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Exploration of the Sea

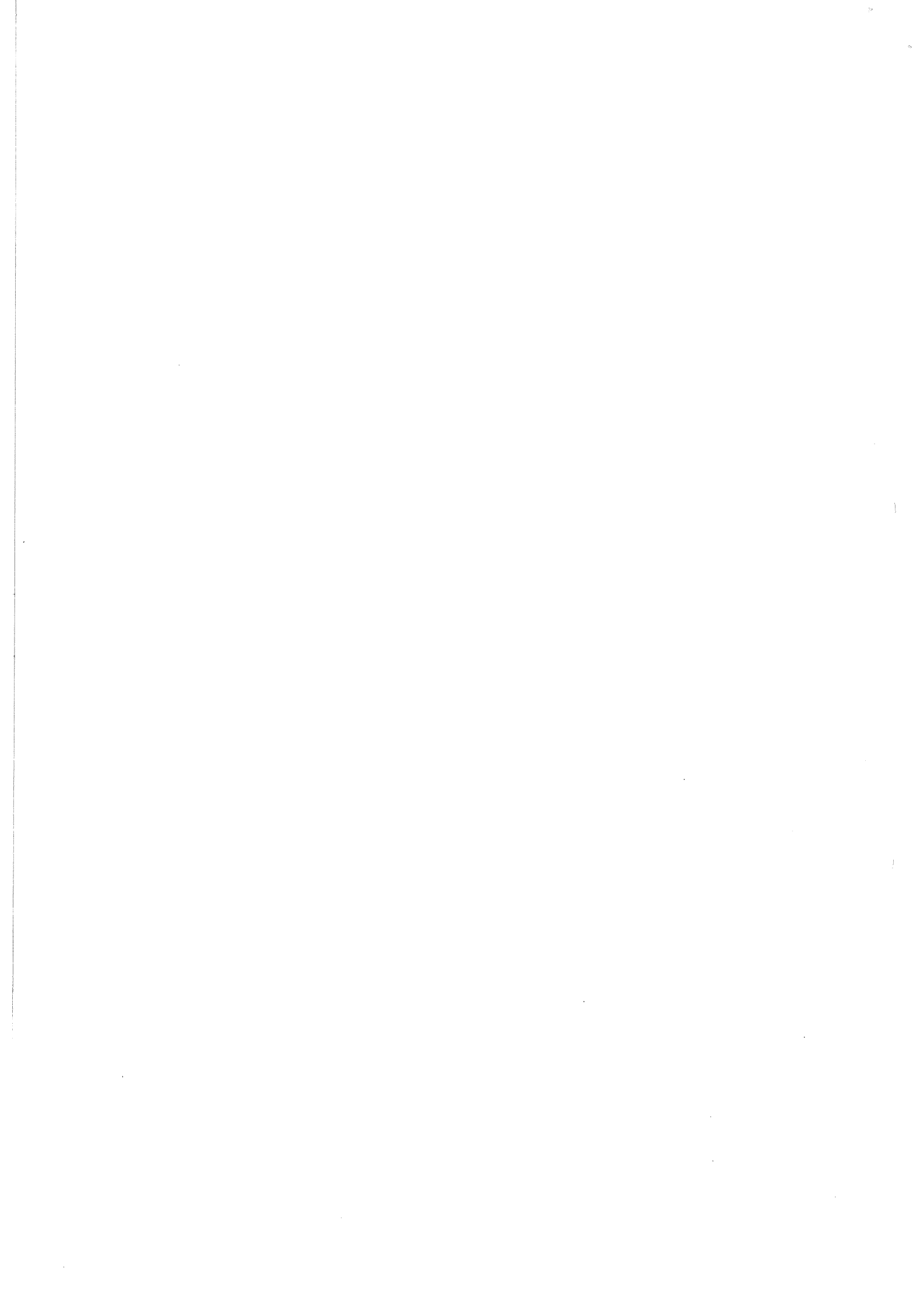
C.M.1992/N:3
Marine Mammals Committee

REPORT OF THE STUDY GROUP ON PILOT WHALES

Montreal, 3-4 December 1991

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Introduction

This study group, of which this was the first meeting, was established at the 1990 Statutory Meeting by virtue of Council Resolution (C. Res. 1990/2: 7), which reads in part: "A Study Group on Pilot Whales will be established . . . and will meet . . . to:

- "a) identify the information available for characterizing the status of pilot whales in the north Atlantic, with a view to establishing an understanding of the dynamics of this species;
- "b) advise on research necessary to further develop this understanding;
- "c) advise on whether a scientific dialogue with the International Whaling Commission is required;
- "d) report on the potential scientific possibilities of ICES providing advice on this species and how such advice could best be generated."

The meeting was called to order at 10 a.m. on Tuesday 3 December 1991. Those present at the meeting are listed in Appendix I. The meeting began with a review of the terms of reference and the background of the setting up of the Study group. This included reference to a request made to ICES by the *North Atlantic Committee for Cooperation on Research on Marine Mammals*, to the draft *Agreement on the Conservation of Small Cetaceans*, to the consideration given by the Council to these requests, and to the wording, by the Council and its Consultative Committee, of the terms of reference of the study group. The Study Group proceeded in plenary session.

