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The Role of Marine Mammals in the Ecosystem

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Foreword

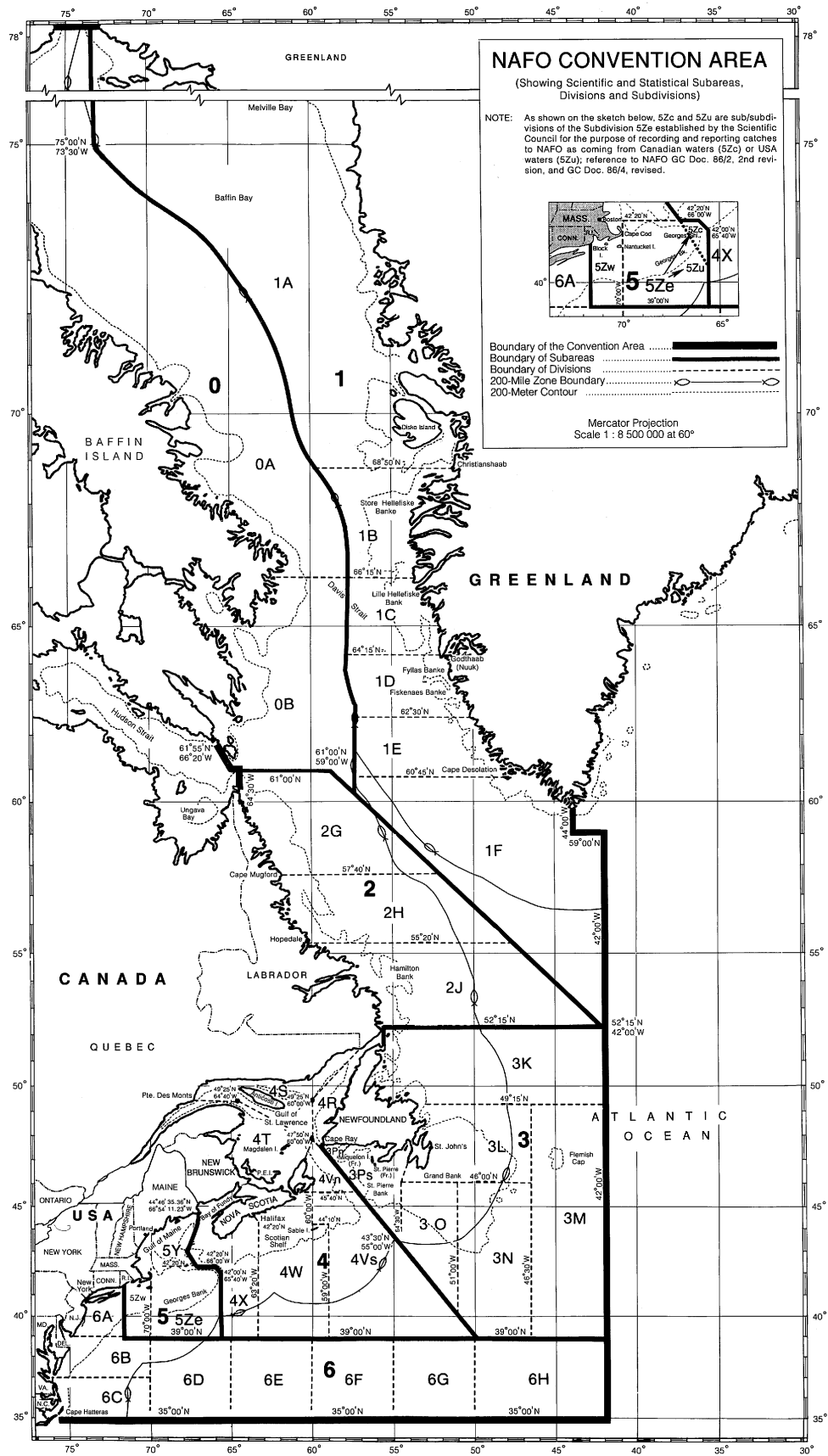
In accordance with its mandate to disseminate information on fisheries research to the scientific community, the Scientific Council of NAFO publishes the *Journal of Northwest Atlantic Fishery Science*, which contains peer-reviewed primary papers and notes on original research, and *NAFO Scientific Council Studies*, which contains papers of topical interest and importance. Each year since 1981, the Scientific Council has held at least one Special Session on a topic of particular interest, and many of the contributions to those sessions have been published in either of these NAFO Publications. For 1995, the Scientific Council initiated this Special Session titled 'The Role of Marine Mammals in the Ecosystem', as a Symposium of topical interest to NAFO. Further to the NAFO Scientific Council decision of September 1992, the Council invited International Council for the Exploration of the Sea (ICES) to co-sponsor the Symposium (*NAFO Sci. Coun. Rep.*, 1992, p. 177). The Joint NAFO/ICES Symposium was hosted by the NAFO Scientific Council at the NAFO 17th Annual Meeting held at the Holiday Inn, Dartmouth, Nova Scotia, Canada. In accordance with the decision of the Scientific Council of September 1995 (*NAFO Sci. Coun. Rep.*, 1995), this volume of the *Journal of Northwest Atlantic Fishery Science* contains papers presented at the Symposium.

