

# *The international research program on the ecology and status of the Long-Finned Pilot Whale off the Faroe Islands.*

Presentation, Results and Reference.

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## **Introduction**

Long-finned pilot whales have been used for human consumption by Faroe Islanders since the earliest settlement of the islands (Dahl, 1971). The deliberate driving of whales has always been conducted on an opportunistic basis, traditional hunting methods are still in use and the meat and blubber are shared free among local inhabitants for local human consumption. No factory processing nor exportation occur. Since 1584, from when regular records of catches exist, the official number of animals taken annually ranges from 0 to 4,447 (in 1941), following a long term cycle of approximately 120 years (Joensen and Zachariassen, 1982; 1987; Hoydal, 1986). The catch statistics are unbroken from 1709 and in the period 1709-1992 a total of 1,683 schools representing 239,149 pilot whales were caught. In this period three years saw catches of more than 3,000 (1843, 1939, 1941), 25 years saw catches of more than 2,000 whales and there were 44 years with-

out any catches at all. In the nineteen-eighties, an average of 2,063 pilot whales were landed annually, with a range from 1,258 to 2,973 whales. See Bloch, Desportes, Hoydal and Jean (1990a) and Sanderson (1991) for details and references related to the fishery. The entire catch statistics, including all available details, are kept at the Faroese Museum of Natural History in Tórshavn.

To date there are no management policies and drives take place as long as there is a need. This whaling has been treated in various ethnological and biological reports (see Bloch *et al.* 1990a for references) but no comprehensive study of the harvested population and the impact of the fishery had been undertaken before the International Research Programme was initiated in 1986.

This international programme was set up to gather the essential information for an understanding of the social and ecological dynamics of the exploited population(s),

and to provide the biological basis for a management programme (Desportes, 1990). In Faroese pilot whaling, entire schools are normally driven ashore to be dispatched, regardless of animal size or sex. The hunting is, then, completely non-selective, and the observed compositions of schools are that of natural groups of whales. The year-round Faroese fishery provides a unique opportunity to obtain biological data on the targeted species, as whole schools of pilot whales are available for sampling, containing animals of both sexes and representing the entire range of age groups and sexual stages. As well, because of its specific characteristics, this fishery also offers a rare chance to gather information on social structure and the mating system.

This paper gives a brief presentation of the international research programme and the institutes involved. It summarizes the most important results, conclusions and hypothesis put forward by the different participants to date. The results are presented to give emphasis on variations between schools and between the Faroes and other geographical areas. Work currently being done and future studies are also mentioned. Relevant references resulting from this programme are listed after each particular section, and these include publications, documents presented to the IWC Scientific Committee, papers currently being reviewed, and works in preparation (references to which may be subject to change). General references for the paper as a whole are located at the end.

Earlier versions of this manuscript have

been presented at a meeting of the ICES Study Group on pilot whales in Montreal in December 1991 (Desportes, 1991) and at a meeting of the North Atlantic Marine Mammal Commission (NAMMCO) in Nuuk in April 1992 (Desportes, 1992).

### **The international pilot whale research programme**

The international research programme was initiated under the auspices of the United Nations Environmental Programme (UNEP) and the International Whaling Commission (IWC). The Faroese Government welcomed and supported the project by financing most of the expenses related to the sampling of the Faroese fishery. This included travel of foreign scientists, personal assistance, accommodation for the foreign participants, all local expenses and materials, support of the year round sampling, and, of course, specific Faroese investigations.

The Faroese pilot whale research programme had two aspects, the above-mentioned land-based project, and Faroese participation in the North Atlantic Sightings Surveys in 1987 and 1989 (NASS), a cooperative programme by North Atlantic nations (Faroe Islands, Greenland, Iceland, Norway, Spain) to assess the distribution and abundance of cetaceans in the North East Atlantic.

The leader of the project was D. Bloch (Faroese Museum of Natural History). Dr. C. Lockyer (Sea Mammal Research Unit, Cambridge, UK) was scientific adviser, Dr. G. Desportes (Faroese Museum of Natural

History) coordinated the field work while R. Mouritsen (Department of Fisheries, Faroese Government) was responsible for all technical aspects of the sampling. K. Hoydal, Director of the Fisheries Department of the Faroese Government, was responsible for the project and its funding on the governmental level. From the outset, ten main institutes from six countries were involved in the programme, and limited sets of samples were collected for other laboratories in different countries. The 10 institutes involved were:

**Faroese Museum of Natural History, Tórshavn, Faroe Islands.**

- Age determination and age-related parameters.
- Morphological characters.
- Population estimate.
- Stock identity.
- Reproductive parameters and reproductive rates, sexual cycles.
- Social structure.
- Feeding ecology.

**Department of Fisheries, Faroese Government, Tórshavn, Faroe Islands.**

- Long-term analysis of catch series.

**Institute of Natural Science, University of the Faroe Islands and Institute of Ecology and Genetics, University of Aarhus, Denmark.**

- Genetic variability.
- Stock identity and population structure.
- Karyological analysis.
- Long-term analysis of catch series.

**Center for Titration of Trace Elements, University of Pharmacy, Nantes, France.**

- Heavy metal contamination and mother-offspring transfer.
- Transfer through the food chain.
- Biochemical and physiological aspects of the contamination.

**Center for Biological Studies on Wild Animals (CEBAS), National Center for Scientific Research (CNRS), France.**

- Cyclical changes in sexual activity by means of hormonal titration.

**Sea Mammal Research Unit (SMRU), British Antarctic Survey - Cambridge, England.**

- Assessment of body condition, bioenergetics, growth.
- Experimentation on age determination.
- Mortality and survivorship.
- Reproductive rates.
- Distribution of pilot whales by satellite telemetry tagging for longterm tracking of individuals.

**Department of Genetics - Cambridge University, England.**

- Paternity and mating systems.

**Department of Animal Biology and Parasitology, University of Valencia, Spain.**

- Parasite fauna composition.
- Age-related evolution of various infestations.
- Parasitic pathologies.

**Department of Animal Biology, University of Barcelona, Spain.**

Organochlorine contamination.  
Variation pattern according to biological parameters.

**Marine Research Institute (MRI) - Reykjavík, Iceland.**

Distribution and abundance of pilot whales in the North East Atlantic.

More recently, a new institute joined the project:

**Northeast Fisheries Center, NOAA, NMFS - Woods Hole, USA.**

Use of age-structured and individual-based population models to estimate the effect of mortality due to harvesting.