The interpretation to be placed on the word "status" was discussed, and hence to the importance of defining the management objectives was noted. It was agreed that interpretation of status might well depend on the decisions to be made in a management context. The question of multispecies versus single-species approaches to assessment was discussed. It was pointed out that some nations might have a particularly strong interest in studying the effect of prey-species fisheries on whale populations as well as the effects of whale predation on commercially important fish stocks and their role in the ecosystem in general, and that multi-species as opposed to single-species approaches might be appropriate. As against that view, it was pointed out that single-species approaches are more often realisable with current states of knowledge. A three-level structure was thought useful for the present discussion: a "conventional" single-species approach; a development of that to include dependence on food stocks; and a multi-species approach in which the simultaneous and mutual effects of predator populations and the stocks of their prey might be considered in a more symmetrical fashion. The first of these might in some aspects now be possible, the second would be a necessary future development to make any model truly useful for decision-making; the third is longer-term, and would usefully involve interaction with the ICES Multi-Species Working Group. ICES is developing a strong background in

multispecies assessments, albeit primarily for fish stocks, while the IWC has typically used single-species approaches. The Study Group decided that it should target its analysis of the information available on pilot whales at the second of these levels: i.e. a single-species approach including the consideration of prey stocks as a contributing factor in determining stock status or limiting abundance.

The question of the time horizon of the relevance of data, analyses, and information was also considered. Although the evidence from life history information is that pilot whales are long-lived species, it was noted that a 1975 paper by M. C. Mercer showed strong variations in indices of pilot whale and squid abundance with periods of the order 10 years; hence the possible limitations on the usefulness of more remote historical data should be kept in mind.

a) Identify the information available for characterizing the status of pilot whales in the north Atlantic, with a view to establishing an understanding of the dynamics of this species.

In analysing the information available for characterizing the status of the pilot whale in the north Atlantic, the Study Group listed four principal questions, viz. what information is available:

- 1) on the stock structure of the species: i.e. what stocks can be defined, and what are their boundaries?
- 2) on the stock sizes: i.e. how many are there in each stock?
- 3) to detect, or measure, trends in abundance?
- 4) to assess changes in prey availability and (associated) changes in vital rates for each stock?

On the population size question, two possible bases for management actions were identified:

- comparison with some historic population size;
- assessment of current population trends;

The value of historical or retrospective estimation of "carrying capacity", or any similar concept, was regarded as in general doubtful, associated as it was with great difficulty in evaluating the effects of changes in ecosystem parameters.

The Study Group proceeded to more detailed examination of the data for answering these questions with brief presentations of working papers tabled by those attending (for full titles and abstracts where available, see Appendix II):

1. Nelson and Lien: Status of the long-finned pilot whale, *Globicephala melas*, in Canada.
2. Öien: Summary of available information from Norway on pilot whales.

3. Desportes: The international research programme on the ecology and status of the long-finned pilot whale off the Faroe Islands: presentation, results and references.
4. Heide-Jørgensen and Bunch: Occurrence and hunting of pilot whales in Greenland
5. Smith and others: Research on long-finned pilot whales in the northeastern U.S.A.
6. Buckland and others: Abundance and distribution of long-finned pilot whales in the north Atlantic, estimated from NASS-87 and NASS-89 data.
7. International Whaling Commission (various authors): Abstracts of papers submitted to Special Issue 14 (on pilot whales) of the Reports of the I.W.C.
8. Hoydal: Data on the long-finned pilot whale (*Globicephala melas*) in Faroe waters and an attempt to use a 280-year time series of landings to assess the state of the stock.

The study group then continued its work in answering item a) of its terms of reference, reviewing these papers in terms of the information they contained that would answer the four questions listed above.

Question 1. What are the stocks and where are they?

Working Paper 1. The authors referred to Sergeant's observation that the depletion of the Newfoundland stock did not appear to be associated with depletion or reduction of any index of any other stock; the working paper considered this some slight evidence for the separation of this stock from others.

Working Paper 2. The data presented in this working paper is not likely to yield much information on stock separation or stock boundaries. No analysis of these data with the objective of identifying pilot whale stock boundaries has been considered. The sightings of pilot whales were made incidentally to other activities, and may be of variable reliability. The distribution data for catches was rather different from the distribution data for sightings from the recent (1987 and 1989) North Atlantic Sightings Surveys, but this difference may be due to seasonal movements, as the catches were made later in the summer than the time when the sightings surveys were executed. Gaps in the catch distributions were not thought to reflect the distributions of different stocks.

Some information is available for areas west of Iceland from observers on whaling vessels, and may be particularly useful for indicating seasonal occurrence. Incidental information that has been gathered by fishing vessel observers in northern waters, where few pilot whales are seen, contribute to determining the northern limits of the distribution of the species (see Sigurjónsson and Gunlaugsson, 1990, Rep. I.W.C. 40: 537--551).

Working Paper 3. Information from the Faroese project has shown in general a degree of homogeneity within schools, with greater variation between schools. This is true of analysis of genetic material, of organochlorine pollutants, of heavy metals, and of parasite fauna. The heterogeneity observed between schools using electrophoretic markers could best be explained by the school structure rather than by a geographical or seasonal pattern. The schools probably consist of several matrilineages, as females within a school seem to be more related to each other than to females in other schools. The isozyme study also provided evidence for a gene flow, generated by mature males, between schools. DNA fingerprinting has shown close relationships within the schools and furthermore gives evidence of gene-flow between schools, paternity testing of foetuses having shown that they are seldom fathered by adult males that have remained within the same school. Analysis of females in this study revealed genetic distinction between schools, probably constituting part of a matrilineal system. There is no indication to date that more than one distinct population is represented in the Faroese harvest. The between-school variation in pollutant and helminth loads may indicate that the schools have fed on prey with different burdens, and this in turn may suggest that the population uses a wide geographic feeding area.

Some analyses have shown that the pilot whales of the Faroes are different from those from some other areas. In particular, morphometric analyses, based on length proportions (snout to eye : eye to anus : anus to tail-notch) appear to be different from whales taken in the Newfoundland drive fishery in the 1950s; and all these data sets were obtained by experienced field workers using standard methods. There are differences in pollutant levels and parasite fauna between pilot whales at Newfoundland and the Faroes; however, these samples were taken at different times.

