social odontocetes to adapt to one of the most challenging marine habitats in the world: shallow estuaries, high turbidity, shifting packice and extreme tidal fluctuations. Part of their survival strategy is to maintain herd integrity of hundreds, to thousands of individuals. Harsh seasonality dictates that beluga exploit those brief seasonal opportunities for breeding, calving and migration through herd synchrony. Pregnant animals acquire and transfer exceptionally large stores of fat energy and remobilized skeletal mineral reserves. Parental investment begins with a lactation period which lasts at least two years, a period resulting in rapid growth rate of the calf, coincident with a training period to aquire social, feeding, and navigational skills. As a consequence of the brief annual calving period, the first 4-5 year classes are recognizable according to length, body colour and morphology. This population had been reduced through generations of hunting and it is unlikely that the present numbers are food limited, therefore reflecting maximum rate of reproduction for a wild stock. We examine similar growth indices for two captive groups, some captured as calves, as well as first and second generations born in captivity, to compare known-age animals. Growth rates to earliest onset of sexual maturity of male and females are similar to those estimated for the Cumberland Sound population.

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The Role of Marine Mammals in the Ecosystem in the 21st Century
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Monday, 1150-1210 S. Murphy, G.J. Pierce, R. J. Law, M.B. Santos, J.A. Learmonth, M. Addink, W. Dabin, E. Rogan, P.D. Jepson, R. Deaville, A.F. Zuur, P. Bustamante, F. Caurant, V. Lahaye, V. Ridoux, B.N. Zegers, A. Mets, C. Smeenk, T. Jauniaux, A. López, J.M. Alonso Farré, A.F. González, A. Guerra, M. García-Hartmann, S. P. Northridge, R.J. Reid, C. Lockyer, J.P. Boon **Assessing the effect of contaminants on reproductive success**

As top predators marine mammals can provide information on the accumulation of anthropogenic toxins which present the greatest risk to consumers, we assessed the impacts of persistent organic pollutants (POPs) on two cetacean species that feed on commercially important fish species in the eastern North Atlantic; the common dolphin *Delphinus delphis* and the harbour porpoise *Phocoena phocoena*. In order to evaluate the possible long-term effects of POPs on the continued viability of these populations, we investigated their effects on reproductive output in females, and produced both individual and population-level datasets for use in comparisons and modelling. A large proportion of the blubber samples analysed from *D. delphis* and *P. Phocoena* were above a threshold level (17 µg/g total PCBs lipid weight), which has been reported to have adverse health in marine mammals. This threshold was frequently exceeded in both porpoises (47% of individuals) and dolphins (40%), especially porpoises from the southern North Sea (74%) and dolphins inhabiting waters off the French coast (50%). Results also identified that the individual common dolphins with the highest contaminant burdens were resting mature females, and these individuals also had the highest number of ovulation scars, suggesting either that (a) due to high contaminant burdens, females may be unable to reproduce, thus continue ovulating, or (b) females are not reproducing for some other reason, either physical or social, and started accumulating high contaminant levels. However, information on health status for these individuals was lacking, and it was not known if these females were unable to reproduce for other reasons. Thus, additional analyses were carried out on a "control group" of *D. delphis*, i.e. animals diagnosed as bycaught, and were not suffering from any infectious or non infectious disease that would inhibit reproduction, in order to identify if POPs are causing a decline in reproductive success.

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The Role of Marine Mammals in the Ecosystem in the 21st Century
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Monday, 1210-1230 Frouin H., Fournier M., Lebeuf M., St.-Louis R., Pelletier E., Hammill M. **Toxic effects of tributyltin and its metabolites on harbor seal (*Phoca vitulina*) immune cells**

The widespread environmental contamination, bioaccumulation and endocrine disruptor effects of butyltins (BTs) to wildlife are well documented. Although suspected, the effects of BTs in marine mammal immune function have not been described. In this study, we assessed the effects of tributyltin (TBT) and its dealkylated metabolites dibutyltin (DBT) and monobutyltin (MBT) on the immune responses of pinnipeds. Peripheral blood mononuclear cells isolated from pup and adult harbor seal were exposed to varying concentrations of BTs. DBT resulted in a significant decrease at 100 nM and 200 nM of phagocytotic activity and reduced significantly phagocytic efficiency at 200 nM in adult seals. There was no effect in phagocytosis with TBT. Reduction of tumor-killing capacity of adult Natural Killer cells occurred when leukocytes were incubated in vitro with 50 nM DBT and 200 nM TBT for 24 h. In adults, concanavalin A (Con-A)-stimulated mitogenesis was significantly suppressed when the cells were exposed to 200 nM TBT and 100 nM DBT. In pups, the proliferative response increased after an exposure to 100 nM TBT and 50 nM DBT, but decreased with 200 nM TBT and 100 nM DBT. BTs exposure did not affect pup immune functions suggesting that other mechanisms could affect immune parameters. The toxic potential of BTs followed the order of DBT > TBT > MBT. Butyltin speciation was measured in pup harbor seals from the St Lawrence estuary (Bic National Park). For these animals, DBT concentrations were consistently below the detection limit and the MBT and TBT concentrations were very low in both blood and blubber. Concentrations measured in pups were to low to induce toxic effects to their immune system during first days of life.

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Theme Session 2.

Foraging strategies and energetic requirements

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Monday, 1400-1445 ***keynote*** Dan Costa - **Foraging Ecology and Energetics of Pinnipeds: Conservation Implications**

Measurements of energy acquisition and allocation provide a quantitative assessment of how animals organize their daily or seasonal activities and how they prioritize their behaviors. Animals can compensate for decreases in energy acquisition by reducing their overall rate of energy expenditure, or they can utilize their stored energy reserves. Conversely, in order to grow and reproduce, animals must obtain more energy than is needed to survive. Marine mammals (especially capital breeders) undergo profound variations in this feast-or-famine dynamic equilibrium as they can gain significant amounts of food energy while feeding in highly productive environments followed by prolonged negative energy balance while fasting during migration or reproduction. The rate of prey energy acquired is directly related to the availability and quality of prey. As prey becomes less available the cost of finding it increases and the animal spends a greater proportion of its time and therefore energy searching for it. Eventually, there is a threshold when more energy is spent searching for prey than is obtained and the animal goes into negative energy balance.

As pinnipeds dive for their prey, the availability of prey is determining not only by its absolute abundance but by where it is located in the water column. For marine predators there appear to be three distinct foraging types, those that feed in the near surface water or epipelagic zone (near surface above 200m), those that forage deep into the mid-water or mesopelagic zone (below 200m) and those that forage on or near the bottom (benthic/demersal). Further, the ability of pinnipeds to forage into these different habitats is constrained by their physiological capability. Recent studies suggest that pinnipeds that forage epipelagicaly have the least physiologically demanding strategy, whereas mesopleagic and benthic foragers have the most demanding physiological foraging strategy. In addition, the physiologically more demanding foraging strategies are associated with a greater proportion of time spent foraging. Finally, these foraging patterns are associated with different demographics. Benthic foraging species have smaller populations and lower growth rates compared to those species that forage epipelagically. These patterns suggest that species with specific foraging behaviors may be more or less sensitive to environment change and is relevant to the conservation and management of pinniped populations.

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Monday, 1445-1505 Tsutomu Tamura and Kenji Konishi **Feeding strategy and prey consumption of Antarctic minke whale *Balaenoptera bonaerensis* in the Southern Ocean**

The Antarctic minke whale (*Balaenoptera bonaerensis*) is the most abundant baleen whale species in the Southern Ocean. They feed mainly on the Antarctic krill (Euphausia superba). Quantitative information on prey consumption of whales is useful to understand their feeding ecology and role in the ecosystem. The purposes of this study are 1) to investigate the feeding strategy of Antarctic minke whales based on information on freshness and diurnal change in stomach contents, 2) to estimate the amount of prey consumed by whales. Estimates are made for whales of different reproductive status as it is expected that the energy requirements vary among them and 3) to investigate yearly changes in prey consumption. The analysis is based on the data from whales taken by JARPA (Japanese Whale Research Program under Special Permit in the Antarctic) in a longitudinal sector between 35ºE and 145ºW, south of 60ºS. Sampling was conducted in the austral summer seasons from 1987/88 to 2004/05, mainly in the months from December to March. Daily prey consumption by the whales in each reproductive status group was estimated using energy-requirement and energy deposition. The whales feed mainly before 5AM, which suggest that they cease to feed early in the day. Daily prey consumptions were estimated as 2.7 to 3.5 % of body weight. A decreasing yearly trend was found in the amount of prey consumed, which coincides with the increase in abundance of other baleen whales species in the research area, possibly feeding on the same prey species.

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The Role of Marine Mammals in the Ecosystem in the 21st Century
29 September -1 October, 2008
Alderney Landing, Dartmouth, NS, Canada

Monday, 1505-1525 Gísli A. Víkingsson **Feeding ecology of common minke whales (*Balaenoptera acutorostrata*) in Icelandic waters**

Common minke whale is the most abundant species of baleen whales in Icelandic coastal waters. The total consumption by this species has been estimated as around 2 million tons of biomass, or about a third of the total consumption by all 12 Icelandic cetacean species. However, very little information has been available on diet composition of common minke whales in this area. During 2003-2007, 200 minke whales were sampled for research on the feeding ecology and various aspects of the biology of this important component of the Icelandic coastal marine ecosystem. Here we present the first results from this study based on the analysis of stomach contents. Overall the results show considerably higher proportions of cod, haddock and other large teleost fish species than indicated by the limited data collected mainly in the 1970's. The prey size consumed by common minke whales ranged from krill and 0-group fish to 90 cm (10 year old) cod. The present study also indicated a higher incidence of sand-eel than the previous one, while krill and capelin contributed less to the diet. A high degree of geographic variation was found in the diet composition and indications of changes throughout the sampling period were detected. These results will be discussed in connection with pronounced changes in hydrographical parameters and in distribution and abundance of various species of fish and seabird that have occurred in recent years.

