Western North Pacific Bryde's Whale *Implementation*: Report of the First Intersessional Workshop

Western North Pacific Bryde's Whale *Implementation*: Report of the First Intersessional Workshop[1]

The Workshop took place at the National Research Institute of Far Seas Fisheries, Shizuoka, Japan from 25-29 October 2005. The list of participants is given as Annex A.

1. INTRODUCTORY ITEMS

1.1 Convenor's open remarks
Kawahara welcomed the participants to Japan and in particular to this Institute. He noted that the whale section would soon be moving to Yokohama and so this would be the final IWC Scientific Committee Workshop to be held here. The practical arrangements for the Workshop were given by members of the Institute staff.

1.2 Election of Chair and appointment of rapporteurs
Donovan was elected Chair. On behalf of the IWC, he thanked the participants for attending and especially the National Research Institute of Far Seas Fisheries for hosting the Workshop and for providing such excellent facilities.

With regard to working arrangements, he drew attention to the precedent set at the JARPA review meeting in 1997 where it was agreed that in line with current Scientific Committee practice, automatic consecutive translation from English to Japanese or *vice versa* was not appropriate (IWC, 1998, p.377). As at that meeting, he proposed to allow translation of specific points or discussions as they arose, at the Chair's discretion. Given that, he stressed the need for all participants to speak slowly and clearly.

He reminded participants that the objective of the meeting was to develop an appropriate *Implementation Simulation Trials* (*ISTs*) structure and to specify the associated conditioning so that it can be carried out before the following Annual Meeting. Full details can be found in the 'Requirements and Guidelines for *Implementations*' agreed by the Committee in 2004 (IWC, 2005b); the relevant text for this first intersessional Workshop is given as Annex D.

Allison, Butterworth and Punt acted as rapporteurs, with assistance from the Chair.

1.3 Adoption of Agenda
The adopted Agenda is given as Annex B.

1.4 Review of documents
The documents available for the Workshop were SC/O05/BWI1-7 (see Annex C), IWC (2006b) (henceforth referred to as the '*pre-Implementation* Workshop') and extracts from the reports of previous annual meetings.

[1] Presented to the meeting as SC/58/Rep1.

2. HYPOTHESES FOR INCLUSION IN TRIALS

2.1 Stock structure and mixing
2.1.1 Review of hypotheses presented at the pre-Implementation assessment
The Workshop on the *pre-Implementation assessment* of western North Pacific (WNP) Bryde's Whales (IWC, 2006b) identified five general broad hypotheses about mixing and stock structure for WNP Bryde's whales. At that stage, it was agreed that these five hypotheses were considered to be sufficiently inclusive that it was deemed unlikely that collection of new data during the *Implementation* process would suggest a major novel hypothesis. In the developing these hypotheses, the *pre-Implementation* Workshop assumed that:

(1) the breeding grounds are in the low latitudes and that no whaling will take place on these grounds;
(2) no whaling will occur during migration to the feeding grounds; and
(3) hypotheses could be represented using three spatial cells (sub-area 1W, sub-area 1E, and sub-area 2; Fig. 1).

The five hypotheses (Fig. 2) are summarised below.

(1) There is only one stock of Bryde's whales in sub-areas 1 and 2.
(2) There are two stocks of Bryde's whales in sub-areas 1 and 2. One stock is found in sub-area 1 and the other is found in sub-area 2.
(3) There are two stocks of Bryde's whales in sub-areas 1 and 2. One stock is found in sub-areas 1 and 2, and the other is found in sub-area 2 only.
(4) There are two stocks of Bryde's whales in sub-areas 1 and 2. One stock is found in sub-area 1 and the other is found in sub-area 2. Stock 1 consists of two sub-stocks that mix in sub-areas 1W and 1E.
(5) There are two stocks of Bryde's whales in sub-areas 1 and 2. One stock is found in sub-areas 1 and 2, and the other is found in sub-area 2. Stock 1 consists of two sub-stocks. One of these sub-stocks is found in sub-areas 1W and 1E, and the other is found in sub-areas 1W, 1E and 2.

Although not assigning plausibility (that is a task for the First Annual Meeting once the *Implementation* process had begun), the *pre-Implementation* Workshop noted that: (1) not all of these hypotheses have equal plausibility; and (2) it was not necessarily the case that all of these hypotheses would be included in the final *ISTs*.

The Workshop reviewed the evidence for each of the five hypotheses (and was greatly assisted in this by the review given in SC/O05/BWI3). It noted the considerable additional data that have become available since the Comprehensive Assessment of North Pacific Bryde's whales (IWC, 1996; 1997) and the first development of *ISTs* in 1999, as shown in Table 1. The availability of these

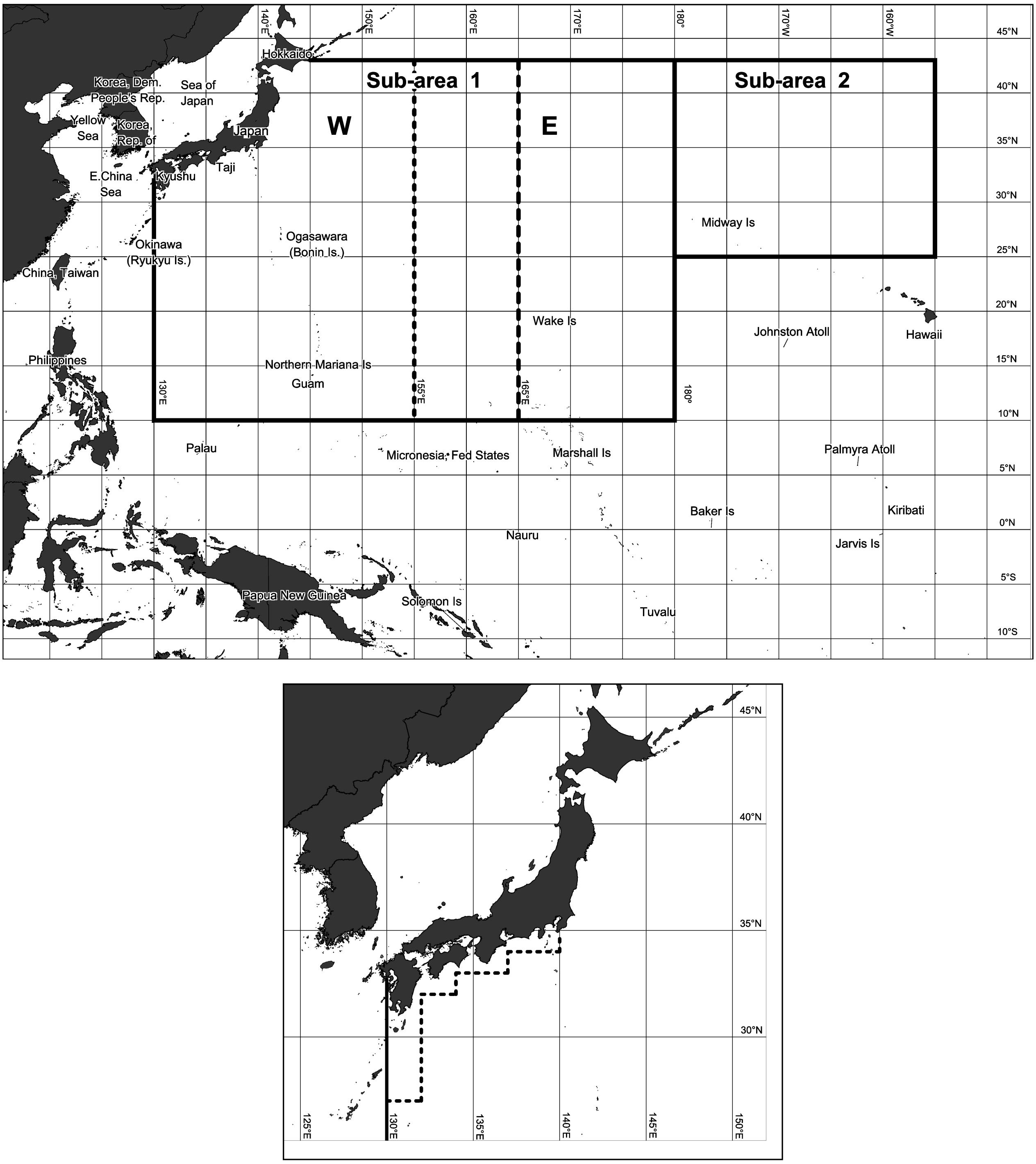

Fig. 1. Map of the WNP showing the sub-areas defined for the WNP Bryde's whales (based on IWC, 2006b). Note that the boundary between 1W and 1E is now set at 165°E (see text).

