Annex O
Report of the IWC-ASCOBANS Working Group on Harbour Porpoises

8-10 March, 1999, Gatty Marine Laboratory, University of St Andrews, Scotland

1. WELCOME AND INTRODUCTIONS

Hammond welcomed members of the Working Group to the Gatty Marine Laboratory. Read was elected Chair. A list of participants is given in Appendix 1.

2. ADOPTION OF AGENDA

The revised agenda is given as Appendix 2.

3. APPOINTMENT OF RAPPORTEURS

Bravington, Northridge, Palka and Rosel acted as rapporteurs.

4. REVIEW OF BACKGROUND DOCUMENTS

A list of background documents used at the meeting is given as Appendix 3.

5. REVIEW OF ASCOBANS CONSERVATION OBJECTIVES

Read reviewed the goals of the meeting in light of the conservation objectives set forth by ASCOBANS. The aim of ASCOBANS is

> …to restore and/or maintain biological or management stocks of small cetaceans at the level they would reach when there is the lowest possible anthropogenic influence.

The interim objective of ASCOBANS is

> …to restore populations to, or maintain them at, 80% or more of carrying capacity.

In addition, the Bonn Convention, under which ASCOBANS was formed, states that the conservation status of a population will be considered favourable when

> …the range of the migratory species is neither currently being reduced nor is likely to be reduced on a long term basis;

and

> …the distribution and abundance of the migratory species approach historic coverage and levels to the extent that potentially suitable ecosystems exist and to the extent consistent with wise wildlife management.

The Working Group noted that ASCOBANS had

> …recognised that while it is difficult, and perhaps impossible, to determine carrying capacity, such a theoretical target level will allow the development and application of a longer-term approach, which will take into account the uncertainty, which is inevitably inherent in the data required to assess the status of stocks.

ASCOBANS further

> …agreed that this defined longer term approach was appropriate and that it should be developed further by the Advisory Committee in cooperation with other organisations, particularly the International Whaling Commission (Jensen, 1998).

The Working Group's terms of reference from the IWC Scientific Committee were as follows (Vely, 1991):

> The working group should provide scientific assistance to the Advisory Committee of ASCOBANS on issues relating to assessment of the status of harbour porpoises in the North Sea and adjacent waters. This assistance should include: generating plausible hypothesis regarding population structure; providing information on life history parameters, abundance and trends in abundance; identifying methodology to estimate bycatch levels; identifying demographic models to assess the status of populations in the North Sea and adjacent waters. The working group should report on its progress at the 1999 meeting of the Scientific Committee.

The Working Group agreed to develop the outline of a model that could ascertain whether present removal rates would allow populations of harbour porpoises to reach and/or be maintained at 80% of carrying capacity, and if not, what removal rates would achieve this objective. The Working Group also agreed that maintenance of range was an important objective, and that while the resultant model would make use of stocks based on biologically meaningful data, this did not preclude management on smaller spatial scales. This is how the Revised Management Procedure (RMP) of the IWC is implemented, and it provides a precautionary management approach.

6. DEFINITION OF GEOGRAPHICAL AREA

The Working Group noted that ASCOBANS, ICES and the SCANS (Small Cetacean Abundance in the North Sea) project all cover slightly different geographic areas of the Northeast Atlantic. For example, the ASCOBANS area includes the Baltic Sea, but excludes areas such as the Celtic Shelf (SCANS Block A). The Working Group agreed to include the Celtic Shelf (SCANS Block A) in its deliberations. There was general consensus that some other areas not included in the ASCOBANS area should also be included in the development of the model, because there is no evidence that the movement of porpoises between these regions and the ASCOBANS area is restricted. These regions are the west coasts of Ireland and Scotland, the Irish Sea, and waters north of 62°N in the North Sea.

There may be spatial non-congruence between available estimates of abundance and bycatch within the defined geographical area. Porpoise bycatches may be reported by ICES Division, for example, but abundance estimates are

Fig. 1. Harbour porpoise density (number of groups per km^2), estimated from the SCANS survey data, summer 1994. Density was estimated using a spatial model for line transect data.

available for individual SCANS blocks. However, methodologies exist to recalculate abundance estimates from the SCANS data for ICES Divisions or other spatial strata (e.g. see Fig. 1).

There was some discussion as to what defines the Baltic 'proper'. The group concluded that the ICES boundaries provide precision to area definitions. Thus, the 'Baltic Sea' was defined as ICES Division IIId.