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The Role of Marine Mammals in the Ecosystem in the 21st Century
29 September -1 October, 2008
Alderney Landing, Dartmouth, NS, Canada

Monday, 1555-1615 Stevens, T.S. and Lawson, J.W. **Using recent distribution and behavioural data for killer whales (*Orcinus orca*) in Atlantic Canada to assess the influence of predation pressures on the movement and social patterns of minke whales**

Killer whales (*Orcinus orca*) occur throughout the northwest Atlantic. A sightings database and photographic catalogue was used to examine the occurrence of killer whales in Atlantic Canada. A majority of the sightings are from the Newfoundland and Labrador (NL) region despite better observer coverage in adjacent areas such as the Gulf of St. Lawrence and Scotian Shelf, which suggests greater abundance in NL waters. The distribution, movement, and residency patterns of killer whales may be closely linked to that of their prey; they have been observed harassing, attacking, and eating marine mammals, including minke whales (*Balaenoptera acuterostrata*), humpback whales (*Megaptera novaeangliae*) dolphins, and seals, and potentially eating fish. Some killer whales appear to remain year-round in NL and have been sighted during the spring within pack ice, potentially feeding on breeding harp seals (*Pagophilus groenlandicus*). A majority of reported foraging accounts have involved minke whales. Although there is no evidence of spatial or temporal migration, killer whales may be reliably seen in certain areas during particular times of the year, suggesting that long-term site fidelity patterns may exist within this population. These particular distribution characteristics may influence the movement and residency patterns of their prey. Depending on the degree to which minke whales constitute the diet of killer whales, predatory interactions between these species in this region may represent opportunistic foraging attempts by the killer whales. Alternatively, if minke whales are a preferred dietary item, then predation pressure by killer whales may have been influential in determining the distribution and social patterns exhibited by these prey.

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The Role of Marine Mammals in the Ecosystem in the 21st Century
29 September -1 October, 2008
Alderney Landing, Dartmouth, NS, Canada

Monday,1615-1645 Hammill, M.O., M. Ryg, D. Chabot. **Seasonal Changes in Energy Requirements of Harp Seals**

Seasonal changes in energy intake of Northwest Atlantic Harp seals were modelled and implemented as a Microsoft Excel ? spreadsheet. Energy intake of adults during the fourth quarter is almost double estimated intake during the second quarter, with intermediate values during the first and third quarters. Reproduction increases female annual energy requirements by 15%, and adds 4% to the estimated population energy intake. The model was sensitive to changes in metabolizable energy, body mass, and the Kleiber factor. Changes in blubber conductivity and body composition had intermediate effects, while changes in water and air temperature and activity had little effect on model output. Comparing annual energy intake between a seasonally varying model and a simplified model (Growth *Activity * Mass0.75) intake estimates were similar if an annual maximum body mass was used. Using minimum estimates of body mass underestimated annual energy intake, but provides more reasonable estimates of energy consumption when seasonal requirements are at a minimum. A simple model adequately describes pinniped energy intake in consumption studies. More realistic estimates of consumption would be obtained without increasing model complexity by incorporating seasonal changes in body mass.

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The Role of Marine Mammals in the Ecosystem in the 21st Century
29 September -1 October, 2008
Alderney Landing, Dartmouth, NS, Canada

Tuesday, 0900-0920 Ono, Kathryn and Bertrand, Matthew **Diving, Movements, and Habitat Preference in Gulf of Maine Harbor Seal Pup (*Phoca vitulina concolor*)**

Newly weaned harbor seal pups underwent relatively large movements away from their natal site, in contrast to the general belief that the species is philopatric in nature. Eighteen satellite tags (Wildlife Computers SPLASH and SDR-T16) were deployed on harbor seal pups ~1-4mos of age in the Gulf of Maine. Both wild caught as well as rehabilitated (Marine Animal Rehabilitation Center, University of New England) pups were utilized in this sample. Some weaned wild pups moved North up to 290km from their natal site, but the majority of both the wild and rehabilitated pups headed South up to 350 km. Most dive durations were three minutes or less, however, for some pups, up to 20% of dives were greater than 20min duration. Rehabilitated pups accounted for a greater proportion of the longer dive durations. The majority of dives were to 60m and below, some pups dove to 200m, but none dove deeper than 200m (tags programmed to >600m). Wild pups tended to dive deeper than rehabilitated pups. GIS data from the Gulf of Maine was compared with pup locations to determine if the pups utilized the habitat in a selective manner. Habitat variables included: Sea surface temperature (SST), plankton biomass (chlorophyll), distance from land, and benthic substrate, depth, slope, and water mass influence. Characteristics of pup locations were compared with random points within 106km of shore and 250m depth. Both wild and rehabilitated pups preferred higher SST, higher plankton biomass, steeper slope, closer to shore, and more shallow locations compared to random points. They also preferred gravel-sand substrates and moderate water temperature (8-10oC)/salinity (33ppt) combination conditions that tend to occur close to shore.

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The Role of Marine Mammals in the Ecosystem in the 21st Century
29 September -1 October, 2008
Alderney Landing, Dartmouth, NS, Canada

Tuesday, 0920-0940 Julie M. Andersen, Yolanda Wiersma and Garry Stenson.Habitat **Selection By Hooded Seals (*Cystophora cristata*) In A Dynamic Marine Ecosystem**

Hooded seals are a highly migratory phocid that spend much of their time in areas of complex seafloor relief where they may dive to depths of more than 1500m. Although hooded seals conduct extensive migrations, they have been observed to spend considerable time within relatively restricted regions which are assumed to provide important foraging habitat for the species. Monitoring movements and diving behaviour when seals are assumed to be foraging can improve our understanding of how this species uses its environment and what factors influence habitat selection. We examined location and diving data obtained from 26 hooded seals equipped with satellite telemetry tags off east Greenland between 2004-2008 to investigate habitat selection in Baffin Bay (North West Atlantic Ocean) during the period between completion of their moult until they began their breeding migration (July-March). We combine these data with spatially referenced data in a Geographical Information System (GIS) where we examine how environmental variables such as seafloor depth and - slope, temperature, currents and ice cover may affect the choice of foraging areas. The results of this study will help us understand hooded seal habitat requirements during post-moult and pre-breeding periods, and will in turn inform future work on hooded seal habitat selection at larger spatial and temporal scales.

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The Role of Marine Mammals in the Ecosystem in the 21st Century
29 September -1 October, 2008
Alderney Landing, Dartmouth, NS, Canada

Tuesday, 0940-1000 Kimberley T.A. Davies, C. T. Taggart and K. Smedol **The role of physical oceanography and zooplankton in controlling the spatiotemporal distribution of the North Atlantic right whale**

The goal of many marine science initiatives has become to develop effective and functional recovery strategies founded on explained variation in the ecology of endangered species. This goal prompted a shift in focus from single-species research to the examination of food web interactions among trophic levels and oceanographic forcing mechanisms; especially where variability in plankton abundance and energy content can exert a bottom-up control. Here, I use a model system to study zooplankton control over the ecology of a critically endangered species. I test the hypothesis that spatiotemporal variability in feeding-habitat occupancy of North Atlantic right whales in the Scotia-Fundy region can be explained by spatiotemporal variability in their zooplankton prey where the latter is a function of variation in regional water mass characteristics. This is achieved through analyses of a unique 20-year set of historical zooplankton samples coupled with contemporary zooplankton measures (abundance, size, biomass, energy content) and historical and contemporary measures of the regional oceanography and whale occupancy.

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The Role of Marine Mammals in the Ecosystem in the 21st Century
29 September -1 October, 2008
Alderney Landing, Dartmouth, NS, Canada

Tuesday, 1050-1110 Kenji Konishi, Tsutomu Tamura, Tatsuya Isoda, Ryosuke Okamoto, Koji Matsuoka, Takashi Hakamada **Prey consumptions and feeding strategies of three baleen whale species around the Kuroshio-current extension**

Minke *Balaenoptera acutorostrata*, sei *B. borealis* and Brydefs *B. edeni* whales are all common whale species in the western North Pacific where the Kuroshio-current extension transports large amount of fish eggs and juveniles of commercially important Japanese anchovy *Engraulis japonicus*, Pacific saury *Cololabis saira* and *Scomber* spp., to pelagic waters. These three whale species sometimes feed on the same fish resources despite having different distribution patterns and foraging strategies, e.g. whales can feed on different developmental stages of the fishes or change food items according to changes in the environment. The purposes of this study are 1) to estimate the amount of fish resources consumed by the three whale species and, 2) to investigate the difference of feeding strategies among these whale species by examining the diets, length classes of the fish consumed and the environmental variables where whale and prey species were sampled.

The three whale species used in this study were sampled during the Second Phase of the Japanese Whale Research Program under Special Permit in the western North Pacific (JARPN II) from May to September during 2000-2007. The research area involved the longitudinal sector between the Pacific coast of Japan and 170E, and the latitudinal range between 35° and 50°N. Prey species of whales were identified by examining their stomach contents, and the amount of prey consumed in the research area was estimated by extrapolation using information on food consumption per individuals and abundance of whales. To address the second objective of the study, the fishes taken from the stomach contents were examined by length classes and the geographical positions of whales sampled (and the prey species) were plotted against data on sea surface temperature (SST) and height (SSH) obtained from satellite images for each year.

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The Role of Marine Mammals in the Ecosystem in the 21st Century
29 September -1 October, 2008
Alderney Landing, Dartmouth, NS, Canada

Tuesday, 1110-1130 Brodie, P. and Gisli Vikingsson **Observations of the feeding mechanics of the Sei whale (*Balaenoptera borealis*), based on the examination of hunted specimens off Nova Scotia and Iceland**

The Sei whale (*Balanoptera borealis*) is a medium sized rorqual with basic features similar to the larger fin and blue (*Balaenoptera* sp.).