The intensive sampling period was initiated in July 1986 and lasted for two years. The scientists and the staff of the Faroese Natural History Museum kept it going continuously during this period, assisted mostly during the summer by some of the other biologists involved. In this two year-period, 47 notifications of pilot whale schools were recorded, 43 were followed by actual landings, and of these, 40 schools, with a total of 3,470 whales, were systematically examined.

Finally, besides the main purpose of examining the status of the exploited population(s), this research programme made more fundamental studies possible, particularly because of

- 1) the year-round sampling,

- 2) the large number of animals sampled,

- 3) the fact that results from different fields of the investigations are based on data collected from the same whales, allowing a strict analysis of the correlations existing between the different factors.

**Main results obtained to date**

*Distribution and abundance*

In the summers of 1987 and 1989 the Faroese Islands took part in the North Atlantic Sightings Surveys (NASS) to assess the distribution and abundance of pilot whales in particular in the North East Atlantic. The Faroese and Icelandic data on pilot whales were analysed together.

In 1987, one Faroese and three Icelandic vessels surveyed an area of which the main part was bounded by 8°E and 41°W longitude and 61°N and 68°N latitude with two extensions north and south between the longitudes 8°W and 20°W. The area to the southeast, i.e. southwest of the Faroes, had by far the greatest occurrence of pilot whales and the species seemed to be scarce in the northernmost regions of the northeast Atlantic.

In 1989, the area was expanded and one Faroese and four Icelandic vessels surveyed an area bounded by 06°W and 40°W longitude and 67°N and 50°N latitude.

An estimate of 104,000 (cv=0.3) pilot whales was made from NASS-87 for the surveyed area. A new analysis of pilot whale abundance was carried out, including Icelandic and Faroese data from NASS-87 and NASS-89, as well as Spanish data

from NASS-89. The smearing method 2 of Buckland and Aganuzzi (1988) and a hazard-rate model (Buckland, 1985; 1987) were used, and different stratification factors were analysed. This analysis led to an estimate of 778,000 pilot whales in the central and eastern North Atlantic ( $cv=0.295$ , 95% CI 442,000-1,370,000). The Scientific Committee of the International Whaling Commission endorsed this figure at its 44th Annual Meeting in Glasgow, June 1992.

Both sets of analysis emphasised the potential biases resulting from the difficulty in estimating the number of schools and their size, in a loose aggregation of pilot whales.

- Bloch, D., Gunnlaugsson, T., Hoydal, K. and Sigurjónsson, J. 1989. Distribution and abundance of pilot whales (*Globicephala melas*) in the Northeast Atlantic in June-August 1987 based on shipboard sightings surveys. Paper SC/41/SM10 presented to the *IWC Scientific Committee*, May 1989 (unpublished). 1-16.
- Buckland, S.T., Cattanach, K.L., Gunnlaugsson, T., Bloch, D., Lens, S. and Sigurjónsson, J. 1992. Abundance and distribution of long-finned pilot whales in the North Atlantic, estimated from NASS-87 and NASS-89 data. Paper SC/44/SM19 presented to the *IWC Scientific Committee*, June 1992 (unpublished). 1-17.
- Buckland, S.T., Cattanach, K.L., Gunnlaugsson, T., Bloch, D., Lens, S. and Sigurjónsson, J. In press. Abundance and distribution of long-finned pilot whales in the North Atlantic, estimated from NASS-87 and NASS-89 data. *Rep.int.Whal.Comm (Special Issue 14)*.
- Gunnlaugsson, Th. and Sigurjónsson, J. 1990. NASS-87: Estimation of whale abundance based on observations made on board Icelandic and Faroese survey vessels. *Rep.int.Whal.Comm* 40: 571-580.
- Joyce, G.G., Desportes, G. and Bloch, D. 1990. The Faroese NASS-89 Sightings Cruise. Paper SC/42/O11 presented to the *IWC Scientific Committee*, May 1990 (unpublished). 1-10.
- Joyce, G.G., Desportes, G. and Bloch, D. 1991. The Faroese NASS-89 Sightings Cruise. *Rep.int.Whal.Comm* 41: 592.

### *Long-term analysis of catch series*

The catch series go back to 1584 and are unbroken from 1709 onwards. They revealed a periodic occurrence of long-finned pilot whales in Faroese waters, with a period of c. 120yrs and two main peaks around 1710-1730 and 1830-1850. Catch series analysis did not reveal any strong periodic signals and the time series model (ARIMA) explains 32% of the variance. Data series which could explain the long term trends and year-to-year variations were long-term climatic series, data on the prey species, *Todarodes sagittatus* and the blue whiting *Micromesistius poutassou* and experiences from sightings. Similarities between three sets of time series are analysed: Pilot whale and Bottle nose whale, *Hyperoodon ampullatus*, catch series, temperature series from Greenland and a temperature series from the Faroes. A shift in the correlation between series appeared around 1890. There is evidence of a long term stability, and catch levels experienced historically did not seem to affect numbers caught subsequently.

Abundance of whales was positively related to abundance of squid, blue whiting, herring, cod and seabirds (Alcidae), all positively correlated with sea-surface temperature. Certain weather and main current conditions on the Faroe Plateau also influenced the abundance of whales.

There was seasonal variations in the abundance of pilot whales, with a peak in July-August (21% and 28% of the catch) and a valley in February-March (2% and 2%). The geographical (North-East vs. South-West bays) and the seasonal

(January-July vs. August-December) grouping of grinds showed significant variations through times, with the January-July proportions and the North-East bays proportions being correlated. The number of whales per grind varied seasonally, 94-126 in December-March and 158-163 in July-August. There was clustering of the catches on a weeks and days time scale, so catches were not statistically independent events. The shift in climatic and biological conditions observed in the North Atlantic at the end of the sixties coincided with changes in catch statistics. Geographical and seasonal variations in the Faroese catches were compared between the research period and the long term series and some dissimilarities appeared. In particular, the summer peak of high catches observed in July-September in the long time series was not visible during the sampling period.

The average size of landed pods (N=148) was much greater than the size of pods observed offshore (N=26), as also observed off Newfoundland (Sergeant, 1962a).

Attempt is made to correlate the traditional skinn assessment with actual length, weight and age of the whales. This would allow the possibility of analysing time variation in life-related parameters for the entire catch series.