additional data will enhance the ability of the Committee to assign plausibility ranks to simulation trials during the First Annual meeting. The Workshop considered information from several approaches, both genetic and non-genetic, as a number of studies (e.g. Donovan, 1991) have concluded that this is the most effective way to address questions of stock identity.

2.1.1.1 HYPOTHESIS 1

Only one stock of Bryde's whales is found in the area from 130°E to 155°W (excluding the area in which East China Stock is found) and there are no sub-stocks.

The Workshop **agreed** that this hypothesis is consistent with the results of all past genetic and other studies, as summarised below.

(1) *Allozymes*. Wada (1996) analysed samples (n=2,521 collected between 1974-84) from most of the longitudinal range of sub-areas 1 and 2 i.e. between 20°N–40°N and 140°E and 160°W. He found no significant frequency differences by 10°square for the allele, *Got-1*^{f}, which had been shown to differ significantly between recognised stocks of Bryde's whales in the Pacific Ocean (Wada and Numachi, 1991). The Workshop **agreed** that while the power to detect genetic structure might be considered to be low as only a single locus was analysed, the fact that this had been sufficient to detect structure in the Pacific Ocean suggests that if there are multiple stocks differentiated at a level similar to that between the WNP stock and other Pacific stocks, examination of *Got-1*^{f} should be sufficient to detect this.

Table 1

Information available to define stock structure in the WNP Bryde's whales: 1998 data (the last time the Scientific Committee discussed *Implementation*) and 2005 data.

	1998	2005
Genetics		
Allozymes		
Covered areas/years	20-40°N, 140°E-160°W (SA1 and SA2)/1974-84	Same as 1998
No. loci/no. samples	1 locus/1,848 samples	Same as 1998
Analysis	Heterogenity test, HW test (Wada, 1996)	Same as 1998
Microsatellites		
Covered areas/years	No data	20-40°N, 130°E-180° (SA1)/1979 (CP); 1983-84 (CLB); 2000-03 (JARPN II)
No. loci/no. samples	No data	17 loci/385 samples
Analysis	No data	Heterogeneity test, HW test (Pastene *et al.*, 2004); Power analysis (Kitakado *et al.*, 2005a); Clustering analysis (Martien and Taylor, 2004)
Mitochondrial DNA		
Covered areas/years	20-30°N, 130-145°E, 160°E-180/1979 (CP); 1983-84 (CLB)	20-40°N, 130°E-180°E (SA1)/1979 (CP); 1983-1984 (CLB); 2000-2003 (JARPN II)
No. samples	150 samples	401 samples
Analysis	Heterogeneity test (Pastene *et al.*, 1998)	Heterogeneity test (Pastene *et al.*, 2004); Power analysis (Kitakado *et al.*, 2005a); Clustering analysis (Martien and Taylor, 2004)
Non-genetics		
Catch - distributions		
Covered areas/years	20-45°N, 130-150°E (CLB)/1906-87; 20-45°N, 160°E-160°W (CP)/1971-79	20-45°N, 130-150°E (CLB)/1906-87; 20-45°N, 160°E-160°W (CP)/1971-79; 35-42°N, 140-170°E (JARPN II)/2000-05
No. catches	7,038 catches	7,038 + 293 catches
Analysis	IWC (1999 p.116)	IWC (1999 p.116); SC/O05/BW13
Sighting - distributions		
Covered areas/years	0-43°N, 130°E-155°W/1988-96	0-43°N, 130°E-155°W/1988-2002
No. animals sighted	548 sighted	881 sighted
Analysis	Shimada and Miyashita (1999)	Shimada and Miyashita (1999); Shimada (2004)
Biological parameters		
Covered areas/years	20-45°N, 130-150°E (CLB)/1973-87; 20-45°N, 160°E-160°W (CP)/1971-79	Same as 1998
No. samples	7,602	Same as 1998

(2) *Mitochondrial DNA and microsatellites.* Data (n= 401, collected from sub-area 1 in 1979, 1983-84 and 2000-03) have been analysed using clustering techniques (Martien and Taylor, 2004) and formed the basis for hypothesis tests (Pastene *et al.*, 2004). As noted previously by the Committee (IWC, 2005a), none of these analyses revealed any significant heterogeneity (and hence evidence for more than one stock) in sub-area 1.

(3) *Sightings and catches.* The Workshop examined the sightings data collected during systematic surveys undertaken from 1988-95 (Shimada and Miyashita, 1999); (Fig. 3) and 1998-2002 (Shimada, 2004); (Fig. 4) and **agreed** that it revealed no evidence of a discontinuity in distribution within sub-area 1 and 2. A similar conclusion was reached with respect to catch distributions; (commercial and JARPN II; Fig. 5); discontinuity in the commercial catches identified in earlier meetings merely reflected operational constraints.

(4) *Biological information.* Kato and Yoshioka (1995) examined external body proportion data (three features) from 237 Bryde's whales taken off the Bonin Islands and the central western Pacific (between 140°E and 160°W) and found no evidence of differentiation. Using data (n=7,602) from coastal and pelagic whaling operations from 1948-52 and 1971-87, they also examined a number of biological parameters (e.g. body length, pregnancy rate, length at sexual maturity, seasonality in breeding). Although operational differences (e.g. different minimum length limits for coastal and pelagic whaling) meant that some comparisons could not be made, the authors concluded that there were no differences found that could not be attributed to operational factors.

(5) *Mark-recaptures.* Kishiro (1996; 1998) examined 51 marks recaptured between 1958 and 1986 for the Japanese coastal and pelagic operations which reveal movements of animals within sub-area 1 (from 130°E to at least 180°).

2.1.1.2 HYPOTHESES 2 AND 3

Different stocks in sub-areas 1 and 2. Hypothesis 3 differs from hypothesis 2 in that the stock found in sub-area 1 is also found in sub-area 2.

These hypotheses were generated primarily because there are very few genetic data for sub-area 2 (n=6, from Hawaii); (Martien and Taylor, 2004).

A very limited number of marks were placed in sub-area 2 and while none has been recovered in sub-area 1, the sample sizes for this sub-area are sufficiently small that even if there is mixing between sub-areas 1 and 2, zero recaptures would not be highly unlikely. The lack of recaptures of tags in sub-area 2 is not surprising because the catches in sub-area 2 occurred in only few years before the majority of the tags were placed. The results of the genetics and non-genetic studies, while not providing positive evidence in favour of these hypotheses, are not however, incompatible with them. The Workshop **agreed** that there was no need for a new stock structure hypothesis based on stock structure hypothesis 3 in which animals from the stock found in sub-area 2 are also found in sub-area 1 because the primary rationale for stock structure hypotheses 2 and 3 is lack of genetics data for sub-area 2.

