SC/33/Rep4

Report of the Workshop on Identity, Structure and Vital Rates of Killer Whale Populations, Cambridge, England, June 23–25, 1981

1. PARTICIPANTS AND AGENDA

Members (M) of the Scientific Committee of the IWC, invited experts (E) and observers (O) attending were G. Anderson (M), K. Balcomb (E), P. Best (M), M. Bigg (E), R. Borodin (M), H. Braham (M), I. Christensen (M), M. Dahlheim (E), W. Evans (E), L. Fleischer (M), J. Ford (E), M. Ivashin (M), S. Leatherwood (E), C. Lockyer (M), S. Ohsumi (M), T. Øritsland (M), W. Perrin (M), Y. Riazantsev (M), T. Smith (M), P. Spong (O) and R. Walker (E). Some participants did not attend all sessions of the meeting.

Perrin chaired the meeting and edited the report. Bigg, Dahlheim, Ford and Balcomb acted as rapporteurs.

The draft Agenda was discussed and approved with some additions (Appendix 1). The scope of the meeting was broadened to include consideration of vital rates.

2. BACKGROUND OF THE MEETING

During attempts at the 1980 meeting of the IWC Scientific Committee to assess the status of recently exploited stocks of killer whales, it became apparent that information available to the meeting was not adequate to allow delineation of management units with confidence. For this reason it was decided to convene a meeting of experts on killer whales for the purposes of reviewing all relevant information and making recommendations for definition of management units. A brief review of recent developments in the major killer whale fisheries follows.

2.1 The Northeastern Atlantic

After a 5-year period of very low catches (0–7 per year), in 1978 Norway took 63 killer whales under a license-subsidy system occasioned by the belief that concentrations of killer whales in certain fjord areas were doing harm to depleted but recovering herring stocks. The 1979 take was 221. The killer whales were taken by 'small-type whaling' vessels that usually take minke whales. The catches were processed for oil and animal food. As no stock assessment had been made, the Scientific Committee recommended in 1979 that Norway be urged to provisionally limit its take in 1980 to 52 whales (the average annual coastal take over the 10-year period 1969–78) and be requested to produce at the 1980 meeting the information necessary for an assessment. The recommendation was not acted on by the Commission, but Norway voluntarily limited its take in 1980 to 52 whales, all taken in January. No data on abundance and stock structure were made available at the 1980 meeting, however, and the Committee recommended that the stock(s) be classified provisionally as Sustained Management Stock(s) (on the grounds that there has been a long history of sustained catches), that the catch be limited to 52 whales, and, again, that Norway be asked to conduct research that would make possible a stock assessment. The Committee was especially concerned that the historical catches may not have been all from the same population(s) presently being fished.

2.2 The Southern Hemisphere

Pelagic catches of killer whales by the USSR in the Southern Hemisphere in the 1950s were as high as 110 per season (1958/59 season), but from the mid-1960s until recently they ranged from 0 to 48 per season. Takes of 78 whales were reported in the 1977/78 season and 49 in the 1978/79 season. In 1979 the Committee recommended that the USSR be requested to provide at the 1980 meeting the information necessary for a stock assessment and that the take during the 1979/80 season be provisionally limited to 24 whales, the average season's take over the period 1969–78. The Commission did not act on the recommendation, and the USSR took 916 killer whales during the 1979/80 season. The USSR did not provide information at the 1980 meeting adequate for a stock assessment, but abundance estimates for portions of the Southern Hemisphere (Statistical Areas III and IV) were made based on sightings data from IDCR minke whale cruises in 1978/79 and 1979/80. Data and hypotheses suggestive of the existence of several stocks of killer whales in the Southern Hemisphere were available, but it was felt that there was insufficient evidence on which to base geographical stock boundaries which would be of long-term use for assessments. Because of the uncertainty over stock identities and a lack of knowledge about population parameters and the effects of exploitation on social structure, the Committee recommended that the catch limit for Antarctic killer whales be set at zero. The Commission adopted this recommendation and broadened the existing moratorium on factory-ship whaling (for other than minke whales) to include killer whales.

3. REVIEW OF EXISTING INFORMATION

3.1 Distribution and Migration

3.1.1. North Atlantic

Killer whales in the North Atlantic occur with varying density in different areas. They are frequently observed off Greenland, Iceland, in the Barents and White Seas, and off Novaya Zemlya. Norwegian data indicate that killer whales occur in coastal waters all year round and that there are concentrations in the Lofoten, Møre, and Finnmark areas (SC/Jn81/KW1). Little is known about killer whale movements there, although it was suggested that they migrate in response to movements of their prey. Killer whales are also reported off Great Britian, Iceland, Denmark and France.

In the northwest Atlantic, killer whales remain in the cold waters of the Arctic until driven out by ice. Sergeant and Fisher (1957) reported killer whales off the eastern

Canadian coast (Baffin Island and Lancaster Sound), noting that their appearance in the area may be related to the movements of rorquals and seals. Areas of concentration were noted in the Straits of Belle Island, off Newfoundland and in the Bay of Fundy. Killer whales have been recorded off the northeastern coast of the USA, with a marked decline in numbers of observations to the south (Fig. 1).

A review of the North Atlantic distribution suggests a preference for coastal and continental-shelf waters.

3.1.2. Southern Hemisphere

Data from the Southern Hemisphere suggest that the killer whale is widely distributed, occurring in off-shore as well as coastal areas (SC/Jn81/KW10; Mikhalev *et al.*, 1981) (Fig. 2).

Areas of concentration are apparent in the waters near Antarctica (SC/Jn81/KW10 and SC/Jn81/KW5), off Tasmania, New Zealand and along the western coast of South America. A corridor of high density has been observed between the tip of South America and the Antarctic Peninsula (SC/Jn81/KW5; Brownell, 1974). Killer whales are regularly seen near South Georgia and the South Orkney Islands, thence southward to the Antarctic ice edge (SC/Jn81/KW5). Observations have been made off Cape Town, South Africa, but sightings decrease northward along both coasts of Africa (Dahlheim, 1981). Killer whales are occasionally seen in lower latitude areas of the Indian Ocean (Best, 1971). A north/south migration was proposed (SC/Jn81/KW10; Mikhalev *et al.*, 1981) from low latitudes in the spring to high latitude waters in summer, with a return to low latitudes in autumn (March).

These data are preliminary, and it was suggested in the meeting that they be re-examined in relation to effort. It was pointed out that while no sightings are reported for high latitudes during the austral winter, there has been no sighting effort there at that time. Minke whales migrate north in the fall, but large numbers of seals and penguins (killer whale prey) overwinter in high latitudes. The group concluded that at least part of the picture indicating migration of killer whales north in the fall could well be artifactual.

Killer whales occur off New Zealand and Tasmania during the austral summer. The data suggest that some animals may remain in the lower latitudinal waters and not undertake an extensive migration to the Antarctic region.

3.1.3 North Pacific

Killer whales occur throughout the Bering Sea and have been reported as far north as the Chukchi and Beaufort Seas (Tomilin, 1957) (SC/Jn81/KW2) and as far east as the eastern Beaufort Sea (Richardson (ed.), 1981). Sightings are concentrated near the 200 m contour over the shelf slope in the southeastern Bering Sea; in Unimak Pass and near the Aleutian Island chain; in the waters off Kodiak Island; in Prince William Sound and off southeastern Alaska (SC/Jn81/KW2). These data indicate preference for continental shelf waters. Little is known about killer whale movements within these areas. In the Beaufort, Chukchi and northern Bering Seas they undoubtedly move south with the advancing pack ice and thus long-range movements must occur. Local, more restricted movements may occur in other areas of Alaska. Year-round occurrence of killer whales is documented in the waters of southwestern, southern and southeastern Alaska. Year-round and seasonal occurrence of killer whales are recorded for the inland waterways of British Columbia and Washington State (SC/Jn81/KW4 and SC/Jn81/KW9). Some pods in this area are known to range approximately 370 nm (SC/Jn81/KW2).

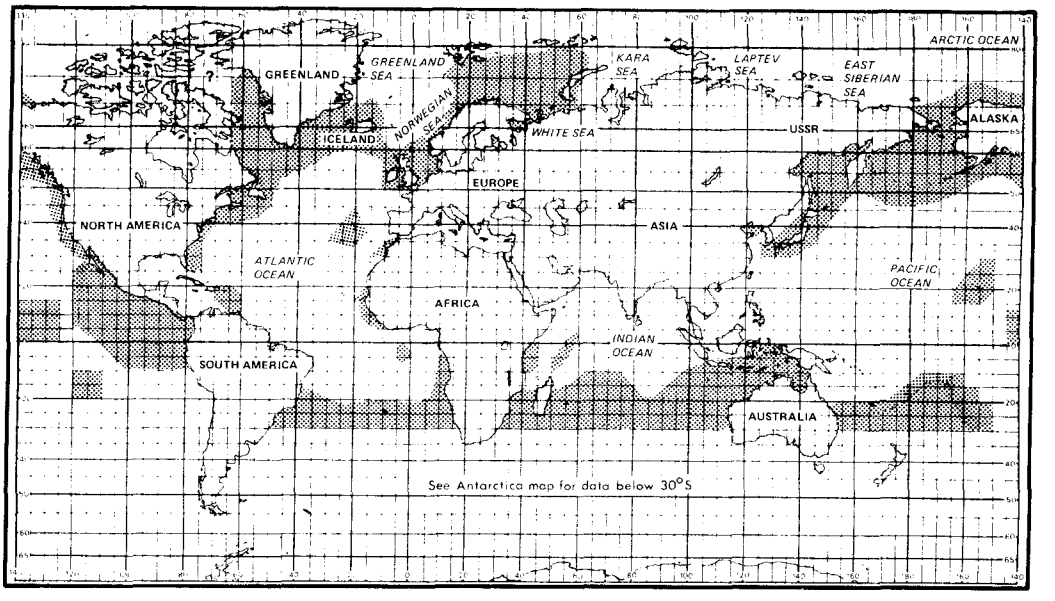

Fig. 1. Distribution of killer whales, *Orcinus orca*, north of 30°S latitude from available published sightings (see Appendix 3 for references used by area).