7. INFORMATION ON TRENDS IN ABUNDANCE

The abundance of harbour porpoises is believed to have declined significantly in several locations within the ASCOBANS area, particularly in the Channel, southern North Sea and Baltic Sea. There was little new information available on this subject since the Small Cetacean sub-committee reviewed the situation in Dublin in 1995 (IWC, 1996). In the absence of other information, it is assumed that there are still no significant numbers of porpoises in the English Channel. There have been very few strandings, sightings or incidental catches reported in the Baltic Sea in recent years and it is assumed that the population remains at historically low levels. In the southern North Sea porpoises appear to be virtually absent from Dutch coasts during summer months, although the Working Group was informed that a recent paper has suggested a possible increase in summer sightings of porpoises in Dutch waters. However, there are no data to determine whether abundance has increased in other areas of the southern North Sea.

8. INFORMATION ON BYCATCH

The Working Group reviewed available information on porpoise bycatches in the ASCOBANS area as summarised by Bravington *et al.* (IWC, 1999b). Information on bycatches of harbour porpoises in the large Danish gillnet fisheries is presented in Vinther (1995). Gillnets constitute a significant proportion of UK fishing effort, and the estimated annual porpoise bycatch for UK gillnet fisheries in the North Sea between 1995 and 1997 was 600-800 animals per year (Northridge, pers. comm.). Significant Norwegian gillnet fisheries may occur in the ASCOBANS area as well (particularly in ICES Division IVa), but bycatch from these fisheries has not been quantified.

Estimated annual bycatches of harbour porpoises for the UK and Irish fleets on the Celtic Shelf between 1993 and 1994 was 2,200 animals per year (Tregenza *et al.*, 1997). This estimate is negatively biased as only boats larger than 15m were monitored. Furthermore, data for French vessels operating in this area were not available.

Other fisheries operate outside the ASCOBANS area and experience bycatch that may impact stocks of porpoises within the area; these include an Anglo-Spanish gillnet fleet off the west coasts of Ireland and Scotland and a UK gillnet fishery operating off the west coast of Scotland. Bycatch estimates for other areas may be found in IWC (1996) and Bravington *et al.* (IWC, 1999b).

The Working Group noted that a variety of other fisheries exist for which no bycatch estimates are available (e.g. trawl fisheries, the salmon driftnet fishery along the east coast of England, mackerel driftnet fisheries off the coasts of Sweden and Norway, and many gillnet fisheries operating in the Baltic Sea). Bycatches of porpoises are known to occur in these fisheries, but no estimates of bycatch are available. The EU trawl fishery discard project may provide information on the general magnitude of porpoise bycatch in this fishery. The Working Group recommends that estimates of bycatch from all fisheries operating in the ASCOBANS area be generated and made available to ASCOBANS.

9. DEMOGRAPHIC PARAMETERS

9.1 Harbour porpoise life history

The Working Group noted new information in a report prepared by Lockyer and Kinze (1999) for BYCARE updating values of life history parameters for harbour porpoises from waters around Denmark - chiefly ICES Divisions IVb, IIIas, IIIan, IIIb and IIIc. Samples came from a comprehensive database containing nearly 1,900 records obtained from 1834 to the present; most records were from directed catches and incidental takes. Harbour porpoises in Danish waters appear very similar in most characteristics to those around the British Isles. Sexual maturity occurs between ages three and four in both females and males; conception most likely occurs during August; most births occur in June after a gestation of about 10 months; there is a slight bias towards males in the foetal stage; the average ovulation interval is about 1.5 years, i.e. the reproductive interval is one or two years. The age distribution was dominated by young animals; the largest age class was 0+ in both sexes, maximum longevity was 22-23 years and few animals older than 15 years were present in the sample.