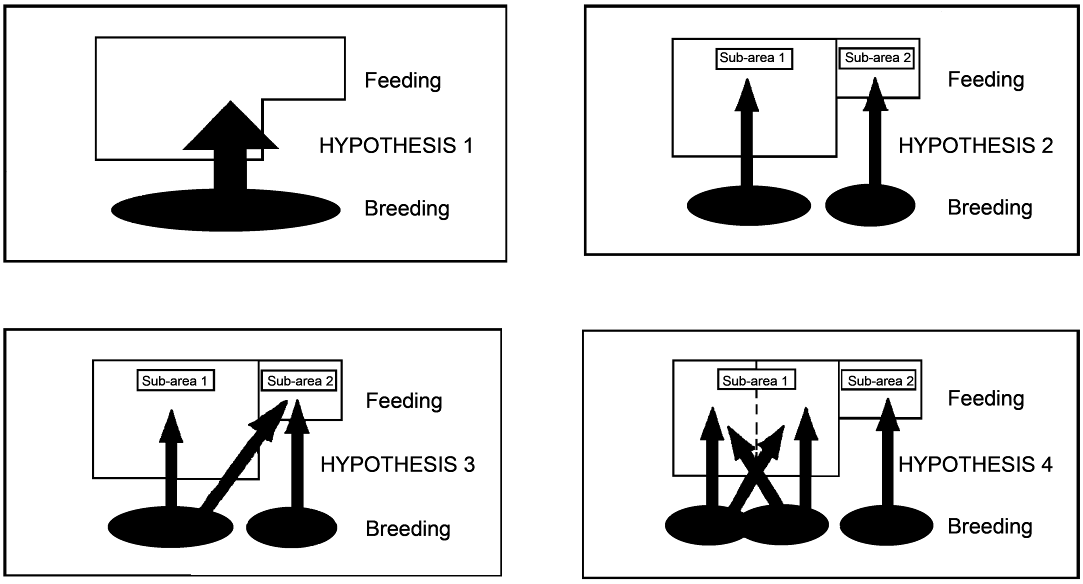

Fig. 2. Stock structure hypotheses selected by the Workshop on the *pre-Implementation assessment* of the WNP Bryde's whales.

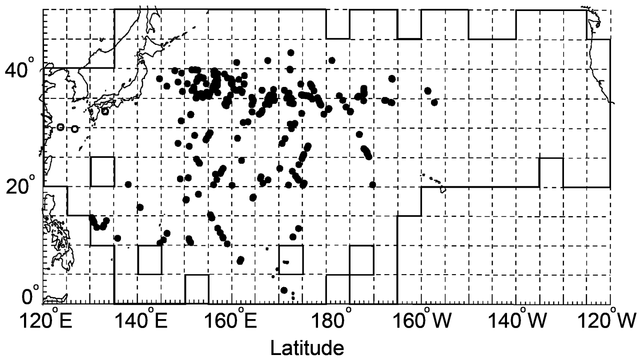

Fig. 3. Positions of primary sightings of WNP Bryde's whales in August and September 1988-95 (Shimada and Miyashita, 1996).

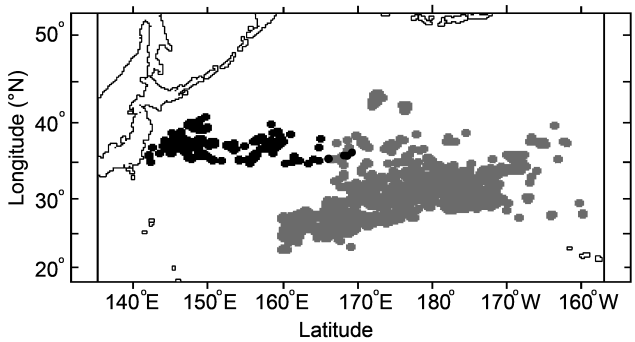

Fig. 5. Catches of Bryde's whales in the WNP. The grey dots are the pelagic catches and the black dots are the catches by JARPN II between 2000 and 2005.

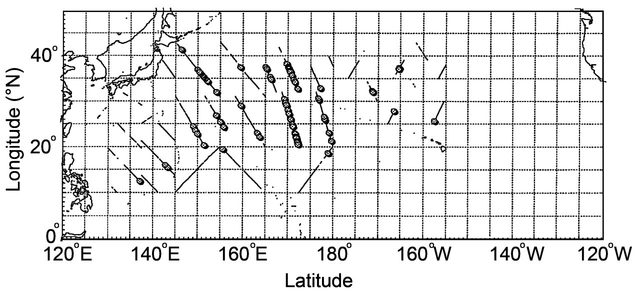

Fig. 4. Distribution of primary sightings of WNP Bryde's whales and track lines under passing mode effort 1998-2002 (Shimada, 2004).

2.1.1.3 HYPOTHESES 4 AND 5

Identical to hypotheses 2 and 3 except that there are two sub-stocks which mix in sub-area 1.

The possibility of sub-stocks in sub-areas 1 and 2 that do not mix is not considered plausible given the mark-recapture data which suggest considerable movement within sub-area 1. As for hypotheses 2 and 3 above, there is no direct information which provides positive evidence for these hypotheses. However, these hypotheses are not inconsistent with one of the possible explanations for differences in the age distributions for sub-area 1W and sub-area 1E+2 (see the extensive discussion under Item 2.5). The *pre-Implementation* Workshop included these hypotheses in the set of inclusive stock structure hypotheses primarily because there are no genetic data for the breeding grounds so the possibility of multiple sub-stocks cannot be excluded. Furthermore, if two breeding stocks mix almost completely, it will be difficult to detect differences using, for example, genetics tests based on comparisons between data for the west and east of sub-area 1 (but see Martien and Taylor, 2004; Pastene *et al.*, 2004). However, while complete mixing may lead to all methods of detecting stock structure having low power, the plausibility of this was considered fairly low given the behaviour of most large whales.

In principle, evidence for hypotheses 4 and 5 could be obtained by testing for deviations from the Hardy-Weinberg equilibrium within sub-areas 1W and 1E because such deviations provide evidence of non-random mating as well as selection or migration, i.e. when genetically two different populations are being sampled (e.g. Pastene *et al.*, 2004; Wada, 1991). Analyses of nuclear markers for Bryde's whales in sub-area 1 have been conducted by Wada (1996) and Pastene *et al.* (2004).

Although two of the individual tests based on the microsatellite data showed p-values <0.05 (Pastene *et al.*, 2004), this is not unexpected given that 17 microsatellites were analysed. As a result, these analyses provide no evidence for the significant deviations in the Hardy-Weinberg equilibrium within sub-areas 1W and 1E which would provide support for multiple sub-stocks.

Hypothesis tests based on comparisons for approximately the same area in sub-area 1 found no significant differences among years (Pastene *et al.*, 2004), which suggests that if two sub-stocks mix in sub-area 1, there is little difference in the distribution proportion among years. Although the data set on which Pastene *et al.* (2004) is based encompasses only four years, such a lack of variation in distribution proportions among years seems unlikely given the known behaviour of large whales.

2.1.1.4 EVALUATING THE STATISTICAL POWER OF GENETIC METHODS

The Workshop reviewed the discussions during the *pre-Implementation* Workshop regarding the power of genetics methods to detect differences within sub-area 1. That Workshop received a paper (Kitakado *et al.*, 2005a) which evaluated the power to detect population structure using the χ^2 permutation test and Fisher's Exact test under an island model in which population differentiation is controlled using a single parameter, F_{ST}. Statistical power was found to be high for moderate sample sizes and quite small values for F_{ST}, while it was higher for microsatellite data than for mtDNA data. The *pre-Implementation* Workshop concluded that for the sample sizes available, the power to detect genetic differences for the WNP Bryde's whales was high unless the value of F_{ST} is very small. It noted that the approach of Kitakado *et al.* (2005a) did not take into account the impact of changes over time in the demographic structure of the simulated stocks and consequently recommended the consideration should be given to evaluating power using models that explicitly include changes over time in demographics and that can be tailored to resource under consideration. The Workshop **re-iterated** this recommendation (see Item 8.1).