Bloch, D., Desportes, G., Mouritsen, R., Debes Dahl, M., Skaaning, S. and Stefansson, E. 1989. Study on the ecology and status of the long-finned pilot whale (*Globicephala melas* Traill) off the Faroe Islands in the period 1986 to 1988. General paper. Paper SC/41/SM8 pre-

- resented to the *IWC Scientific Committee*, May 1989 (unpublished). 1-32.
- Bloch, D., Desportes, G., Mouritsen, R., Skaaning, S. and Stefansson, E. In press. An introduction to studies on the ecology and status of the longfinned pilot whale (*Globicephala melas*) off the Faroe Islands in 1986-1988. *Rep.int.Whal.Comm (Special Issue 14)*.
- Bloch, D., Hoydal, K., Joensen, J.S. and Zachariassen, P. 1990. The Faroese Catch of the Long-Finned Pilot Whale. Bias shown of the 280 year time series. *Journal of North Atlantic Studies* 2(1-2): 45-46.
- Bloch, D. and Joensen, H.P. in prep. The influence of abiotic factors prior to a grind in the Faroe Islands, and some comments on techniques used to drive pilot whales.
- Bloch, D., Lastein, L. and Zachariassen, P. In prep. Modeling analysis on the inside school structure of the data on the long-term catch series of long-finned pilot whales in the Faroe Islands.
- Bloch, D., Lastein, L. and Zachariassen, P. In prep. Zoological analysis of the ethnological data on the long-term catch series of long-finned pilot whales in the Faroe Islands.
- Bloch, D. and Zachariassen, M. 1989. The "skinn" values of pilot whales in the Faroe Islands. An evaluation and a corrective proposal. *North Atlantic Studies* 1: 38-56.
- Hoydal, K. 1986. Data on the long-finned pilot whale (*Globicephala melaena*, Traill) in Faroe waters and an attempt to use the 274 years time series of catches to assess the state of the stock. Paper SC/38/SM7 presented to the *IWC Scientific Committee* (unpublished). 1-27.
- Hoydal, K. and Lastein, L. In press. Analysis of data on the long-finned pilot whale, *Globicephala melas*, in Faroe waters in relation to climatic variations. *Rep.int.Whal.Comm (Special Issue 14)*.
- Joensen, J.S. and Zachariassen, P. 1987. Statistics for pilot whale catches in the Faroe Islands 1584-1640 and 1709-1978. Paper SC/38/SM20 presented to the *IWC Scientific Committee* (unpublished). 1-22.
- Skov, H., Durinck, J., Danielsen, F. and Bloch, D. In prep. Patterns of co-occurrence of cetaceans and seabirds in the North East Atlantic. Submitted to *J. Zoogeography*.
- Zachariassen, P. In press. Pilot whale catches in the Faroe Islands 1709-1992. *Rep.int.Whal.Comm (Special Issue 14)*.

### *Stock identity*

*Use of electrophoretic markers:* Isoenzyme electrophoresis analysis performed on 31 schools showed that the allele frequencies

of some schools differed significantly from that of the remainder. This heterogeneity, however, cannot be explained by any obvious geographical or seasonal pattern. The schools presenting a significant deviation in allele frequencies from most of the other schools were landed at the following places and dates, presented in descending order in allele frequencies, beginning with Tórs-havn, 081087 as the school most different from the others, followed by Leynar 120786; then at the same level Víðvík, 270986; Hvalvík, 241186; Miðvágur, 240787; Leynar, 100688; and Funnings-fjørður, 201086. The rest of the schools showed some degree of genetic differentiation, but not as frequently as the above-mentioned.

The females within one group were more related to each other than with the females of other groups and this could suggest a strong maternal family structure with breeding males migrating between the schools.

Analyses of genetic variation at three polymorphic allozyme loci using a selection component analysis is currently being carried out. It has already provided further genetic evidence for migration of breeding males between schools. Modelling of the population structure based on genetic variation will be undertaken (Andersen, pers. comm.).

- Andersen, L. W. 1987. An investigation of the population structure of the long-finned pilot whale, *Globicephala melaena*, around the Faroe Islands on basis of isoenzyme. Paper SC/39/SM13 presented to the IWC Scientific Committee, May 1987 (unpublished). 1-10.
- Andersen, L.W. 1988. Electrophoretic differentiation among local populations of the long-finned pilot whale,

*Globicephala melaena*, at the Faroe Islands. *Can. J. Zool.* 66: 1884-1892.

- Andersen, L.W. 1989. Further studies on the population structure of *Globicephala melas* off the Faroe Islands. Paper SC/41/SM17 presented to the IWC Scientific Committee, May 1989 (unpublished). 1-21.
- Andersen, L.W. 1990. The population structure and sex determination of the long-finned pilot whale, *Globicephala melas*, and the harbour porpoise, *Phocoena phocoena*. PhD thesis, Aarhus University, Denmark. 1-65.
- Andersen, L. W. In press. Further studies on the population structure of *Globicephala melas*, off the Faroe Islands. *Rep.int.Whal.Comm (Special Issue 14)*.
- Andersen, L.W. and Siegismund, H.R. in press. Genetic evidence for migration of males between schools of the long-finned pilot whale, *Globicephala melas* off the Faroe Islands. *Marine Ecology Progress*.

*Comparison of morphological parameters:* Faroese pilot whale data is being compared with pilot whale data from the Newfoundland drive fishery (Sergeant, 1962a; 1962b), Icelandic mass strandings (J. Sigurjónsson, pers. comm.), and French strandings (A. Collet, pers. comm.). Preliminary results from morphological comparison indicate that long-finned pilot whales off Newfoundland differ significantly from pilot whales off the Faroes. Northwest Atlantic pilot whales seem to have longer skulls and shorter torsos than the Northeast Atlantic ones. Flipper lengths are longer in Newfoundland males than in Faroese ones. Sea current patterns and oceanic topographical conditions have been linked to data on distribution.

- Bloch, D. and Lastein, L. 1992. Biometrical segregation of pilot whales off eastern and western North Atlantic. ICES C. M. 1992/N:21 (unpublished). 1-18.
- Bloch, D. and Lastein, L. 1993. Biometrical segregation of pilot whales off eastern and western North Atlantic. *Ophelia* 38(2): 55-68.

*Paternity and mating system using DNA fingerprinting techniques*

Paternity testing of foetuses using DNA fingerprinting showed that they are seldom (<12%) fathered by adult males in the same school. This implies that there is considerable gene flow between schools and is confirmed by comparing foetuses born in different cohorts within the same school. These reveal an annually changing male input. If paternal alleles are considered within a cohort, strong allelic biases are indicative of a non-random pattern, either produced by males, each mating with several females, or by related males entering a school and mating with receptive females.