The Symposium was jointly convened by G. B. Stenson (Canada–NAFO) from the Northwest Atlantic Fisheries Centre, St. John's, Newfoundland, Canada, and J. Sigurjónsson (Iceland–ICES) from the Marine Research Institute, Reykjavik, Iceland. A total of 51 papers and posters were presented of which 26 papers were submitted by the authors for consideration for publication in this issue.

In accordance with the decision of the Scientific Council, J. Sigurjónsson and G. B. Stenson were invited to undertake the normal Journal editorial process. At the NAFO Secretariat some final editorial work was done as needed and this issue was printed. While the NAFO Scientific Council and ICES had intended to complete this publication sooner, unforeseen delays were experienced. However, the quality of the presentations, the stimulating discussions at the Symposium, and the comprehensive coverage achieved in this publication does not diminish the timeliness and importance of the proceedings.

December 1997

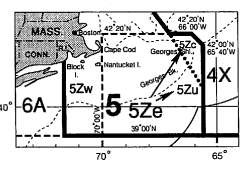
Tissa Amaratunga
Technical Editor, *Journal of Northwest
Atlantic Fishery Science*



NAFO CONVENTION AREA

(Showing Scientific and Statistical Subareas, Divisions and Subdivisions)

NOTE: As shown on the sketch below, 5Zc and 5Zu are sub/subdivisions of the Subdivision 5Ze established by the Scientific Council for the purpose of recording and reporting catches to NAFO as coming from Canadian waters (5Zc) or USA waters (5Zu); reference to NAFO GC Doc. 86/2, 2nd revision, and GC Doc. 86/4, revised.



Boundary of the Convention Area **—————**
 Boundary of Subareas **-----**
 Boundary of Divisions **- - - - -**
 200-Mile Zone Boundary **.....**
 200-Meter Contour **.....**

Mercator Projection
 Scale 1 : 8 500 000 at 60°

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Introduction

The set of papers that appears in this special volume is a result of the international Symposium entitled 'The Role of Marine Mammals in the Ecosystem' jointly organized by the Northwest Atlantic Fisheries Organization (NAFO) and the International Council for the Exploration of the Sea (ICES). In total 30 oral and 21 poster contributions were presented at the Symposium that was held 6–8 September 1995 near NAFO Headquarters in Dartmouth, Nova Scotia, Canada. A total of 26 of these papers appear in this special volume, most having been revised since they originally were presented at the Symposium. A summary report of the Symposium follows with details on the sessions and contributions. The list of participants and the related list of NAFO SCR documents circulated at the Symposium is given at the end of this edition.

As evidenced from this volume of papers, many researchers are devoting their efforts towards questions relating to the role of marine mammals in the ecosystem. The wide variety of geographical areas represented in these papers indicate the global nature of these questions. Although the objectives of the studies vary from examining by-catches to estimating the impact of marine mammals on commercial fisheries, it is clear that the role of marine mammals in their ecosystem is an important one. Certainly, more research is required to answer many of the questions posed during this Symposium. However, we believe that the published proceedings will be a very useful reference for later studies and form the basis for the evaluation of the role of mammals in marine ecosystems.