2.1.2 Results of 'simple model filter'

SC/O05/BWI2 extended the approach developed in Punt *et al*. (2005) for using abundance and mark-recapture data to estimate distribution proportions for Bryde's whales in the WNP. The revised analysis is based on an updated time-series of catches and revised estimates of abundance and assumes that recaptures are negative binomially rather than Poisson distributed. The implications of different scenarios related to Maximum Sustainable Yield Rate (*MSYR*) and mixing are examined in terms of the conservation performance of the four variants of the Revised Management Procedure (RMP). The results indicate that while a scenario of two stocks that do not mix can be excluded from trials as being implausible, the available data are not very informative regarding mixing rates.

The results from the 'simple model filter' updated to include revised abundance estimates in the context of hypothesis 4 are discussed under Item 2.1.3.

2.1.3 Final choice of plausible stock structure hypotheses for inclusion in trials

The purpose of this agenda item was to decide, after reviewing the hypotheses arising from the *pre-Implementation assessment*, whether it was appropriate to eliminate any hypotheses because they are either: (1) inconsistent with the available data; or (2) their management implications are captured adequately by other stock structure hypotheses.

In its discussions of stock structure, the Workshop recognised the problem that often faces the Committee, i.e. that genetic studies that do not provide evidence for stock structure rarely can be said to *completely* eliminate the possibility that some structure exists. Reaching decisions on plausibility in such cases relies on an examination of the weight of the evidence from a number of genetic and non-genetic techniques, available sample sizes and power analyses, etc. At this stage of the *Implementation* process, the instruction from the Committee is to eliminate hypotheses only if they are incompatible with the data (or the management implications are already covered). The assignment of plausibility of hypotheses is a task for the First Annual Meeting. The Workshop **agreed** that it would interpret its instructions from the Committee strictly, even if it meant continuing to include one or more hypotheses that it would consider to be much more unlikely than others, recognising that it (or they) could be assigned low plausibility at the next stage of the *Implementation*. The Workshops recommendations with respect to hypotheses 1-5 are given below.

HYPOTHESIS 1: ONLY ONE STOCK OF BRYDE'S WHALES IS FOUND IN THE AREA FROM 130°E TO 160°W (EXCLUDING THE AREA IN WHICH EAST CHINA STOCK IS FOUND) AND THERE ARE NO SUB-STOCKS.

The Workshop **agreed** to retain this hypothesis.

HYPOTHESES 2 AND 3: DIFFERENT STOCKS IN SUB-AREAS 1 AND 2. HYPOTHESIS 3 DIFFERS FROM HYPOTHESIS 2 IN THAT THE STOCK FOUND IN SUB-AREA 1 IS ALSO FOUND IN SUB-AREA 2.

The Workshop **agreed** to retain these hypotheses.

HYPOTHESES 4 AND 5. IDENTICAL TO HYPOTHESES 2 AND 3 BUT WITH TWO SUB-STOCKS THAT MIX IN SUB-AREA 1.

Most of the discussion at the Workshop focussed on hypotheses 4 and 5. It **agreed** that in the review of these hypotheses under Item 2.1.1 above, there is no positive evidence for sub-stocks from any of the available genetic and non-genetic studies listed in Table 1, even with the greatly improved genetic information that has become available since 1998. However, after considerable discussion, it also **agreed** that at this stage, a hypothesis that included sub-stocks was necessary to implement one of the possible explanations for the differences in the age distributions for JARPN II and for sub-areas 1E and 2 (i.e. the one where differences in age distributions are real and may indicate some degree of stock structure between sub-area 1W and 1E+2; Item 2.5.2). It recognised that further work may eliminate this explanation by the next annual meeting (see Item 8.1).

In its discussion of this item, the Workshop also considered the implications of stock structure hypothesis 4 using the 'simple model filter' (see Item 2.1.2). The updated results for this situation are given in Annex E. It is stressed that the results do not provide evidence to support or deny the existence of sub-stocks. Rather they suggest that *if* there is more than one sub-stock in sub-area 1, then there is likely to be considerable mixing. The uncertainty in estimation of mixing rates is considered in the trials. The Workshop also **agreed** that the results of genetics studies indicate that any trials that include more than breeding sub-stock in sub-area 1 should, in principle, incorporate fairly substantial dispersal between them. However, this would first require the provision of analyses to provide a reliable estimate of such dispersal, an extremely difficult task.

In conclusion, the Workshop **agreed** that while incorporation of a hypothesis that includes sub-stocks in sub-area 1 was needed to capture the full range of uncertainty for the WNP Bryde's whales, this should be recognised as being much more unlikely than the other hypotheses retained. It **agreed** that there was no need to include both hypotheses 4 and 5 in the trials and decided to retain hypothesis 4 but eliminate hypothesis 5, since the management implications of that hypothesis will be adequately captured by the results for hypotheses 4 and 3.

2.2 *g*(0)

The *pre-Implementation* Workshop agreed that the upper bound for $g(0)$ in trials would be 1 and that a decision on the lower bound for $g(0)$ would be made at the 2005 annual meeting taking account of papers reported to that meeting. No papers regarding the lower bound for $g(0)$ were received. The Committee therefore agreed that the lower bound for $g(0)$ for the purposes of *ISTs* would be 1. The *ISTs* for the WNP Bryde's whales therefore all assume that $g(0)=1$.

2.3 Maximum Sustainable Yield Rate (MSYR)

The Comprehensive Assessment conducted *HITTER* analyses for the WNP Bryde's whales based on the range 0-6% for *MSYR* in terms of the mature female component of the population ($MSYR_{(mat)}$), and agreed that 1% is a reasonable lower bound (IWC, 1999b, p.166). The *ISTs* for the North Pacific minke whales considered a range of 1-4% for $MSYR_{(mat)}$. The Scientific Committee discussed the relative plausibility of $MSYR_{(mat)}$=1% and $MSYR_{(mat)}$=4% for North Pacific minke whales in considerable detail and several views emerged. Eventually the Committee agreed to treat trials with $MSYR_{(mat)}$=4% as having a 'high' plausibility, and those with $MSYR_{(mat)}$=1% as having 'medium' plausibility (IWC, 2004, pp.82-3).

The *pre-Implementation* workshop had noted that while there are no data that can be used to estimate *MSYR* for WNP Bryde's whales, it might be possible to use data on calving intervals (and other biological parameters) to constrain the possible range and recommended that this be investigated. The Workshop was pleased to receive SC/O05/BWI14 that addressed this issue.

SC/O05/BWI4 used annual pregnancy rates of 0.55 and 0.59 obtained from JARPN II data and estimated a rate of increase using the method in Brandão *et al.* (2000). SC/O05/BWI4 used inequalities between the estimated instantaneous increase rate and MSYR derived by Butterworth and Best (1990), to compare *MSYR* to the estimated increase rate. *HITTER* runs conducted at the Comprehensive Assessment for the WNP Bryde's whales suggests that the current population size exceeds the Maximum Sustainable Yield Level (*MSYL*) for $MSYR_{(mat)}$=1-6%. Therefore, SC/O05/BWI4 used the inequality that *MSYR* is not less than instantaneous increase rate. Assuming 0.1-0.5yr^{-1} are plausible values for juvenile natural mortality by analogy with the other large whales, lower bounds for *MSYR* of 2-4% are obtained. SC/O05/BWI4 concluded that $MSYR_{(mat)}$=1% should not be used in the *ISTs* for the WNP Bryde's whales.