Analyses of females in different schools show strong allelic biases, suggesting that they are genetically distinct, and hence, presumably, part of a matrilineal system. Furthermore, by combining allelic data with the age of individuals it is possible to reconstruct the genetic history of a school. Comparison between two schools caught close together in time and space (Leynar, 220787 and Miðvágur, 240787) suggest a shared origin and may represent the splitting of a school into two daughter schools.

Detailed analysis of the two pods mentioned above has modified and extended this picture of school structure. The matrilineal structure has been strongly substantiated and there is evidence that males do not leave their natal pods. Not more than about 50% of animals are accompanied by their mothers, not surprisingly since many individuals are too old to have surviving parents. The maximum proportion of foetuses accompanied by their fathers have been

further reduced to 3%. By inference, therefore, mating occurs by reciprocal fertilisations between the males of one school and the females of another. A new, extremely variable genetic locus (microsatellite) has distinguished between the two possible patterns of male mating: related males mate with females in a school and that individual males seldom mate with more than one female. The data also suggest that mature males neither disperse from nor mate within their natal pods. Pilot whales must mate when two or more pods meet or when males pay short visit to other pods.

A complete genealogy for some schools is on the way. Emphasis of future work will be on relationships between schools, school splitting and population size estimates.

- Amos, W. 1987. Pod-relatedness and population structure in pilot whales. *Cetus* 7: 31-32.
- Amos, W. 1993. The social structure of pilot whale pods in the Faroe Islands. Genetic insights. *ESC* 7:13.
- Amos, W., Barrett, J., Bancroft, D., Majerus, T., Bloch, D., Desportes, G. and Dover, G.A. 1989. Breeding system and social structure in the Faroese pilot whale as revealed by DNA fingerprinting. Paper SC/41/SM30 presented to the *IWC Scientific Committee*, May 1989 (unpublished). 1-15.
- Amos, W., Barrett, J., Bancroft, D., Majerus, T., Bloch, D., Desportes, G. and Dover, G.A. In press. A review of molecular evidence relating to social organisation and breeding system in the Long-finned Pilot whale. *Rep.int.Whal.Comm (Special Issue 14)*.
- Amos, W., Barrett, J., and Dover, G.A. 1991a. Breeding behaviour of pilot whales revealed by DNA fingerprinting. *Heredity* 67(1): 49-55.
- Amos, W., Barrett, J., and Dover, G.A. 1991b. Breeding system and social structure in the Faroese pilot whale as revealed by DNA fingerprinting. *Rep.int.Whal.Comm (Special Issue 13)*: 255-268.
- Amos, W. and Dover, G.A. 1990. DNA fingerprinting and the uniqueness of whales. *Mammal Rev.* 20: 23-30.
- Amos, W., Schlötterer, C., and Tautz, D. 1993. Social struc-



ture of pilot whales revealed by analytical DNA profiling. *Science* 260:670-672.

Schlötterer, C., Amos, W. and Tautz, D. 1991. Conservation of polymorphic simple sequence loci in cetacean species. *Nature* 354: 63-65.

Schlötterer, C., Amos, W. and Tautz, D. in prep. Cloning and characterisation of 6 simple sequence loci from the long-finned pilot whale, *Globicephala melas*.

### *Organochlorine contamination (DDT and PCBs)*

The levels of organochlorines were at an intermediary level in the range found in cetaceans in the North Atlantic, mysticetes having lower concentrations and smaller odontocetes higher. Concentrations were cumulative with age in males but decreased in sexually mature females, suggesting a transfer from mother to offspring during pregnancy and lactation.

PCBs and total DDT levels found in the blubber were relatively low when compared with those found in pilot whales off the coast of Rhode Island and Maine (USA) and off the coast of France, but higher than those found off the coast of Newfoundland.

The analysis of organochlorine loads in females from five schools (230387; 100487; 020887; 200887; 081087) showed significant differences between some of these schools. Two schools (Miðvágur, 020887; Tórshavn, 081087) exhibited organochlorine concentrations significantly different from each other and from the remaining schools. These differences could not be explained by any seasonal or geographical pattern. This refutes the possibility of a geographical segregation of the schools and suggests that different popula-

tions may coexist in Faroese waters at any time of the year.

Current investigations emphasize the variations of organochlorine pollutant levels in relation to life-history data (Aguilar, pers. comm.).

Aguilar, A. and Borrell, A. 1989. Preliminary results on the DDT and PCB concentrations in the muscle and blubber of long-finned pilot whales from the Faroe Islands. Paper SC/41/SM22 presented to the *IWC Scientific Committee*, May 1989 (unpublished). 1-10.

Aguilar, A., Borrell, A., Bloch, D. and Lockyer, C. in prep. Age and sex related variations of organochlorine pollutant levels in the Faroese long-finned pilot whale.

Aguilar, A., Jover, L. and Borrell, A. In press. Heterogeneities in school composition of Faroese long-finned pilot whales as indicated by organochlorine profile analysis of females. *Rep.int.Whal.Comm. (Special Issue 14)*.

Borrell, A. and Aguilar, A. In press. Pollution by DDT and PCB in blubber and muscle of long-finned pilot whales from the Faroe Islands. *Rep.int. Whal.Comm. (Special Issue 14)*.

Borrell, A. 1993. Dinámica de los compuestos organochlorados en la ballena de aleta y el calderon del Atlántico Norte. Thesis Doctoral, *Universitat de Barcelona*.

Borrell, A. 1993. PCB and DDTs in blubber of cetaceans from the northeastern North Atlantic. *Marine Pollution Bulletin* 26(3): 146-151.

### *Heavy metal contamination*

Arsenic, copper, selenium, zinc, mercury (Hg) and cadmium (Cd) levels were analysed in eight schools (300786; 150986; 241186; 231286; 100487; 220787; 240787; 081087).

Total-Hg concentrations were high but within the range encountered in most dolphin species elsewhere. They were much lower than the concentrations found in *Stenella* off Japan. Total-Hg was cumulative with age. The average percentage of organic mercury with respect to total-Hg

was 33% in the liver, ranging from 3% to 62%, the lowest fractions being encountered in the older individuals. Cadmium concentrations were very high and higher than those found in other cetacean species anywhere else, even from highly industrialised areas. In foetuses concentrations of Hg and Cd were lower than in the mothers, but they were already cumulative. A transfer from mother to offspring is likely to be observed.