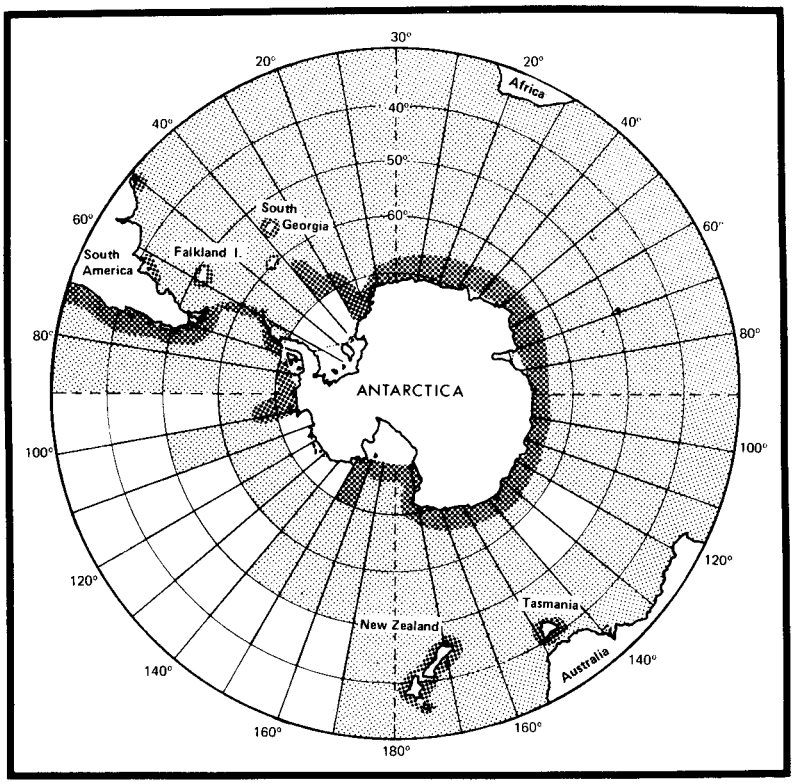

Fig. 2. Distribution and areas of seasonal concentration (dark shading) of killer whales south of 30°S latitude from published sightings (references in Appendix 3).

Sporadic occurrence is noted for the coasts of Washington, Oregon and California (Dahlheim, 1981). In the warm-temperate and tropical Pacific, records of killer whales extend along the Pacific coast from 35°N to just below 5°S (SC/Jn81/KW3). The majority of these records are within 600 km of the mainland coast. Sporadic sightings also occurred in the Gulf of California. Two clusters of observations occurred (1) from 7° to 14°N, 127° to 139°W, and (2) within a band between the equator and 5°N from the Galapagos Islands to 115°W. No seasonal pattern was apparent which could not be readily related to variable effort.

In the western North Pacific, killer whales occur frequently along the Soviet coast in the Bering Sea, in the Sea of Okhotsk, off the eastern side of the Kurile Islands, and off Japan and China (Tomilin, 1957; Nishiwaki and Handa, 1958; Wang, 1979). Here also, a preference for coastal waters is suggested. Little is known about movements in the northwest Pacific. Occasional sightings have also been made in the mid-Pacific (Fig. 1).

3.2 Geographical variation

3.2.1. Morphology

3.2.1.1. External and skeletal size and shape

Mikhalev *et al.* (1981) presented data on external size and shape indicating existence of a 'dwarf' form of the killer whale in the Southern Hemisphere (discussed below under 'Species identity'). The group reviewed the available data and agreed that bimodality in several character suites supports the idea that more than one breeding population exists in the Southern Hemisphere. The dwarf form was first recognised to exist in the course of analyses of data and specimens from the Amundsen Gulf (Appendix Fig. 1 in Mikhalev *et al.*, 1981), but what is not clear from the information available to the meeting is the procedure by which specimens from other areas (Brazil, the Antarctic Peninsula, the South Atlantic off Argentina and other areas) were assigned to the dwarf form. Ivashin agreed to investigate the matter and bring information on the procedure to next year's meeting of the IWC Scientific Committee.

Evans (SC/Jn81/KW11) reported that studies underway by Berzin and Vladimirov at TINRO may result in the description of a morphologically distinct form of killer whale that inhabits the ice edge and ice leads of the Antarctic. Details of this work are not yet available.

Length-frequency data from unaged animals (Table 1, *Rep. int. Whal. Commn* 31: 143) indicate a three to four foot (91–122 cm) difference between median lengths from Norway and those from the Antarctic, with the Norwegian animals being on the average smaller. Mikhalev *et al.* (1981) compared length data for 4 sub-areas of the Antarctic. For males, they found statistically significant differences between the samples from Area 1, which contains most of the 'dwarf' animals, and those from the other three Areas, but found no differences among Areas 2, 3 and 4. For females, they found significant differences between Area 1

and Areas 2 and 4, and between Areas 1 and 2. They pointed out, however, that the samples had not been stratified by age. Also, Ivashin cautioned that some selectivity for large animals may exist in the fisheries. The same caution applies to the Norwegian data.

No useful analyses of geographical skeletal variation exist, but Braham reported that series of osteological specimens that would possibly allow such analysis exist at the US National Marine Mammal Laboratory, Seattle and elsewhere. The group agreed that a first step in this direction should be to compile a list of available materials.

3.2.1.2. Meristics

As is the case with skeletal variation, no useful analyses of geographical variation in meristic characters exist, but accumulating material may now make possible analyses such as those carried out by Soviet scientists (Yablokov, Berzin and others) on phalangeal counts in *Delphinapterus leucas* and *Physeter macrocephalus*. Evans reported (pers. comm. from A. Yablokov) that data collected in the Antarctic during the 1979/80 season included toothcounts.

3.2.1.3. Colouration

The group discussed the work of Yablokov and Evans (SC/Jn81/KW11) on variation in colour pattern. Statistically significant geographical variation was found in four of fourteen catalogued *Orcinus* colour-pattern components. Antarctic specimens have a distinct dorsal cape; those from the Northern Hemisphere, South Pacific and South Atlantic lack such a cape. Differences in shape and position of post-ocular patches were observed between specimens from McMurdo Sound – Ross Sea – Antarctic Peninsula and specimens from IWC Areas III, IV and V. These colour-pattern differences support the conclusion that regional groups exist in the Antarctic. However, for some areas the samples represent as few as 5–20 individuals, possibly drawn from single pods (SC/Jn81/KW11).

Detailed examination of colouration of 110 males and 106 females taken by the Soviet whaling fleet in 1977–78, 78–79 and 79–80 further distinguishes animals collected in Area I from those taken in III and IV combined and suggests existence of separate 'in-ice' and 'open water' forms. No significant sexual dimorphism in colouration was found in this sample.

The results of these analyses are consistent with the existence of at least two forms in Antarctic waters but are inconclusive with respect to the 6–8 longitudinally-defined stock divisions proposed by Mikhalev *et al.* (1981).

In British Columbia there are distinct differences in colouration between pods (SC/Jn81/KW4 and KW9). The apparent differences between 'in-ice' and 'open water' forms noted for the Antarctic may be sufficient to mask such pod or area differences there (Table 4 SC/Jn81/KW11). Therefore, there is concern that photographic sample sizes must be substantially increased to ensure that pod-level differences are not misinterpreted as population-level differences or vice-versa.

3.2.2. Sound production

Reports submitted to the meeting describe variation in the vocal patterns of killer whales related to pod and population identity and geographical location. A study of the acoustic behaviour of killer whales in British Columbia (SC/Jn81/KW8) has shown that the predominant social signals are repetitious, pulsed calls which can be organised into discrete, non-overlapping categories. Repeated encounters with 15 photographically-identified pods in this region during 1978–80 demonstrated that each pod has a limited repertoire of 8 to 15 ($\bar{x}$ = 11.9) discrete call types. These repertoires are consistent regardless of changes in behavioural context. Recordings obtained from captive animals of known pod origin indicate that pod repertoires are highly stable for periods of at least 15 years (1965–80), and that each pod member produces most or all of the group's calls.

Significant differences exist between the discrete-call repertoires of different pods in British Columbia. Individual pods can be reliably identified solely on the basis of dialectal variation. The degree of similarity in dialects is also a reliable index of the degree of association of pods. Pods which associate and travel together (a pod 'community') tend to share certain calls in their repertoires, while those that do not associate (different communities) produce entirely different calls. Pods which associate most often within a community have the greatest dialectal similarity.

Two of the three pod communities off Vancouver Island, B.C., have separate, well-defined ranges, while the third is widely distributed on the coast and occurs within the other community ranges. Since each pod community is acoustically unique, major dialectal differences in this case exist in both geographically separated and socially isolated (but sympatric) communities.