Working Paper 4. Sightings of pilot whales in West Greenland waters are made in summer, on the edge of deep water (at about the 200-metre isobath) or in the deep channels between the fishing banks. A review of historical data on catches showed no clear indication that catches in West Greenland waters declined markedly after the collapse of the Newfoundland drive fishery.

Working Paper 5. Sightings data was obtained year-round under the Cetacean and Turtle Assessment Programme (CETAP) of aerial surveys in 1979--1981, and from a 1991 summer survey. For the CETAP surveys, the area was limited, but the information obtained was very detailed. The more recent survey extended further offshore. For both surveys, the data on numbers and distribution is good inshore, and at the southern part of the range of the pilot whale, but not further offshore or further north.

There is currently a continuing by-catch from the Atlantic mackerel fishery on the eastern US seaboard, and a tissue sampling programme, now in progress for that by-catch, will allow genetic and other comparisons with other collections.

Restriction enzyme analyses have been undertaken on DNA samples from the eastern USA to investigate stock structure, and further genetic studies are planned by

more sensitive methods, to further investigate genetic variation in the western North Atlantic.

In the eastern US programme of research, a satellite transmitter tag attached to a rehabilitated male pilot whale gave location data for three months, and showed a pattern of high mobility over a spatial range of several hundred kilometres in a short time period.

Working Paper 6. The North Atlantic sightings survey was not designed to investigate stock structure. However, distribution observations made in the course of these surveys, and incidental to other activities, may be relevant. In particular, it was observed that fewer pilot whale observations were made in the blocks at the western edge of the survey area. The sightings survey data also indicated different geographical patterns in the distribution of encounters between the two years (1987 and 1989) of the survey. This could imply that pilot whales are not confined to areas of the size of the survey blocks used: of the order of 300,000 sq. km; however, the Icelandic part of the 1989 survey, which contained the bulk of the 1989 sightings, was carried out later than in 1987 (viz. 10 July--14 August 1989, compared with 24 June--20 July 1987).

Working Paper 7. The abstracts of the papers submitted for the IWC Special Issue on Pilot Whales contained much information; however, a large part of what was most relevant to the question that we were discussing had been extracted by the authors of the other working papers, or had been identified in the discussion of them.

Concluding this discussion, the Study Group reviewed the information on the possible existence of separate stocks within the North Atlantic. Some lines of evidence seemed to support a difference between the eastern and the western North Atlantic. These were: morphometric analyses of length proportions; a lack of evidence of reduced numbers in the eastern north Atlantic at the time when the pilot whales disappeared from Newfoundland waters; differences in the parasite fauna between Newfoundland and the Faroes. It was agreed that this evidence was not convincing, but also that evidence to support a hypothesis that there was a single North Atlantic stock was poor or lacking. There was no evidence for any further discrimination between more than one stock on the east or on the west side of the North Atlantic. As a practical measure, to structure the discussion of stock sizes and trends, we used a working hypothesis of two stocks, with an undefined boundary between them.

Question 2. How big are the stocks?

Eastern North Atlantic

Working Paper 2. It was thought unlikely that either the Norwegian catch data, or the incidental sightings data, should be able to provide current quantitative estimates of the density or abundance of pilot whales in those areas.

Working Paper 6. The North Atlantic Sightings Surveys of 1987 and 1989 were intended to produce quantitative estimates of distribution and abundance of a number of whale species. Although pilot whale sightings were recorded, the surveys were not designed exclusively to estimate pilot whale density, and some aspects of their execution were not perfectly suited to the problem of estimating numbers of gregarious species. In particular, decisions on the use of passing or closing survey modes were not made in a standardised way. Another problem that arose was in the enumeration of "large loose groups"; but since such groups were few, the problem was not thought to be serious. Estimates of total numbers within the survey areas were 128,000 (error c.v. 0.295) for 1987 and 705,000 (error c.v. 0.282) in 1989. But the 1989 survey was not a close copy of the 1987 survey: it was done at a different time (mid-July to the end of August, whereas the 1987 survey went from mid-June to mid-August) and it covered an area that was larger than in 1987 and further south. If the two sets of results are compared by including only the blocks that were covered in both years, the estimates become 128,000 for 1987 and 261,000 for 1989. These are not significantly different.

In the search to identify other sources of information that might be relevant to the question of stock sizes, the Study Group discussed whether the sustained catch in the Faroese fishery could be combined with an estimate of sustainable catch rate for the species to generate a minimum estimate for the size of the standing stock from which the catch is being taken. We concluded that we did not have at the meeting good enough estimates of the vital parameters of the population to discuss this further, but that such information will probably be available in the future, from analysis of material already in hand.

Western North Atlantic.

Working Paper 1. The population in eastern Newfoundland waters may have numbered 50,000 to 60,000 in the 1940s; 54,000 whales were taken in a drive fishery between 1947 and 1971. The fishery apparently collapsed through over-exploitation of the stock, which appears not yet to have fully recovered. There is little recent data on the current size of stocks in Newfoundland waters. Estimates, made by various surveys using different methods and covering different areas, have varied between 4,000 and 13,000.

Working Paper 4. The information contained in the historical catch data or in the sightings data from West Greenland can not be used to generate estimates of density, species range, or stock size in that area.

Working Paper 5. Information on density and distribution is available from CETAP surveys flown year-round from 1979 to 1981. While these data are good, especially for seasonal variation in distribution in inshore waters, the survey was not extensive enough to generate a total stock estimate, as it did not go offshore beyond the shelf break into the deeper waters where pilot whales are found. However, within the area covered, viz. the continental shelf from C. Hatteras to Georges Bank, the total numbers were estimated at 10,000--12,000. Another aerial survey, flown in 1991, followed the CETAP protocols, but extended farther offshore. Pilot whales were seen to the limit of the survey area, indicating that the full range of the species was not surveyed. Another data set bearing on density and distribution in eastern U.S. waters arose from a survey carried out by observers on vessels undertaking research survey cruises for fish stock assessments. These data indicate seasonal variations in distribution, but have not been analysed to estimate abundance.