The concentrations in Hg, Cd and Zn varied significantly between schools and the Cd particular may be used as a tracer of the school history. Two schools (Tórshavn, 081087; Øravík, 150986) showed significantly higher concentrations of Hg in the liver than the remaining schools. The school landed in Tórshavn (081087) showed also significantly lower levels of Cd and Zn in the liver than the remaining schools, while a school landed in Miðvágur (240787) showed significantly higher concentrations of Cd and Zn.

Similar variations between schools were found in Cd concentrations in milk, which results in a different exposure of the newborn as soon as it begins suckling. Milk could represent another way of elimination of Cd, which could explain the significantly lower Cd concentrations observed in the liver of lactating females.

Comparison of levels of Cd between schools continues, in order to confirm differences and verify hypotheses on the existence of several populations of pilot whales.

Future work will try to determinate, through histo-pathological analysis of the

kidney, whether Cd has toxic effects in pilot whales. Parallel to this, the metabolism of Cd will be investigated by qualitative and quantitative evaluation of metalloproteins, the soluble forms of Cd. The levels of methyl-Hg in the different organs will be determined, and an analysis of the system of detoxification by selenium will be studied. An in-depth study of mother-offspring transfer is planned, particularly for methyl-Hg. It has already been shown that the levels of CH<sub>3</sub>Hg in foetuses could be determined by furnace atomic absorption spectrometry (Caurant, pers. comm.).

- Caurant, F. in prep. Contamination par les métaux lourds du globicephale noir (*Globicephala melas*) pêché aux îles Féroé. Doctoral thesis, University of Nantes.
- Caurant, F., Amiard-Triquet, C. and Amiard, J.-C. In press. Factors influencing the accumulation of metals in pilot whales (*Globicephala melas*) off the Faroe Islands. *Rep.int.Whal. Commn (Special Issue 14)*.
- Caurant, F. and Amiard-Triquet, C. In press. Cadmium concentration in pilot whales, *Globicephala melas*: source and potential hazard to the species. *C.R.Acad.Sci. Paris*.
- Caurant, F., Amiard-Triquet, C. and Amiard, J.-C. In press. Ecological and biological factors controlling the concentrations of trace elements (As, Cd, Cu, Hg, Se, Zn) in delphinids (*Globicephala melas*) from the North Atlantic Ocean. *Marine Ecology Progress Series*.
- Jean-Caurant, F. 1987. Etudes préliminaires de la contamination par les éléments traces du dauphin *Globicephala melaena*. *J. Rec. Océanogr.* 12(3-4): 85-89.
- Jean-Caurant, F. and Amiard-Triquet, C. 1991. The consumption of marine mammals' flesh as a way of exposure to cadmium and mercury in Faroese population. In: J.G. Farmer (ed). *Heavy metals in the environment*, 1. CCP Consultants, Edinburgh: 464-467.
- Jean-Caurant, F., Amiard-Triquet, C. and Amiard, J.-C. 1989. Ecological and physiological factors influencing the metal contamination of pilot whales (*Globicephala melas*) from the Faroe Islands. Paper SC/41/SM21 presented to the IWC Scientific Committee, May 1989 (unpublished). 1-21.
- Schintu, M., Jean-Caurant, F. and Amiard, J.C. 1992. Organomercury determination in biological reference materials: Application to a study on mercury speciation

in marine mammals off the Farøe Islands. *Eco-toxicology and Environmental Safety* 24: 95-101.

### Parasite fauna

16 species of helminths and three species of crustaceans were identified. The most prevalent species were the nematodes *Anisakis simplex* and *Stenurus globicephalae*, and this can be paralleled with the abundance of larval stages in some fish and squids found in Faroese waters, especially in *Todarodes sagittatus*. Prevalence of all species tended to be cumulative with age. Nevertheless, the abundance of some parasites showed a decline in older animals, e.g. the nematode *A. simplex* and the trematode *Pholeter gastrophilus*. This may indicate a higher mortality rate of the most severely infested animals. Furthermore other species are also considered as having significant pathological effects and parasitism could then be a non negligible factor of mortality.

Prevalence, abundance and spatial distribution of the whale-louse *Isocyamus delphini* on sexually mature males was significantly higher and different from those of the remainder. Behavioural factors seemed to account for these differences, with mature males exhibiting additional whale-louse shelters such as tooth-rake scars and severe wounds which probably result from sexual fighting.

Qualitative and quantitative differences in the parasite fauna composition of pilot whales were found between the Farøe Islands, the Atlantic French coasts and Spanish Mediterranean coasts, as well as Newfoundland (Cowan, 1966; 1967).

Eight schools were examined with respect to the abundance of the helminth species (220787; 240787; 020887; 190887; 180987; 081087; 201087; 100689). The abundance of the acanthocephalean *Bolbosoma capitatum* was significantly higher in 3 schools (Leynar, 220787; 240787; Miðvágur 020887) and significantly lower in one school (Tórshavn, 081087). As well, the latter school showed a significantly higher abundance of the trematode species *Hadwenius delamurei* and *H. subtilis*. This supports the idea of several sympatric populations in Faroese waters, but might also be partly due to seasonal or long-term variations of the abundance of infective stages. Differences between schools could also be observed in the population structure of the nematode *Anisakis simplex* (Desportes *et al.*, 1993).

Future work will be devoted to studying the intestinal helminth communities, their structure and the mechanisms determining their appearance (Balbuena, pers. comm.).

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- Raga, J.A. and Balbuena, J.A. 1989. Parasites of the long-finned pilot whale, *Globicephala melas* (Traill, 1809), in European waters. Paper SC/41/SM28 presented to the

*IWC Scientific Committee*, May 1989 (unpublished). 1-20.

Raga, J.A. and Balbuena, J.A. In press. Parasites of the long-finned pilot whale, *Globicephala melas* (Traill, 1809), in European waters. *Rep.int.Whal.Comm (Special Issue 14)*.

#### *Age determination and tooth structure*

The deposition rate of dentinal and cemental layers is one growth layer group (GLG) per year. Five types of mineralisation anomaly were recognised. Their incidence varied according to age, sex and state of maturity and they are at least partly of systemic origin.

The patterns of occurrence of some of these anomalies (cemental disturbance and dentinal resorption) were significantly different between pilot whales landed in the Faroes and pilot whales stranded on the Icelandic coast.

Comparison of tooth mineralisation anomalies between different regions of the N.E. Atlantic - Iceland and the Faroes - continues, mainly from increasing numbers of Icelandic animals from mass strandings (Lockyer, pers. comm.).