Variation in killer whale vocalisation is also apparent on a larger geographical scale. Studies on the sounds of Antarctic killer whales have noted differences in the frequency structure, timing, and pattern of calls from those recorded in the North Atlantic (SC/Jn81/KW5) and North Pacific (SC/Jn81/KW6 and SC/Jn81/KW7). Vocalisations recorded in the Ross Island area of the Antarctic were reported to be similar in 1980 and 1981 (SC/Jn81/KW6).

It is apparent from these studies that the examination of killer whale sounds represents a potentially important technique for identifying populations and determining their social organisation. The degree of difference in dialects may correlate with the degree of breeding isolation. If so, the pod will be even more useful in identifying populations. While acoustical studies in other areas have identified geographical variation between widely separated regions (SC/Jn81/KW5, KW6, KW7), it is likely that dialectal variation on a local scale also exists within these regions, and the caution stated above with respect to interpretation of colour-pattern data applies here.

3.2.3. Behaviour

There is no evidence of significant geographical variation in the basic behaviour patterns of killer whales, with the exception of that in sound production (Section 5.2.2) and feeding habits, which probably reflect availability of prey (Section 5.2.5). Group sizes and composition are similar in the North Pacific (SC/Jn81/KW2, KW3, KW4, KW9: Dahlheim, 1981), the Bering Sea (Ivashin and Votrogov, 1981), the coast of Norway (SC/Jn81/KW1), the South Atlantic (Budylenko, 1981), and the Antarctic (Budylenko, 1981; Mikhalev *et al.*, 1981). These sources generally report groups of 1 to 100 individuals, with the majority containing between 5 and 20 individuals. In the coastal waters of Washington and British Columbia, groups with less than 20 animals typically represent primary social units, or pods, with stable membership

(SC/Jn81/KW4, KW9; Section 5.5). Stable groups have also been documented in other areas of the world (SC/Jn81/KW9).

There are several reports of large aggregations containing 100 or more killer whales, primarily in the Antarctic (SC/Jn81/KW7; Budylenko, 1981; Doroshenko, 1978), Alaskan (SC/Jn81/KW2) and Norwegian waters (Christensen, 1978), all high-latitude areas. These large groups probably result from the temporary joining of a number of pods and may be related to seasonal peaks in prey density in certain areas. Killer whales in the Antarctic are frequently observed in the company of other cetaceans (Mikhalev *et al.*, 1981), but this may reflect the fact that the sightings have been made from whaling vessels. However, the participants reported that such associations also occur in several other areas.

Opportunistic feeding behaviour associated with human activities is known to have developed in killer whales in various localities. Among these is the unusual relationship between killer whales and shore-based whalers at Eden, Australia during the later 1800s and early 1900s (reviewed by Mitchell and Baker, 1980), a recently developed interaction between killer whales and a drop-line fishery off Tasmania (*Rep. int. Whal. Commn* 31: 147) and similar interactions with a long-line fishery near Iceland (SC/Jn81/KW1). Such occurrences appear to be localized phenomena and may, as in the case at Eden, Australia, involve only one or a few pods. That these behaviours do not seem to spread is suggestive of little exchange of animals between local areas.

3.2.4 Biochemical and chromosomal characters

Polymorphism has been described in the C-banded karyotype of the killer whale (Árnason, Lutley and Sandholt, 1980), and studies are presently underway to compare chromosomes of killer whales from different locations (D. Duffield, pers. comm. to Dahlheim, June 1981). There is preliminary chromosomal and biochemical evidence that certain pods may be genetically isolated (Duffield and Cornell, 1979). The group agreed that while this area of research is promising for future studies of stock identification, it has not yet progressed sufficiently far to be of use in the present exercise.

3.2.5. Feeding habits

Food items found in the stomachs of killer whales encompass a wide range of species (Appendix 4). The list presented is incomplete and does not represent a comprehensive review of the literature or a complete listing for any geographic area. Fish prey from stomach contents may be less likely to be identified to species and thus may be under-represented in the table. Composition of diet varies among areas and within areas, both seasonally and between individuals sampled.

The broad range of diet items is reflected in diverse feeding behaviours associated with different prey. These behaviours have been described by the authors listed in the table.

The present data do not suggest systematic geographical variation in feeding habits not related to distribution of prey.

3.3 History of catches with respect to geographical sub-areas

3.3.1 North Atlantic

As noted above, there has been concern that the long history of take of killer whales by Norway may not pertain to a single breeding population. Christensen reported that all killer whales taken in recent years have been taken in Norwegian fjords and coastal inshore waters. Data in Jonsgård [Christensen (1975) and in catch records (*fide* Christensen)] indicate that about 70% of the killer whales taken by Norway since 1938 were taken from Norwegian coastal waters. In recent reports (see, for example, Christensen, Jonsgård and Rørvik, 1981) the statistics indicate that the take has been from a portion of the coastline, centred about Lofoten.

Christensen reported (SC/33/KW1) the existence of several (7–8) areas of concentrations of killer whales along the coast of Norway. The whales are found in these areas in large numbers throughout the year; there is no evidence of seasonal migration. The coastal statistical reporting areas in Christensen *et al.*, 1981, correspond roughly to the reported areas of concentration of killer whales. Considering these facts and the limited ranges and long-term stability of local populations observed in the Northeastern Pacific (the only areas where killer-whale movements have been intensively studied for long periods of time) the group thinks it likely that the Norwegian fishery may be exploiting one or a few local breeding populations.

3.3.2. Southern Hemisphere

Mikhalev *et al.* (1981), presented catch statistics for the Southern Hemisphere for the period 1969/70–1978–79 by 10-degree square. The catches were concentrated in roughly 3 regions: southeast of Africa, southeast of Australia, and southwest of South America. These areas correlate roughly with the Areas 1, 2 and 3 defined in the same paper for purposes of analysis of geographical variation in length (discussed above). The authors concluded that at least two populations are probably involved. These analyses do not include data from the 916 killer whales taken during the 1979/80 season. To date, the 1979/80 catch statistics have been reported only by expedition (SC/33/ProgRep USSR).

3.3.3 Other Areas

No detailed information on distribution of catch by sub-areas is available for other fisheries.

3.4 Age and structure of catches

3.4.1 Live capture for display

Killer whales taken for display (about 100) in Washington, British Columbia and Iceland have been young males and females, with selection against large bulls. Pods were enclosed, one or more individuals were selected and removed, and the remainder were released. No information was available on catches for display off Iceland.

3.4.2. Soviet pelagic catches in the Southern Hemisphere

Two sets of data giving length composition are available—one for the period 1961/62 to 1978/79 (Mikhalev *et al.*, 1981) and the other for 1979/80 (IWS LVXXXI) and are shown in Table 1.

Size composition of the earliest catches indicates that there was selection for larger animals, with more males than females taken, and some selection for large animals may

Table 1

Length-frequency data for Soviet takes of killer whales in the Antarctic

	Length																			
	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	Totals
1961/62–1978/79																					
Males							2	7	10	21	17	14	27	31	33	24	13	5	1		205 males
Females							4	10	11	20	19	26	15	5	2	—	—	—	—		118 females
																					323
1979/80																					
Males			1	1	4	6	6	13	39	32	52	69	72	45	41	24	9	14	21	1	450 males
Females	1	1	3	6	9	25	66	46	60	85	88	56	17	2	1	—	—	—	—	—	466 females
																					916

also have occurred in the later catches. Ivashin and Evans reported that the 1979/80 catch of 916 killer whales may incorporate an open-water form and an ice-edge form of different sizes. The relationship of those forms to the dwarf form proposed by Mikhalev and Ivashin is not clear, but it is apparent that detailed consideration of the data from the 1979/80 catch will require further analysis of its possible components.

There is little information on the way in which the killer whales were taken, i.e., whether an attempt was made to take all members of a pod or only a small number of individuals selected at random. If possible, the information will be obtained and presented to the Scientific Committee next year. It is understood that there are no data available on the age composition of the recent Soviet catches.

3.4.3 Other coastal catches

Nishiwaki and Handa (1958) gave details of coastal Japanese killer whale catches for the period 1948–57, in which 567 animals were taken:

	1948		1949		1950		1951		1952		1953		1954		1955		1956		1957		Totals	
	no.	size	no.	size	no.	size	no.	size	no.	size	no.	size	no.	size	no.	size	no.	size	no.	size	no.	size
♂	12	19.4	19	21.6	11	22.5	40	21.9	33	21.8	39	21.7	66	22.5	43	20.2	22	21.0	35	21.2	320	21.5
♀	15	18.6	24	18.3	7	20.1	27	19.1	21	20.7	26	21.7	43	21.9	34	19.8	16	21.0	34	18.4	247	20.0

It is clear that there was selection for males, with more males than females taken in all years but 1948 and 1949. The mean lengths of males taken are greater than mean lengths of females in years other than 1953 and 1956, when the mean lengths were equal. Total coastal Japanese catches in the period 1948–80 were 1,452 animals. Detailed information was not available for the period 1958–80 for the Japanese coastal fishery. Similarly, no information beyond that presented by Dahlheim (1981) was available for Denmark, Peru, South Africa, USA or the West Indies.