9.2 Rate of increase

Three studies have estimated maximum rate of increase for harbour porpoise populations using demographic models (Barlow and Boveng, 1991; Woodley and Read, 1991; IWC, 1999c). Each study had slightly different objectives and generated different estimates. The studies differed primarily in their estimation of the mortality schedule, although all three used schedules generated from other mammals. Woodley and Read (1991), using an age-specific population model with a mortality schedule from Himalayan thar, estimated the maximum rate of increase as approximately 5%. Barlow and Boveng (1991), using a mortality schedule from a human, and scaled so that only 1% of the population lived for more than 10 years, estimated the maximum rate of increase to be approximately 9.5%. (Barlow noted that modifying longevity so that 1% live past 15 years resulted in a maximum rate of increase of 15%). Caswell *et al.* (1998) re-sampled nine mortality schedules from other mammals and re-scaled the resulting distributions to the age of first reproduction. The median value of the maximum rate of increase in these simulations was approximately 10%. The Working Group noted several of the mortality schedules used in the Caswell *et al.* (1998) paper were not plausible for harbour porpoise populations and, thus, the median value of 10% was positively biased. The Working Group agreed to use an estimate of maximum rate of increase of 4% in the simulation model, noting that it was unlikely that the actual value was less than this figure.

9.3 Density-dependence

The Working Group first considered the relationship between *r* (population rate of increase) and *K* (population carrying capacity). The maximum net productivity level (MNPL) for marine mammals is generally believed to occur between 60% and 70% of *K*. The Working Group agreed that a value of 60% should be used in the model. Harbour porpoises have relatively short life spans and higher reproductive rates than most cetaceans, and are thus comparatively '*r*-selected.' This suggests they may have MNPL values closer to 50% of *K* than other cetaceans. The Working Group therefore agreed that it would also be appropriate to investigate the effect of an MNPL of 50% of *K* in simulation trials (see below).

Changes in survival rates, age at sexual maturity and fecundity could all cause *r* to vary in a density-dependent fashion. No time series of fecundity is available for any porpoise population, but there are differences in fecundity among populations, demonstrating that fecundity is a potential source of variation in *r*. Changes in age at sexual maturity have been documented for Bay of Fundy porpoises (Read and Gaskin, 1990), but the Working Group considered that, for a stage-structured model, such changes would be very difficult to model, and would be equivalent to increasing survival in the immature stage. Changes in immature survival seem likely to be significant, but are very difficult to detect or measure. Similarly, changes in adult survival rates are very difficult to demonstrate and there is no *a priori* reason to expect them. The Working Group therefore agreed that the simulation trials should address possible density-dependent changes in immature survival and fecundity only (see Item 11).

10. PLAUSIBLE HYPOTHESES OF STOCK STRUCTURE

10.1 Definition of stock boundaries

The Working Group received a summary of a BYCARE report on porpoise population structure in the Northeast Atlantic (IWC, 1999a). Over 600 animals were sampled from the region and comparisons made using variation in 12 polymorphic microsatellite DNA loci. The region was divided into five areas (inner Danish Waters including the Baltic Sea, Danish North Sea, British North Sea, Ireland and the Netherlands), although the exact delimitation of these areas was difficult to determine. Numerous pair-wise comparisons were made among these areas and various sex/season/area combinations. Using an F_{ST} measure of population sub-division, there was some indication of population structure, although absolute differences among the five areas were very small. The Working Group noted that mitochondrial DNA studies had yielded greater differences among putative populations, and it was suggested that this might be due to female philopatry. The Working Group concluded, therefore, that it would be more appropriate to use existing mitochondrial DNA studies to determine stock structure.

Tiedemann reported that there is good evidence from analyses of mtDNA sequence patterns for a distinct Baltic stock, but that it was not clear how or where this merged with the neighbouring stock in the inner Danish Waters. A precautionary approach would be to treat the small Baltic stock as distinct from the inner Danish waters, where large numbers of porpoises are present. It was noted that the Baltic is a huge area, and that some population structure within the Baltic might be expected. Tiedemann reported some clinal variation mitochondrial haplotypes in Baltic porpoises when moving from east to west (Tiedemann *et al.*, 1996). It was agreed that more information on population size, structure and distribution was urgently needed in the Baltic. The Working Group recommends that further genetic analyses should be undertaken, especially in Baltic waters. For the time being the Working Group agreed that porpoises in the Baltic Sea should be treated as a single stock, bearing in mind that possible differences may exist within this area. It was also agreed that, in the present context, the Baltic should be considered to include ICES Division IIId, but none of the inner Danish waters, nor Kiel or Mecklenburg Bays. The Darss and Limhamn Ridges are therefore taken as the dividing line between the porpoise stock in the Baltic proper and that in inner Danish and German waters.