In summary, we concluded that while we have some data for some areas, the areas surveyed do not constitute the whole range for any stock, and thus we have inadequate information to estimate the total size of any stock.

Question 3. What are the trends in stock size?

Eastern North Atlantic.

Working Paper 2. The information available from past Norwegian catches and from incidental sightings will not allow estimates of current trends.

Working Paper 8. The Faroese drive fishery for pilot whales has for centuries been the subject of careful record-keeping. This long time-series of catch data was reviewed to see whether it would be possible to use it to generate estimates of current or longer-term trends in abundance. However, the year-to-year variation in actual catch is high, and this precludes using the series as a trend index in the short term. The overall stability of the long-term catch series appears to be consistent with the hypothesis that the stock from which the catch is being taken is capable of sustaining it, but a comprehensive modelling exercise would be necessary to further explore the hypothesis.

In discussion of other information sources on trends, we noted that strandings data would be unreliable because of unknown variation in the effort put into recording these events, even in densely-populated areas of north-western Europe. No general information was available to the meeting on incidental sightings, or on their possible usefulness, even when systematically recorded, as indicators of population trends.

Western North Atlantic.

Working Paper 1. Pilot whales become entrapped in fishing gear in Newfoundland coastal waters. These events are sometimes recorded. However, their occurrence was thought to be too much influenced by local shifts in distribution of whale pods following food-fish or squid to be reliable as an indicator of trends in stock abundance.

Working Paper 4. There was a significant decline in reported catches in West Greenland between 1921--39 and 1954--1990. However, the pilot whale is at the edge of its range in these waters, and there are reasons to suppose that observed changes in sea temperatures explain this decline.

Working Paper 5. The CETAP survey and the 1991 aerial survey used similar methods, and may provide an estimate of trend over a ten-year time interval for the area that they cover in common. This analysis has, however, not yet been carried out. The data arising from the observer programme on fish stock assessment cruises could perhaps generate trend information, but further analyses of the searching effort are required.

Question 4. Interactions with other species.

For characterising the status of the species in general, and in the north Atlantic in particular, we considered two components of information related to interactions of the pilot whale with other species: the condition of individuals in the population, and the condition of their food stocks.

Dynamic response variables have been suggested as useful tools for population management in a variety of contexts, and in the present case we considered indices such as:

- indices of individual condition such as blubber thickness, girth, or weight:length ratio;
- changes in population mean vital rates such as age at maturity;

While good recent information on these parameters is available for some areas, we concluded that further research is necessary to determine how to use them in an assessment context.

The abundance or sufficiency of food stocks was discussed as a possible index of stock status. This information could be used in assessments if available, but the problems identified were first that the diet, and especially food preferences, are not completely known in all areas. Secondly, since pilot whales feed mostly on commercially non-valuable species, data on the abundance or distribution of the prey stocks are scarce. Raw data on bycatch of non-commercial species in research survey cruises for commercially valuable fishes exists in

some cases, but is hard to access. There is in general little information on the sizes, distribution or movements of stocks of prey species beyond the continental shelves.

b) Advise on research necessary to further develop this understanding.

We considered necessary research in three main areas:

1. - stock separation and structure;
2. - sizes of and trends in stocks;
3. - population dynamics, stock status and condition, interactions with other species

1. Stock separation, stock boundaries, movements and migrations.

Three main possible research lines were mentioned: they were genetic analyses, tagging, and pollutant loads. Other less important research areas were analyses of numbers, such as cross-correlations of time series of abundance indices in separated areas.

The principal sample collections now available are those from the Faroes, and those from eastern USA, and much work can be done to compare those collections with each other. To complete a North-Atlantic-wide understanding of the population structure of the species, additional sampling of animals at sea would be necessary, and in this connection, the possibility of biopsy sampling as a component of future sightings surveys was recommended for examination.

The further analysis of genetic material available from the international research project at the Faroes, and from comparable samples from the by-catch and strandings sampling programme on the eastern US was emphasised as a research priority, especially using mitochondrial DNA techniques and isozyme analysis, which can potentially identify stocks. It was seen as a necessary and highly important step to complete the analysis of genetic material from the Faroes and to review the implications of the school structure information it contains, in order to be able to design efficient programmes for other sampling opportunities such as mass strandings or by-catches.

Recommended research: Complete the genetic analyses of the Faroese material, including mitochondrial DNA. Analyse the resulting information on school structure and relatedness, and use these results to design optimal schemes for sampling from other groups.

Data on the movements, behaviour, and associations of individual animals can be used to infer separation or identity of stocks. Data on movements can, especially, be gained from recovery tagging or marking, and from the tracking of active (radio) tags. Satellite radio tags, in particular, can provide data on movements and on home range. Development of long lived tags, both active and passive, is a research priority.

Recommended research: development of long-lived radio and recovery tags for use in conjunction with future sightings surveys or strandings rehabilitation.

The association of the ratios of the stable isotopes of carbon with latitude of residence in marine animals was mentioned as possibly being applicable to the question of the north-to-south continuity of pilot whale populations of West Greenland and eastern north America.

2. Numbers and trend indices.

Three major gaps in the data were emphasised. The first was the lack of data from NASS-87 and NASS-89 sightings surveys south and west of southern Greenland toward the American east coast.

Recommended research: Conduct sightings surveys between the NASS-87 and NASS-89 Iceland effort and the eastern coast of north America, using designs and methods comparable with these earlier surveys.