It has been our great pleasure to have had the opportunity to meet and get to know the many participants and contributors to these proceedings. It has been an honour for us to help bring the papers into a single volume of high quality scientific contributions. However, the credit for this publication should go in first place to the dedicated authors that shared their patience with us in a rather tedious and long process. Secondly, we are indebted to several anonymous reviewers and to the many colleagues who offered so much of their time to critically, and constructively, read over one or more versions of the draft manuscripts. They are in alphabetical order below. If anyone was accidentally missed, we apologize and extend our thanks.

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Finally, we are grateful to Tissa Amaratunga, Assistant Executive Secretary of NAFO and his staff for taking care of the final technical editing of the papers as well as providing assistance at all stages of the preparation of the proceedings and organization of the conference.

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Report of the Symposium

Further to the NAFO Scientific Council initial discussion in June 1989 (*NAFO Sci. Coun. Rep.*, 1989, p. 116) and its decision in September 1992 (*NAFO Sci. Coun. Rep.*, 1992, p. 177), the Joint NAFO/ICES Symposium on 'The Role of Marine Mammals in the Ecosystem' was held during 6–8 September 1995. The Symposium was hosted by the Scientific Council in conjunction with the NAFO 17th Annual Meeting.

The meeting was opened by W. B. Brodie (Canada), Standing Committee on Fishery Science (STACFIS) Chairman, who on behalf of the Scientific Council, gave a brief introduction on NAFO and its structure and activities, and commented on the importance of the scientific information from this Symposium to NAFO. J. Harwood (EU–United Kingdom), on behalf of ICES then welcomed the participants.

The following report was prepared by the co-convenors with the assistance of the session chairs.

Introduction

The Symposium on the 'Role of Marine Mammals in the Ecosystem' was co-sponsored by the NAFO Scientific Council and the International Council for the Exploration of the Sea (ICES) with G. B. Stenson (Canada) and J. Sigurjónsson (Iceland) as co-convenors. It was held 6–8 September 1995 at the Holiday Inn, Dartmouth, Nova Scotia, Canada.

The aim of the Symposium was to attract scientists from relevant disciplines with expertise in different geographical areas to address the question of the role of mammals in the marine ecosystem. The three day Symposium was divided into four theme sessions: 1) Environmental, spatial and temporal influences on life histories (Chair: T. Haug, Norway), 2) Foraging strategies and energetic considerations in the diet (Chair: I. McLaren, Canada), 3) Marine mammal – fisheries interactions (Chair: W. D. Bowen, Canada), and (4) Theoretical considerations on the role of apex predators and multispecies models (Chair: G. A. Víkingsson, Iceland). Each session consisted of a keynote address, followed by contributed oral presentations and an extended general discussion. Poster presentations were displayed throughout the Symposium in addition to specific poster sessions.

The Symposium was attended by 113 participants from 16 countries (Argentina, Brazil, Canada, Denmark (Greenland), France, Germany, Iceland, Japan, Norway, Portugal, Russia, South Africa, Spain, The Netherlands, United Kingdom and United States of America). In total, 30 oral and 21 poster contributions were presented. A list of contributions and participants is included at the end of this report.

The Scientific Council agreed the contributions will be published in a special volume of the *Journal of Northwest Atlantic Fisheries Science*, inviting G. B. Stenson and J. Sigurjónsson to be co-editors of this issue.

Thematic Considerations

Following is a brief summary of the presentations and of discussions that took place at the end of the respective theme sessions.

Environmental, Spatial and Temporal Influences on Life History

Seven oral and four poster presentations were presented on the relationships between environmental, spatial, temporal factors and life history parameters. The session began with a keynote address (Symposium Paper 1.1)¹ entitled 'The Spatial Dynamics of Large Marine Organisms' presented by D. Schneider (Canada) who illustrated that the distribution and spatial dynamics of large marine organisms in relation to physical environment may be more productively investigated by testing hypotheses in relation to well defined

¹ Symposium Paper Numbers shown in "Symposium Sessions" below.

models than by direct correlation with physical measurements such as temperatures, salinity, or depth. Correlations may, however, be useful in identifying potential hypothesis for testing. Biological and physical processes need to be examined over a large variety of scales which may not be similar for all disciplines or objectives.