3.5 Definition of breeding unit

3.5.1 Size

In British Colombian waters, at least, the primary social unit (in which calves are reared) is a pod, and the basic breeding unit is demonstrably no larger than a 'community' composed of several pods (SC/Jn81/KW4; SC/Jn81/KW9). The pod sizes range from 1 to 50 whales. Periodically pods join with others to form larger aggregations of up to 80 individuals. Pods around Vancouver Island form three communities whose individuals associate with one another but not with individuals of other communities. One, a resident community off southern Vancouver Island, contains three pods totalling 79 whales that are seen year round. The second, resident off northern Vancouver Island, contains 12 pods with about 136 whales. At least one of these 12 pods is seen year round. A third community is made up of transient whales which range in a loose network around Vancouver Island, incorporating the ranges of the other communities. This group contains 15 pods and 47 individuals, which are seen infrequently. The transient pods differ from resident pods in swimming and feeding behaviour. They also range farther than do the other two communities.

In other regions, aggregations of several hundred are commonly reported, and in one instance a group of 2,500 was noted in Alaska (SC/Jn81/KW2). There was discussion about the difficulty in counting cetaceans in large groups.

3.5.2 Structure

Pods typically contain individuals of mixed ages and sexes (SC/Jn81/KW4; SC/Jn81/KW9; Grieg, 1889). Based on 30 pods containing 260 whales in British Columbia and Washington, the average pod contains 23.0% bulls, 34.1% cows, 38.5% juveniles and 4.4% young of the year. Solitary whales can be male or female. Some small pods (<7 whales) in British Columbia contain no adult males. Such pods can contain calves and thus must breed with males of other pods. At the opposite extreme is a pod of eight whales of which five are bulls.

3.5.3 Stability

Pods are long-term association of the same individuals (SC/Jn81/KW4; SC/Jn81/KW9; Wellings, 1944). Associations within entire pods have been recorded for seven years in British Columbia and Washington. Four

individuals in one pod are known to have associated for 13 years. Based on observed annual changes in pod size, these pods increase at an average rate of 2.52%. One suggestion for new pod formation is that it occurs through the gradual splitting of established pods over perhaps several decades. Related sub-pods would gradually spend less time in association with one another. Evidence is now accumulating to indicate that mothers and their accumulated young form subgroups within pods. Such maternal associations may well be the basis on which pods eventually divide. There have been no instances observed of individuals moving out of one pod and into another on a permanent basis, although temporary associations across pods within a community do occur.

3.6 Vital parameters

3.6.1. Age at sexual maturity

Based upon catches of killer whales by Norway reported by Jonsgård and Lyshoel (1970) and Christensen (SC/Jn81/KW1) and by the USSR in 1979/80 (IWS LXXXVI and Table 1), few pregnancies occur among females less than 16 ft long, and a marked increase in pregnancies occurs among females 16 ft long and larger. These data indicate that most first pregnancies occur at about that length. Age at first pregnancy is not directly known. However, based on rates of growth of captive killer whales (SC/Jn81/KW4) it is at least 7 years. Based on growth layers in the teeth of whales taken in the Norwegian fishery (SC/Jn81/KW1, Fig. 9), both sexes attain the length of 16 ft at an age of about 8 years.

Based upon testes weight and the presence of sperm, as well as the onset of dimorphism of the dorsal fin, males reach sexual maturity at about 19 ft (SC/Jn81/KW4). Age at sexual maturity is not directly known, but based on captive whale growth rates (SC/Jn81/KW4), it is at least 10–12 years. Growth layers in the teeth (SC/Jn81/KW1) indicate that this length is attained at about 16 years.

There are no data on changes in the age at sexual maturity with level of exploitation.

3.6.2 Pregnancy rate

Reported pregnancy rates for adult females ≥ 16 ft vary from 14.8% to 42.3% (SC/Jn81/KW4). However, if gestation is more than 12 months, annual pregnancy rates calculated without allowing for foetuses from more than one breeding season will be too high. As shown in Appendix 5, there is definite bimodality in the length frequencies of foetuses from Antarctic catches. Pregnancy rates (including known pregnancies for females of less than 16 ft) recalculated to provide an annual rate corrected for a 15-month gestation period are given in Table 2.

There may be decreased reproductive activity in older females. Data from Antarctic 1979/80 catches indicate a decreasing proportion of pregnant females over 20 ft. There are in addition data on known pods in which adult females are known to have calved at three-year intervals while others have calved much less frequently or not at all in 7–10 years of observation. It appears that there may be social control maintaining relatively low levels of pregnancy.

3.6.3 Birth rates

Studies in British Columbia (SC/Jn81/KW4) and Greater Puget Sound (SC/Jn81/KW9) provide estimates of birth rate for calves which survived to an age of at least six months. Over the same seven-year study period, both studies yielded identical birth-rate information for pods studied in common, but the British Columbia study included more pods and is used here for a best estimate. Table 3 summarizes their data. The birth rate in cropped pods was slightly higher than that for uncropped pods. The estimated population birth rates correspond well with the observed ratio of 7.45% calves-and-juveniles to other ages noted by Best (1980) in Antarctic sighting cruises. Also, they are close to 2.99% ratio of newborn to other ages observed in aerial surveys in the Ross Sea and McMurdo Sound (SC/Jn81/KW6), although some field observations of higher proportions exist, e.g., Christensen (1978) reported a pod of 4–6 animals with one newborn calf and another pod of 15–20 with 5 small calves. However, while it had been considered that the birth rates for adult females were much lower than the pregnancy rates from some whaling records, a re-examination of pregnancy-rate data indicates a much closer correlation of birth and pregnancy rates (Appendix 6). The Committee discussed the discrepancy in rates but could not establish the cause. It could be due to some selection of pregnant whales by whalers, which could happen if females with calves are more difficult to capture, or due to high mortality of calves in the first six months of life.

3.6.4 Natural mortality rate

Natural mortality rates were estimated based on the disappearance of identifiable individuals in pods in the Vancouver Island study (SC/Jn81/KW4). Bulls, cows and juveniles all exhibited low overall rates. These data are presented in Table 3. In each case the cropped pods had a slightly lower rate than the uncropped pods. Further studies are needed to confirm the rates.

3.6.5 Net annual change in pod size

The annual net pod change was determined by following the sizes of individual pods over several years. The data are given in Table 3. The cropped pods have a slightly higher rate than the uncropped pods (SC/Jn81/KW4 and 9).

3.6.6 Length of gestation

The commonly quoted range for duration of gestation is 12–16 months (Nishiwaki and Handa, 1958). The duration is probably more than 12 months. A bimodal peak in foetal lengths occurred during January-March 1979/80 in the Antarctic (Appendix 6), indicating two developmental stages of foetal growth occurring at the same time. Additional data are available from captive animals. The conception time of a female at Marineland of the Pacific was determined to be at about mid-March 1979, based on progesterone levels (Dahlheim, pers. comm. 25 June 1981) and a calf was born prematurely on 1 April 1980, suggesting a gestation close to 15 months.

3.6.7 Length of lactation

There are no direct observations on the duration of lactation in killer whales, although the calf remains in close association with the mother for about a year after birth.

3.7 Species identity

The group discussed the new species, *Orcinus nanus*, proposed by Mikhalev, *et al.* (1981) based on data and specimens collected in the Southern Hemisphere, 1972–79.

Ivashin explained that the description is based on modal

Table 2

Killer whale pregnancy rates from catch data

Source		Length in feet 11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	Corrected % annual		
Norway (Jonsgård & Lyshoel, 1970)	♀					39	48	55	83	72	53	29	28	9	6	4	2	1	1	430		
	pregnant					1	8	9	12	10	4	4	5	3	2	0	0	0	1	59	51.6[1]	
	% of mature ♀					2.6	16.7	16.4	14.5	13.9	7.5	13.8	17.9	33.3	33.3	—	—	—	1.00	13.72%	12.00%	
Norway (SC/Jn81/KW1) (i) foetus present	♀					9	23	37	35	26	23	5	2	1						161		
	pregnant					1	11	16	15	6	5	1	0	1						56	46.7[2]	
	% of mature ♀					11.1	47.8	43.2	42.9	23.1	27.7	25	0	100						34.87%	28.9%	
(ii) ovarian examination	♀				7	4	3	16	13	8	8	2								61		
	mature ♀				0	2	2	16	13	8	8	2								51		
	pregnant				—	1	1	7	7	2	2	0								20	16.7[2]	
	% of mature ♀					50.0	50.0	43.1	53.9	25.0	25.0	—								39.22%	32.8%	
Antarctic (Mikhalev *et al.*, 1981)	♀							4	10	11	20	19	26	15	5	3				118		
	mature ♀							2	8	7	15	16	21	15	4	3				91	(50% of total)	
	pregnant								4	2	4	2	7	4	1	1				25	12.5	
1961/62 to 1978/79	% of mature ♀								50.0	28.6	26.7	12.5	33.0	26.7	25.0	33.3				27.47%	13.74%	
(IWS LXXXVI)	♀	1	1	3	6	9	25	66	46	60	85	88	56	17	2	2				466		
	estimated mature ♀	—	1	—	4	—	25	66	46	60	85	88	56	17	2	1				448	small	large
	pregnant		1		1		11	14	15	21	35	32	10	3	—	—				143	57	85
	% of mature ♀	100			25.0	44.0	21.2	32.6	33.0	41.2	36.4	17.9	17.7	—	—					31.92%	12.72%	18.97%

[1] Where corrected value = No. pregnant $-0.5 \times 3/12$ (No. pregnant)
[2] Where corrected value = No. pregnant $-0.5 \times 6/18$ (No. pregnant)

Table 3

Rates of birth, natural mortality and net pod change in cropped, uncropped and combined pods off British Columbia and Washington, 1973–81