The second was data to the south of the southern limit of the Spanish cruise in both the North Atlantic Sightings Surveys. Since pilot whales were seen to the southern limit of the cruise, there is an implication that the full range of the species was not covered.

The third was development of the survey methods, including use of radio-tagging and other behavioural research methods to study diving behaviour and develop corrections for it, and aerial surveillance to correct observer estimates of school size & spatial structure.

3. Population dynamics, stock status and condition, and interaction with other species.

The priority activity in this area was seen as completing the analysis of the intensive collections from the Faroes, and to clarify and complete the description of the reproduction biology. This was expected to have a strong bearing on the design and interpretation of future monitoring programmes.

Recommended Research: Complete the analysis of the existing samples from the Faroese studies, and describe the reproductive biology of the species. Use as initial input to a description of the dynamics of the species.

In wild animal population dynamics research, the estimation of survival rates is usually a problem. The Faroese collection of whole schools of pilot whales may, however, offer an unusual opportunity for the estimation of this and other life history parameters. It was emphasized as a research priority to subject these data to the most thorough examination, in order to find out to what extent these expectations are, in fact, satisfied.

The development of robust analytic methods of estimating vital rates that will account for the dynamics of pods--viz. the processes by which pods may come into existence, grow, be extinguished, or combine with others--will be necessary.

Recommended Research: Thorough analysis of the age structure and life history data from the Faroese whole-school collections for estimation of life history parameters, and consequent recommendations for sampling strategies in other situations offering similar opportunities.

We had difficulty in arriving at concrete suggestions for research in the area of food habits, dietary preferences, the sufficiency of food stocks, and the effect of food stocks on population dynamics. However, comparative studies of the diets of whales in different areas, and the relation of the results to prey availability were recommended.

A research project under way in the eastern US is studying stable isotope ratios, to identify at what trophic level pilot whales feed.

Items c) and d) were taken in reverse order. For considering them, a further working paper was tabled:

9. Horwood: ICES and the pilot whales.

d) Report on the potential scientific possibilities of ICES providing advice on this species, and how such advice could be generated.

There is enough information to permit an assessment to be seriously attempted in the near future given adequate analysis and consideration of material now in hand; but more field work may be needed before an assessment would be agreed. The conduct of such an assessment would be dependent on the presence of certain critical scientific expertise.

ICES is actively developing the methodology for multispecies assessments, including both technical and biological interactions, and we see that as an advantage in dealing with pilot whale issues.

There is within ICES member states scientific expertise to adequately address most aspects of whale stock assessment at the technical level. However, any assessment would have to be reviewed and interpreted to develop advice, and within ICES, this is normally done by ACFM. The study group felt that assessment methods, and the type of advice generated, differ between fish and cetaceans. Therefore, the Council may consider it necessary for ACFM to acquire a wider range of expertise in their review of pilot whale assessments.

c) Advise on whether a scientific dialogue with the International Whaling Commission is required.

A scientific dialogue, while perhaps not absolutely required, is nevertheless highly desirable. It would ensure at a formal level the exchange of scientific information and of information on assessment methods, and would permit ICES to have access to whale stock assessment expertise from outside ICES. We did not recommend a structure for such a dialogue, because it would depend on the structure adopted within ICES for developing assessments.

This concluded our discussion of the terms of reference. The Study Group made no recommendations as to further meetings. The meeting was adjourned at 9:30 pm on 4 December.

Appendix I Those present

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Appendix II: Working Papers tabled at the meeting.

Note: some of these documents are preprints of articles prepared for purposes other than, although related to, the ends of the Study Group; others represent work in progress or contain findings or conclusions that have yet to be reviewed and confirmed. As is usual, no reference should be made to working papers without the author's permission.

1. Nelson, D. and J. Lien. Status of the long-finned pilot whale, *Globicephala melas*, in Canada.

Abstract: The long-finned pilot whale, *Globicephala melas*, is a mainly pelagic species widely distributed in the cold temperate waters of the North Atlantic and the Southern Hemisphere. It regularly migrates in summer to Canadian inshore waters in pursuit of squid species. Drive fisheries from 1947 to 1971 seriously depleted numbers of *G. melas*. Mass strandings represent a major known source of mortality for this species, while the effects of incidental entrapments, pollutants, and fisheries for prey species remain relatively unknown, and have the potential for limiting this species. *G. melas* is a regular subject in studies utilizing satellite tracking and DNA fingerprinting, as well as in the study of mass strandings. Such studies hold promise for expanding the knowledge of small cetaceans. There are no reliable recent population estimates for *G. melas* but even optimistic recovery forecasts from drive fisheries in Newfoundland would produce a present population substantially lower than pre-whaling numbers. Given this, along with incomplete documentation of sub-populations and lack of knowledge of limiting factors, this species should be considered vulnerable in Canadian water.

2. Öien, Nils. Summary of available information from Norway on pilot whales.
3. Desportes, Genevieve. The international research programme on the ecology and status of the long-finned pilot whale off the Faroe Islands: presentation, results and references.

Abstract: The ecology and status of the long-finned pilot whale, *Globicephala melaena*, harvested in the Faroese drive fishery have been the object of an international research programme initiated in July 1986 under the auspices of the United Nations Environmental Programme (UNEP), the International Whaling Commission and the Faroese Governments.

The intensive year-round sampling period of two years, July 1986--July 1988, led to an important collection of biological sample taken from 3470 whales belonging to 40 schools. The analysis of the data provides information on age-related factors, reproductive parameters, energetics, feeding ecology, breeding behaviour and social structure, relationships between schools and stock identity, parasite infestation and pollutant loads.

This working paper gives a short presentation of this research programme and the institutes involved. It also summarizes the main results obtained to date and lists all relevant references.