Several contributions addressed the physical and biological characteristics of the habitats of marine mammals. Correlations between cetacean distribution data and physical and biological parameters were demonstrated (1.7, 1.8, 1.15) and the potential of using detailed habitat analyses to predict potential areas of occurrence of the same species was shown (1.9). Dimensionless ratios of various scales were used to determine changes in distribution (1.10). Apparent changes in the distribution of various species of marine mammals have been observed (1.3, 1.12, 1.13, 1.14) which may be related to changes in environmental conditions, sighting effort, or other factors.

Changes in the reproduction potential and body condition of harp seals in the Northwest Atlantic have been observed, which may be related to changes in seal population size, prey availability or an interaction between them (1.3). The occurrence of significant seasonal variation in body condition of Barents Sea harp seals was considered to be of importance in evaluation of the ecological role of the species (1.4).

The general discussion focused on two main issues. The first was related to the correlation between marine mammals and the scale of observations. The scale at which a marine mammal and fisheries scientists operate may not be comparable and information about prey abundance are often collected for assessment purposes which may not always fulfil the requirements needed for evaluation of marine mammal ecology. Therefore, correlation must often be made to physical or oceanographic factors which do not vary within a short time frame.

The second major topic of the discussion was the question of density dependent changes in populations of marine mammals. Although changes in morphology and reproduction parameters have been demonstrated for a number of species, such as the Northwest Atlantic harp seals, it was not clear that they have been proven to be due to classical density dependent processes. The cause of these changes becomes important if we wish to predict future changes in the population.

Foraging Strategies and Energetic Consideration

Six oral and seven poster contributions were presented on the theme of this session. The keynote address (2.1) entitled 'Approaches to the quantification of the energetic requirements of marine mammal populations and their impact on marine ecosystems' was presented by G. A. J. Worthy (USA). Although the relative frequencies of food items in the diet can often be established, estimates of consumption required for determining the role and impacts of marine mammals require a variety of approaches for estimating metabolic demand to quantify and apportion prey items. Recent information on the energetic requirements of a variety of species indicate that assuming energy requirements based upon generalized mammalian relationships with body mass (the "Kleiber line") may not be appropriate for all marine mammals. New techniques of estimating diet, such as fatty acid signature analysis and stable isotope ratios, were presented and their applicability to answer different types of questions were discussed (2.2, 2.3).

A number of presentations extended traditional dietary analysis beyond the usual mere enumeration of stomach contents. Using data from the stomachs contents of fin whales off Iceland (2.4), a diel rhythm in feeding was identified and the average daily intake estimated. Recent studies provide new insights into various aspects of the foraging behaviour of Northeast Atlantic minke whales; comparison of prey consumed to estimated prey abundance obtained from resource surveys using qualitative and quantitative statistics suggests that minke whales exhibit prey selection (2.5, 2.9) while examination of the stomach contents lead to the hypothesis that the meal size varies according to the spatial distribution of the prey (2.6). Also, large and small minke whales appear to exploit the same resources in given areas, although whale size and prey type influence meal size (2.6).

An example of the use of spatial and temporal patterns in the distribution of prey and predator to identify potential interactions was presented (2.13) as well as a method of investigating prey selection in captive seals (2.7). Information on the diet of a number of species in areas which were previously unknown were presented (2.9, 2.10, 2.12) along with comparisons of the diet of co-existing predators (2.8, 2.11), or the same predator in different geographical areas (2.11).

The general discussion focused upon the usefulness of fatty acid signature analysis and stable isotope ratios for determining diets. It was noted that these methods are not intended to replace traditional techniques, but rather provide additional tools to answer specific questions. However, in order for these techniques to be useful, adequate baseline data from the potential prey species in the ecosystem must be obtained.

Marine Mammal-Fisheries Interactions

A total of 12 oral and 10 poster contributions addressing issues of marine mammal – fisheries interactions were presented. The keynote paper (3.1) entitled 'On modelling approaches for evaluating seal-fishery interactions: initiatives in South Africa and for the Antarctic' was presented by D. Butterworth (South Africa). It reviewed recent modelling studies of the Benguela Current and Southern Ocean ecosystems. Perhaps the most important results of these studies is the recognition that realistic models of the interactions between marine mammal populations and fisheries must account for the major interactions affecting the system, while at the same time simplifying the system to the point where analyses are tractable. Associated with this process is the need for the development of a risk assessment framework within which the probabilities and consequences of different outcomes may be evaluated.