There have been no studies to address differences in mtDNA between porpoises in the inner Danish waters and those in the Kattegat. Porpoises tagged in inner Danish waters (ICES Division IIIc) have moved to ICES Divisions IIIas and IIIan. In the absence of other information, the Working Group decided to treat porpoises in ICES Divisions IIIc, IIIb and IIIas as a putative stock. Discussion of the

Skagerrak was more difficult, but it was concluded that there was no firm evidence to support differences between animals found in the Skagerrak and previously discussed areas. The limits of the Skagerrak were taken to be those defined by the SCANS Block I, and this was included with ICES Divisions IIIc, IIIb and IIIas as a unit.

The Working Group recalled Walton's previous studies of North Sea animals (Walton 1997), in which analysis of mtDNA had demonstrated a significant difference between animals from northeastern Scotland (including the Shetlands) and eastern England. Rosel reported that Tolley, using relatively small sample sizes, had found no differences between animals from northeastern Scotland and the Norwegian coast south of about 65°N. It was therefore agreed that porpoises in the northern North Sea should be treated as a separate stock. Buckland reported that recently completed spatial modelling of the SCANS data, which had generated an extrapolated population density map (Fig. 1), showed a hiatus in porpoise density across this part of the North Sea. The Working Group agreed to use this hiatus in density as a provisional boundary between putative stocks in the northern and central North Sea, demarcated by a line from Peterhead in Scotland (57°30'N) to Bergen in Norway (60°30'N). This was in part an arbitrary line, but supported by the SCANS survey data. There was no information to delimit the northern or western boundaries of this putative northern North Sea stock.

Walton found no differences between Dutch and English animals in the central and southern North Sea (Walton, 1997). Previous reports (IWC, 1996) have suggested that Dutch animals exhibited anomalous reproductive patterns, but the Working Group was not aware of sufficient evidence to support the existence of a separate Dutch or southern North Sea stock. The southern limit to the central North Sea stock was accordingly taken as the straits of Dover, or ICES Division IVc.

The Celtic Shelf stock was taken to include all of SCANS block A, but it was noted that this stock could extend into the Irish Sea and along the west coast of Ireland.

The Working Group was unable to determine whether harbour porpoises formerly present in the English Channel were part of the putative stock in the central North Sea or the stock in the Celtic Shelf. It is also possible, although unlikely, that porpoises in this area formed part of a separate population, now greatly reduced or extinct. A more likely scenario is that the current density minimum in the Channel reflects a range constriction of either the central North Sea or Celtic Shelf stock, or both. Simulation modelling should explore these alternatives, as they are directly related to the ASCOBANS objectives described above. The Working Group also noted that it might be possible to test the hypothesis of a separate Channel population by collection and analysis of genetic material from museum specimens.

It was therefore agreed to proceed with the modelling using five stocks:

(1) Baltic Sea;
(2) Kattegat, inner Danish Waters and German Baltic Sea;
(3) Northern North Sea;
(4) Central and Southern North Sea;
(5) Celtic Shelf.

In view of the difficulties that the Working Group encountered in trying to decipher several previous genetic studies (because of imprecise details of sample locations and geographical areas) it **recommends** that all future studies of porpoise population structure should specify the location and date where samples were collected.

10.2 Movements between stocks

Measures of F_{ST} can be used to generate measures of dispersal using analytical formulae, but this requires an assumption that adjacent populations are of equal size and in mutation-drift equilibrium. When these assumptions are violated, modelling becomes necessary. Tiedemann reported that, in his individual-based simulation model of Baltic animals, the best fit to the observed allele frequencies at different geographical locations along a one dimensional gradient was obtained by assuming an average effective genetic dispersal of no more than 15km per year. The Working Group agreed that, given the sizes of the areas under consideration, dispersal at this rate could effectively be ignored between adjacent stocks in the base model. It was noted that such an approach for the Baltic would also be precautionary, as any dispersal would likely result in net immigration to the Baltic, given the relative sizes of the Baltic and its adjacent stock.

Some discussion followed on the possible consequences of local depletion within putative stocks. In the context of the RMP, *Medium Areas* define putative stocks, and are based on the best available biological evidence. Their boundaries are likely to be arbitrary to some extent. Management measures are best framed in the context of *Small Areas*. Issues such as local depletion are then examined within the framework of *Small Areas* as consequences of management measures. In the present context the base model (see Item 11.2) need not take account of dispersal between adjacent *Medium Areas*, although seasonal mixing of putative stocks between adjacent areas needs to be addressed in the simulation trials.