4. Heide-Jørgensen, M. P. and C. Bunch. Occurrence and hunting of pilot whales in Greenland.

Abstract: We extracted information on pilot whales, *Globicephala melaena*, in Greenlandic waters from published and unpublished sources. Pilot whales are observed almost annually in Greenlandic waters and the reported observations are concentrated in the deep-water areas off the west coast of Greenland south of Disko Island. Only few observations are from East Greenland. Pilot whales have been seen in groups size with up to a thousand individuals, but the usual group sizes range between 8--50. Catches declined between 1921---39 and 1954--1990. This probably related to a decline in abundance of whales which again most likely is related to the simultaneous decline in sea temperature. A minimum of 2465 have been killed and landed since 1921, but official reported catches underestimate the actual kill to an unknown extent, because whales struck but lost are usually not reported and presumably some whales caught after 1970 have not been reported either. Most of the pilot whales (82%) were caught along the coast between Sisimiut and Paamiut. In the period 1975--79, 85% of the pilot whales were caught during August to October, while 76% of the sighting were from July through August.

5. Smith, T. D., S. Brault, J. Nicolas, G. Waring, and A. Abend. Research on long-finned pilot whales in the northeastern U.S.A.
6. Buckland, S. T., K. L. Cattanch, Th. Gunnlaugsson and J. Sigurjónsson. Abundance and distribution of long-finned pilot whales in the north Atlantic, estimated from NASS-87 and NASS-89 data.

Abstract. During June-August 1987 and 1989 large scale transect surveys were conducted throughout the North Atlantic by several national agencies in Denmark (off Greenland), Faroe Islands, Iceland, Norway and Spain (North Atlantic Sightings Surveys, NASS-87 and NASS-89). The paper gives an analysis of pilot whale (*Globicephala melas*) survey data collected by three Icelandic and one Faroese survey vessel in 1987, and four Icelandic, one Faroese and one Spanish vessel in 1989. Norwegian survey vessels operated north and east of this area in both years, but only five groups (three primary sightings) were observed in 1989 and none in 1987. Furthermore, no sightings were made in the area north and northeast of Iceland, thus indicating that the joint surveys covered the northernmost area of pilot whale distribution east of 42°W, while the area farther to the west was not covered in either survey. The coastal European waters between 40°--52°N were covered by the Spanish vessel in 1987, but not in 1989. In 1989 sightings were made at the southernmost boundaries of the survey area.

The present data were examined with respect to several potential stratification factors, i.e. by geographic block, Beaufort, vessel and school size, but sample size precluded stratification by all these factors simultaneously. The encounter rate by geographical blocks was found to be lower in the 1987 survey than in 1989, but the difference was not statistically significant. The total estimate for the 1989 survey, covering a wider area and further to the south than in 1987, was 705,000 (cv=0.282). This is regarded as the best available estimate for the total stock of long-finned pilot whales in the North Atlantic Ocean, notwithstanding the lack of information in the western and southernmost areas of its distribution.

The paper discusses potential biases and specific problems with respect to pilot whale abundance estimation from sighting data.

7. [Collected abstracts of papers submitted to the International Whaling Commission, after the 1989 meeting of the Scientific Committee, for consideration for inclusion in a proposed Special Issue (#14) of the Reports of the I.W.C., on pilot whales. The full texts of these submissions were made available to the meeting, by the IWC, for reference.]
8. Hoydal, K. Data on the long-finned pilot whale (*Globicephala melas*) in Faroe waters and an attempt to use a 280-year time series of landings to assess the state of the stock.
9. Horwood, J. ICES and the pilot whales. (with foreword by D. J. Garrod.)

Appendix III: Report of Discussions on Research Collaboration, Woods Hole, December 11-13, 1991

Between December 11th and 13th, Toshio Kasuya (Japan), and Dorete Bloch, Genevieve Desportes and Liselotte W. Andersen (Faroe Islands) visited the Northeast Fisheries Science Center in Woods Hole, Mass., USA. A series of meetings were convened with two general aims: to encourage discussion of international cooperative projects in view of the recommended research discussed during the ICES study group, and to promote communication among different research institutions in the area working on pilot whales. A brief description of these meetings is presented below with the list of participants, followed by a description of the projects agreed upon by various participants.

OVERVIEW OF MEETINGS

December 11:

A.M. Research coordination meeting with the Marine Mammal Investigation staff at Northwest Fisheries Science Center (Drs. S.Brault & T. Smith, convenors):

- (1) Presentation of research activities and objectives by guests and NEFC staff.
- (2) Preparation of a preliminary agenda for coordinated projects on North

Atlantic pilot whales, including:

- East-west comparison of morphometry, through use of information from fisheries by-catch;
- Comparative study of life history and population dynamics of short-finned (Pacific) and long-finned (Atlantic) pilot whales.
- East-west comparison of stable isotope ratios of nitrogen and carbon and heavy metal loads, both in individual whales and in prey species.

P.M. Research coordination meeting with the Woods Hole Oceanographic Institution (Dr. P. Tyack, convenor):

- (1) Presentation of research on pilot whales at WHOI:

- Vocalization and behaviour (Peter Tyack)
- Mitochondrial DNA and stock differentiation (Liese Siemann)
- Chemical toxicology (Michael Moore, Mark Hahn)

- (2) Discussion of possible joint projects on pilot whale stock differentiation, using mitochondrial DNA, and biochemical studies of trace organic compounds and metals, and of the biological significance of these chemicals.

December 12:

Discussion group on sampling of pilot whale mass strandings and research projects using these samples, at the Cape Cod Museum of Natural History, Brewster, MA. (Dr. T. Smith, convenor):

(1) Presentation of sampling methodology and sample use from stranded pilot whales, by Greg Early, New England Aquarium.

(2) Presentation of aims of research of the Center for Coastal Studies, by David Mattila. This group is focusing on events that lead to strandings and conditions favourable for the successful return of stranded animals to sea.