Several presentations provided information that showed strong geographic and seasonal variation in the composition of the diets of pinnipeds and cetaceans. These data coupled with information on mammal abundance, individual energy requirements, and prey energy content were used to estimate the biomass of prey consumed by harp seals in the Northwest Atlantic (3.5), hooded seals in the Gulf of St. Lawrence (3.18), Cape fur seals in the Benguela ecosystem (3.2), cetaceans along the northeastern continental shelf of the United States (3.8), in waters around and adjacent to Iceland (3.22), and off the coast of Patagonia, Argentina (3.10). In all areas, marine mammals consumed large amounts of biomass, often equal to or greater than that taken by commercial fisheries, but the species consumed were a mixture of commercial and non-commercial prey. Estimates of consumption by harp seals in Atlantic Canada (3.5) illustrate the importance of understanding how diet data are incorporated into the model since changes can result in substantially different estimates. A study of estimated consumption of Atlantic cod by grey seals on the Eastern Scotian Shelf, Canada (3.4), emphasized the need for a better understanding of the functional form of seal predation, the level of natural mortality on young cod, and the sources and relationships among other components of natural mortality before the impact of seals on prey populations could be assessed.

A significant change in the age distribution of cod in the diet of seals off Iceland and concurrent declines in the size of seal stocks was observed (3.3). To determine if there was evidence of increasing juvenile mortality consistent with predictions based upon predation by seals, mortality was estimated from research vessel surveys for several Northwest Atlantic cod stocks (3.6). Although no trends were detected, the ability of the tests to detect such changes given the variability of the survey data was debated.

The potential competition between marine mammals and fisheries for prey and primary productivity in the Pacific Ocean was examined using a steady state model (3.9). Although data for many species of the marine mammals included can only be approximated as order of magnitude, the study indicated that marine mammals likely consume three times as much food (commercial and non-commercial species) as that taken by fisheries. Another study (3.7) suggested that comparison of different ecosystems, such as the Bering Sea and Barents Sea, might yield insights as to the nature of the ecological interactions between pinnipeds and fisheries.

Operational interactions between marine mammals and fisheries were discussed in six presentations. Mortalities or injuries to cetaceans due to interactions with fishing gear were documented for the US

Atlantic coast and Gulf of Mexico (3.14), and the waters of the continental slope southwest of Ireland (3.15). A review of documented interactions between cetaceans and trawlers was presented (3.16) along with a study of gear damage and depredation due to apex predators in eastern Florida, USA (3.13). Preliminary results of the use of acoustic devices to reduce the incidental catch of harbour porpoise in groundfish gillnets (3.12) are encouraging. A study of surfacing patterns in captive and wild harbour porpoise (3.21) may provide behavioural data related to the incidental capture of porpoise in fishing gear.

Still another form of interaction was illustrated by two presentations describing the parasitic fauna of beluga in the Gulf of St. Lawrence, Canada (3.19) and grey seals in Iceland (3.20). Parasites may be an important cause of mortality in beluga and a useful tool for identifying stock identity while parasitic loads in grey seals may have an impact on the parasitic burdens of commercially important fish species.

A framework developed by the Scientific Advisory Committee of the Marine Mammal Action Plan coordinated by UNEP for the scientific evaluation of programs to cull marine mammals to benefit fisheries (3.11) was presented for discussion.

The general discussion focused on the fact that the results of models designed to determine impact of marine mammals on fisheries are imprecise in most situations. Therefore, we should consider developing robust models which provide us with information on the direction and the order of magnitude of the impact. The ability of the model to distinguish among alternative scenarios must be considered. It was also noted that several studies indicate that consumption of fish resources by other predators such as predatory fish or seabirds may be important in some ecosystems.