The Workshop thanked the author of SC/O05/BWI4, which was written in response to a request from the *pre-Implementation* Workshop. The workshop **agreed** that, in the absence of information on juvenile survival rate and given uncertainties in calving rate (see Item 4.3), it was not possible determine a lower bound for *MSYR* using a Leslie matrix model although calculations along the lines in SC/O05/BWI5 are illustrative. The Workshop also **agreed** that it was not possible place on lower bound on *MSYR* using the estimate of rate of increase reported in SC/O05/BWI6 because this estimate is highly imprecise. The Workshop **agreed** the analyses presented indicated that *MSYR* for Bryde's whales cannot be very high (in contrast with what appears to be the case for humpback whales). It also **agreed** that if analyses such as those in SC/O05/BWI4 are to be taken further, the literature for other baleen whales should be examined in detail to develop a basis for making inferences for juvenile natural mortality for Bryde's whales.

2.4 Alternative catch series

The catch data to be used in the trials was agreed by the Scientific Committee at the 2005 meeting (IWC, 2006a), with the exception of the items discussed below. A 'best' series was developed, which will be used as the base case, together with a 'high' and a 'low' series. The full details of the sources of data and the methods used to estimate the catches used in the catch series are given in Annex F.

The question of allocation of historic catches (1922-49) in the Bonin Islands between sei and Bryde's whales was discussed. Ohsumi believed that the catches in the period 1946-50 were all Bryde's whales and he undertook to provide detailed references to confirm this as soon as possible. Following confirmation from Ohsumi, all catches of sei/Bryde's whales since 1946 will be assumed to be Bryde's whales.

Omura and Fujino (1954) showed that the catch from the Bonin Islands in 1935-36, which was taken in the period Nov-Apr, was exclusively of sei whales (with the exception of one animal which could not be classified), in comparison with the catch in 1952 which was taken in the period May-Jun and was exclusively of Bryde's whales. In their opinion sei whales are found in the vicinity of the Bonin Islands in the period from December to the middle of April, after which they go north. Bryde's whales arrive in the middle or end of April. Before 1945, whaling in the Bonin Islands was conducted from December to May with a peak in March, implying that the historic catch would have included both sei and Bryde's whales.

However, results from a whale marking trip conducted in Bonin waters in 1952 imply that sei whales are found in the area in July whereas examination of Japanese Scouting Vessel (JSV) sightings data from 1964-90 between February and July showed no sei whales at all, but only Bryde's whales.

The uncertainties in the classification of the Bonin Island catches are such that the Working Group agreed that two catch series would be used in the trials. The base case will assume the Bonin Islands catch to be 100% Bryde's whales, whereas the 'Low' catch series will assume the historic catches in the Bonin Islands prior to 1945 do not include any Bryde's whales. This will ensure that the full range of uncertainty is covered, while using the more precautionary series for the base case. Further information may narrow the plausible range of proportions to be used.

The Working Group also considered a suggestion that the periodic nature of the Kuroshio Current might be correlated with Bryde's whale catches. When the current was strong the warm water moving north might lead to an increase in the numbers of Bydes's whales in the Sanriku area of Japan. It was agreed that it would be interesting to investigate the effect, but that the results would be unlikely to affect the catch series agreed to be used in the trials.

Perrin reported that he had examined papers on catches in the Philippines from 1983-85, which confirmed previous indications that most of the catch was taken in more distant and deeper waters, possibly as far as the Bonin Islands.

However, some catches were taken in the vicinity of the Caroline Islands and so may not have been taken from the WNP Stock, but rather from the Bryde's-like pygmy species. It was **agreed** that the official catch series will be used, but with the 'best' and 'high' series assuming all the catches were taken from the WNP Stock and the 'low' series removing 50% assumed to have been taken from another stock or species.

2.5 Interpretation of age data

Age data are potentially valuable for the *Implementation* process for a number of reasons:

(1) estimating age at first parturition (t_m) and age at recruitment to the fishery (e.g. SC/O05/BWI7);
(2) estimating natural mortality rate (M) (e.g. SC/O05/BWI7);
(3) examining lower and upper bounds of *MSYR*, which requires inter alia information on t_m and M (e.g. SC/O05/BWI4);
(4) providing possible information on age-specific distribution and/or stock structure.

From previous discussions of age data within the Scientific Committee, a number of features of such data need to be borne in mind. These include:

(a) representativeness of the sampled animals to the true population (e.g. size limit regulations, selectivity by whalers);
(b) representativeness of the aged animals to the sampled animals (some earplugs may be unreadable);
(c) accuracy with which lengths are determined;
(d) differences in readings between individual readers and/or differences in readings for the same reader over time (e.g. if there is a long gap between the times a reader undertook readings) which may be systematic (e.g. a reader always underestimates or overestimates counts over full age range, always underestimates or overestimates counts for particular age classes, e.g. young animals, very old animals).

SC/O05/BWI7 estimated some biological parameters of the WNP Bryde's whale using age data collected during the pelagic whaling (1971-79) and by JARPN II (2000-03). The total, natural and fishing mortality coefficients were estimated from age distribution to be 0.095, 0.078 and 0.017, respectively. The age at sexual maturity of males and females was estimated to be 8 and 6 years old, respectively.

In discussions of SC/O05/BWI7, the Workshop examined the age distributions for the commercial (1971-79, n=646) and JARPN II (2000-03, n=131) catches.

In that paper, the commercial data were divided into sub-area 1E (155°E–180°E) and sub-area 2 (180°-155°W); the JARPN II data only came from west of 160°E. Coastal whaling had a minimum size limit of 35 feet (10.7m) while pelagic whaling had a limit of 40 feet (12.2m). Commercial operations were carried out quite differently to the JARPN II programme. In the former, whalers would steam directly to areas where high densities were expected and would select for larger animals where possible. The JARPN II programme, however, involves the vessels steaming along pre-determined tracklines and sampling animals at random (including cow-calf pairs in 2000 and 2001).

The total pelagic catch for sub-area 1E+2 during the period 1971-79 was 5,404. Thus, a total of 12% of the catch was aged. By contrast, for JARPN II, of the 193 animals that were caught, it was possible to obtain ages from 131 or almost 68% of the catch.

The reasons that animals could not be aged include lack of collection of earplugs and/or difficulties when reading earplugs and/or other reasons. It is important to investigate these reasons in order to try to ascertain whether the age distribution of the aged animals reflects the distribution of the caught animals or whether any bias has been introduced (e.g. certain ages are more likely to be unreadable).

From both the method of sampling and the percentage of animals aged, one would assume that the JARPN II data are more representative of the 'true population', stock identity questions aside.

In terms of potential issues arising out of differences among readers (or time), age readings for the JARPN II data were carried out by two scientists, Kato and Zenitani. Both scientists read all earplugs but further details on the reading process (e.g. whether they were they read blind and then compared, how discrepancies were dealt with, the proportion of unreadable earplugs etc.) were not available to the meeting. It is not clear who was involved in reading the complete commercial data set. Ohsumi recalled that he read all of the earplugs for the period 1971-74 as these were used in his 1977 paper (Ohsumi, 1977). The Workshop **agreed** that it would be valuable if as much information as possible on the reading process for both the commercial and JARPN II could be compiled before the next meeting (see Item 8.1).