Lockyer, C. 1989. Preliminary report on patterns of deposition of dentine and cement in teeth of pilot whales, genus *Globicephala*. Paper SC/41/SM4 presented to the *IWC Scientific Committee*, May 1989 (unpublished). 1-17.

Lockyer, C. In press. A report on patterns of deposition of dentine and cement in teeth of pilot whales, genus *Globicephala*. *Rep.int.Whal.Comm (Special Issue 14)*.

#### *Growth, mortality and survivorship*

The mean size at birth was estimated to be 177.6 cm and 75 kg, with no significant dif-

ferences between sexes. Males grow faster and become larger than females. They attain a maximum size of 625cm in length and 2320kg in weight, and females 512cm and 1320kg respectively. The mean length for whales older than 25 yrs was 570cm for males and 446cm for females. Growth appeared to fall into four phases: early post-natal, juvenile, young adult, and pre-physically mature adult, with a rapid growth rate in the first phase and a declining rate as physical maturity was approached. The growth curve in both sexes was uncomplex with no obvious secondary pre-pubertal growth spurt. Physical maturity was reached at a length of c. 570cm and between 25 and 30 years of age in males, and c. 425cm and c. 30 years of age in females.

Longevity was greater in females, which reached over 59 yrs, while males reached 46 yrs. The mean age of females was 15.6 years and of males 11.8 years. Overall mortality rates were higher in males, and mean estimates ranged from .0745-.0817 in males and .0622-.0737 in females. The females exhibited a high mortality in the juvenile phase, followed by a period of relatively low mortality during mid-life, and finally a steeper mortality in the older age classes. The males also showed highest mortality in the juvenile phase, followed by a steady decline with age. Part of the high mortality in mature males may be related to mating-related competition and fighting, as suggested by the significantly higher occurrence of tooth scars in bulls (Bloch, 1992).

Three schools exhibited a growth pattern

significantly different from the average, one showing a higher growth rate (Sandur, 110986) and two showing lower growth rates (Hvannasund, 220187; Vágur, 230187).

Female pilot whales off the Faroes were found to grow longer than those off Newfoundland (Sergeant, 1962a; Kasuya et al., 1988) and Iceland (Sigurjónsson et al., 1993) but with similar body lengths to those stranded on the British coast (Martin et al., 1987). The longer females and protracted growth pattern off the Faroes may be explained by the favourable feeding possibilities in these waters, or may point to the existence of more than one stock in the North Atlantic. Overall there are many similarities in growth patterns, mortality and survival throughout the North Atlantic, especially in the northeast.

Age, growth and morphometric studies of Californian short-finned pilot whales are currently being carried out, based on strandings from 1960 to 1990. Comparative studies between those pilot whales, Japanese short-finned pilot whales and North Atlantic long-finned pilot whales are landed (Lockyer, pers. comm.).

Bloch, D. In prep. The social structure in schools of long-finned pilot whales off the Faroe Islands with remarks on the occurrence of fighting marks.

Bloch, D. and Lockyer, C. 1989. Age related parameters of the pilot whale off the Faroe Islands. Preliminary results. Paper SC/41/SM15 presented to the *IWC Scientific Committee*, May 1989 (unpublished). 1-20.

Bloch, D., Lockyer, C. and Zachariassen, M. In press. Age and growth parameters of the long-finned pilot whale off the Faroe Islands. *Rep.int.Whal.Comm. (Special Issue 14)*.

Lockyer, C., Desportes, G. and Waters, T. 1987. Preliminary studies of pilot whales from Faroese waters

since 1986: Age determination. IWC Doc. Paper SC/39/SM16 presented to the *IWC Scientific Committee*, May 1987 (unpublished). 1-9.

Martin, A.R. and Rothery, P. In press. Reproductive parameters of female long-finned pilot whales (*Globicephala melas*) around the Faroe Islands. *Rep.int.Whal.Comm. (Special Issue 14)*.

### *Reproductive parameters*

The analysis of the data on female reproduction raised some analytical problems. The dataset and the methods of analysis as they stand to date have not allowed a choice to be made between a unimodal and a bimodal pattern of breeding. However, the estimate of some of the parameters is sensitive to this choice. Some of the results given here are, thus, preliminary and subject to changes.

Females reached sexual maturity between 5 and 15 years of age, at a mean age of 8.7 yrs and a mean length of 378.5cm and a weight ranging between 524 and 620 kg, 600 kg in mean.

Males reached puberty later, between 11 and 18 years, at a mean age of 14.3 yrs, a mean length of 493.8 cm and a weight ranging between 1.0 and 1.5 tonnes, in mean 1.277 kg. The testes became fully histological mature some years later at a mean age of 17.3 yrs and males might become socially mature, i.e. mate successfully, only some years later maybe at around 25yrs of age.

The average rate of ovulation was predicted to be one corpus every 4 years. However, examination of ovaries showed

evidence of infertile ovulations, since at least 10% of mature females exhibited one or several corpora lutea though no pregnancy was detectable. The existence of a post-reproductive phase is controversial. The age-related decrease in ovarian activity and in the proportion of pregnant females suggested the existence of a post reproductive phase while other analyses support the hypothesis that active reproduction can potentially continue throughout life. In any case, the pattern of apparition of a post reproductive phase would be different from the pattern described for short-finned pilot whales (Kasuya and Marsh, 1984; Marsh and Kasuya, 1984; 1986; 1991). Long-finned pilot whale females may become post-reproductive much earlier, but in the same time some females were still reproductively active at an older age, with the two oldest pregnant females of the Faroese sample being 41yrs and 55yrs old respectively.

There is uncertainty on the length of gestation, though newly developed statistical techniques resulted in a much shorter gestation period than the 15.5 months usually accepted for pilot whales (Sergeant, 1962a). The gestation seemed more likely to last between 11 and 12 months.

The mean duration of lactation was assumed to be 3.4 years, but the duration of lactation increased dramatically with mother age and may last more than 9 years in female older than 40 years. Other independent parameters indicated also that the lactation period may be extended. Based on the comparison between the number of lactating females and the age composition of

juveniles in a school, the age at which weaning was completed varied between 3 and 6 yrs according to schools and assumptions made. On the basis of stomach and parasite examination, the mean age at which pilot whales begin to catch prey was calculated to be five months for both sexes, with important individual variations. There was, however, evidence for a protracted period of partial suckling with more than 25% of calves in the age-classes 3 and 4, and the observation of milk in the stomach of a 7 year-old male and a 12 year-old female.