While the Sei whale has an expandable buccal pouch, it's capacity is substantially reduced by the length of the ventral grooves relative to fin and blue whales. The finer filtration capacity of the baleen allows predation on smaller prey spectra as a skimfeeder, with the option to engulf where prey are larger, or in greater densities. The sei whale exhibits some features of the mouth cross-section that are reminiscent of right whales (*Eubalaena* sp.) and there appears to be a difference in the degree of arch of the rostrum when comparing the sexes. The dynamics of skimfeeding and prey reaction time is discussed and stomach contents of sei whales captured off Iceland are described.

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The Role of Marine Mammals in the Ecosystem in the 21st Century
29 September -1 October, 2008
Alderney Landing, Dartmouth, NS, Canada

Tuesday, 1130-1150 Alice I. Mackay and Peter C. Stephenson. **An assessment of the foraging behaviour of bottlenose dolphins interacting with a bottom trawl fishery**

Numerous accounts exist globally of foraging associations between bottlenose dolphins (*Tursiops* sp.) and bottom trawl fisheries. Dolphins have been observed to feed from the discards of such fishing operations as well as directly from the codend of the net. However observations of foraging events (e.g. searching, pursuit and capture) are limited, with most information on foraging behaviour restricted to inferences made from the surface activity of dolphins in the vicinity of trawl nets. Here we present data on the underwater interactions between bottlenose dolphin and a bottom trawl fishery and the first quantification of individual foraging behaviour inside such nets. Underwater video recordings were collected in 2003, 2005 and 2006 as part of projects conducted by the Department of Fisheries Western Australia to assess and mitigate dolphin interactions with the Pilbara Finfish Trawl Interim Managed Fishery. The fishery is prosecuted in the Pilbara region of northwest Australia, in water depths of 50 - 100m. Video cameras were deployed at 4 different positions inside trawl nets, orientated either towards the vessel or the codend. Over 60 hours of video footage were examined and results are presented on the presence and behaviour of bottlenose dolphins relative to different areas both inside and outside the trawl net. 16 hours of this footage was used to conduct focal animal follows, providing the first documentation of individual foraging behaviour inside the belly of the trawl net. Results from these videos indicate that the lengths of time individuals are present and the behaviours they exhibit vary between animals. Complimentary observer data provide an indication that the utilization of trawl nets to capture fish may be an important foraging specialization for some individuals. We discuss these results in relation to current and future bycatch mitigation strategies in this fishery.

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The Role of Marine Mammals in the Ecosystem in the 21st Century
29 September -1 October, 2008
Alderney Landing, Dartmouth, NS, Canada

Theme Session 3

Marine mammal – fisheries interactions

NAFO ICES NAMMCO

The Role of Marine Mammals in the Ecosystem in the 21st Century
29 September -1 October, 2008
Alderney Landing, Dartmouth, NS, Canada

Tuesday, 1320-1405 ***Keynote*** John Harwood, Jason Matthiopoulos and Sophie Smout - **Quantifying marine mammal-fisheries interactions**

Marine mammals interact with fisheries both directly (through by-catch and removal of fish from gear) and indirectly (through competition and facilitation). Such interactions may have important consequences for fish stocks, marine mammal populations, and the health of ecosystems. We will describe what information is needed to quantify indirect interactions, and how this information can be inferred from the kinds of data that are routinely collected from fisheries and marine mammals. In particular, we will focus on the need to understand how marine mammal predation may vary with prey availability, the importance of modelling interactions over appropriate temporal and spatial scales, the role of variability in predator behaviour, and the need to account for all important sources of uncertainty. Finally, we will discuss how marine mammal-fisheries interactions can be incorporated into the ecosystem approach to fisheries.

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The Role of Marine Mammals in the Ecosystem in the 21st Century
29 September -1 October, 2008
Alderney Landing, Dartmouth, NS, Canada

Tuesday, 1405-1425 Christopher D. Orphanides **Comparison of Methods for Estimating the Bycatch of Protected Species: Estimating the Bycatch of Harbor Porpoise (*Phocoena phocoena*) in U.S. Gillnet Fisheries in the Northwest Atlantic**

Observed catches of harbor porpoise incidentally taken during 1999-2006 in U.S. gillnet fisheries off the Northeastern coast of the United States were used in a modeling framework to evaluate the factors affecting porpoise bycatch and also to derive annual bycatch estimates.

Ancillary objectives were to improve on the existing method for estimating harbor porpoise bycatch in the gillnet fishery, and to compare the utility and precision of model-based vs. ratio-based estimates of bycatch. Harbor porpoise bycatch was modeled using a GAM forward-stepwise process, and involved testing numerous variables describing: (a) the time, duration, and location of fishing operations; (b) the configuration of the gillnet gear; and (c) the environmental characteristics (both in time and space) of the locations where gillnetting occurred. The final model was simplified to a GLM and included variables on water temperature, bottom depth, stretched mesh size, gillnet closures and/or gear modification areas, and year. Annual bycatch estimates were similar between modeling and ratio estimator approaches, but the CVs for the model-based estimates were significantly lower than the ratio-based estimates.

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The Role of Marine Mammals in the Ecosystem in the 21st Century
29 September -1 October, 2008
Alderney Landing, Dartmouth, NS, Canada

Tuesday, 1425-1445 Min-Yang Lee **Whale-watching and Herring Fishing: Joint or Independent?**

Ecosystem based management has becomes an important decision-making framework for regulation of marine resources. Under this rubric, regulation aims to move away from a single species framework in favor of a more holistic approach that includes all species and all users.

The effects of ""localized depletion"" of a pelagic fishery (herring) on a non-extractive marine activity (tourism) are investigated. Proponents of the localized depletion theory claim that intense fishing effort can lead to areas that are unsuitable for predators like tuna, groundfish, and whales. For the whale-watching industry, this can lead to increased search times. However, there has been no consensus in the scientific community about the existence of the localized depletion phenomenon. This theory would be consistent with joint production: near-shore herring stocks are an input in production of both herring and whale-watching trips. A unique dataset of daily whale-watching outcomes is combined with fishing effort and oceanographic data. This dataset is used to test the hypothesis that intensive fishing effort increases the search time of whale-watching companies. Our results suggest that while fishing has a statistically significant impact on sightings, this magnitude of this effect is fairly small. Sightings seem to be determined mostly by large scale oceanographic processes. These results should be of interest to policymakers in determining future fishing regulations.

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The Role of Marine Mammals in the Ecosystem in the 21st Century
29 September -1 October, 2008
Alderney Landing, Dartmouth, NS, Canada

Tuesday, 1445-1505

Goetz, S.; G. Hernandez-Milian; Varela-Dopico, C.; Rodriguez-Gutierrez, J.; Romón, J.; Fuertes-Gamundi, J. R.; Ulloa, E.; Tregenza, N.J.C.; Smerdon, A.; Otero, M.G.; Tato, V.; Wang, J.; Santos, M.B.; López, A.; Lago, R.; Portela, J. ; Pierce, G. J. **Results of a Short Study of Interactions of Cetaceans and Longline Fisheries in Atlantic Waters: Environmental Correlates of Catches and Depradation Events**

In the Atlantic, economic losses have been reported from shark, swordfish and tuna longline fisheries due to depredation by cetaceans. We examined interactions of odontocete cetaceans with commercial longliners operating in waters off Brazil and the Azores archipelago during 2006-07, analysing relationships between catches, depredation on hooked fish, cetacean sightings, acoustic records of cetacean presence and environmental variables. In addition, we briefly discuss the results from a pinger trial survey carried out in spring 2008. Data were provided by skippers of six vessels and by on-board observers for two vessels. The percentage of longline sets depredated by cetaceans was low (ranging from 1 to 9 % of total sets per ship) but the proportion of fish damaged was high (up to 100%) when depredation occurred. Catches were related to the phase of the moon, cloud cover, sea surface temperature and water depth whereas cetacean sightings were primarily related to catches. In particular there was a positive association between *Delphinus delphis* sightings and catches of swordfish and Stenella frontalis sightings and mako catches. Acoustic detection was low when depredation by false killer whales occurred although high rates of clicks were detected when delphinids were sighted and false killer whales were by-caught. This may indicate that false killer whales are not echolocating when feeding on fish hooked on a longline.

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The Role of Marine Mammals in the Ecosystem in the 21st Century
29 September -1 October, 2008
Alderney Landing, Dartmouth, NS, Canada

Tuesday,1505-1525 Ignacio Payá and Paul Brickle **Changes of fishing gear design for reducing whale interference: Impacts on stock assessment and management of toothfish off Falkland Islands**

Whale predation on toothfish hooked in the longlines has been claimed to reduce the catch per unit of effort (CPUE in g/hook) and has impacts on stock assessment and management. CPUE, after a standardization procedure, are used as relative abundance indices in the stock assessment model and then in estimations of maximum sustainable yield (MSY). In 2007 the fishing industry introduced a new design to reduce the whale predation, which is called "Umbrella system". The aim of this study is to evaluate the impacts of the umbrella system on the relative abundance indices of toothfish and in the stock assessment and management. The umbrella and longline system are described. The ratio between CPUE of umbrella and longline system were calculated by two methods: 1) Comparing the umbrella CPUE with the longline CPUE average of the previous 4 years, and 2) Comparing the CPUE of 16 days in which both system were used in the same day and therefore in the same area. The first method estimated the ratio at 3.6 and the second one at 3.2. After corrections by this ratio the CPUE were standardized by general linear model and the relative abundance index was estimated. The relative abundance index with the umbrella correction was 15% lower in the last year while the abundance index without umbrella correction was similar than the previous year. For the stock assessment an age structured production model (ASPM) was programmed in MatLab. The model included longliner and trawler fleets, which effects were modelled by different selectivity patterns. The umbrella corrected abundance index was used to fit the adult stock and the trawler CPUE index was used as a recruitment index. Different cases scenarios were analyzed according to the weights assigned to the different data and abundance indices. MSY were estimated for each scenario.