2.5.1 Examination of age distributions

Visual inspection of these age distributions plotted in SC/O05/BWI7 suggested differences between the commercial and the JARPN II data. In order to examine this, a χ^2 test for independence was used to compare the age-composition data for sub-areas 1E + 2[2] and those for sub-area 1W. The data have been pooled to satisfy the requirement that the predicted numbers in each cell exceeds 5 (Table 2). The data for ages 0-9 have been ignored for the purposes of this calculation (the Committee had previously agreed to assume knife edge selectivity at age 9 for sub-areas 1E and 2 (IWC, 2000). The null hypothesis of independence is rejected at the 5% level (p=0.0107; df=4). Most of the discrepancy between the expected and observed age-compositions can be attributed to the lowest (10+) and oldest (21+) age-classes (Table 2).

Table 2

Comparison of age composition data for sub-areas 1E+2 and for JARPN II (see text).

Area	Ages					Total
	10-11	12-13	14-15	16-20	21+	
Sample size						
Sub-areas 1E + 2	71	56	53	136	190	506
JARPN II	17	10	13	19	14	73
Total	88	66	66	155	204	579
Expected age-frequencies under the null hypothesis of independence						
Sub-areas 1E + 2	76.9	57.7	57.7	135.5	178.3	506
JARPN II	11.1	8.3	8.3	19.5	25.7	73
Total	88	66	66	155	204	579

The Workshop **agreed** that it was important to try to determine whether this difference was real (which may have implications for stock structure hypotheses) or could be explained by other factors (e.g. features (a)-(c) above or geographical segregation by age) since there are implications for factors (1)-(4) above.

[2] No significant difference had been detected for commercial catches in sub-areas 1E and 2 (p=0.21; df=14).

The first potential explanation considered was related to the possibility that the proportion of older animals increases as animals are further away from Japan. However, there is no obvious increasing trend in average age trend with longitude (Fig 6).

Fig. 7 shows the length-age data for sub-areas 1E and 2, and for JARPN II. The lack of old animals in the JARPN II sample is evident. The average length of young animals in sub-areas 1E and 2 is much larger than in the JARPN II sample. Possible explanations for this include: (a) ageing error, (b) selectivity by whalers for larger animals (i.e. only the faster growing animals from the younger cohorts will be caught), and (c) 'stretching' of whales smaller than the minimum size limit for pelagic operations of 12.2m.

Given that it was certain that the 1971-74 data were all read by Ohsumi (1977) over a relatively short period, it was decided to compare that age distribution with that for JARPN II as well as with the data for 1975-79. The results of this comparison (Table 3) indicate that there are significant differences between age-composition data from JARPN II and those for 1971-74 (p=0.0056; df=4) and between the age-composition data for 1971-74 and those for 1975-79 (p=0.0340; df=4).

2.5.2 Hypotheses arising

Depending on the assumptions made, there are several implications arising out of the above and the inability to determine the reasons for the differences in the age distributions. Possible assumptions are:

(1) The differences are related to age reading and/or sampling issues in the commercial data. An implication of this assumption that the JARPN II data should be used to calculate t_m and M and those values should be for conditioning, trials (and consideration of *MSYR*). This will also have no implications for stock structure.

(2) The differences are real and reflect age-segregated distribution. An implication of this assumption is that trials should allow for smaller proportions of older animals in 1W than in 1E+2.

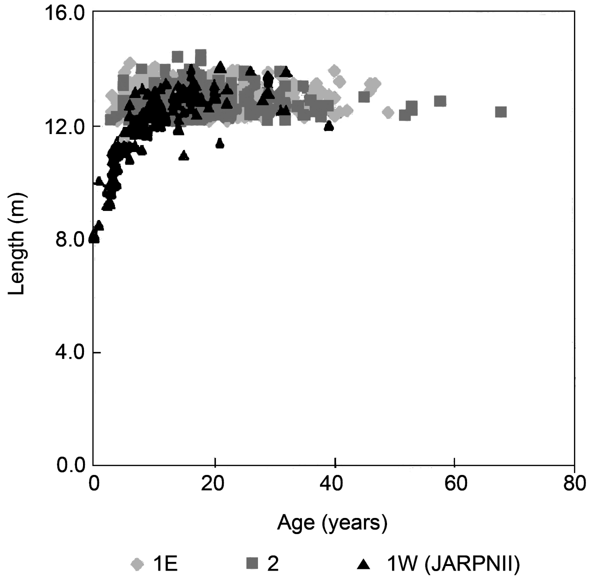

Fig. 7. Length versus age for sub-areas 1E, 2 and JARPN II.

(3) The differences are real and may indicate some degree of stock structure between sub-area 1W and 1E+2. An implication of this assumption is that there need to be trials in which there is stock structuring between sub-areas 1W and 1E+2.

The Workshop **agreed** that in order to investigate whether any of these possibilities can be eliminated, an inter-reader calibration experiment should be conducted (see Item 8.1).

3. SPECIFICATION OF *IMPLEMENTATION SIMULATION TRIAL* STRUCTURE

3.1 Selection of sub-areas

Previous developments of a basis for *ISTs* have implicitly envisaged three sub-areas, 1W, 1E and 2, with the boundaries set at 155°E and 180° respectively. The

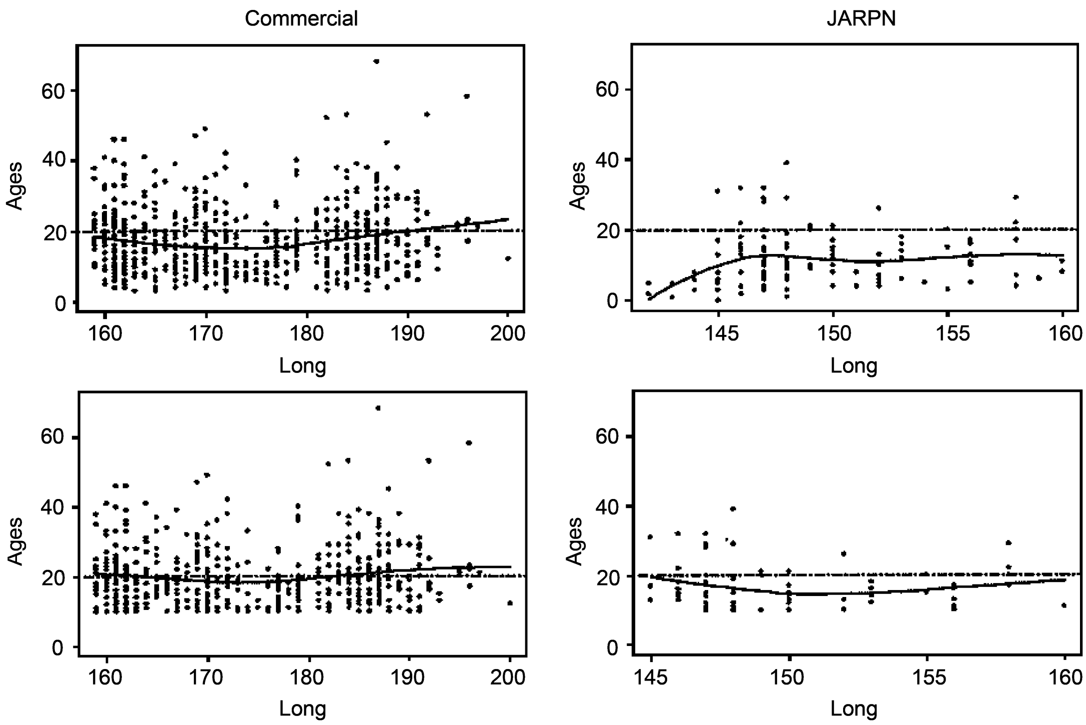

Fig. 6. Age versus longitude for sub-areas 1E+2 ('Commercial') and for JARPN II. The upper panels show all of the data while the lower panels are restricted to animals 10 and older. The solid lines in each panel are loess smoothers.