10.3 Recolonisation

Simulation trials should also consider the effect of local depletion within a putative stock. This is particularly relevant given the very low densities of porpoises observed in the Channel, southern North Sea and Baltic Sea. A cell-based model would enable the recolonisation of depleted areas to be examined as a diffusion process. To address the issue of recolonisation of a depleted area, the movement rates used by Tiedemann in the Baltic could be used to parameterise female dispersal.

11. DEVELOPMENT OF A SIMULATION MODEL

11.1 Previous approaches

The Working Group reviewed two previous simulation approaches: the IWC's Revised Management Procedure (RMP) and the US Potential Biological Removal (PBR). In the development of the RMP, a simple population dynamics model (PDM) was applied to a generic single stock, together with some assumptions about the type of data that would be available both historically and in the future. The base model was then used to develop *Catch Limit Algorithms* (*CLA*s), which provide fixed quotas that are revised on the basis of newly-collected data (catches and estimates of absolute abundance). Candidate *CLA*s were compared by their performance in robustness trials which altered the basic population dynamics model and varied assumptions about the quantity, quality and reliability of available data. For implementation of the RMP, the single stock 'core procedure' (base model and *CLA*) is applied to large areas, typically ocean basins, through the application of multi-stock rules. The most appropriate option for these rules is determined by case-specific *Implementation*

Simulation Trials designed to test robustness to plausible alternative hypotheses, particularly concerning population structure.

The PBR system was developed using an approach very similar to that used in development of the RMP (Wade, 1998). PBR is calculated for each stock of marine mammals in US waters and is used to identify stocks with unsustainable levels of anthropogenic mortality. The equation for calculating PBR was specified in the enacting regulations of the US Marine Mammal Protection Act (MMPA). Two underlying population dynamics models were developed to represent generalised cetaceans and pinnipeds. Simulations based on these models were used to tune the parameters of the PBR equation to meet the MMPA goal (to maintain populations at or above their maximum net productivity levels) for 95% of simulated populations. The 'base-case' for simulations incorporated statistical uncertainty in the estimation of population size and bycatch and was used to tune PBR parameters for populations known to be above the Maximum Net Productivity Level (MNPL) or known to be growing. 'Bias trials' which accounted for potential biases in the model, in abundance, or in bycatch, were used to tune PBR parameters for populations that are threatened, depleted, or of unknown status. Wade made a copy of his computer program for tuning PBR parameters available to the Working Group.

11.2 Base Model

The Working Group used the terminology of 'base model' and 'simulation trials.' The base model should incorporate a simple PDM of the form:

$$N_{t+1} = N_t + N_t R_{\max}(1 - (N_t/K)^{\theta}) - C_t \qquad (1)$$

where N is population size, K is carrying capacity, θ determines the MNPL and C is 'catch' (anthropogenic removals). This is effectively a single-stock model in which there is no mixing between putative stocks. In applications of the base model, the Working Group agreed to use values of 0.04 for $R_{\max}$ and 2.4 for θ (corresponding to an MNPL of 60% of K).

The algorithm governing bycatch, and the information available to assess bycatch levels, may well be quite different in Europe from the IWC and PBR algorithms, because the management context and legal framework is very different. Indeed, there are many different algorithms that would achieve the ASCOBANS conservation objectives. Subject to the constraint of porpoise conservation, those who ultimately manage porpoise bycatch in Europe will also have to consider a wide range of issues, which are beyond the scope of this Working Group. The model approach should allow a wide class of algorithms to be tested, since managers may wish to consider a wide range of management options.

When designing an algorithm, it is not necessary to assume there will be future monitoring and feedback. However, algorithms without feedback need to be more precautionary at the outset. It would be instructive to compare the performance of different algorithms, some with feedback and some without. This may serve to demonstrate the value of future monitoring, in that less draconian management is required to achieve a given level of precaution. When simulating models with feedback, it is necessary to ensure that the feedback mechanism is realistic in terms of management. The RMP has a specific objective of keeping down year-to-year fluctuations in catches, whereas PBR does not. Similarly, although future estimates of Danish and UK bycatch are likely to be available in the central/southern North Sea, we cannot simply assume that abundance and bycatch estimates will be available at regular intervals for all putative stocks. Algorithmic details will ultimately be up to those who implement the simulation model, based on a consideration of what makes sense for local conditions.