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The Role of Marine Mammals in the Ecosystem in the 21st Century
29 September -1 October, 2008
Alderney Landing, Dartmouth, NS, Canada

Tuesday, 1605-1625 Teija Aho, Anna Gårdmark, Karl Lundström and Jukka Pönni **Effects of grey seals on the herring population in the Baltic Sea area**

Population of grey seal (*Halichoerus grypus*) is rapidly increasing in the Baltic Sea. This is likely to have ecosystem effects as predation pressure on several fish species increases. Herring is the most preferred prey species for grey seals in the Baltic. We estimated total herring consumption by seals from estimates of fish consumption rate per seal and seal population size in the Bothnian Sea. According to these estimates, grey seals consume ca 9050 tonnes herring annually in the Bothnian Sea area. This corresponds to 12% of the total landings and is three times as much as the Swedish landings in the sama area. The predation pressure is highest towards the oldest year classes (biggest fish), 46% of all the consumed herring individuals belong to year classes 9 years and older. Furthermore, 86% (7800 tonnes) of the seal predation was targeted mature herring, corresponding to 2,2% of the spawning stock biomass. It is likely that recent population assessments of herring in Bothnian Sea have underestimated the natural mortality of herring. To estimate the relative effects of seal predation compared to the fishing mortality on the herring population in the Bothnian Sea a virtual population analysis was conducted. This analysis takes into account seal predation and provides results for discussion on the effects of grey seals on the Baltic ecosystem.

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The Role of Marine Mammals in the Ecosystem in the 21st Century
29 September -1 October, 2008
Alderney Landing, Dartmouth, NS, Canada

Tuesday,1625-1645 Sven Gunnar Lunneryd, Sara Königson and Karl Lundström **The grey seal- fishermen cod competition in the Baltic Sea**

In the Baltic Sea there is a steady increase of the conflict between fishery and seals, especially the grey seal, Halichoerus grypus. After a long lasting conflict in the salmon fishery in northern Baltic Sea, the focus is now on cod gill-net fishery. This fishery is the most important part of the inshore fishery in the central and southern Baltic. Year

2007 the Swedish fishermen in the central Baltic reported seal damage in over 50 % of their fishing days while the figure in the southern part of the Baltic was 13 %. It was estimated from voluntary detailed logbooks that, during occasions with seal damage, the sum of observed damaged cod was between 9 to 26 kg per day. Studies have shown that seals tear out whole cod specimens without leaving traces and that for every observed damaged cod, five are missing. From those figures it was calculated that over 300 tonnes of cod were damaged or lost in the cod gill-net fishery.

This is 13 % of the total catch in gillnets.

As there are no immediate ways to solve the conflict, either by gear development or management of the increasing seal population, the amount of lost cod from fishing net will certainly increase.

This will cause an uncertainty about the quota regulations. A question is whether lost cod's should be regarded as a fishing mortality or a natural mortality? Studies show that herring dominate the general diet and also that a majority of seal eaten cods in seal stomachs are below the allowed minimum size, which together indicate that the grey seal contribute to the total human fishing mortality of cod in the Baltic Sea. In fact in the same range as estimations of the illegal fishing.

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The Role of Marine Mammals in the Ecosystem in the 21st Century
29 September -1 October, 2008
Alderney Landing, Dartmouth, NS, Canada

Tuesday, 1645-1705 Crystal Lenky and Becky Sjare **Interactions between harp seals and salmon in coastal habitats of Newfoundland and Labrador**

Many resource users consider predation by seals in rivers and estuaries to be a contributing factor to the decline of some Atlantic salmon (*Salmo salar*) stocks in Newfoundland and Labrador. To address this concern, semi-directed interviews (n=57) were conducted from 2004 to 2006 with resource users on 29 rivers throughout the Province. Respondents were requested to comment on any changes in the relative abundance, timing of migration, habitat use and foraging behavior of harp seals (*Pagophilus groenlandicus*) frequenting the area during the last 5 years (2000-2005), during the 1990s, and 1980-1990. Starting in the mid 1990s, harp seals increased their residency time in some rivers and estuaries by 1-3 months. Based on this increased spatial and temporal over-lap, potential seal predation on salmon was considered to be high for 8/16 rivers frequented by harp seals on the northeast coast of Newfoundland and southern coast of Labrador. In 6 of these rivers, the reported increase in the occurrence and relative abundance of seals was concurrent with the migration or spawning of pelagic forage fish in the area. A combination of spring ice conditions and presence of forage fish was important for the other two rivers. A directed harp seal diet study was then carried out in 2005 and 2006 on the Campbellton River, one of the rivers considered to have high potential for predation during the smolt salmon run. A total of 122 stomachs were analyzed and there was no evidence that seals were feeding on salmon; capelin (*Mallotus villosus*) was the major prey component in both years. Although information from resource users suggested that the potential for harp seal predation on salmon had increased since the mid-to late 1990s, the diet component of the project indicated that seals were not necessarily feeding on salmon when these species co-occurred.

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The Role of Marine Mammals in the Ecosystem in the 21st Century
29 September -1 October, 2008
Alderney Landing, Dartmouth, NS, Canada

Tuesday, 1705-1725 Fiona L. Read, Jose Martínez-Cedeira, Ángel F. González, Alfredo López, Begoña Santos and Graham J. Pierce **Understanding marine mammal and fisheries interactions in Galicia, north-west Spain: Past, present and future**

Galicia, north-west Spain, is one of the world's main fishing regions and, with an estimated 1.1 million trips per annum from 87 fishing ports, it is socially and economically dependent on fisheries. In Galicia, around 250 cetacean strandings occur annually of which 25% have evidence of fisheries interactions. An interview surveys of fishermen in 1998-1999 (n=405) estimated that around 1700 cetaceans are by-caught annually while in a second study in 2003 (n=264) 64% of interviewees were aware of by-catch. The number of cetaceans caught depends on the type of gear, with pair trawl followed by gillnet having the highest by-catch rates. Both studies concluded that the rate of by-catch is most likely unsustainable. *Delphinus delphis* and *Tursiops truncatus* are the most commonly by-caught species. In 2007, 158 *Delphinus delphis* necropsies were conducted, 24% (n=39) were of known by-catch from a pair trawl and a further 17% (n=27) had indications of by-catch such as net marks and mutilations. Males were caught more frequently than females and juvenile males were caught more frequently than older males although no such pattern was seen for females. Few data exist for mortality and reproductive rates of cetaceans in Galician waters. The present project aims to use data on life-history and by-catches of *Delphinus delphis*, *Tursiops truncatus*, *Stenella coeruleoalba* and *Phocoena phocoena* to determine trends in population numbers and estimate more realistic by-catch mortality rates. In co-operation with the fishing industry, we also aim to quantify economic damage to prey and gear by the cetaceans and develop plans for the conservation of these cetaceans and the management of interactions with fisheries in Galicia.

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The Role of Marine Mammals in the Ecosystem in the 21st Century
29 September -1 October, 2008
Alderney Landing, Dartmouth, NS, Canada

Wednesday, 1725-1745 J.W. Lawson and J.-F. Gosselin **Don't Ignore The Whales: Cetacean Biomass Consumption Estimates Based On The Recent TNASS Aerial Survey of Atlantic Canada**

Cetaceans represent a large portion of upper trophic vertebrate predators in the Atlantic. However, while much research has been focussed on considerations of the prey consumption of seals, considerably less attention has been paid to the potential effects that whales, dolphins, and porpoises have on the biomass of their prey. In the summer of 2007, the Department of Fisheries and Oceans conducted a large-scale aerial survey of Atlantic Canadian waters (a component of the international TNASS survey) from the U.S. border to the northern tip of Labrador. Using visual line transect survey methods and statistical analyses, we derived abundance estimates for the cetacean species most seen in these waters. Total prey biomass requirements were derived from the multiplication of three factors: the TNASS abundance estimates of the 10 most commonly seen cetacean species, the species' average body weights, and mass-specific consumption values ranging from 4% to 6% of body weight. We then apportioned these requirements based on published diet data to obtain daily prey consumption estimates for a range of species including capelin, herring, squid, euphausiids, and cod. Even with negatively-biased abundance estimates, cetaceans in Atlantic Canada likely consume more than 10,000 metric tonnes of prey per day. If we assume these animals spend only 150 days per year in Canadian waters this equates to an annual consumption in excess of 1.7 million tonnes of prey. Comparing this crude estimate with the estimated 4.0 million tonnes of prey required by seals in Atlantic Canada in 1996 (Hammill and Stenson 2000), it is clear that the "cetacean" component should be more thoroughly considered when modelling the impacts of marine predators in the ecosystem. Such a large biomass removal, with much from important ecosystem prey components such as capelin and herring, could have significant controlling effects on the biomass of other consumers as well as the prey.

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The Role of Marine Mammals in the Ecosystem in the 21st Century
29 September -1 October, 2008
Alderney Landing, Dartmouth, NS, Canada

Session 4.

Theoretical considerations on apex predators and multispecies models

NAFO ICES NAMMCO

The Role of Marine Mammals in the Ecosystem in the 21st Century
29 September -1 October, 2008
Alderney Landing, Dartmouth, NS, Canada

Wednesday, 0900-0945 ***keynote*** Andrew Trites **Marine Mammals and the Theoretical Considerations Associated with Apex Predators and Multi-Species Models**

Theoretically, the interaction between marine mammals and their prey influences the structure and dynamics of marine ecosystems. Similarly, predators and prey have shaped each other's behaviors, physiologies, morphologies, and life-history strategies. However, there is little empirical evidence of these influences due to the relative scale and complexity of marine ecosystems and the inherent difficulties of observing and documenting marine mammal predator – prey interactions. On short ecological time scales, marine mammals can affect the abundance of other species by consuming or outcompeting them. They can also indirectly affect the abundance of nontargeted species by consuming one of their predators, and can have strong impacts on the overall dynamics and structure of their ecosystems. Ecosystem models are one of the best tools for understanding predator– prey interactions and the role of marine mammals in the ecosystem. However, more work is required through experimental manipulations and observational studies to evaluate the choices made by marine mammals and the costs of obtaining different species of prey. In particular, the models point to the importance of deriving functional response curves, estimating vulnerabilities to being eaten, and establishing the seasonal energy densities of prey.