Parameter	Source	Cropped (%)	Uncropped (%)	Combined (%)
Birth rate				
Adult females[1]	SC/Jn81/KW4	11.64	8.02	10.30
	SC/Jn81/KW9	8.90	—	—
Population[2]	SC/Jn81/KW4	4.56	3.15	3.90
	SC/Jn81/KW9	2.60	—	—
Natural mortality rate				
Bulls	SC/Jn81/KW4	2.50	3.06	2.81
Cows	SC/Jn81/KW4	0.46	1.52	0.70
Juveniles	SC/Jn81/KW4	1.99	4.35	2.30
Total	SC/Jn81/KW9	0.80	—	—
Net pod change	SC/Jn81/KW4	3.01	1.67	2.52
	SC/Jn81/KW9	2.30	—	—

[1] ≥ 16 ft

[2] = $\frac{\text{No. calves}}{\text{No. all other ages}}$

differences between a dwarf form and the ordinary killer whale in external proportions, weight of gonads, length at attainment of sexual maturity and maximum length. The dwarf form on the average has relatively larger anterior measurements, a higher and longer-based dorsal fin placed closer to the head, larger flippers placed closer to the head, larger flukes and a shorter peduncle than does the ordinary killer whale. The weight of the testes in the dwarf form at 6.1–6.5 m is the same as in the ordinary killer whale at 7.1–7.5 m. The ovaries of dwarf females 18–19 ft long weigh the same as those of 25 ft long ordinary females, and dwarf females 5.6–6 m long have the same number of ovarian corpora as do ordinary females 7.5–8 m long. Maximum length for the dwarf form is 7.5 m in males and 6.5 m in females, as opposed to 9.0 m and 7.7 m in the ordinary form. Ivashin emphasised that further data and analyses are desirable to adequately delineate the differences between the two forms and settle the question of whether a new species or sub-species is involved. He suggested that studies of colour-pattern differences and of sound production may be helpful in this regard. Ongoing studies of 1979/80 data and specimens by Berzin of TINRO, Vladivostok may also contribute to description of variation of killer whales in the Antarctic.

The group believes that the data are more suggestive of sub-specific-level differentiation than of existence of an unrecognised species, as the differences are modal rather than absolute. In any case, under the international rules of zoological nomenclature, the name *Orcinus nanus* Mikhalev *et al.* 1981 is at this point a *nomen nudem*, because it is not accompanied by figure, diagnosis and designation of a holotype specimen. These items will presumably be included in the final description of the dwarf form.

4. SUMMARY OF CONCLUSIONS

4.1 Nearly every area of the world's ocean that has been examined contains killer whales, but there are obvious concentrations of abundance, mainly within a few hundred miles of coasts and in high latitudes.

4.2 There is not a strong case for extensive migrations, with the exception of migration with the retreating ice edge in polar areas. This suggests the existence of local populations.

4.3 There is good evidence for a high degree of isolation over a few hundred miles for coastal animals, but the data are inadequate to define larger units. Pelagic animals may have larger ranges. Some members of the group believe that while the existence of broader regional groupings has been proposed, the application of a broader-scale concept of stock areas for management by analogy with species such as sperm and baleen whales is not appropriate for this species.

4.4 The sorts of population units (groups of pods or 'communities') that can be defined with present methods probably contain only tens or hundreds of animals.

4.5 Given the extreme stability of local populations and the low reproductive rates evidenced by the available data, any exploitation can be expected to have long-term impacts on population size and structure.

5. RECOMMENDATIONS FOR RESEARCH

5.1 Noting that a large sample (916) of killer whales was taken in 1979/80 by the USSR and not yet fully reported upon, the meeting recommends that the USSR be asked to provide a report at next year's meeting of the Scientific Committee detailing the specimens and data available, including analysis of sightings per effort. Also, specific questions were raised about hunting strategy of the whalers which may have biased the age structure and size structures of the catch; these should be addressed by the report.

5.2 Noting that the question of number of stock(s) of killer whales in the waters near Antarctica remains unresolved, the meeting recommends that studies be continued on existing data bases concerning colour patterns and morphology of killer whales taken and that acoustic methods of distinguishing pods and populations by their vocalisations be further explored.

5.3 Noting that the social and breeding population structure of Southern Hemisphere killer whales has not been studied and might be different from that of eastern North Pacific killer whales reported here, the meeting recommends that reports be solicited from other researchers in the Southern Hemisphere to ascertain whether differences exist.

5.4 Noting that specimen materials exist in public museums and various institutions that have not been examined and described in the literature and that they potentially could yield valuable data on age and morphological variation, the meeting recommends that these materials be inventoried and that their study be encouraged.

5.5 Noting that inadequate information exists for stock definition of the killer whale population in Norwegian coastal waters, the meeting recommends that research be carried out to provide this and other information necessary for adequate stock assessment. The programme of marking to study movements should continue. The possibility of using natural marks should be investigated. Considering the existence of a live-capture fishery in Icelandic waters, the same recommendation should be made to Iceland.

5.6 Noting that teeth for age determination have not been consistently collected for all killer whales taken commercially or found stranded, the meeting recommends that in the future every effort be made to collect and examine such materials, as well as gonads, stomach contents, morphometric and meristic data, and other biological materials whenever possible.

5.7 Precise data on locality and date of capture for the

live-capture fishery in Iceland and elsewhere should be provided to the Scientific Committee.

5.8 Noting that chromosomal and biochemical studies may yield information concerning stock and populations of killer whales, the meeting recommends that such studies be undertaken for all killer whales currently in captivity, and, whenever opportunity exists, to conduct such studies on stranded and harvested whales and whales in the wild.

5.9 Noting that field studies of killer whales in waters around Vancouver Island and in Greater Puget Sound have produced significant new information concerning vital parameters, as well as precise assessments of the local populations, the meeting recommends that such studies be continued, in order to accurately determine: (1) at what age killer whales become adult, (2) age-specific birth and mortality rates, and (3) immigration/emigration rates for the local population, especially as they may correlate with changes in the habitat. It is further recommended that similar studies be encouraged in other areas of the world for comparative purposes.

5.10 Existing data on dates and localities of take of killer whales in Japanese coastal waters should be made available and analysed to elucidate patterns of distribution and abundance in that area.

REFERENCES

Aguayo, A. L. 1975. Progress report on small cetacean research in Chile. *J. Fish. Res. Bd Can.* 32: 1123–43.

Anon. 1981. Japan progress report on cetacean research, June 1979–May 1980. *Rep. int. Whal. Commn* 31: 195–200.

Árnason, Ú., Lutley, R. and Sandholt, B. 1980. Banding studies on six killer whales: an account of C-band polymorphism and G-band patterns. *Cytogenet. Cell Genet.* 28: 71–8.

Balcomb, K. C., Boran, J. R., Osborne, R. W. and Haenel, N. J. 1980. Observations of killer whales (*Orcinus orca*) in Greater Puget Sound, State of Washington. Final Report to the Marine Mammal Commission. Contract No. MM1300731–7.

Barr, N. and Barr, L. 1972. An observation of killer whale predation on a Dall porpoise. *Can. Field-Nat.* 86(2): 170–71.

Best, P. B. 1971. Order Cetacea. Part 7. *In*: J. Meester and H. W. Setzer (Eds.). *The Mammals of Africa. An Identification Manual.* Washington, D.C. Smithsonian Institution. ISBN 0 87474 116 5.

Best, P. B. 1980. Notes on abundance of killer whales in Antarctic Areas III and IV. Paper SC/32/SM10 presented to the IWC Scientific Committee, June, 1980 (unpubl.).

Blokhin, S. A. 1981. The results of the cruise of the whaler *Recordniy* in the coastal waters of Australia in March, 1979. *Rep. int. Whal. Commn* 31: 723–7.

Brown, D. H. and Norris, K. S. 1956. Observations of captive and wild cetaceans. *J. Mamm.* 37(3): 311–26.

Brownell, R. L. Jr. 1974. Small odontocetes of the Antarctic. *Am. Geogr. Soc., Antarctic Map Folio* 18: 13–19, pls. 8–9, 11.

Budylenko, G. A. 1981. Distribution and some aspects of the biology of killer whales in the South Atlantic. *Rep. int. Whal. Commn* 31: 523–5.

Caldwell, D. K. and Caldwell, M. C. 1969. Addition of the leatherback sea turtle to the known prey of the killer whale, *Orcinus orca*. *J. Mamm.* 50(3): 636.

Caldwell, D. K. and Caldwell, M. C. 1975. Dolphin and small whale fisheries of the Caribbean and West Indies: occurrence, history and catch statistics—with special reference to the Lesser Antillean Island of St Vincent. *J. Fish. Res. Bd Can.* 32: 1105–10.

Christensen, I. 1975. Preliminary report on the Norwegian fishery for small whales: expansion of Norwegian whaling to Arctic and northwest Atlantic waters, and Norwegian investigations of the biology of small whales. *J. Fish. Res. Bd Canada* 32: 1083–94.

Christensen, I. 1978. Spekkhoggeren (*Orcinus orca*): i det Nordøstige Atlanterhav. (The killer whale in the northwest Atlantic). *Fisken Hav. 1978* (1): 23–31.

Christensen, I., Jonsgård, A. and Rørvik, C. 1981. Catch statistics for minke whales (*Balaenoptera acutorostrata*) and killer whales (*Orcinus orca*) caught by Norway in 1979. *Rep. int. Whal. Commn* 31: 635–7.