Theoretical Considerations on the Role of Apex Predators and Multispecies Models

Five oral contributions considered theoretical considerations on the role apex predators and the use of multispecies models. The keynote address (4.1) entitled 'Assessing the relationship between apex predators and fisheries: where do we go from here?' was delivered by J. Harwood (UK). Examples of marine mammal – fisheries interactions and methods for studying these were presented. Recent studies of grey seals off the coast of England (UK) show great "patchiness" in foraging behaviour. Therefore, it is necessary to study all of the interacting components, including the marine mammals, the prey species and the fisheries, at a finer scale than has been done previously. In order to develop dynamic models of interactions, information on the functional relationship between marine mammals and their prey, other predators, and fishermen are required.

An example of a method for quantifying sources of uncertainty for each of the components involved in estimating prey consumption of harp seals was presented (4.2) indicating considerable uncertainty in the estimates of consumption due to variability in the diet samples. Such calculations are important in identifying research needs and for evaluating alternative management options.

Alternative hypothesis proposed to explain declines in Stellar sea lions and seabirds, and increases in groundfish in the Bering Sea were described and evaluated (4.4). These changes could have been caused by changes in the environment, competition with commercial fisheries, or direct competition between sea lions and gadids for food.

Multispecies interactions in the Barents Sea were explored by using a simulation model (4.3). Sensitivity of the model to food preferences and stock sizes of harp seals and minke whales, and the relative importance of these two species to the main fish predator, cod, was described. Off Iceland, the potential interactions among three piscivorous baleen whales and their principal prey were explored using a multispecies simulation model (4.5). The results indicated that baleen whales may have significant direct and/or indirect long-term impacts on the prey species.

The general discussion dealt with specific aspects of the analysis presented and restated many of the common themes of previous discussions. The concern that multispecies models should take into account uncertainties in the inputs was emphasized.

Summary

Throughout the Symposium, reoccurring themes became evident. The basic premise of the Symposium that a variety of biological and physical components in the ecosystem must be considered in order to determine the role of marine mammals and the need to include scientists from various disciplines, was emphasized. It was also evident that marine mammals must be considered on a variety of spatial and temporal scales and that their role may vary among them. The scales at which marine mammals are studied are often not compatible with the information available from other disciplines and this can only be resolved through cooperative studies with other disciplines. With respect to marine mammal – fisheries interactions, studies should take into account potential secondary interactions such as other predators or prey, which may result in conclusions which are counter-intuitive. However, in many cases it may not be possible to quantify the interactions precisely and therefore, models incorporating uncertainties in the inputs must be robust and yet capable of identifying the magnitude and direction of competitive interactions within the system.

Symposium Sessions

Theme Session 1: Environmental, Spatial and Temporal Influences of Life History

Oral Presentations

- 1.1¹ **D. C. Schneider.** The Spatial Dynamics of Large Marine Organisms.
- 1.3 **B. Sjare, D. Chabot and G. Stenson.** Declines in the Reproductive Potential and Body Condition of Harp Seals: Response to a Changing Marine Environment?
- *1.4 **K. T. Nilssen, P. E. Grotnes, T. Haug and V. Potelov.** Seasonal Variation in Condition of Adult Barents Sea Harp Seals, *Phoca groenlandica*.
- *1.7 **R. B. Griffin.** An Investigation of Relationships Between Delphinid Distributions and Copepod Abundances.
- 1.8 **C. T. Tynan.** Characterization of Oceanographic Habitat of Resident and Migratory Species of Cetaceans in the Southern Ocean Between 82-115E.
- *1.9 **E. Moses and J. T. Finn.** Using Geographic Information Systems to Describe Associations Between Right Whale (*Eubalaena glacialis*) Distribution and Sea-surface Temperature and Bathymetry on the Scotian Shelf.
- 1.10 **F. Marques, J. K. Horne and J. Lien.** Evaluating the Influence of Biological and Physical Processes on North Atlantic Humpback Whale Distribution.

Poster Presentations

- 1.12 **D. Borggaard, J. Lien, S. Todd, P. Stevick and P. Hennebury.** Long-term Effects of Underwater Noise Associated with Industrial Activity on Cetaceans in Trinity Bay, Newfoundland.
- *1.13 **E. Hauksson and V. Bogason.** Occurrences of Harp Seal (*Phoca groenlandica*), Hooded Seal (*Cystophora cristata*), Bearded Seal (*Erignathus barbatus*) and Ringed Seal (*Phoca hispida*) in Coastal Waters of Iceland, in the Period 1989–1994.
- 1.14 **F. Marques, J. Lien, D. E. Sergeant and R. Seton.** Changes in Sightings, Strandings and Fishing Gear Entrapments of Arctic Species of Cetaceans in Newfoundland Waters: A response to Changes in Ice Conditions?
- *1.15 **S. E. Moore and D. P. DeMaster.** Cetacean Habitats in the Alaskan Arctic.