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The Role of Marine Mammals in the Ecosystem in the 21st Century
29 September -1 October, 2008
Alderney Landing, Dartmouth, NS, Canada

Wednesday, 0945-1005 U. Lindstrøm, K.T. Nilssen, L.M.S. Pettersen, T. Haug **Use and selection of prey by harp seals in the northern Barents Sea**

The aim of this study was analyse harp seals prey use and selection during summer in Svalbard waters in the northern Barents Sea. A total of 244 seals and 80 individual faeces were sampled during May-July in 1996, 1997, 2004, 2005 and 2006. Krill was the overall dominant prey species followed by polar cod and other fish species in terms of a combined index based on frequency of occurrence and biomass. Resource mapping was performed in two areas simultaneous with the seal sampling, in 1996, 1997 and 2006 by using standard acoustic methods. These surveys suggested that krill was the most abundant prey in both areas and in all years. With exception of amphipods (Parathemisto sp.), that was avoided by the seals in 1996 and 1997, considerable variation in prey selection indicate that harp seals exhibit threshold foraging behaviour to their prey. Preliminary results suggests that harp seals selected and avoided krill in 1996 and 1997, respectively. Polar cod was randomly exploited in 1996 but selected in 1997. The data from 2006 are being analysed now, and all results will be presented at the symposium.

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The Role of Marine Mammals in the Ecosystem in the 21st Century
29 September -1 October, 2008
Alderney Landing, Dartmouth, NS, Canada

Wednesday, 1005-1025 Buren, A. D., Koen-Alonso, M., Stenson, G.B. **Reconstructing diet composition using a multinomial regression approach**

Food habits studies of marine mammals and large predatory fishes are based, to a large extent, on the analysis of stomach contents. Diet quantification typically involves the calculation of classical indices such as percentage biomass and/or abundance of the prey, frequency of occurrence, and composite indices (e.g. Index of Relative Importance). Although easy to calculate, statistical assessments of these indices are not straightforward, and often require numerically intensive methods (e.g. bootstrapping, Monte Carlo simulations, etc). Using a harp seal stomach content database as study case, we explore the feasibility of estimating diet composition in biomass from frequency data such as the identity of the main prey in biomass in each stomach and the mean weight of prey in the stomach when the prey is the main item. A multinomial regression was used to evaluate the statistical significance of potentially relevant factors (e.g. location of samples, year, sex and stage of predator, etc), and the predicted probabilities of being a main prey obtained from this regression, in conjunction with the mean weight of prey in the stomachs, were used to generate a reconstructed diet. This method requires less information than classical approaches (only the main prey is considered from each stomach) but provides a similar picture of the diet. Furthermore, this approach easily lends itself to fill gaps in the sample, and could provide a cost-effective way of assessing diets when reasonably large sample sizes can be collected.

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The Role of Marine Mammals in the Ecosystem in the 21st Century
29 September -1 October, 2008
Alderney Landing, Dartmouth, NS, Canada

Wednesday, 1055-1115 Lyne Morissette, Kristin Kaschner, Jenny Lynn Melgo and Leah Gerber **Declining fish stocks: are whales the culprits?**

Recent studies have proposed that whales are the culprits behind decreased fish populations and as a result they should be culled. However, the rationale for such arguments is questionable in light of documented overfishing occurring on a global scale, the lack of scientific evidence for existing large-scale competition between marine mammals and fisheries, and the unpredictable consequences of culling. Nonetheless, the "whales eat fish" issue has become a significant point of contention at recent International Whaling Commission (IWC) meetings. To understand the impact of whales on commercial fisheries, we analyzed the situation in the context of ecosystems in order to examine the scientific evidence for the assertion that commercial fisheries are negatively impacted by whales in three regions where the "whales eat fish" assertion has become a political and management issue: Caribbean islands, South Pacific and northwest Africa. Food web models were constructed using the Ecopath and Ecosim software to examine the potential impact of a reduction in the abundance of great whales on fishery yield. Preliminary results indicate that: 1) The overlap between prey species consumed by marine mammal and species targeted in fisheries is low; and 2) Given a wide range of assumptions about whale abundances, diet composition and food consumption in breeding areas, we consistently found that: (a) Whale consumption is several orders of magnitude lower than total fishery catches; (b) Indirect impacts of great whale consumption on fisheries yield are positive in some cases (beneficial predation); and (c) In simulations, reducing whale biomass does not influence the biomass of commercially important fish. We expect that our approach will begin to answer questions about the competition between whales and commercial fisheries in these regions, and will allow the identification of data gaps and additional research needs.

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The Role of Marine Mammals in the Ecosystem in the 21st Century
29 September -1 October, 2008
Alderney Landing, Dartmouth, NS, Canada

Wednesday, 1115-1135 Tor Arne Øigård, Tore Haug, Kjell Tormod Nilssen and Arnt-Børre Salberg **Estimation of pup production of hooded and harp seals in the Greenland Sea in 2007: Reducing uncertainty using Generalized Additive Models**

The pup production of the Greenland Sea populations of hooded and harp seals were assessed in aerial surveys using aircrafts for reconnaissance flights and photographic surveys along transects over the whelping areas 14 March to 3 April 2007. Helicopter, operated from the applied expedition vessel, flew reconnaissance flights, monitored the distribution of seal patches and performed age-staging the pups. The pup production was estimated using a conventional method and a recent developed method which utilize Generalized Additive Models (GAMs) and thin plate regression splines. The total estimate of hooded seal pup production was 15 370 (SE = 1 675, CV = 10.9%), which is similar to an estimate obtained in comparable surveys in 2005. The total pup production estimate obtained for harp seals was 102 200 (SE = 25 400, CV = 24.9%), which is slightly higher than an estimate obtained in a similar survey in 2002. Using the two estimation methods on data from all three surveys (2002, 2005, 2007), comparable estimates of pup production were obtained. In scenarios where pups are clustered, the estimated uncertainty of the pup production estimate is much higher for the GAM method than for the conventional method. This results in a considerable reduction of the estimated coefficient of variation. In scenarios where pups are uniformly distributed, both methods performs the same.

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The Role of Marine Mammals in the Ecosystem in the 21st Century
29 September -1 October, 2008
Alderney Landing, Dartmouth, NS, Canada

Wednesday, 1135-1155 Lavery, TJ and Mitchell, JGM. **Marine Mammals Stir the Ocean**

Marine mammals consume commercially important fish species but may also sustain fish biomass by increasing turbulence while diving, and thereby transporting nutrient rich water into the photic zone. We consider a population on the order of 10^5 New Zealand fur seals inhabiting oligotrophic waters off South Australia and find they are significant allochthonous contributors to photic zone nutrient standing stock, raising nitrogen and iron levels compared to background concentrations. Increased nutrient inputs likely promote proliferation of eukaryotic microalgae, channelling energy away from the microbial loop, and directly increasing fisheries productivity. Historical commercial exploitation of New Zealand fur seals in South Australia has reduced nutrient inputs from seals, decreasing background nutrient concentrations and reducing fishery productivity. We calculate nutrient additions from present and historical populations to estimate the biomass of commercial fish supported by this population of fur seals. By stimulating primary productivity, nutrient additions can increase carbon drawdown. We calculate the carbon drawdown potential of the current populations of New Zealand fur seals in South Australia, and show how this has been decreased due to historical seal exploitation.

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The Role of Marine Mammals in the Ecosystem in the 21st Century
29 September -1 October, 2008
Alderney Landing, Dartmouth, NS, Canada

Wednesday, 1325-1345 Mette Mauritzen, Edda Johannesen, Per Fauchald, Arne Bjørge, Erik Olsen and Nils Øien

Large-Scaled Distribution Of Baleen Whales In The Barents Sea: The Role Of Competitive And Trophic Inteactions With Pelagic Fish

Distributions of fin, humpback and common minke whales were recorded synoptically with distribution of pelagic fish during cruises in the Barents Sea (BS) annually in 2003 – 2007, in late summer. During these years, the BS was recognized by low abundances of capelin, a key prey species. Capelin occurred along the polar front in central areas, while abundant polar cod occupied the northern Arctic waters and abundant herring and blue whiting occupied the southern and south-western Atlantic waters, respectively. All three whale species inhabited both Arctic and Atlantic waters, with highest densities in Arctic waters, north of the front. In the north, the baleen whales aggregated at medium densities of capelin and polar cod, at the rim of the fish distributions. Areas with high pelagic fish density were not used by the baleen whales, suggesting that, at least in years with low capelin abundance, i) northern baleen whales in Arctic waters target other prey than pelagic fish, i.e. zooplankton, and ii) foraging at the rim of the fish distributions, the whales respond to prey depletion within high density areas of pelagic fish. In that case, pelagic fish in Arctic waters are competitors, structuring the baleen whales' distributions. In the south, both fin and minke whales aggregated at high herring and blue whiting densities, indicating that pelagic fish is preyed upon in this area. Nevertheless, the low density of baleen whales in southern BS suggests that the abundant pelagic fish stocks in the south experience relatively low predation pressure by baleen whales, also when capelin abundance is low. Our results pinpoint the importance of studying processes of trophic and competitive interactions on large scales, and demonstrate the value of synoptic cruises for studying such processes.