Clarke, R. 1981. Whales and dolphins of the Azores and their exploitation. *Rep. int. Whal. Commn* 31: 607–15.

Cook, J. H. 1926. *Pursuing the Whale: A Quarter Century of Whaling in the Arctic.* Houghton Mifflin, New York. 344 p.

Dahlheim, M. E. 1981. A review of the biology and exploitation of the killer whale, *Orcinus orca*, with comments on recent sightings from Antarctica. *Rep. int. Whal. Commn* 31: 541–50.

Doroshenko, N. V. 1978. On the relationship (predator-prey) between the killer whale and the minke whale in the Antarctic. pp. 107–109. In: *Marine Mammals. Abstracts of Reports to the 7th All-Union Meeting*, Moscow.

Duffield, D. and Cornell, L. 1979. Observations on population structure and dynamics in *Orcinus orca*. Third Bien. Conf. Biol. Mar. Mammals (Abst.). October 7–11, 1979. Seattle, Wa.

Evans, W. E. and Yablokov, A. V. 1982. Geographic variation in the color pattern of killer whales (*Orcinus orca*). Paper SC/Jn81/KW11 (published in this volume).

Fay, F. H., Shultz, R. M. and Djeterich, R. A. 1979. Natural mortality of marine mammals in Alaskan waters. (Abstr), *Amer. Assoc. Advan. Sci., Proc. 29th Alaskan Sci. Conf.*

Grieg, J. A. 1889. Cetologiske notiser. (Cetacean notes). *Bergens Mus. Årb.* 4: 1–25. (In Norwegian.)

Ivashin, M. V. 1981. USSR Progress report on cetacean research June 1979–May 1980. *Rep. int. Whal. Commn* 31: 221–28.

Ivashin, M. V. and Votrogov, L. M. 1981. Killer whales, *Orcinus orca*, inhabiting inshore waters of the Chukotka Coast. *Rep. int. Whal. Commn* 31: 521.

Jehl, J. R., Evans, W. E., Awbrey, F. T. and Drieschmann, W. S. 1980. Distribution and geographic variation in the killer whale (*Orcinus orca*) populations of the Antarctic and adjacent waters. *Arct. J.* 15(5): 161–3.

Jonsgård, A. and Lyshoel, P. B. 1970. A contribution to the knowledge of the biology of the killer whale, *Orcinus orca* (L.) *Norweg. J. Zool.* (Nytt mag. Zool.) 18(1): 41–8.

Kasuya, T. 1971. Consideration of distribution and migration of toothed whales off the Pacific coast of Japan based upon aerial sighting record. *Sci. Rep. Whales Res. Inst., Tokyo* 23: 37–60.

Leatherwood, J. S. and Dahlheim, M. E. 1978. Worldwide distribution of pilot whales and killer whales. NOSC Tech. Rep. 295, Naval Ocean System Center, San Diego, Ca. 92152. 39 p.

Martinez, D. R. and Klinghammer, E. 1970. The behaviour of the whale, *Orcinus orca:* a review of the literature. *Z. Tierpsychol.* 27: 828–39.

Mikhalev, Yu. A., Ivashin, M. V., Savusin, V. P. and Zelenya, F. E. 1981. The distribution and biology of killer whales in the Southern Hemisphere. *Rep. int. Whal. Commn* 31: 551–65.

Mitchell, E. 1975. Porpoise, dolphin and small whale fisheries of the world. *IUCN Mono. No. 3.*

Mitchell, E. and Baker, A. N. 1980 [1981]. Age of reputedly old killer whale, *Orcinus orca*, 'Old Tom' from Eden, Twofold Bay, Australia. *Rep. int. Whal. Commn* (special issue 3): 143–54.

Nikulin, P. G. 1941. Chukotskii morzh (Chukotsky walrus), Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. (TINRO) 20: 21–59. (In Russian.) [Transl. by Bur. Commer. Fish., Seattle, Wa., 1953, 52 p.]

Nishiwaki, M. and Handa, C. 1958. Killer whales caught in the coastal waters off Japan for recent 10 years. *Sci. Rep. Whales Res. Inst., Tokyo.* 13: 85–96.

Norris, K. S. and Prescott, J. H. 1961. Observations on Pacific cetaceans of California and Mexican waters. *Univ. of Cal. Publ. Zool.* 63(4): 291–402.

Pike, G. C. and MacAskie, I. B. 1969. Marine mammals of British Columbia. *Fish. Res. Bd Can. Bull.* 171: 1–54.

Rice, D. W. 1968. Stomach contents and feeding behavior of killer whales in the eastern North Pacific. *Norsk Hvalfangsttid,* 57(2): 35–8.

Richardson, W. J. (ed.) 1981. Behavior, disturbance responses and feeding of bowhead whales in the Beaufort Sea, 1980. Report to the U.S. Bureau of Land Management by LGL Ecological Consultants.

Scammon, C. M. 1872. The orca. *Overland Monthly* 9(1): 52–7.

Scheffer, V. B. and Slipp, J. W. 1948. The whales and dolphins of Washington State. *Amer. Midl. Nat.* 39: 257–337.

Sergeant, D. C. and Fisher, H. D. 1957. The smaller Cetacea of eastern Canadian waters. *J. Fish. Res. Bd Can.* 14: 83–115.

Sleptsov, M. M. 1961. Nablyudeniya nad melkimi kitoobraznymi v Dal'Nevostochnykh moryakh i severo-zapadnoy chasti tikhogo okeana (Observations of small cetaceans in far eastern seas and northwest Pacific). *Tr. Inst. Morf. Zhiv.* 34: 136–43. (In Russian.) (Transl. U.S. Naval Oceanographic Office, Washington, D.C. 20390, 1970. Transl. 482).

Smith, T. G., Siniff, D. B., Reichie, R. and Stone, S. In press. Coordinated behaviour of killer whales, *Orcinus orca,* hunting a crabeater seal, *Lobodon carcinophagus*. *Can. J. Zool.*

Tarpy, C. 1979. Killer whale attack. *Nat. Geog.* 155(4): 540–45.

Tomilin, A. C. 1957. *Kitoobraznye* (Cetacea). Vol. IX of *Zveri SSSR i prilezhashchikh stran* (Mammals of the USSR and Adjacent Countries). Izd. Akad. Nauk SSSR, Moskva, 756 pp. (In Russian.) (Transl. by Israel Program Sci. Transl., 1967, 717 pp., avail. Natl. Tech. Inf. Serv., Springfield, Va.).

Wada, S. 1981. Japanese whaling and whale sighting in the North Pacific 1979 season. *Rep. int. Whal. Commn* 31: 783–86.

Wang, P. 1979. Investigations on the medium and small size tooth whales of the Yellow Sea and Bohai Sea. *Zool. Mag.* 2: 31–3.

Wellings, C. E. 1944. Killer-whales of Twofold Bay, NSW Australia Grampus area. *Aust. Zool.* 10(3): 291–3.

Zenkovich, B. A. 1938. O kosatke ili kite-ubiitse (On the grampus or killer whale, *Grampus orca* Lin.). *Priroda, Acad. Sci. USSR* 4: 109–112 (In Russian.). (Engl. transl. avail. through Natl. Mar. Mammal Lab., Seattle, Wa 98115).

Appendix 1

AGENDA

1. Participants and agenda
2. Background of the meeting
   - 2.1. The northeastern Atlantic
   - 2.2. The Southern Hemisphere
3. Review of existing information
   - 3.1. Distribution and migration
     - 3.1.1. North Atlantic
     - 3.1.2. Southern Hemisphere
     - 3.1.3. North Pacific
   - 3.2. Geographical variation in:
     - 3.2.1. Morphology
       - 3.2.1.1. External and skeletal size and shape
       - 3.2.1.2. Meristics
       - 3.2.1.3. Colouration
     - 3.2.2. Sound production
     - 3.2.3. Behaviour
     - 3.2.4. Biochemical and chromosomal characters
     - 3.2.5. Food habits
   - 3.3 History of catches with respect to geographical sub-areas.
     - 3.3.1. North Atlantic
     - 3.3.2. Southern Hemisphere
     - 3.3.3. Other areas
   - 3.4. Age and sex structure of catches
     - 3.4.1. Live capture for display
     - 3.4.2. USSR pelagic catches in the Southern Hemisphere
     - 3.4.3. Other coastal catches
   - 3.5. Definition of breeding unit
     - 3.5.1. Size
     - 3.5.2. Structure
     - 3.5.3. Stability
   - 3.6. Vital parameters
     - 3.6.1. Age at sexual maturity
     - 3.6.2. Pregnancy rate
     - 3.6.3. Birth rate
     - 3.6.4. Natural mortality rate
     - 3.6.5. Net annual change in pod size
     - 3.6.6. Length of gestation
     - 3.6.7. Length of lactation
   - 3.7. Species identity
4. Summary of conclusions
5. Recommendations for research
6. Literature cited
7. Other business
   - 7.1 Production of the meeting report
   - 7.2 Publication of the meeting documents

Appendix 2

LIST OF DOCUMENTS SUBMITTED TO THE MEETING

SC/Jn81/KW1* Christensen, I. Killer whales in Norwegian coastal waters.

SC/Jn81/KW2* Braham, H., Dahlheim, M. and Consiglieri, L. Killer whales in Alaska from at sea sightings documented in the U.S. Platforms of Opportunity Program.

SC/Jn81/KW3* Dahlheim, M., Leatherwood, J. S. and Perrin, W. F. Distribution of killer whales in the warm temperate and tropical eastern Pacific.