11.3 Simulation trials

The Working Group agreed that simulations would be useful to: (1) investigate violations of assumptions in the base model; (2) explore sensitivity of the results to variation in certain parameters; and (3) potentially modify the base model to incorporate additional factors, as necessary. The simulation trials should use a different PDM from the base model, and should incorporate consideration of finer-scale stock structure and movements. The tuning and evaluation of an algorithm may well be based on the results of the trials, rather than simply on the base-case results. Nevertheless, the base-case results may be very useful for ASCOBANS in the shorter term. The possibilities listed below are by no means extreme, and it should not be inferred that a 'simulation trial' for Northeast Atlantic harbour porpoise is an extreme test that goes beyond the range of plausibility. However, if several possibilities are simultaneously set to 'pessimistic' in a simulation trial, then the results in some sense deserve less weight than the results of single trials. The Working Group suggested several areas where the base model should be extended for simulation trials, including: seasonal mixing, dispersal, stock sub-structure, age/stage structure, stochastic variability in $R_{\max}$ and K, catastrophic events, value of MNPL, bias in estimated bycatch, variation in monitoring schemes, variation in initial depletion level and long-term variation in carrying capacity.

11.3.1 Seasonal mixing

'Seasonal mixing' covers both within-year movement and directed migration. Telemetry provides direct information on movement rates and migration patterns. The time frame of the model, over which mixing and bycatch are calculated, should be made appropriate to the spatial scale of the model (see Item 11.3.3). Over large spatial scales, quarterly timing may be appropriate. To address seasonal movements it is necessary to know how fast porpoises move over cell-sized distances. Data from telemetry studies are needed to parameterise this aspect of the simulation.

11.3.2 Dispersal

Tiedemann's individual-based models use genetic data to give some insight into average rates of female dispersal between breeding sites. Estimates from the Baltic are already available, and could be applied to other Northeast Atlantic stocks. However, it would be preferable to repeat the exercise in other areas for which we have data, for example along a latitudinal gradient in the North Sea. This would be a quick exercise, as the genetic analyses for these areas have been completed. Given the relatively large population sizes outside the Baltic, computing power may become limiting. Barlow noted that Taylor and Chivers are working on a parallel algorithm using a very large computational capacity. Even if the computing problem cannot be solved, it may be possible to extrapolate correction factors for drift rate as a function of population size, allowing the model to use smaller and more tractable 'population sizes.' Tiedemann noted that his approach provides a plausible range of annual dispersal rates for females, although there are several ways to combine parameters that give similar fits to the genetic data. However, this is not really a limitation in the context of robustness trials; all that is necessary is a plausible range of annual dispersal rates.

11.3.3 Stock substructure
To make a realistic allowance for the possibility of local depletion, it is important to build models that incorporate small-scale movements within the putative stock boundaries, using smaller cells in a regular grid or irregular network. This does not necessarily mean that management needs to be based on the same small scale. Appropriate sizes for the cells/grid may be determined by biological considerations, e.g. the desire to protect against depletion of a putative sub-stock, or by pragmatic ones, such as the distribution of a fishery.

11.3.4 Age/stage structure
A stage-structured model is required that mimics the simple aggregate PDM used for the base model. The Working Group agreed that three stages should be included: dependent calves (first-year animals), immature animals and adults. Age and sex structure are relevant only if there are differential removals in the bycatch. Differential removal by stage is potentially important, as young animals (which seem to have higher bycatch rates) have lower reproductive value. Even if estimates of differential removals are currently lacking, the model should be structured to allow the incorporation of stage data in the future.

11.3.5 PDM stochasticity
Stochastic variability in recruitment can be accommodated through random interannual fluctuations in R_{max} and K. An appropriate level of variability can be estimated from the extra-Poisson variability in the tail of age composition in either bycatch or strandings.

11.3.6 Catastrophes
One RMP robustness trial evaluated the effect of catastrophes, in which a large portion of the population is removed in a short time period. The outbreak the of phocine distemper virus in the Northeast Atlantic and the epizootic of striped dolphins in the Mediterranean are relevant examples of catastrophes. Some possibility of catastrophe should be considered in Northeast Atlantic harbour porpoise simulations. If a major catastrophe was to strike harbour porpoises, it would certainly be noticed and the objectives of ASCOBANS might change if this occurred. Performance criteria might therefore require some additional consideration in trials where catastrophes are allowed for.