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The Role of Marine Mammals in the Ecosystem in the 21st Century
29 September -1 October, 2008
Alderney Landing, Dartmouth, NS, Canada

Wednesday, 1345-1405 S. Egorov, V. Zabavnikov, and S. Zyryanov.**Marine Mammals Status in the Barents Sea in Modern Stage as Element of its Ecosystem and Climatic Changes**

To the last time considered that about 24 marine mammals species regularly occur in the Barents Sea, comprising 7 species of pinnipeds, 12 of large cetaceans, and 5 of small cetaceans species. The most met frequently of marine mammals species are harp seal (*Phoca groenlandica*), white-beaked dolphin (*Lagenorhynchus albirostris*), walrus (*Odobenus rosmarus*), and minke whale (*Balaenoptera acotorostrata*). Some of marine mammals species observe in the Barents Sea area all year around and some of them can be occur in certain time their life or time of year.

In carrying out of annual Russian-Norwegian ecosystem surveys in the Barents Sea (August-September) during 3 last years were discovered some evident changes in distribution, numbers and marine mammals staying in the Barents Sea area among animals who traditionally registered here (area expansion, numbers, and time duration staying increasing). Also here were observed some marine mammals species who did not discover earlier. This fact is closely associated with considerable the Barents Sea water warming which was registered in the last years.

This circumstance it is necessary to take into account in rational management by fisheries, including development and improvement ecosystem models, as it is known that marine mammals are top predators and they are significant of the Barents Sea ecosystem component, where they have annual food consumption in assume of marine fisheries organisms (prey) in several times more than total catch by commercial marine fisheries. For example, minke whales and harp seals consume 1.8 million and 3.5 million tones of prey per year, respectively, where prevail crustaceans, capelin, herring, polar cod, and gadoid fish, dependent on area and time of year. Functional relationship between marine mammals and their prey seem closely related to fluctuations in the marine ecosystems.

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The Role of Marine Mammals in the Ecosystem in the 21st Century
29 September -1 October, 2008
Alderney Landing, Dartmouth, NS, Canada

Wednesday, 1405-1425 Buren AD, Koen-Alonso M, Dwyer KS, and Stenson GB **Is there room for competition among fish top predators and harp seals in the Northwest Atlantic (NAFO Div. 2J3KL)?**

The northern cod *Gadus morhua* stock off Newfoundland (NAFO Div. 2J3KL) collapsed in the early 1990s and has not recovered. Direct predation by harp seals *Pagophilus groenlandicus* is one of the proposed mechanisms to explain this lack of recovery. Another less explored mechanism by which harp seals may be indirectly affecting cod recovery is the potential of competition for food resources. This paper is a preliminary attempt to explore this possibility by comparing the diet composition among three high trophic level predators of this system: cod, Greenland halibut *Reinhardtius hippoglossoides* and harp seals. Diet composition of these predators in the offshore waters of NAFO Div 2J3KL were compared for the pre-collapse (1986-1991) and post-collapse (1992-1996) periods. Fish diets were directly evaluated from stomach contents, while seal diet was reconstructed using a multinomial regression model based on available stomach content information. All three predators relied heavily on capelin, but the cod diet showed a higher consistency over time. Assuming that availability of capelin has been reduced in the more recent period as suggested by some acoustic indices, this diet consistency could indicate that cod has less trophic plasticity than Greenland halibut and seals. This low plasticity could not only be a contributing factor in the lack of recovery of cod, but also suggests that other generalist predators like Greenland halibut, and possibly seals, may be better positioned for utilizing a changing resource base.

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The Role of Marine Mammals in the Ecosystem in the 21st Century
29 September -1 October, 2008
Alderney Landing, Dartmouth, NS, Canada

Wednesday, 1700-1800 **General Discussion**

How have we improved our understanding in the past 13 years?

What is our current understanding of the role of marine mammals?

What needs to be done next to improve our understanding?

Posters

The Role of Marine Mammals in the Ecosystem in the 21st Century
29 September -1 October, 2008
Alderney Landing, Dartmouth, NS, Canada

Patrick Miller, Yuuki Watanabe, Patrick Robinson, Martin Biuw and Mike Fedak **Establishing the costs and benefits of reproductive strategies in seals**

In pinnipeds, the adaptive value of the parental reproductive strategies observed on shore are difficult or impossible to appreciate unless they can be related to the foraging conditions faced when animals go to sea to acquire the resources. Tthe distribution of prey and its interannual variability are often very difficult or expensive to get and quantitative records of prey capture are also often problematic. However, by mapping where animals grow and fatten and relating these to proxies of prey distribution, we can overcome some of these practical limitations. Using the drift rate during resting dives in southern elephant seals where, Biuw et al (PNAS 2007) were able to show where animals increased their buoyancy (and therefore relative fat content) in relation to geography and physical oceanographic characteristics. This latter approach provided a way to map areas of resource acquisition and partially overcome biases related to the particular locations where tagging occurred and the particular individuals that were tagged. However, because somatic growth may occur while animals remain lean, finding only the places in geographical and oceanographic space where relative fat content increases may not identify places where animals acquire important resources. To overcome this limitation we are investigating methodologies that can use telemetry instruments to monitor both mass and condition while animals are at sea. Using recording accelerometers mounted on translocated elephant seals we have examined how the accelerations during swimming vary as buoyancy and mass are changed by experimentally dropping attached floats and weights. We will use these data to refine the methodology and develop algorithms to allow on-board estimation of mass and condition in real-time by Satellite Relay Data Loggers equipped with accelerometers. This methodology has the potential to substantially improve our ability to examine the costs and benefits of particular patterns of reproductive expenditure and at-sea foraging strategies.

The Role of Marine Mammals in the Ecosystem in the 21st Century
29 September -1 October, 2008
Alderney Landing, Dartmouth, NS, Canada

Vladimir Zabavnikov. **Correlation Between Harp Seal Distribution On Whelping Patches In The White Sea And Ice Conditions**

On base of data which were got in harp seal (phoca groenlandica) White Sea population on whelping patches researches in the White Sea during 10 last years (annually – before March 20) was carried out complex and system analyze of animals distribution and ice conditions, including correlated estimation between its.

In accomplishment this scientific-applied work were used data of coastal observations (information about current ice conditions and harp seal distribution), materials of multispectral air surveys (current ice conditions and animals distribution), and also data of satellite remote sensing (current ice conditions only).

The main result of carried out research was defined close correlation between harp seal distribution on whelping patches in the White Sea, from one side, and ice conditions (shape, concentration and ice formations structure), from other side. This circumstance can be use very effectively, reliably, and qualitatively in planning and carrying out of animals account multispectral air surveys in whelping patches directly. It can allow to reduce considerably expenditures in carrying out of preliminary reconnaissance air surveys and maximally optimize the tracks of main account air surveys that enable to increase economical effectiveness this research direction considerably.

The Role of Marine Mammals in the Ecosystem in the 21st Century
29 September -1 October, 2008
Alderney Landing, Dartmouth, NS, Canada

Hammill, M. and G. B. Stenson **Possible Impacts of Ice Related Mortality on Trends in the Northwest Atlantic harp seals population**

The harp seal is a medium sized highly migratory phocid distributed over continental shelf regions of the north Atlantic. The Northwest Atlantic population currently numbers around 5.5 million animals and is harvested commercially and for subsistence purposes. Harp seals use pack ice to haul out on, to give birth and nurse their young. After weaning the young of the year (YOY) remain with the ice, which they use as a resting platform. The harp seal population is assessed approximately every 4 years using a population model that relies upon independent estimates of pup production obtained from aerial surveys. Since the current harvest is focused on YOY animals, the impact of any unusual mortality will not be reflected in the assessment for at least two decades later. In the Gulf of St. Lawrence, poor ice conditions, which are thought to lead to increased mortality among young animals, have been observed in 6 of the last 10 years. A factor to account for increased mortality during poor ice years has been incorporated into the assessment model since 2004, but the impacts of this factor on model predictions has not been evaluated. Under scenarios of a constant harvest, an annual mortality of 30% or higher, due to ice, in a single year would result in significant changes in the population trajectory within a decade, but these changes would not be noticed as detectable changes in pup production for at least 20 years. Repeated ice-related mortality of 10% had limited impact unless it occurred in 6 or more winters within a decade. Changes in the population and pup production due to increased YOY mortality could not be detected until 15 or more years had passed even under high levels of mortality or variability among years, by which time significant changes in the population can occur. For management considerations, taking into account possible changes in natural mortality due to ice would not appear to be important in the short-term, but will have more important longer term implications.

The Role of Marine Mammals in the Ecosystem in the 21st Century
29 September -1 October, 2008
Alderney Landing, Dartmouth, NS, Canada

Dashiell Pappas, Kathryn Ono, Mark Sweezy. **Molecular methods for differentiating gray seal (*Halichoerus grypus*) and harbor seal (*Phoca vitulina*) scat with a note on summer diet of gray seals in outer Penobscot Bay, Maine**

The population of gray seals (*Halichoerus grypus*) in New England is currently increasing at a rapid rate. The diet of this piscivorous species has not been studied in Maine, and knowledge of its prey is important for understanding trophic level and fisheries interactions. Gray seals often intermingle at haulouts with harbor seals (Phoca vitulina) therefore, we developed molecular methods to differentiate the species' scats.

During field sample collection, a small portion of the scat was placed in 100% biological grade ethanol for DNA preservation and stored at -20°C. DNA was extracted from the stored samples using the QIAGEN stool mini kit. We created PCR primers that amplify a portion of the 16s mitochondrial DNA in both gray seals and harbor seals. Once the samples were amplified, they were then digested using the restriction enzyme Tsp509I. The gray seal DNA sequence was cut four times resulting in five fragments, whereas the harbor seal DNA sequence was cut three time resulting in four fragments. The samples were run on a 3% agarose gel and based on the banding patterns of the DNA, we were able to determine the species of origin of individual scats. These tools provide a mechanism by which separate dietary analysis can be achieved for gray seals and harbor seals at mixed haulouts.