SC/Jn81/KW4* Bigg, M. An assessment of killer whale, *Orcinus orca,* stocks off Vancouver Island, British Columbia.

SC/Jn81/KW5 Jehl, J. R., Evans, W. E., Awbrey, F. T. and Dreischman, W. S. Distribution and geographic variation in the killer whale, *Orcinus orca,* populations in the Antarctic and adjacent waters.

SC/Jn81/KW6 Thomas, J. A., Awbrey, F. T., Leatherwood, J. S. Evans, W. E. and Jehl, J. R. Ross Sea killer whale, *Orcinus orca,* distribution, behaviour, colour pattern and vocalizations.

SC/Jn81/KW7* Awbrey, F. T., Evans, W. E., Thomas, J. A., and Leatherwood, J. S. Comparison of Ross Sea and Pacific northwest killer whale vocalizations.

SC/Jn81/KW8* Ford, J. K. B. and Fisher, H. O. Killer whale, *Orcinus orca,* dialects as an indicator of stocks in British Columbia.

SC/Jn81/KW9* Balcomb, K. C. III., Boran, J. R. and Heimlich, S. L. Killer whales in Greater Puget Sound, a population ideally suited for statistical modelling.

SC/Jn81/KW10 Ohsumi, S. Distribution and abundance of killer whales in the Southern Hemisphere.

SC/Jn81/KW11* Yablokov, A. V. and Evans, W. E. Geographic variation in the color pattern of killer whales (*Orcinus orca*).

* Published in this volume.

Appendix 3

LITERATURE CITATIONS DOCUMENTING KILLER WHALE SIGHTINGS CORRESPONDING TO GEOGRAPHIC AREAS OF DISTRIBUTION DEPICTED IN TEXT AND FIGURES 1 AND 2

Area	Literature citations
Atlantic Ocean	
Northeast (including Greenland and Barents Seas)	Geptner (1936) and Chapskii (1941) cited in Tomilin (1957); Jonsgård and Lyshoel (1970); Christensen *et al.* (1981); SC/Jn81/KW1.
Northwest	Sergeant and Fisher (1957).
Central	
Caribbean	Caldwell and Caldwell (1975).
Azores	Clark (1981).
West Africa	Bourne (1965) cited in Mitchell (1975); Evans and Yablokov (In ms).
Southern	
South America	Aguayo (1975); Budylenko (1981).
Africa	Budylenko (1981).
Pacific Ocean	
Northeast	
Alaska	Wada (1981); SC/Jn81/KW2.
North America and Mexico	Scheffer and Slipp (1948); Norris and Prescott (1961); Pike and MacAskie (1969); Balcomb *et al.* (1980); SC/Jn81/KW3, SC/Jn81/KW4; SC/Jn81/KW9.
Northwest	
Japan–China	Nishiwaki and Handa (1958); Kasuya (1971); Wang (1979); Anon. (1981); Wada (1981).
Pacific Ocean (continued)	
USSR	Zenkovich (1938); Nikulin (1941); Tomilin (1957); Sleptsov (1961); Ivashin and Votrogov (1981).
Central	
Eastern	SC/Jn81/KW3.
Hawaii	Richards (1952) cited in Leatherwood and Dahlheim (1978). SC/Jn81/KW3.
Southern	
South America	SC/Jn81/KW10.
Western	Blokhin (1981); SC/Jn81/KW10.
Indian Ocean	
Africa	Best (1971).
Australia	Blokhin (1981).
Arctic Ocean (US)	Cook (1926); Sleptsov (1961); Richardson (1981).
Antarctic Ocean	
Atlantic	Brownell (1974); Jehl *et al.* (1980); Dahlheim (1981).
Pacific	Brownell (1974); Jehl *et al.* (1980); Dahlheim (1981).
Indian	Brownell (1974); Best (1980).

Appendix 4

FOOD ITEMS OF KILLER WHALES BY GEOGRAPHIC AREAS

Area	Food Items	References
Atlantic Ocean		
Northeast	Herring (*Clupea spp.*) cod and squid, 'seal', birds (Norway), salmon (England).	Lepekhin (1805) cited in Tomilin (1957); Pike and MacAskie (1969); Jonsgård and Lyshoel (1970); Norman and Fraser (1949) cited in Martinez and Klinghammer (1970); SC/Jn81/KW1.
Northwest	Minke whale (*Balaenoptera acutorostrata*), seals (harp seal? *Phoca groenlandica*).	Sergeant and Fisher (1957).
Caribbean (St Vincent)	Leatherback turtle (*Dermochelys coriacea*), pygmy sperm whale (*Kogia breviceps*), *Stenella spp.*, sperm whale (*Physeter macrocephalus*), squid.	Caldwell and Caldwell (1969); R. V. Walker (unpublished).
Southern	Dolphins, fishes, pinnipeds.	Shevchenko (1975) cited in Budylenko (1981).
Pacific Ocean		
Arctic and Sub-Arctic	Walrus (*Odobenus rosmarus*), bearded seal (*Erignathus barbatus*), ringed seal (*Phoca hispida*), salmon (*Oncorhynchus spp.*), northern sea lion (*Eumetopias jubatus*), Alaskan fur seal (*Callorhinus ursinus*), gray whale (*Eschrichtius robustus*), bowhead whale (*Balaena mysticetus*), white whale (*Delphinapterus leucus*).	Scammon (1872); Cook (1926); Zenkovich (1938); Nikulin (1941); Nishiwaki and Handa (1958); Fay *et al.* (1979); SC/Jn81/KW2.
Northeast	Calfornia sea lion (*Zalophus californianus*), elephant seal (*Mirounga angustirostris*), Dall's porpoise (*Phocoenoides dalli*), harbor porpoise (*Phocoena phocoena*), striped dolphin (*Stenella coeruleoalba*), salmon, Pacific halibut (*Hippoglossus hippoglossoides*), merganseropah (*Mergus serrator*), harbor seal (*Phoca vitulina*), deer (*Odocoileus sp.*), squid (moon fish), carcharhinid shark, minke whale, blue whale (*Balaenoptera musculus*), ray (*Torpedo californica*), common dolphin (*Delphinus delphis*), greenling (*Hexagrammidae sp.*), Ling cod (*Ophiodon elongatus*).	Scheffer and Slipp (1948); Brown and Norris (1956); Nishiwaki and Handa (1958); Norris and Prescott (1961); Rice (1968); Barr and Barr (1972); Tarpy (1979); Balcomb *et al.* (1980);
Northwest	Cod (*Gadus* spp.), flatfish, sardine, salmon, tuna, mackerel, Atka mackeral, bonito, cephalopods (squid and octopus), Dall's porpoise, striped dolphin, Baird's beaked whale (*Berardius bairdii*), goose-beaked whale (*Ziphius cavirostris*), sei whale (*Balaenoptera borealis*), pilot whale (*Globicephala macrorhynchus*), finless porpoise (*Neophocaena phocaenoides*), harbor seal.	Nishiwaki and Handa (1958).
Southern	No data.	

Appendix 4—*continued*

Area	Food Items	References
Indian Ocean	Pygmy sperm whale (*Kogia* spp.), minke whale (*Balaenoptera acutorostrata*), elephant seal (*M. leonina*).	P. Best (unpublished).
Antarctic	Antarctic cod (*Dissostichus mowsoni*), adelie penguin, crabeater seal (*Lobodon carcinophagus*), minke whale, pinnipeds, squid, fish, leopard seal (*Hydrurga leptonyx*), southern elephant seal (*M. leonina*).	Ivashin (1981); Mikhalev *et al.* (1981); Siniff and Bangston (1977) and Carrick and Ingham (1962) cited in Smith *et al.* (1981); SC/Jn81/KW6.
Other	Skate, smelt, capelin, herring (*Clupea harengus*), right whale (*Balaena glacialis*), humpback (*Megaptera novaeangliae*), fin whale (*Balaenoptera physalus*), narwhal (*Monodon monoceros*), Weddell seal (*Leptonychotes weddelli*), sea otter (*Enhydra lutris*), white winged scoter (*Melanitta fisca leglandi*), black brant (*Branta nigricans*).	Tomilin (1957); Martinez and Klinghammer (1970).

Appendix 5

A RE-EXAMINATION OF PREGNANCY RATES AND CALF RATIOS IN *ORCINUS ORCA*

G. R. V. Anderson

INTRODUCTION

Estimates of pregnancy rates, and hence of expected numbers of young-of-year, observed birth rates and calf ratios have been reported as ranging from 5–42%. Variations of such magnitude may arise from extreme bias in sampling or for other reasons, and some resolution is required. Data from the 1979/80 USSR catch of killer whales in the Antarctic have been re-examined and pregnancy rates and expected numbers of young-of-year recalculated with account taken of a gestation period of 15 months.

PREGNANCY RATE DATA FROM ANTARCTIC CATCHES

Deriving estimated numbers of young-of-year from pregnancy rate data is relatively simple where gestation periods are 12 months or less and there is strong seasonality in breeding. Where a gestation period of greater than 12 months is expected, however, samples may include months in which both young to be born in that year and young conceived in that year are represented. Inflated estimates of birth rates may be produced. The tendency would be most marked in samples taken over a short period in which overlap may be expected.

Fig. 1 is a schematic representation of a strongly seasonal reproduction pattern with a 3 month breeding season and a 15 month gestation period—one pattern which may be considered for Antarctic killer whales. Killer whales were taken in January, February and March in 1980.