11.3.7 MNPL
As noted above, harbour porpoises seem to be relatively *r*-selected for a cetacean species, so an MNPL at 50% of K should be evaluated in simulation trials. Lower MNPLs make it more difficult to achieve target fractions of K above MNPL within a given time frame.

11.3.8 Bias in estimates of bycatch
There are three main sources of potential bias in bycatch estimates: unsampled fisheries, dropout and sampling bias. Estimates of bycatch are not yet available for all gillnet fisheries in the North Sea known to take porpoises (see Item 14). Dropout occurs when a bycatch is not detected because the porpoise carcass drops out of the net before it can be observed; dropout can presumably occur when nets are on the bottom, as well as during haulback. It is not obvious how to estimate the extent of dropout. Sampling bias can occur when the fishing practices of a fleet are not observed randomly. For example, some fishermen may refuse to take observers if they are fishing in areas of high bycatch rate or may change their fishing behaviour when an observer is onboard. All of these sources of bias will generally result in the underestimation of bycatch.

11.3.9 Variation in monitoring schemes
Regular monitoring provides a means of evaluating the performance of any algorithm. The effectiveness of a monitoring programme depends, in part, on the frequency of monitoring. The Working Group agreed that the following scenarios should be explored in simulation trials with respect to monitoring frequency: a single abundance estimate; abundance estimates available every five years; abundance estimates available every 10 years; bycatch estimates available every year; bycatch estimates available every two years; and bycatch estimates available every five years.

11.3.10 Initial depletion
The Working Group agreed that simulation trials should be run for a range of plausible initial depletions relative to K, with performance criteria set as outlined below (Item 12).

11.3.11 Long-term variation in carrying capacity
Carrying capacity is unlikely to be constant. In addition to exploring the stochastic variation in carrying capacity (see Item 11.3.5), the Working Group agreed that it would be useful to explore the effect of systematic, long-term variation in K. This could occur, for example, if the prey of harbour porpoises was reduced greatly in the North Sea. The Working Group noted that it was possible, and perhaps likely, that such changes had already occurred in parts of the ASCOBANS area.

12. PERFORMANCE CRITERIA FOR SIMULATION TRIALS

The Working Group agreed that performance criteria for the simulation trials could be based on existing criteria developed for the RMP and PBR schemes. Under these criteria, an algorithm is considered adequate if it results in a simulated population meeting the management objective (e.g. 80% of K) in a large proportion (e.g. 95%) of the trials.

The ASCOBANS objectives do not define the time scale on which the conservation objectives are to be achieved, but this information is necessary when evaluating possible management strategies. This is a case where the ASCOBANS objectives need to be refined. The simulations used in development of both the RMP and PBR approaches used 100-year time periods, and PBR also used a 20-year period for evaluating its objective of recovery for threatened and endangered stocks. The recovery time required for populations to reach the ASCOBANS objective (80% of K) will clearly depend on their initial state relative to K. Using the population model specified in Equation 1 and assuming that bycatch is eliminated immediately, populations currently at 30% of K would recover to 80% of K in approximately 30 years. If populations are currently at 60% of K, recovery to 80% of K would take approximately 11 years (again, if bycatch were reduced to zero). No management actions will hasten recovery faster than the complete elimination of bycatch, so it makes sense to set the time frame for simulation studies by using time to recovery in the absence of bycatch. For example, if recovery will take X years without bycatch, simulations could measure the fraction of populations that were above 80% of K after 2X or 3X years, and bycatch limit rules could be developed to ensure that 95% of populations would meet the management objective within this time frame. By scaling time in this way, a management framework can be developed that is insensitive to initial population size. This is desirable because we do not know the current status of any harbour porpoise population relative to K.

The Working Group agreed that the following output statistics were desirable from the simulation trials: the 5th, 50th and 95th percentiles of the distribution of population size at the end of the time period; the number of extinctions (defined as cases in which a simulated population declines to 5% of K or less); and the total number of removals (bycatches) from each simulation.