Once the species from which samples originated was determined, a preliminary description of summer gray seal diet in outer Penobscot Bay, Maine was performed using hard parts analysis. However, there are controversies associated with this type of pinniped dietary studies. Subsequently, this project will address these issues by utilizing fecal DNA to look for prey species that do not normally appear in predator feces due to complete digestion or non-ingestion of identifiable hard parts.

The Role of Marine Mammals in the Ecosystem in the 21st Century
29 September -1 October, 2008
Alderney Landing, Dartmouth, NS, Canada

Witteveen, B.H and Wynne, Kate M. **Consumption and prey removals by humpback whales (*Megaptera novaeangliae*) near Kodiak Island, Alaska: A revision of previous estimates**

Models estimating consumption and prey removal by humpback whales (Megaptera novaeangliae) off northeastern Kodiak Island, Alaska were revised in light of new information on diet composition and population size. Previous models were based on the assumption that humpback whales foraged on available prey species in proportion to their relative abundance in 2002. New methodologies have since been applied to study the foraging ecology of these whales, including analysis of dive profiles through attachment of acoustic tags and stable isotope analysis. Results suggest humpback whales are more selective in their prey choice and previous estimates of consumption may have misrepresented removal of certain species. Analyses of stable carbon and nitrogen isotope ratios of humpback whale skin and dive profiles of tagged animals suggest juvenile walleye Pollock (Theragra chalcogramma) and eulachon (Thaleichthys pacificus) are not likely a significant contribution to the regional humpback whale diet as modeled in the previous diet. Results support a diet comprised of primarily euphausiids (Thysanoessa spp.), capelin (Mallotus villosus), and Pacific sandlance (Ammodytes hexapterus) may be the preferred forage fish species. An estimate of humpback whale abundance for northeastern Kodiak Island was also updated from 2002 (N = 157) to 2007 based on photo-identification efforts. Abundance was estimated using two methods; the first applied a growth rate of 6.5% per year to the previous estimate of abundance (N = 253) and the second used the Schnabel maximum likelihood estimator and incorporated all mark-recapture histories between 1999 and 2007 (N = 977). Revisions to the consumption model had significant effects on estimates of prey removal. Total prey removal increased from 8,834 kg in the previous model to between 17,940 and 69,279 kg in revised models. Seasonal removal of capelin, Pacific sandlance, and euphausiids all increased dramatically, while increases in the consumption of juvenile walleye Pollock were small.

The Role of Marine Mammals in the Ecosystem in the 21st Century
29 September -1 October, 2008
Alderney Landing, Dartmouth, NS, Canada

Marjorie Rossman. **Estimated Bycatch of Small Cetaceans in Northeast U.S. Bottom Trawl Fishing Gear During 2000-2005**

The U.S. Marine Mammal Protection Act mandates monitoring of incidental marine mammal mortality and serious injury attributable to commercial fishing operations. Generalized linear models were utilized to estimate incidental bycatch rates of pilot whales, white-sided dolphins, and common dolphins in U.S. bottom trawl fisheries operating off the Northeast coast of U.S. during 2000-2005. Spatial, habitat and environmental covariates were significant in the best fitting GLM models. Highest bycatch rates occurred in deep waters with low sea surface temperature (white-sided dolphins), on vessels with large vessel horsepower targeting squid species in areas of high relief (pilot whale spp.), and in offshore statistical areas (common dolphins). Estimated bycatch rates were expanded by total bottom trawl effort (days fished) to derive the mean annual bycatch mortality for each of the three species. The estimated mean annual bycatch during 2000-2005 of pilot whale spp., white-sided dolphins, and common dolphins in U.S. Atlantic bottom trawl fisheries is 55, 212 and 142 animals, respectively. These estimates are 22%, 42%, and 14%, respectively, of their current potential biological removal levels for these three species.

Graham Pierce, Santiago Lens, Ursula Pena, Sabine Goetz, Martin Laporta, Jose Luis del Río, Julio Portela, Sergio Iglesias. **Observer programmes to record marine mammal and seabird distribution and interactions with fishing operations in Southwest Atlantic waters**

Since 1993, fishery observers from the Instituto Español de Oceanografía (IEO) have recorded incidental sightings and by-catches of marine mammals and seabirds from Spanish fishing boats in international waters of the southwest Atlantic. The IEO recently implemented an observer programme on-board research vessels in the area, recording data on marine mammal and seabird sightings. The objectives of this programme include (a) determining the distribution of marine mammals and seabirds, (b) modelling habitat use, and (c) monitoring interactions with fishing operations. Data are collected on species present, numbers, behaviour, environmental conditions and interactions with fishing activities.

Here we present a summary of results from the fishery observers and a preliminary report on the results from surveys including distribution maps. The cetacean species most frequently sighted from commercial vessels were Peale's dolphin (*Lagenorhynchus australis*) and hourglass dolphin (*Lagenorhynchus cruciger*). Other species of cetaceans observed included common dolphin (*Delphinus* sp.), pilot whale (*Globicephala* sp.), sperm whale (*Physeter macrocephalus*) and southern right whale (*Eubalaena australis*), minke whale (*Balaenoptera acutorostrata*), killer whales (Orcinus orca) and southern right whale dolphin (*Lissodelphis peronii),* . Recent observations from a longliner include sperm whales following the boat for several days, suggesting that they were feeding in association with the boat, e.g. on fish hooked on the lines. Pinnipeds were observed frequently in the vicinity of the boats. By-catches of small numbers of marine mammals and seabirds were recorded, including hourglass dolphin and several pinniped species.

During a hydrographic survey in December 2007 and a fishing survey in March-April 2008, the most frequently sighted cetaceans were dusky dolphin (*Lagenorhynchus obscurus*) and fin whale (*Balaenoptera physalus*). Other marine mammals recorded include hourglass dolphin, sperm whale, South American fur seal *Arctocephalus australis*, pilot whale, minke whale and Peale's dolphin.

Dana Belden, Gordon T. Waring, James R. Gilbert, Amy Williams and Debra L. Palka. **Characteristics of phocid seal bycatch in New England fisheries**

The Role of Marine Mammals in the Ecosystem in the 21st Century
29 September -1 October, 2008
Alderney Landing, Dartmouth, NS, Canada

New England populations of harbor seal and grey seal have increased and expanded their range in the 35 years since passage of the U.S. Marine Mammal Protection Act (1972). Extralimital appearances of harp seal and hooded seals have also increased since the early 1990s. Seal bycatch has been observed in several U.S. fisheries since 1990, particularly the Northeast sink gillnet (NSG) fishery. Further, the NSG is the only fishery that has been observed continuously since 1990. Annual estimated bycatch in the NSG has been variable [i.e., harbor seal (230-1475); gray seal (0-575); harp seal (0-860); hooded seal (0-82)] and no clear trends are evident. During the 5-year period (2002-2006), estimated bycatch (and associated CV) in the NSG were: harbor seal = 585 (0.15); gray seal = 314 (0.22); harp seal = 80 (0.31); and hooded seal = 0. Harbor and gray seal bycatch has been observed in all seasons, whereas harp seal bycatch has not been observed in summer or autumn. Observed hooded seal bycatches occurred on only three occasions, and thus the data are too scant to be statistically meaningful. Harbor, gray, and harp seal bycatch was concentrated in the Western Gulf of Maine but south of Cape Cod bycatches extended southward to Long Island and out to the 100m isobath .

We examined the characteristics (e.g., distribution, rates, biology) of seal bycatch in New England (Maine to New York) fisheries. For harbor seal and gray seal bycatch in the NSG, we used general linear modeling (GLM) to determine which covariates (e.g., fishery target species, gear configuration, pingers, fishing depth, etc.) were important in explaining the bycatch patterns.

The Role of Marine Mammals in the Ecosystem in the 21st Century
29 September -1 October, 2008
Alderney Landing, Dartmouth, NS, Canada

Amanda Caskenette, Steve Crawford, and Daniel Duplisea. **Evaluating the interaction between the southern Gulf of St Lawrence Atlantic cod (*Gadus morhua*) stock and the Northwest Atlantic grey seal (*Halichoerus grypus*)**

The southern Gulf of St Lawrence (sGSL) Atlantic cod population was decimated in the 1990s and is at a record low level with continual decline. The natural mortality rate is estimated to have doubled from 0.2 to 0.4 in1986 and remains high. The grey seal population has been exhibiting continuous growth and has reached an abundance not seen in the sGSL for more than forty years. Grey seals are generalist predators and consume a wide range of invertebrates and fish including cod, predators of smaller cod, and prey of larger cod. The grey seal population has been implicated in the lack of recovery for the Atlantic cod population, however more details about the interaction between the two populations are needed. Seals may impact ground fish populations in several different ways including predation, disruption of spawning activity, competition for resources, and reduction of fish foraging efficiency. The Atlantic cod and grey seal population distributions overlap in the over-wintering grounds and during migration. Accordingly, for Atlantic cod and grey seals, some specific examples of interaction may include grey seal predation when the cod are aggregated during migration, and reduction of Atlantic cod foraging efficiency in winter. These and other competing biological hypotheses for the sGSL Atlantic cod grey seal interactions were developed based on relevant literature and expert advice. Each hypothesis was then expressed mathematically as a component of natural mortality in an Atlantic cod abundance model and effects compared using the observed Atlantic cod abundance indices.