* Revised version in this publication.

¹ Symposium Paper Numbers.

Theme Session 2: Foraging Strategies and Energetic Considerations

Oral Presentations

- 2.1 **G. A. J. Worthy.** Approaches to the Quantification of the Energetic Requirements of Marine Mammal Populations and Their Impact on Marine Ecosystems.
- 2.2 **S. J. Iverson.** Principles of Fatty Acid Signature Analysis and its Use in Studying Foraging Ecology and Diets of Marine Mammals.
- *2.3 **S. Todd, P. Ostrom, J. Lien and J. Abrajano.** Use of the Stable Isotope Ratio $\delta^{13}\text{C}$ to Determine Diet in Humpback Whales (*Megaptera novaeangliae*).
- *2.4 **G. Víkingsson.** Feeding of Fin Whales Off Iceland: Diurnal Variation and Feeding Rates.
- *2.5 **H. J. Skaug, H. Gjøsæter, T. Haug, U. Lindstrøm and K. T. Nilssen.** Do Minke Whales, *Balaenoptera acutorostrata*, Exhibit Particular Prey Preferences?
- *2.6 **T. Haug, U. Lindstrøm, K. T. Nilssen and H. J. Skaug.** On the Variation in Size and Individual Composition of Minke Whale *Balaenoptera acutorostrata* Meals.

Poster Presentations

- *2.7 **G. Boyle.** An Operant Method of Investigating Prey Selection in Seals.
- *2.8 **S. Hassani, L. Antoine and V. Ridoux.** A Comparative Approach to the Diets of Dolphins, Tunas, Sharks and Other Large Oceanic Predators Sampled in the French Tuna Driftnet Fishery of the North-East Atlantic.
- 2.9 **T. Haug, U. Lindstrøm, K. T. Nilssen, I. Røttingen and H. J. Skaug.** Diet and Food Availability for Northeast Atlantic Minke Whale, *Balaenoptera acutorostrata*.
- *2.10 **E. Hauksson and V. Bogason.** Comparative Studies on Food and Feeding Habits of Grey Seals (*Halichoerus grypus*), Common Seals (*Phoca vitulina*), Harp Seals (*Phoca groenlandica*), and Hooded Seals (*Cystophora cristata*) in Coastal Waters of Iceland.
- 2.11 **J. W. Lawson and G. B. Stenson.** Diet of Newfoundland Harp Seals: Nearshore and Offshore Contrasts.
- 2.12 **J. Sigurjónsson, G. A. Víkingsson and S. D. Halldórsson.** Food and Feeding Habits of Harbour Porpoise (*Phocoena*) off the Southwestern Coast of Iceland.
- 2.13 **G. T. Waring and J. T. Finn.** Cetacean Trophic Interactions off the Northeast USA Inferred From Spatial and Temporal Co-distribution Patterns.

Theme Session 3: Marine Mammal – Fisheries Interactions

Oral Presentations

- 3.1 **D. S. Butterworth.** On Modelling Approaches for Evaluating Seal-Fishery Interactions: Initiatives in South Africa and for the Antarctic.
- 3.2 **J. H. M. David, J.-P. Roux and W. K. Oosthuizen.** Consumption and Diet of the Cape Fur Seal and Possible Competition With Fisheries in the Benguela Ecosystem.

* Revised version in this publication.