13. IMMEDIATE ADVICE TO ASCOBANS

The Working Group discussed immediate advice to ASCOBANS relative to its current short-term target level ('…a total bycatch level in all fisheries above 2% of the maximum likelihood estimate of abundance within an appropriately defined management region should be considered as an unacceptable interaction') and its interim objective ('…to restore populations to, or maintain them at, 80% or more of the carrying capacity'). Using a basic population model for harbour porpoises (see Equation 1) and assuming no uncertainty in any parameter, the maximum annual bycatch that achieves the ASCOBANS interim objective over an *infinite* time horizon is 1.7% of the population size in that year. If uncertainty is considered, such as measurement error in estimating population size, maximum annual bycatch must be less than 1.7% to ensure a high probability of meeting the ASCOBANS objective. Meeting the objective in a shorter time will require that annual bycatch be reduced to an even lower fraction of the abundance. Additional sources of uncertainty and potential biases will also require more conservative management to ensure a high probability of meeting the objective. Therefore, the Working Group **advises** ASCOBANS that its interim objective is not likely to be met by reducing annual bycatch to 2% of estimated abundance and that, to meet the objective, bycatch must be reduced further. The results of planned research will provide quantitative guidance for identifying bycatch levels consistent with this objective.

14. RECOMMENDATIONS FOR FUTURE WORK

(1) Porpoise bycatch should be estimated for all fisheries operating within the ASCOBANS area. In particular, estimates should be obtained for Norwegian gillnet fisheries operating in ICES Area IVa.

(2) Abundance should be estimated for portions of the ASCOBANS area where it is currently lacking. In particular, estimates of abundance are required for the southern Baltic Sea.

(3) Abundance should be estimated for waters adjacent to the ASCOBANS area, in particular the Irish Sea, western Scotland and western Ireland.

(4) Spatial modelling of existing line transect data of porpoise density should be expanded to complete coverage of the ASCOBANS area, so that abundance can be estimated for areas defined in simulation models.

(5) Existing mtDNA sequence data from porpoises in the German North Sea, the Netherlands, and southeastern England should be pooled and analysed for evidence of population sub-division, as soon as possible.

(6) Additional mtDNA sequence data should be collected and analysed from geographic regions not yet examined. These regions include the inner Danish Waters, the Kattegat, the Skagerrak and the Baltic Sea.

15. OTHER BUSINESS

The Working Group noted that the Sea Mammal Research Unit (SMRU), under contract to the UK Ministry of Agriculture, Fisheries and Food, was planning to conduct much of the simulation modelling work identified in its deliberations. The Working Group offered to continue its work in a consultative capacity during the development of this research and to review the products of this modelling exercise prior to its submission to ASCOBANS. Working Group members offered to reconvene early in 2000, prior to the meeting of the ASCOBANS Advisory Committee.

16. ADOPTION OF REPORT

The report of the meeting was adopted by the Working Group. It agreed that, after minor editorial amendments, the report would be submitted to the Secretariats of ASCOBANS and the IWC. Auel thanked members of the Working Group for their hard work on behalf of the Parties to ASCOBANS. The Working Group expressed appreciation to Read for his chairing of the meeting. On behalf of the Working Group, Read expressed thanks to Hammond for the hospitality of the Sea Mammal Research Unit and Gatty Marine Laboratory. The meeting adjourned at 18:00 on 10 March.

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Appendix 1

LIST OF PARTICIPANTS

ASCOBANS

Holger Auel

DENMARK

Finn Larsen

GERMANY

Ralph Tiedemann

UK

Mark Bravington
Steve Buckland
Phil Hammond
John Harwood
Simon Northridge
Mark Tasker
Mike Walton

USA

Jay Barlow
Debra Palka
Andrew Read
Patricia Rosel

Appendix 2

AGENDA

1. Welcome and introductions
2. Adoption of agenda
3. Appointment of rapporteurs
4. Review of background documents
5. Review of ASCOBANS conservation objectives
6. Definition of geographical area
7. Information on trends in abundance
8. Information on bycatch
9. Demographic parameters
   - 9.1 Harbour porpoise life history
   - 9.2 Rate of increase
   - 9.3 Density-dependence
10. Plausible hypothesis of stock structure
    - 10.1 Definition of stock boundaries
    - 10.2 Movement within and between stocks
    - 10.3 Recolonisation
11. Development of a simulation model
    - 11.1 Previous approaches
    - 11.2 Base model
    - 11.3 Simulation trials
12. Performance criteria for simulation trials
13. Immediate advice to ASCOBANS
14. Plans for future work
15. Other business
16. Adoption of report

Appendix 3

BACKGROUND DOCUMENTS

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