The proportion of mature females giving birth each year was assumed to range between 0.21 and 0.17. The gross birth rate, or annual reproductive output, was estimated to be 7.5% and the mean inter-birth interval 5.3yrs.

Adult males showed a clear seasonal cycle in testicular activity, with testis weights and testosterone levels being in average 1.5 and 2.5 times higher respectively in the period March-September than in the period October-February. The annual profile of testosterone concentration is, however, bimodal with a significant decrease in July, clearly suggesting two peaks of sexual activity. The frequency distribution of conception dates is also clearly seasonal. More than 50% occurred in the period May-July with a peak in June (a second one in October in a bimodal pattern of breeding) and few conceptions occurring in January and February. However, since conceptions were spread through nearly the entire year

and elevated testis weights and testosterone levels were still observable in males in autumn and winter, a non-negligible proportion of adult individuals were capable of reproducing outside the main breeding season.

The average breakdown for the female sample in 23 schools gave 31% immature, 16% pregnant, 5% simultaneously pregnant and lactating, 34% lactating and 15% resting.

Estimation of reproductive parameters is continuing. Variations of hormones involved in reproduction are being analysed in relation to life-history data and seasonality. Future work will examine in detail the evidence for the existence of a post/non-reproductive stage, on the basis of systematic histological examination of ovaries, mammary gland and reproductive tract of females. Emphasis will also be given to variations between schools, and their potential explanation, and to school structure and its social and behavioural significance.

Bloch, D., Lockyer, C. and Zachariassen, M. In press. Age and growth parameters of the long-finned pilot whale off the Faroe Islands. *Rep.int.Whal.Comm (Special Issue 14)*.

Desportes, G. In prep. Ovarian activity and seasonality in female long-finned pilot whales off the Faroe Islands.

Desportes, G. In press. Symmetry in testicular development in long-finned pilot whales. *Marine Mammal Science*.

Desportes, G., Mauget, R. and Lacroix, A. in prep. Secretion pattern of oestrogens and progesterone in female long-finned pilot whales in relation to life-history parameters and seasonality.

Desportes, G. and Mouritsen, R. In press. Some results on the diet of long-finned pilot whales around the Faroe Islands. *Rep. int. Whal. Comm (Special Issue 14)*.

Desportes, G. and Lacroix, A. 1987. Preliminary study of

the male reproductive cycle in the pilot whale (*Globicephala melaena*) off the Faroe Islands, using testes examination and testosterone assay. Paper SC/39/SM WP2 presented to the *IWC Scientific Committee*, May 1987 (unpublished). 1-21.

Desportes, G., Saboureau, M. and Lacroix, A. 1989. Preliminary study on the male reproductive cycle of *Globicephala melas* off the Faroe Islands, using testes examination and testosterone assay. Paper SC/41/SM11 presented to the *IWC Scientific Committee*, May 1989 (unpublished). 1-18.

Desportes, G., Saboureau, M. and Lacroix, A. In press. Reproductive maturity and seasonality of male long-finned pilot whales off the Faroe Islands. *Rep.int.Whal.Comm (Special Issue 14)*.

Desportes, G., Saboureau, M. and Lacroix, A. In prep. Growth-related changes in testicular weight and plasma testosterone concentrations in long-finned pilot whales, *Globicephala melas*. Submitted to *J.Reprod.Fert*.

Martin, A. R. and Desportes, G. 1987. Preliminary studies of pilot whales from Faroese waters since 1986: reproduction and foetal growth. Paper SC/39/SM15 presented to the *IWC Scientific Committee*, May 1987 (unpublished). 1-8.

Martin, A.R. and Rothery, P. In press. Reproductive parameters of female long-finned pilot whales (*Globicephala melas*) around the Faroe Islands. *Rep.int.Whal.Comm (Special Issue 14)*.

### *Sex identification and variation in sex ratio through life*

Sex chromatin allowed sex identification in fetuses too small to be sex-identified macroscopically or histologically. The method can also be used in post-natal individuals, but is more difficult to handle. The sex of post-natal individuals can be identified with higher confidence by means of a human Y-specific DNA probe.

The overall sex ratio is skewed towards females, with 1.6 females per male. There is an average of 4.4 mature females per mature male but only 0.8 mating females per mating males.

The sex ratio was at parity close to conception, but the proportion of males decreased significantly with increasing gestational age and reached 35% at the time of birth. After birth the proportion of males increased and reached 50% at age 3. There is thus a differential foetal mortality followed by a subsequent differential mortality in the opposite direction in postnatal individuals. Parity is maintained until age 10, and from the period of male puberty the male proportion decreased by stages with increasing age until it reached 0 at age 50. Male-only schools are uncommon in the fishery (Bloch, 1992), though one was landed during the project, and it is not clear whether the decreasing proportion of males from puberty onwards is solely the result of the stronger selection operating on males or whether it is also partly due to some segregational patterns.

The proportion of male foetuses decreased with gestational age and was also significantly lower among older pregnant females. These results suggest strongly that the foetal mortality might be important in pilot whales, as it is in other mammalian species, and should be taken in account when calculating reproductive parameters.

The Faroese sample included a disproportionate number of female foetuses while the Newfoundland sample (Sergeant, 1962a) included a disproportionate number of male foetuses. Variation in foetal sex ratio between Newfoundland and the Faroes may point to the existence of more than one population in the North Atlantic or/and to changes in environmental conditions or population density.

Further analyses are being carried out to examine variations in foetal and post-natal sex ratios between schools and between geographical areas, and their relatedness to biotic and abiotic parameters. Future studies will try to analyse the factors leading to the higher mortality of male foetuses, and of juvenile females, to address the link between the results on sex ratio variation in pilot whales and some theoretical predictions concerning sex ratio trends, and to explore the demographic consequences of these effects

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### *Morphological characters*

Dorsal saddles were observed more frequently than eye blazes. Both patterns occurred beyond a certain body length and age, and became more common with increasing body length and age. The saddle pattern had the same occurrence in males and females, while the eye blaze occurred significantly more in males and was not so strongly related to body length or age. The length of the dorsal fin and the shape of the flukes were linearly correlated to blubber thickness. This explained the seasonal differences found between schools and was related to the seasonal variation of the blubber thickness. Sexual dimorphism was apparent in flippers and flukes, males had longer flippers and longer and wider flukes than females at similar body lengths. Immature males and females had significantly shorter flippers and flukes in proportion to body length than mature individuals. The ratio of flipper length to body length was greater than that previously found (Sergeant, 1962b), and 2.7% of individuals showed a ratio within the range encountered in the short-finned pilot whales (Bree, 1971; Nores and Pérez, 1988; Yonekura *et al.*, 1980).