The distribution of 143 foetus lengths is given in Fig. 2. It is clearly bimodal.

Fig. 2b gives % frequency of pregnant females in the 1979/80 Antarctic killer whale catch by length. The significant number of pregnant females below 16 ft should

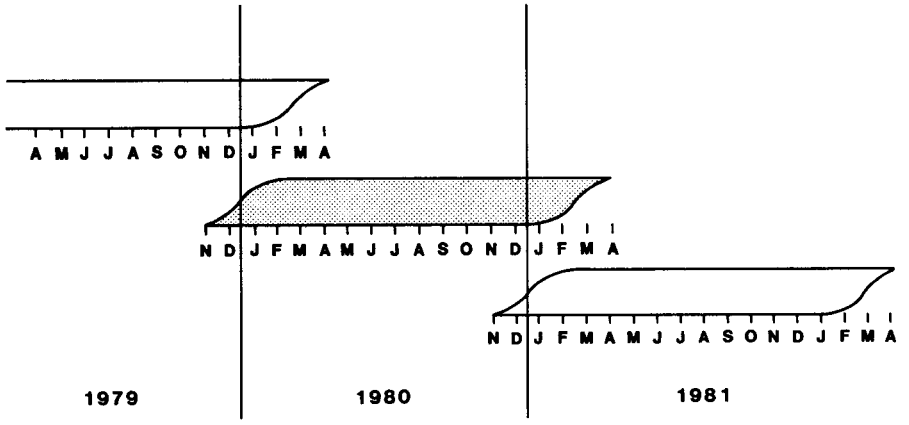

Fig. 1. 3-month breeding period and 15-month gestation.

be noted. No attempt has been made to remove females less than 16 ft from the following calculation.

The bimodal distribution of foetus lengths in Fig. 2a is consistent with a seasonal breeding pattern and a gestation period of more than 12 months as illustrated in Fig. 1. If those assumptions are correct, it is clear that using the overall pregnancy figures will result in an inflated pregnancy rate/female/year and in expected numbers of young-of-year. The bias will be dependent upon the degree of overlap during the sampling period.

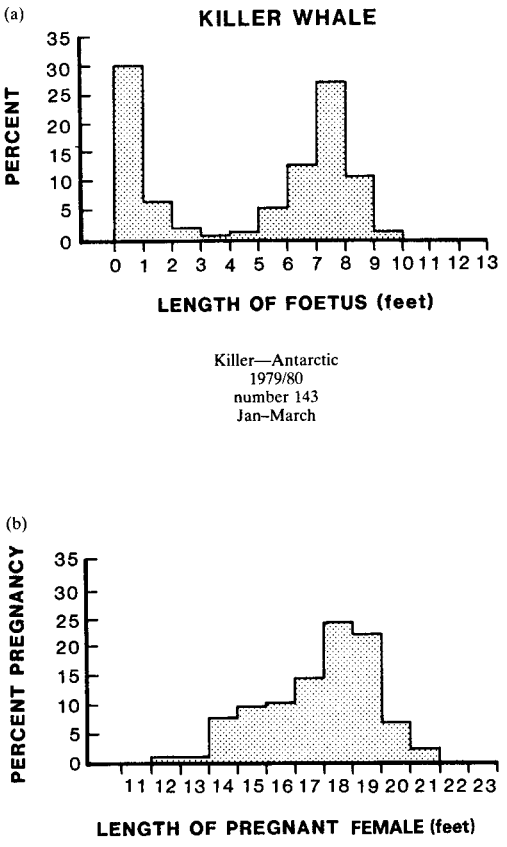

Fig. 2. Distribution of foetus lengths of 143 killer whale foetuses from USSR Antarctic catch 1979/80 (January–March) (a) and length distribution of pregnant females (b).

For comparison, summed foetal length distributions for several seasons are also given for minke whales, with a 12 month gestation period and unimodal length distribution, and for sperm whales, with an approximately 16 month gestation period and a bimodal length distribution (Fig. 3).

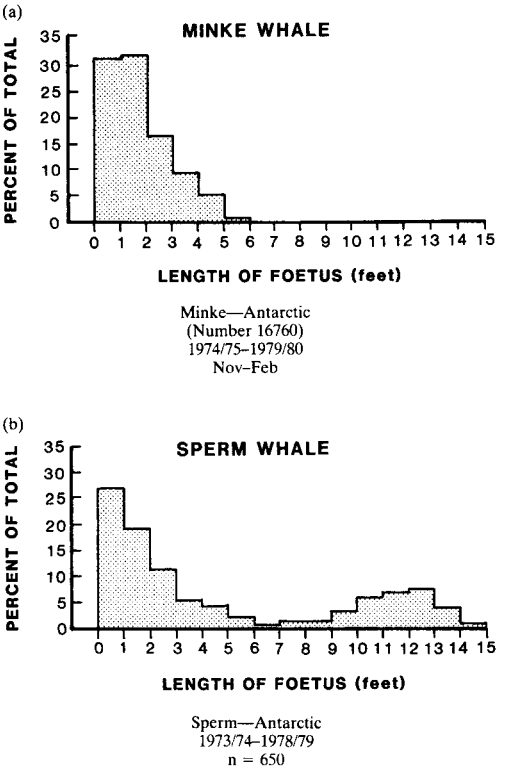

Fig. 3. Distribution of lengths of 1,670 minke whale foetuses (a) and 650 sperm whale foetuses (b) from Antarctic catches.

Antarctic killer whale catch 1979/80 (BIWS 1980)

From the distribution of foetal lengths in Fig. 2, the number of pregnancies resulting from 1980 impregnations can be gauged from the peak of small foetuses between 0–3 ft. The group of larger foetuses between 5 and 10 ft in length are 1978/79 impregnations near term, and two independent estimates of annual pregnancy rate can thus be obtained (see Table below).

Total catch	Immature ♀	Mature	Total pregnant	To term, 1980	Pregnancy/ mature ♀	To term, 1981	Pregnancy/ mature ♀	Average
916	34	428	143	85	0.199	57	0.133	0.166

Similar considerations apply to the data on pregnancy rates given by Mikhalev and Ivashin (1981) for 123 killer whales taken between November and March in the period 1961/62 to 1978/79. Two hundred and five males and 118 females were taken, 92 of which were examined for pregnancy; one was immature. Without foetal length distributions, it is assumed that only half of the pregnancies would lead to calves in the year of capture and the overall pregnancy rate has been halved to obtain the expected corrected pregnancies and the rate for an individual year per mature female (see Table below).

1961/62–1978/79

Total	Total ♀	Total examined	Mature	Pregnant	Overall rate/female	Corrected pregnancy of year/mature female
323	118	92	91	25	0.274	0.137

NORTHERN HEMISPHERE KILLER WHALE CATCHES

Estimates of pregnancy rates from Norwegian catches of killer whales for the period 1938/67 are given in SC/Jn81/KW4, Table 5 as 13.7%. Pregnancy rates were obtained from whales taken in most months of the year, unlike for the Antarctic catches. Correction of pregnancy rates to avoid the incorporation of more than one cycle of impregnation is less straightforward. As a first approximation, however, a correction may be made by reducing the overall pregnancy rate in proportion to months in which there is likely to be an overlap.

$$Pc = Po - 0.5 \frac{(G - 12)}{12} Po$$

Pc = corrected pregnancy rate.
Po = observed pregnancy rate.
G = gestation period in months (15 months).

$$Pc = 59/430 - 0.5\ 3/12\ (59/430)$$
$$= 0.120 \text{ pregnancies/mature female}$$

Data presented in SC/Jn81/KW1 are difficult to partition for the two years in question; foetuses over 100 cm given as occurring in the later September/February period do not appear in the earlier September/February period in Fig. 6. Conversely, foetuses under 100 cm in length are not reported for the second September/February period. As an approximation, however, if breeding is considered to be seasonal to a degree, with a peak in October/December for conception, then 6 of the 18 months listed will be months in which overlap in reproduction cycles occurs and

$$Pc = 51/129 - 0.5 \times 6/18\ (51/129)$$
$$= 0.33 \text{ pregnancies/mature female}$$

It is clear, however, that catches are not distributed evenly throughout the 18 months given in Fig. 6 of SC/Jn81/KW1, and the pregnancy/mature female can be expected to be less than the initially corrected figure.

No account has been taken in the foregoing of the possibility of proportional over-representation of pregnant females in catches through selection or through avoidance by females with calves of catch vessels. Should that occur, it would further depress the corrected pregnancy rate/mature female.

OBSERVED BIRTH RATES AND CALF RATIOS

Available observed birth rates and calf ratios for the northern Pacific and the Antarctic and their sources are given below

Birth rates					Source
0.089	calves/female/year				SC/Jn81/KW9
0.098	,, ,, ,,		cropped pods	}	SC/Jn81/KW4
0.069	,, ,, ,,		uncropped pods	}	

Calf ratios					
Calves	(Mature?) females	Calves/ female	All other ages		
5	37	0.135	94	cropped pods }	SC/Jn81/KW4
3	33	0.091	—	uncropped pods }	
6	58?	0.102	147		
51 (7–12 ft)	274	0.186	736	(Antarctic)	SC/32/SM10

In examining the Antarctic data in SC/32/SM10, it is clear that some of the calves present would have been more than one year old on the basis of length. It is also likely that all 1980 calves were not yet born at the time of the survey, and the figure has not been reduced to remove 1+ juveniles. Mature females were taken as 40% of the total number of whales other than calves sighted.