The Role of Marine Mammals in the Ecosystem in the 21st Century
29 September -1 October, 2008
Alderney Landing, Dartmouth, NS, Canada

Wayne Ledwell, Steven Benjamins, Julie Huntington and Catherine Hood. **Incidental entrapments of large whales in Newfoundland Region from 1999-2007**

Reports of incidental capture or entanglement of cetaceans in commercial fishing operations along the coast of Newfoundland and Labrador have occurred for over three decades. Such incidental capture and resulting mortality in fisheries gear is of particular importance to the humpback whale (Megaptera novaeangliae) population as this region has the largest feeding population of humpback whales in the northwest Atlantic. The presence of large numbers of humpback whales using these waters corresponds with the peak of commercial fishing effort. Thus, the region has been a key area for whale entanglement. This paper reviews records of entanglements of marine mammals in Newfoundland and Labrador waters for the years 1979-2007.

Fishing effort in Newfoundland and Labrador prior to 1990 has primarily been conducted with hook and line, box trap gear and inshore gillnets (Harris 1990). The greatest number of whale entanglements occurred in the latter two fisheries. During recent times however, some historically stable fisheries have been in decline and several have been placed under moratoria. Although there is still a significant inshore fishery in the Newfoundland Region employing both traditional fishing methods the focus of the industry has shifted offshore from traditional inshore small boats using fixed fishing gear set near shore to larger boats fishing in nearshore and offshore waters employing pot gear to harvest snow crab (Chionocetes opilio).This shift towards the snow crab pot fishery has also led to a change in entanglement rates of large whales in Newfoundland and Labrador. From 1979 to 1999, 0.6% of reported entanglements of large whales occurred in offshore waters, but from 2000 to 2007, 27% of humpback entanglements occurred in the offshore. Similarly, from 1979 to 1999, 0.3% of reported entanglements occurred in crab pot gear. From 2000 to 2007, 31% of reported humpback whale entanglements occurred in crab pot gear. This shift in fisheries from the inshore gillnet and cod trap fishery to an offshore snow crab and gillnet fishery has resulted in fewer large whales reported as entrapped but logistically has created problems with more whales towing gear and difficulties associated with getting to offshore entrapments of large whales.

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Alderney Landing, Dartmouth, NS, Canada

Hiroto Murase, Toshihide Kitakado, Koji Matsuoka, Takashi Hakamada, Shigetoshi Nishiwaki and Mikio Naganobu **Predator-prey relationship in spatial context -Is the distribution pattern of krill the determinant factor of the distribution pattern of Antarctic minke whale?**

Predator-prey relationships in the polar region, especially in high latitude area such as the Ross Sea of Antarctic have been rarely studied quantitatively in a spatial context because of the difficulty to collect an extensive data set in such harsh environments. A multi-disciplinary study combining cetacean, krill and oceanographic surveys was carried out as a part of the Japanese Whale Research Program under Special Permit in the Antarctic (JARPA) in the Ross Sea in austral summer in 2005. Generalized Additive Model (GAM) based spatial modeling was applied to assess the effect of prey distribution on the distribution pattern of Antarctic minke whales in the Ross Sea. A hierarchical structure with three strata of spatial models is considered in this study: (1) presence and absence of Antarctic and ice krill, (2) biomass density of Antarctic and ice krill and (3) school counts of Antarctic minke whales. Three abiotic factors, distance from physical boundary (combination of coast, ice edge and shelf ice lines), integrated temperature and salinity mean from surface to 200m (ITEM-200 and ISAM-200) as well as latitude and longitude were used as covariates for models (1) and (2). Predicted surfaces of distribution of krill were also used as covariates in the model (3). The scale of interactions between Antarctic minke whales and the environmental factors were investigated at a segment length of 5 n.miles. Predicted school counts of Antarctic minke whales were low where ice krill were distributed while it was high where Antarctic krill were distributed. The results indicated that the abundance of Antarctic minke whales could be related to the biomass of Antarctic krill. Continuation of the multi-disciplinal ecological survey is critically important to detect interactions between fluctuations of abundance of marine mammals and their preys.

The Role of Marine Mammals in the Ecosystem in the 21st Century
29 September -1 October, 2008
Alderney Landing, Dartmouth, NS, Canada

Lavery, T. J. & Mitchell, J. G. M. **Marine Mammals Fertilise the Ocean**

Marine mammals consume commercially important fish species but may also sustain fish biomass by increasing turbulence while diving, and thereby transporting nutrient rich water into the photic zone. We consider a population on the order of 10^5 New Zealand fur seals inhabiting oligotrophic waters off South Australia and find they are significant allochthonous contributors to photic zone nutrient standing stock, raising nitrogen and iron levels compared to background concentrations. Increased nutrient inputs likely promote proliferation of eukaryotic microalgae, channelling energy away from the microbial loop, and directly increasing fisheries productivity. Historical commercial exploitation of New Zealand fur seals in South Australia has reduced nutrient inputs from seals, decreasing background nutrient concentrations and reducing fishery productivity. We calculate nutrient additions from present and historical populations to estimate the biomass of commercial fish supported by this population of fur seals. By stimulating primary productivity, nutrient additions can increase carbon drawdown. We calculate the carbon drawdown potential of the current populations of New Zealand fur seals in South Australia, and show how this has been decreased due to historical seal exploitation.

The Role of Marine Mammals in the Ecosystem in the 21st Century
29 September -1 October, 2008
Alderney Landing, Dartmouth, NS, Canada

Lens, S., Santos, M. B., Oñate, D., Miranda A., Casas G., Cañadas, A., Cabanas, J. M., Iglesias, M., Fernández, R. and Vázquez, J. A. **Distribution of fin whales and krill aggregations off the Galician coasts observed during the CODA-IEO survey**

In July 2007 an internationally coordinated project involving 5 ships from 4 countries surveyed the offshore waters of the Northeast Atlantic. The objectives of the project CODA (Cetacean Offshore Distribution and Abundance in the European Atlantic) are to obtain abundance estimates of cetaceans and model habitat preference of selected species using satellite data. Between the 17th of July and the 1st of August the R/V Cornide de Saavedra carried out the CODA-IEO survey covering the SW part of the total CODA project area. During the cruise, additional data on the physical and biological characteristics of the water column were obtained to investigate the relationship between the distribution of fin whales (Balaenoptera physalus) and their main prey, the krill (Meganyptiphanes norvegica).

A thermo-salinometer and a fluorometer were employed to characterise the surface waters while XBT probes and CTD stations were used to measure the temperature and salinity of the water column to a depth of 300m. Zooplankton sampling with a WP2 net was also carried out at fixed stations. Throughout the surveyed area the scattering layer was observed with a split-beam EK 60 Simrad echosounder while the groundtruthing of the accoustic echotraces was carried out, when possible, with a modified Juday-Bogorov net.

Here we present the characteristics of the water masses in the area prospected together with the distribution of fin whale sightings and presence of krill and other nektonic organisms.

The Role of Marine Mammals in the Ecosystem in the 21st Century
29 September -1 October, 2008
Alderney Landing, Dartmouth, NS, Canada

Martins, C.C.A.; Lamontagne, P.; Parrott, L.; Landry, J.A.; Marceau, D.; Chion, C; Turgeon, S.; Michaud, R.; Menard, N.; Dionne, S. & G. Cantin. **Conceptualizing an individual-based model to simulate marine mammal behaviour in the Saint Lawrence Estuary, Canada**

In July 2007 an internationally coordinated project involving 5 ships from 4 countries surveyed the offshore waters of the Northeast Atlantic. The objectives of the project CODA (Cetacean Offshore Distribution and Abundance in the European Atlantic) are to obtain abundance estimates of cetaceans and model habitat preference of selected species using satellite data. Between the 17th of July and the 1st of August the R/V Cornide de Saavedra carried out the CODA-IEO survey covering the SW part of the total CODA project area. During the cruise, additional data on the physical and biological characteristics of the water column were obtained to investigate the relationship between the distribution of fin whales (Balaenoptera physalus) and their main prey, the krill (*Meganyptiphanes norvegica*).

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Sergey Ignatyev **Long-Term Observations Over Mammals On Ukrainian Antarctic Station Academic Vernadsky (Antarctic Peninsula)**

Ukraine began biological researches in Antarctic Continent in 1996, when she became the full member of modern Antarctic community. Academic Vernadsky (former British Faraday base) is the first Ukrainian Antarctic station (UAS). This station is located on Galindez Island (65°15'S, 64°16'W). The location of Argentina Islands Archipelago is unique. It is the meeting-point of the rather warm Southern-American and cold Antarctic waters. This area of high biological productivity is southern border of distribution and reproduction of mass bird's and mammal's species.

Despite of long period (since 1947) of the presence in region of stationary scientific base, the biological researches here practically were not carried out. Undertaken by British Antarctic Survey in middle of 60-th years the attempt to make the biological description of Islands of the archipelago was reduced to not numerous observations over seals (Elderfield, 1972). Biological researches were begun only in 1997.

Nowadays biological researches were conducted in the following strategic directions: (1) Monitoring of the ecological condition of the sea ecosystems at all levels from microplankton up to whales. (2) Estimation of the condition of living resources, first of all krill *Euphausia superba*. (3) Estimation of the influence of anthropogenic factors (different types of pollution and frightening factor of human presence). (4) Biology of separate mass animal species - krill, fishes, birds and mammals.

The study of marine mammals is relevant and integral part of biological researches, which one are designed on station. They include the analysis of a species structure, number, their seasonal and interannual variability and behaviors peculiarities.

8 species of marine mammalians were observed in region in the season 1997-2006. There are 5 species of seals and 3 species of whales. 3 species of seals (crabeater seal *Lobodon carcinophagus*, weddeli seal *Leptonychtes weddeli* and leopard seal *Hydrurga leptonix*) were observed annually and were numerous. They reproduce in this region and are typical species. We have perennial overseeing by a variability of number of these species during year. Our supervisions show increase of number of crabeater seals and leopard seals. The number of weddeli seals remains practically invariable. Southern fur seal (*Arctocephalus* sp.) and southern elephant seal (*Mirounga leonica*) are observed incidentally. 2 species of whales (humpback whale and minke whale) were marked in UAS region, where they went after krill swarms. Killer whales are observed only in 1999 and in 2006.