Bloch, D., Zachariassen, M. and Zachariassen, P. 1989. The possibility of using morphological characteristics of the long-finned pilot whale (*Globicephala melas* Traill) in school identification. Paper SC/41/SM9 presented to the IWC Scientific Committee, May 1989 (unpublished). 1-15.

Bloch, D., Zachariassen, M. and Zachariassen, P. In press. Some external characters of the long-finned pilot whale off the Faroe Islands and a comparison with the short-finned pilot whale. *Rep.int. Whal. Commn (Special Issue 14)*.

### *Feeding ecology*

A minimum of 13 genera of cephalopods, 14 genera of fish and 3 species of crustacea, plus miscellaneous other items were identified. Pilot whales ate mainly squid around the Faroes. Two squid species, *Todarodes sagittatus* followed by *Gonatus sp.*, were by far the most dominant prey in the diet, both in frequency of occurrence and in quantity. No species of commercial interest were important in the diet.

Around the Faroes, pilot whales fed almost exclusively on *Todarodes sagittatus* whenever this prey was available, otherwise the diet was diversified and supplemented with a large range of items including fish and shrimps. In the summers of 1986 to 1989 when virtually no *T. sagittatus* were landed in the Faroes, pilot whales did not appear to have fed upon densely occurring species of fish (e.g. cod, blue whiting, saithe...) in waters around the Faroes, but to have preyed further offshore, maybe on the slope of the Faroe plateau, on another squid species *Gonatus sp.* This indicates that while the type of prey taken reflects to some extent local availability, some degree of choice is exercised by the pilot whales between squid and fish and among squid species. Seasonal variations are observed, with a greater diversity of prey in winter when more fish is consumed, though squid remain the major part of the diet.

Further work is being carried out to analyse the apparent differences in feeding patterns according to age and sexual status. Future studies will in particular try to estimate the actual choice made by the preda-

tor in reference to prey availability and to assess more closely the impact of pilot whales on the Faroese marine ecosystem.

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### Bioenergetics

The body fat condition showed an annual cycle, the energy reserves increased from November onwards, peaking in late winter before most mating activities take place, and were depleted by the summer. The seasonal pattern in fat deposits was similar in all groups of whales regardless of reproductive status or age, thus food availability is thought to be the more likely driving factor. The energy reserve built up by spring in adult females was less than, but close to, the estimated annual cost of lactation and greater than the estimated cost of pregnancy. Since energy reserves also increased in juveniles, it is not certain that the fat reserves in pilot whales are primarily devoted to reproduction. The timing of

reproductive events suggests, however, an important association.

An in-depth study of lipid class and type from blubber, muscle and body organ fats is planned, in order to gain a better understanding of the dynamics of fat storage and utilisation. This will be based on currently available lipid extracts from Faroese pilot whales, collected from drives in 1986 and 1987 (Lockyer, pers. comm.).

- Lockyer, C. and Waters, T. D. 1987. Preliminary studies of pilot whales from Faroese waters since 1986: Body weight and tissue lipid content. Paper SC/41/SM17 presented to the *IWC Scientific Committee*, May 1987 (unpublished). 1-8.
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- Lockyer, C. In press. Seasonal changes in body fat condition of Northeast Atlantic pilot whales, and the biological significance. *Rep.int.Whal.Comm (Special Issue 14)*.

### Conclusion

This international research programme represents to date the most comprehensive study, with the largest sample size, of an odontocetes species. Unlike most other studies on cetaceans taken in fisheries, the Faroese drive fishery operates throughout the year without any selectivity, probably representing a random sample of the population. It provides, thus, a unique opportunity to estimate population parameters.

As has been emphasized, analysis is still continuing in most fields of research involved in this programme, new laboratory methods and new analytical techniques are currently developed, and the overall picture presented in this paper is likely to

become clearer, maybe modified, as analysis goes on.

In term of management, one of the most critical and exciting questions is to assess on which population the fishery is operating (single or multi stocks, stock boundaries and size, trends in abundance ...) and whether separate stocks exist within the North Atlantic. More work is clearly needed on both sides of the Atlantic to allow any definitive answer to these questions. Already, however, it is interesting to note that several studies connected to the international research programme on the Faroese drive fishery on electrophoretic markers, organochlorine and heavy metal contaminants, and parasite fauna lead to convergent results about differences between schools. The combined results suggest at least three groups of schools among those landed in the period 1986-1988 and analyzed: Øravík (150986), Tórshavn (081087) -/- Leynar (220787), Leynar (240787), Miðvágur (020887) -/- the remainder.

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We would like to mention especially our late British colleague, Timothy David Waters from the Sea Mammal Research Unit. He died tragically in the Faroes in a plane accident in July 1987 at the beginning of a Faroese air survey, which was to have been part of the North Atlantic Sighting Survey. His companionship, kindness and enthusiasm were much appreciated by all of us who met him, and he is greatly missed. Sadly, in the same accident the American whale scientist, Frederick Merrill Fairfield, and the British pilot, Raymond Allan Hughes also disappeared.

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## Úrtak

Vistfrøðin og støðn hjá grindini, *Globicephala melas*, sum er dripin í føroyskum drápi, hava verið evnið í einari altjóða granskingarætlan, sum stig var tikið til í juli 1986 vard av Umhvørvisætlanini hjá Sameindu Tjóðunum (United Nations Environmental Programme - UNEP), altjóða hvalaveiðunevndini (the International Whaling Commission - IWC) og Føroya Landsstýri.

Nágreiniliga tvey-ára innsavningartíðarskeið, juli 1986-juli 1988, gav okkum eitt

týðningarmikið savn av lívfrøðiligum vertum, sum vórðu tiknir av til samans 3.470 hvalum úr 40 grindum. Tá ið tilfarið er greint sundur, gevur tað okkum kunnleika til aldursviðurskifti, nøringareginleikar, virkisfýsni, føðivistfrøðina, atburð í sambandi við uppfostran og sosiala bygnaðin, sambandið millum grindir og ættarsamleika, snultaraplágu og dálkingarnøgðina.

Henda ritgerð er ein stutt framløga av hesi granskingarætlan og um stovnarnar, sum eru uppi í henni. Hon tekur eisini saman um høvuðsúrslitini, sum higartil eru komin, og nevnið allar tær tilvísingarnar, sum hoyra til.

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