(3) Discussion of the existing structure of the stranding network system, with emphasis on the appropriateness of projects using this system.

(4) Discussion of possible collaborations and suggestions for improvement of sample collection, such as:

- Sampling from live animals;
- Use of drive technology and know-how of the Faroese in returning stranding animals to sea;
- Laboratory examinations of ovaries and use of histology for maturity evaluations;
- Use of samples from dead animals for genetic studies;
- Need of an improved data base system for archiving tissue samples.

LIST OF PARTICIPANTS

Alan Abend	University of Massachusetts, Amherst
Liselotte W. Andersen	University of the Faroe Islands
Dorete Bloch Genevieve Desportes	Museum of Natural History, Faroe Islands
Hal Caswell	Woods Hole Oceanographic Institution
Greg Early	New England Aquarium, Boston
Toshio Kasuya	Far Seas Research Lab, Japan
David Mattila	Center for Coastal Studies, Provincetown, MA
Tim Smith Kathryn Bisack Solange Brault John Nicolas Gordon Waring	Northeast Fisheries Science Center, Woods Hole, MA

Peter Tyack
Mark Hahn
Michael Moore
Liese Siemann
Bill Watkins

Woods Hole Oceanographic Institution

Fred Wenzel
Plymouth Marine Mammal Research Center, Plymouth, MA

COOPERATIVE RESEARCH PROJECTS

The projects agreed upon at these meetings are on the biology of pilot whales (rather than management); three pertain to the genetic structure of the North Atlantic population(s), one relates the life history to the population dynamics, and three others attempt to use various characteristics of individual whales as markers of the habitats they use. A number of projects also discussed did not lead to immediate collaborations, but may be the subjects of future research projects.

1. Stock structure identification using isozymes (Liselotte W. Andersen)

The genetic population structure of *G. melas* will be compared between the eastern and western North Atlantic by means of electrophoretic markers for a possible stock structure identification, using tissue samples from both regions.

Status:

- Eastern North Atlantic: 31 schools (1948 individuals) have been analysed from the eastern stock off the Faroe Islands. Three polymorphic enzymes were found, 2 in muscle and 1 in liver.
- Western North Atlantic: 22 muscle and 11 liver samples have been obtained from NEFSC during the Woods Hole meeting, and are presently being analysed.
- Samples from stranded animals on Cape Cod, Mass., from NEA: Tissue samples from the December 24th 1991 stranding (30 animals) were taken specifically for this isozyme study by staff of the New England Aquarium.
- Proposal for analysis of some samples from past strandings and continued sampling from future strandings with NEA is in preparation.

2. Mitochondrial DNA sequence variation in North Atlantic long-finned pilot whale (Liese A. Siemann)

Sequence variation in the mitochondrial D-loop and cytochrome-b gene will be examined to determine if there is significant variability in the western North Atlantic pilot whale population. If evidence of mtDNA sequence variation within schools of pilot whales is found using samples of stranded and by-caught animals, further analysis of school structure will be conducted using techniques which examine nuclear DNA. However, if no evidence

of mtDNA variation is found, samples will be obtained from one school of pilot whales taken in the Faroe Islands. These samples will be used to evaluate the genetic variation between eastern and western stocks of the North Atlantic pilot whale.

Status:

- Samples from previous strandings on Cape Cod have been analyzed by R. Honeycutt (Texas A&M), through a collaboration with NEA.
- Samples have been obtained by L.A. Siemann from NEA and NEFSC, and include single whales and groups of whales (2-30 animals) which stranded or were incidentally caught in the foreign mackerel trawl fishery. Initial analysis of these samples should be completed in the spring of 1992.

3. East-west comparison of mitochondrial DNA sequence in pilot whales and harbour porpoises (Liselotte W. Andersen)

The genetic analyses of the long-finned pilot whales will build on the results from studies 1 and 2 above. MtDNA variation will be analysed within and between different schools off the Faroe Islands, and among schools from the Western Atlantic. Eastern North Atlantic harbour porpoise will similarly be analysed for genetic variability using mtDNA techniques.

Status:

- Faroese material of pilot whales has already been collected.
- Harbour porpoise samples have been obtained from Denmark, Greenland, the U.K., Norway and U.S.A., and requested from Canada.
- An application for post-doctoral funding from Denmark will be submitted in the spring of 1992, to work at a North American or European institution appropriate for this type of genetic study.

4. Life history characteristics and population dynamics of short-finned and long-finned pilot whales. (Solange Brault, Genevieve Desportes, Toshio Kasuya, Dorete Bloch, Greg Early)

Comparisons among and between species in life history and population dynamics will be conducted in three main steps:

A - Comparison of existing life-history data on short-finned pilot whales from Japan and long-finned pilot whales from the Faroe Islands and Newfoundland. Emphasis will be given on reproductive parameters and reproductive strategies and particularly to parameters such as: age at first pregnancy, length of lactation/suckling, age-related decrease in ovulation and pregnancy rates, seasonal timing of events, individual reproductive history. The two species will be compared, using models that will incorporate life history parameters, including reproductive parameters, age-related parameters, and survivorship. This will be

accomplished through: (1) Correspondence/meeting between Japanese and Faroese scientists to compare methodology and results and identify the best parameters to be used in comparative analysis, and (2) Histological reexamination of Faroese female reproductive samples in order to assess more accurately questions on non-reproductive and post reproductive stages, and within and between schools variations in individual reproductive history.

B - Use of existing data on both species (from Japan and the Faroe Islands) to construct models that incorporate school structure in the investigation of the dynamics of the population. These models will be analysed in terms of the role of life history parameters (fecundity and especially estimation of natural mortality) on the population rate of increase. The effects of different harvesting practices (whole pods, partial pods and selected individuals in drive exploitation, and single individuals in fisheries by-catch), and of harvesting levels, on the dynamics will be evaluated theoretically. The NEA is also envisaging an analysis of strandings occurrence relative to population density, after the model proposed by Sergeant (1982).