Table 3

Comparison of age composition data for JARPN II, with the data sub-areas 1E+2 and 1W split into two periods 1971-74 and 1975-79 (see text).

Area	Ages 10-11	12-13	14-15	16-20	21+	Total
(a) 1971-74 versus JARPN II						
Sample size						
JARPN II	17	10	13	19	14	73
1971-74	8	7	14	36	36	101
Total	25	17	27	55	50	174
Expected age-frequencies under the null hypothesis of independence						
JARPN II	10.5	7.1	11.3	23.1	21.0	73
1971-74	14.5	9.9	15.7	31.9	29.0	101
Total	25	17	27	55	50	174
(b) 1971-74 versus 1975-79						
Sample size						
1971-74	8	7	14	36	36	101
1975-79	63	49	39	100	154	405
Total	71	56	53	136	190	506
Expected age-frequencies under the null hypothesis of independence						
1971-74	14.2	11.2	10.6	27.1	37.9	101
1975-79	56.8	44.8	42.4	108.9	152.1	405
Total	71	56	53	136	190	506

boundary between sub-areas 1E and 2 was chosen because there are few genetics data to the east of 180°. The boundary between sub-areas 1W and 1E was set at 155°E primarily because there is a gap in catches between 150°E and 155°E. However, the Workshop noted that this gap was caused by regulations: pelagic whaling was allowed only to the east of 159°E by the Government of Japan, while coastal whaling tends to be restricted by the distance from the land station (IWC, 1999a, p.76). More recent data from JARPN II show no discontinuity in abundance between 150°E and 155°E (Fig. 5).

The Workshop agreed to retain three sub-areas, and to keep the boundary between sub-areas 1E and 2 at 180° as before. Noting that there was no strong biological basis to set the boundary between sub-areas 1W and 1E at 155°E, and further that there is longitudinal boundary at 165°E in the design of past and planned future surveys (see Item 3.3), the Workshop **agreed** to move the 1W/1E boundary to 165°E as this would considerably simplify the technical specification and coding of trials. The Workshop also noted, however, that this boundary placement would have implications for the estimates of mixing proportions obtained from mark-recapture data when conditioning trials for stock structure hypothesis 4 (two sub-stocks that mix in sub-areas 1W and 1E) because many marks had been placed in the area between longitudes 155°E and 165°E, so that estimated mixing proportions could prove quite sensitive to boundary specification. Therefore the trials (see Item 3.4) for stock structure hypothesis 4 will examine alternative placements of this boundary at 155°E and 160°E as well as at 165°E.

3.2 Specification of expected future operations

Hatanaka reconfirmed advice given at the *pre-Implementation assessment* Workshop that future harvesting of Bryde's whales by Japan will occur from May to September in Japanese coastal waters and the high seas, but excluding: (1) a 40 n.mile zone off the coast of southern Japan west of 140°E; (2) the 200 n.mile zone around countries other than Japan; and (3) the area south of 20°N. The proposed timing will avoid both the main breeding season (December-April; Ohsumi, 1995) and the main parturition season (October-March; Ohsumi, 1995). The proposed harvest area (see Fig. 1) ensures that catches will be taken only from the offshore form, and excluding the area south of 20°N ensures that catches are not taken from the breeding area.

The question of the likely division of harvests between coastal and pelagic operations was raised in the context of assumptions for the trials, given that in the past pelagic operations had reflected a higher age at recruitment as a result of minimum length regulations. It was noted that while the specifications of the RMP do not exclude the possibility of implementing such measures in addition to catch limits under some circumstances, the RMP does not assume that such regulations will be imposed. Hatanaka advised that Japan did not intend to impose any national length limits on future catches of Bryde's whales, and accordingly the Workshop **agreed** that trials should assume an age at recruitment as applied to past coastal whaling (in contrast to the higher age corresponding to past pelagic operations). However, given past IWC restrictions of this nature, it was **agreed** that it was appropriate to investigate the implications of retaining or removing such limits. The Workshop welcomed an offer from Punt to compare MSYs for the stock based upon ages at recruitment corresponding to the two earlier forms of operation. It looks forward to receiving the results at the next meeting of the Scientific Committee.

3.3 Future survey plans

At the *pre-Implementation assessment* Workshop, Japan had provided a plan for future surveys, which is reflected in Table 4. Japan advised that these plans remained unchanged at this stage.

Table 4

Sighting survey plan for the WNP Bryde's whales.

Season	Sector 130°E-145°E	145°E-165°E	165°E-180°	180°-160°W
2006		o		
2007			o	
2008	o			
2009				o
2010		o		
2011			o	
2012	o			
2013				o
2014		o		
2015			o	
2016	o			
2017				o
2018		o		
2019			o	
2020	o			
2021				o

The Workshop noted that future survey plans do not need to be finalised until the First Annual Meeting and thus that there remains the opportunity for revised plans to be submitted at that time. The process of conditioning does not require final information on future surveys. Initial trials coding can usefully proceed on the basis of the plans advised in Table 4.

3.4 Trials structure

In developing a trials structure for the WNP Bryde's whales, the Workshop considered the hypotheses related to stock structure, *MSYR*, historical catches, and those arising from the age composition data for JARPN II and for the sub-areas 1E+2 (see Items 2.1, 2.3, 2.4, and 2.5). The trials consequently include hypotheses related to:

(1) the number of stocks in the *Region* (1 or 2);
(2) whether Stock 1 consists of two sub-stocks that mix across sub-area 1;
(3) the extent of additional variance;
(4) whether mixing in sub-area 1 is stochastic;
(5) uncertainty in the estimates of historical catches;
(6) whether there is age-dependent mixing; and
(7) where in sub-area 1 true boundary lies for the trials in which there are two sub-stocks that mix in sub-area 1;
(8) uncertainty in the natural mortality rate *M*.

All of the trials assume that $g(0)=1$. The Workshop **agreed** to base all the robustness tests, except that where there is age-dependent distribution, on hypothesis 4 because it is likely that trials based on this hypothesis will be the most difficult from a conservation viewpoint.

The Workshop **agreed** that this trials structure (Annex G) adequately captures the full range of uncertainty for the WNP Bryde's whales and **recommended** that a control program that implements these trials be developed and that the trials be conditioned and results reported to the 2006 Annual Meeting (see Item 8.2 for the details of the intersessional Steering Group established to coordinate and guide this effort).

4. CONDITIONING

4.1 Abundance estimates and covariances

SC/O05/BWI6 provided an update of an earlier estimate of additional variance by Kitakado *et al.* (2005b). That earlier analysis had been based on abundance estimates from 1988-96 closing mode and 1998-2002 passing mode surveys. Since closing mode estimates for the later period were now available, the new analysis for the estimation of additional variance was restricted to closing mode for improved comparability over time. A restricted maximum likelihood (REML) method was used, as in the earlier analysis, to estimate additional variance. This was applied for different data selections and for alternative models for changes in population size and distribution over time, but in all cases on the log scale of abundance estimates the additional standard deviation was about 0.6. The estimate of absolute abundance presented for the 1998-2002 surveys was based on passing mode as this was considered to be less biased than estimates based on closing mode. For a preferred approach of estimating a common mean school size across survey blocks, an estimate of 25,852 (CV about 0.39) was obtained.

In reviewing this paper, the Workshop noted that SC/O05/BW16 had not implemented a number of suggestions for improvement of methodology of Kitakado *et al*. (2005b) that are recorded in Section 6.1.2.1 of Annex D of the Report of the last Scientific Committee (IWC, 2006a), but also that it had then been agreed that such refinements were not essential for the purposes of estimating a value for additional variance for use in *ISTs*. Such refinements should, however, be considered when abundance estimates are developed for input when applying the RMP.