- 3.3 **E. Hauksson.** Age Selection of Cod (*Gadus morhua*) by Grey (*Halichoerus grypus*) and Common (*Phoca vitulina*) seals, in Icelandic Waters, and Possible Effects of the Predation on the Cod Recruitment.
- 3.4 **R. Mohn and W. D. Bowen.** Grey Seal Predation on Eastern Scotian Shelf Cod: Consumption, Predation Mortality, and Potential Impacts.
- * 3.5 **G. B. Stenson, M. O. Hammill and J. W. Lawson.** Predation of Atlantic Cod, Capelin and Arctic cod by Harp Seals in Atlantic Canada.
- 3.6 **A. Sinclair, R. A. Myers and J. Hutchings.** Seal Predation: Is There Evidence of Increased Mortality on Cod.
- 3.7 **M. Shima, A. B. Hollowed and G. R. Van Blaricom.** Comparing Pinniped-Fishery Interactions in Two Ecosystems.
- * 3.8 **R. D. Kenney, G. P. Scott, T. J. Thompson and H. E. Winn.** Estimates of Prey Consumption and Trophic Impacts of Cetaceans in the Northeast U.S. Continental Shelf Ecosystem.
- * 3.9 **A. W. Trites, D. Pauly and V. Christensen.** Competition Between Fisheries and Marine Mammals for Prey and Primary Production in the Pacific Ocean.
- * 3.10 **E. A. Crespo, S. N. Pedraza, S. L. Dans, M. K. Alonso, L. M. Reyes, N. A. Garcia, M. Coscarella, Y. Adri and C. M. Schiavini.** Direct and Indirect Effects of the High Seas Fisheries on the Marine Mammal Populations in the Northern and Central Patagonian Coast.
- 3.11 **M. Earle (J. Harwood).** Scientific Analysis of Proposals to Cull Marine Mammals for Purposes of Fisheries Management.
- 3.12 **J. Lien, C. Hood, D. Pitman, D. Borggaard and C. Richter.** Field Tests of Acoustic Devices on Groundfish Gillnets: Assessment of Effectiveness in Reducing Harbour Porpoise By-Catch.

Poster Presentations

- 3.13 **N. B. Barros and D. H. Adams.** Fishery Interactions with Apex Predators in the Indian River Lagoon System, Florida.
- 3.14 **R. A. Blaylock and L. J. Hansen.** The Effects of Commercial Fishing Activity on Coastal Bottlenose Dolphin Distribution Behavior, and Mortality Patterns.
- * 3.15 **A. S. Couperus.** Interactions Between Dutch Midwater Trawlers and Atlantic White-sided Dolphins (*Lagenorhynchus acutus*) Southwest of Ireland.
- * 3.16 **D. Fertl and S. Leatherwood.** A Review of Cetacean Interactions With Trawls.
- * 3.18 **M. O. Hammill, C. Lydersen, K. Kovacs and B. Sjare.** Fish Consumption by Hooded Seals in the Gulf of St. Lawrence.
- 3.19 **L. N. Measures.** Helminths of Beluga, *Delphinapterus leucas*.
- * 3.20 **D. Ólafsdóttir and E. Hauksson.** Anisakid (Nematoda) Infections in Icelandic Grey Seals (*Halichoerus grypus*).

* Revised version in this publication.

- 3.21 **C. Richter and H. Van Doninck.** A Comparison of Spatial and Temporal Surfacing Patterns in Harbour Porpoise Observed in the Wild and In Captivity.
- *3.22 **J. Sigurjónsson and G. Víkingsson.** Estimation of Food Consumption by Cetaceans in Icelandic and Adjacent Waters.
- 3.23 **S. S. Wallace and J. Conway.** Developing a System of Integrated Management for the Protection and Conservation of Endangered Marine Mammals.

Theme Session 4. Theoretical Considerations on the Role of Apex Predators and Multispecies Models

Oral Presentations

- 4.1 **J. Harwood and P. Rohani.** Assessing the Relationship Between Apex Predators and Fisheries: Where Do We Go From Here?
- *4.2 **P. A. Shelton, W. G. Warren and G. B. Stenson.** Quantifying Some of the Major Sources of Uncertainty Associated with Estimates of Harp Seal Prey Consumption.
- *4.3 **B. Bogstad, K. H. Hauge and Ø. Ulltang.** MULTSPEC – A Multispecies Model for Fish and Marine Mammals in the Barents Sea.
- *4.4 **R. L. Merrick.** Current and Historical Roles of Apex Predators in the Bering Sea Ecosystem.
- *4.5 **G. Stefánsson, J. Sigurjónsson and G. A. Víkingsson.** On Dynamic Interactions Between Some Fish Resources and Cetaceans off Iceland Based on a Simulation Model.

* Revised version in this publication.