C - Obtaining life-history data of long-finned pilot whales in the Western Atlantic and short-finned pilot whales in the Eastern Pacific, by analysis of biological material already collected in mass strandings and fisheries by-catch. These samples will by no means be as complete as the Faroese or Japanese ones, and will not lead to complete life history information. They will however allow one to see whether the life history patterns appear to coincide, especially in terms of age at maturity, onset of senility, and seasonality of reproductive events. Mass strandings may also provide comparative data on school structure.

D - The New England Aquarium has done tooth age analysis of several whole stranded schools after the method of Sergeant (1962). Funding will be sought to examine the most recent groups with the same method and re-examine teeth after the method of Kasuya (1988) and compile and publish the data. NEA is currently equipped for both methods.

E - Examine the feasibility of establishing a specimen/research clearing house, to provide samples obtained through strandings for ongoing projects. NEA will seek funding to assess the use of existing samples from prior stranded groups of whales.

Status:

- Life history data on individuals from both species from Faroese and Japanese researchers have been collated in a comparable form, and compatible with the construction of a population model.

- Re-examination of the Faroese samples related to maturity information will begin in Spring 1992.

5. Study of stock identity based on morphological parameters. (Dorete Bloch)

From materials from the drive fisheries in Newfoundland and the Faroe Islands, preliminary results from morphological comparisons indicate that long-finned pilot whales off Newfoundland differ significantly from those off the Faroes. Northwest Atlantic pilot whales seem to have longer skulls and shorter torsoes than Northeast Atlantic ones, and the flipper lengths are longer in Newfoundland males than in the Faroes.

Material obtained from mass-strandings from French and Icelandic scientists indicate that the Eastern Atlantic samples are more closely related than they are to the Newfoundland animals.

Further material is available from mass strandings and fishery by-catch from Spain, Newfoundland, and from the east coast of USA. This will allow a detailed comparison of the external morphometry of the long-finned pilot whale from both sides of the North Atlantic. Morphometric differences between regions could be compared taking in consideration current, surface temperature and topographic conditions.

Status:

- Data have been obtained from France (A. Collet), Iceland (J. Sigurjónsson), Spain (A. Aguilar and A.J. Raga), and the Faroe Islands in the eastern Atlantic, and from Newfoundland (D.E. Sergeant) and the U.S.A. (T. Smith and G. Early) in the western Atlantic.
- Preliminary analysis of Faroese data is completed;
- Statistical comparison of all samples will begin in the spring 1992.

6. East-West comparison of heavy metal loads in Atlantic long-finned pilot whales (Florence Jean-Caurant)

Differences in pollutant loads between cetacean species, and within species from different areas, identify pollutants as potential markers of movement history which may be used to corroborate hypotheses on stock identity. Heavy metal examinations have been carried out on pilot whales off the Faroe Islands, analysed at the Center for Titration of Trace Elements, University of Pharmacy of Nantes, France using Atomic Absorption Spectrophotometry. They show especially that cadmium concentrations in these whales vary between schools, and are much higher than those observed in any other cetacean species in the North Atlantic.

A comparison of heavy metal loads, especially cadmium, between pilot whales from the Northeast and Northwest Atlantic will provide data on the movement history of the different groups which could then be used in the determination of stock identity. This should be completed by the analysis of the most informative heavy metals in the main prey species of pilot whales in both areas.

Status:

- This same laboratory in Nantes is now undertaking the analysis of 20 pilot whale samples from the Northwest Atlantic fisheries by-catch sent by the Northeast Fisheries Center, which are to be compared with the Faroese results;
- Other samples may be requested depending on results obtained.

7. Distribution and trophic ecology of pilot whales studied with stable isotope tracers. (Tim Smith, Alan Abend, Genevieve Desportes, Jack Finn, Dorete Bloch)

The population distribution and trophic ecology of pilot whales in the North Atlantic will be analysed by combining data on spatial distribution from sighting surveys, historical observations and satellite environmental monitoring, with stable isotope ratios and whale stomach samples. Distributional data is available from CeTAP and NEFSC surveys, NASS-87,89 and historic fishing activities. Samples from pilot whales and prey species will be collected from strandings, fisheries by-catch, collaborating researchers and tissue banks in the United States and internationally.

The trophic ecology of pilot whales is being studied by measuring levels of stable isotopes of carbon and nitrogen in various tissues. Tissues collected from pilot whale strandings and fishery by-catch in the western North Atlantic have been used. Preliminary results of studies done in collaboration between the University of Massachusetts at Amherst, the New England Aquarium in Boston, and the Marine Biological Laboratory and NMFSC in Woods Hole suggest that there is little variation in isotope ratios between individuals from the same pod and that the values differ among different types of tissues as would be predicted from studies of turnover rates of trace elements in other species.

Status:

- Analysis of ratios of 5 tissue types from on 3 whales from one school from the Western Atlantic has been completed;
- Additional analysis of Western Atlantic samples is under way to measure between school variability (formal collaboration with the NEA presently under review);
- Suitable pilot whale samples from the Faroe Islands catches have been identified, and a specific statistical design to test for differences between eastern and western Atlantic animals will be developed in February 1992;
- Examination of pilot whale stomachs has been carried out in the Faroes. In cooperation with the Faroese Fisheries Laboratory, further analysis will be done in relation to local resources to obtain information on food selection and preferences.
- Data from sighting surveys and sources from the western and eastern Atlantic are being assembled into a single database;
- A design for analysis of prey species from different areas of the North Atlantic is under development.