After discussion, the Workshop **agreed** to certain modifications to the computations of SC/O05/BW16, so that the estimation of abundance and additional variance could be achieved simultaneously whilst taking account of passing as well as closing mode abundance estimates by survey block. This involved estimating a common bias parameter *R* reflecting the ratio of closing to passing mode estimates of abundance within the framework of the linear random effects model approach of SC/O05/BW16, so that all sources of covariance could be appropriately taken into account. Absolute abundance estimates would be taken to correspond to passing mode, as this was considered less likely to introduce sources of bias than closing mode. Full details of the method duly applied, and of the results obtained, are provided in Annex H.

Two other modifications to the method applied, which assumes no temporal trend in abundance or its spatial distribution, were considered, but the Workshop decided not to implement them for the reasons given below.

(1) The possibility of including time-dependence of abundance in the estimation process was discussed. However it was noted that the method adopted essentially provides a form of average abundance estimate for the two sets of surveys, so is not losing information. Furthermore, given that the conditioning process is based on fixed *MSYR* values, that process is considerably simplified by having simulations hit single simulated abundance estimates for a specific year (which was agreed to be taken to be the mid-point year of 1995 for the two sets of surveys), since only a single pre-exploitation abundance parameter *K* has to be estimated to achieve this 'hit' exactly. Whilst the approach adopted loses any information on abundance trend that may be contained in the survey data, this information was noted to be very weak as estimates of a trend parameter provided in SC/O05/BWI6 did not differ significantly from zero.
(2) The possibility of allowing for the closing/passing mode bias factor *R* to vary between survey blocks was considered. However the variance evident for the inter-block estimates of *R* was sufficiently large that it was clear that such dependence would not be well estimated, and consequently could compromise the reliability of eventual estimates.

The eventual abundance estimate obtained for the complete survey area considered (blocks F-M: see fig. 1 of Annex H) was 21,826 (CV = 0.295), to apply to 1995, with an additional standard deviation estimate of σ_A=0.673. These results (and corresponding estimates for smaller areas as reflected in Annex H) were adopted for use in the simple model filter (see Section 2.1.2) and for conditioning the *ISTs*. It was noted that this estimate did not include contributions from blocks A-E (see fig. 1 of Annex H); this was not of concern for conditioning purposes because the 1998-2002 surveys indicated these contributions to be relatively small, but the methodology to be used to obtain abundance estimates for input on application of the RMP will need to take account of these blocks as well.

4.2 Biological parameters

SC/O05/BWI5 estimated pregnancy and lactation rates for the WNP Bryde's whales using data collected by JARPN II during 2000-05. The data were divided into two periods (2000-01 and 2002-05). Cow and calf pairs were collected during 2000-01, but not during 2002-2005. The pregnancy and lactation rates in the latter period were corrected using data for the former period. Thus, the pregnancy rate was estimated to be 55-59% and the lactation rate to be 29-32%.

The Workshop thanked the authors of SC/O05/BWI5 for conducting the analyses, noting that this paper responded to a request during the *pre-Implementation* Workshop. The Workshop considered whether pregnancy rates based on defining as pregnant those animals which have a corpus luteum in the ovaries or are with foetus, information provided which could be used to place a lower limit on the birth rate (a quantity needed to estimate *MSYR*; see Item 2.3). Given the extended breeding season, it seems likely that pregnancy rates calculated in this manner overestimate the birth rate to some extent (Annex I). The Workshop **agreed** that it is not possible to obtain an accurate estimate of calving rate, but that the data are not inconsistent with the traditional view that Bryde's whales are on a two-year cycle.

Annex J provides estimates of *M* for WNP Bryde's whales based on the Chapman and Robson (1960) estimator. This estimator is preferred to the catch curve approach in SC/O05/BWI4 because it deals better with small sample sizes, including zero observations. There was considerable discussion regarding the appropriate value(s) for *M* to use in trials. Points raised in discussion included: that although the estimates of *M* based on JARPN II data, together with an assumption that fishing mortality=0.015, reflect the most recent information and were collected in a random manner, the sample size for older animals is small; the estimate of *M* assumed for WNP Bryde's whales should be consistent with those for other species; ignoring the age data for ages less than 15 allows the impact of selectivity to be reduced or even removed; there would be an inconsistency between basing the estimates of *M* on the JARPN II data and simultaneously specifying trials which deliberately increase the exploitation rate in sub-area 1W to better mimic the age data distribution data from JARPN; and that previous analyses have shown that the value for *M* does not have a major impact on the performance of management procedures (e.g. Cooke and de la Mare, 1994; de la Mare, 1985; 1989; 1990). It was noted that the Committee has always had difficulty determining values for rates of natural mortality. Implications for trials and conditioning are discussed above.

4.3 Other
Section G of Annex G provides the full details of how the data used for conditioning are to be generated.

5. SPECIFICATION OF MANAGEMENT OPTIONS

5.1 Potential *Small Area* definitions
The following *Small Area* definitions are considered for these trials:

(1) sub-areas 1 and 2;
(2) sub-areas 1W, 1E and 2[3].

5.2 Potential management options
Based on the specifications for the intended whaling operations, the Workshop **agreed** that the control program for the WNP Bryde's whales would include following management options:

Management options based on calculating catch limits by *Small Area*:

(1) Sub-areas 1W, 1E and 2 are *Small Areas* and catch limits are set by *Small Area*.
(2) Sub-area 2 is taken to be a *Small Area* and the complete sub-area 1 is treated as a *Small Area*. For this management option, all of the future catches in sub-area 1 are taken from sub-area 1W[4].

Management options based on applying *catch-cascading*:

(3) Sub-area 2 is taken to be a *Small Area* and sub-area 1 is taken to be a *Combination area*. Sub-areas 1W and 1E are *Small Areas*, with *catch-cascading* applied.
(4) Sub-areas 1 and 2 (combined) are taken to be a *Combination area*, and sub-area 2 and sub-areas in 1W and 1E are *Small Areas*, with *catch-cascading* applied.

The specifications for the management options will finalised during the First Annual Meeting.

6. PERFORMANCE STATISTICS AND PRESENTATION OF RESULTS

Section J of Annex G lists the performance statistics that will be used to select among management options. The Workshop noted that selection among management options will also be based on graphical summaries. One graphical summary (which can be used to summarise the time-trajectory of catch/mature female population size) that may be useful is a plot which shows: (a) the results of the first ten simulations; (b) the median of all 100 simulations, and the 90% probability intervals. The 90% probability intervals are summarised on this type of plot by shading the areas between the lines that define the annual upper and lower 5th percentiles.

In relation to evaluating conditioning, the Workshop agreed that the following plots should be created by the Secretariat and made available in electronic form at the 2006 Annual Meeting:

(1) histograms of the standard residuals for each of the data points used when conditioning (these distribution should ideally be centred about zero and model have high variance);
(2) time-trajectories of operating model-predicted population size (medians – solid lines; 90% intervals – dotted lines). The plots for each sub-area should indicate the medians for the target abundances used for conditioning by crosses, and the actual abundance estimates and their 90% intervals by open circles and vertical bars;
(3) time-trajectories of abundance by sub-area for two individual simulations, together with the corresponding (pseudo) target abundance estimates used for conditioning.

7. CONSIDERATION OF WAYS TO DISTINGUISH AMONG COMPETING STOCK HYPOTHESES

Ageing of JARPN II samples in 1E.

8. WORK REQUIRED PRIOR TO 2006 ANNUAL MEETING

8.1 Schedule
The Workshop identified the following research topics (items annotated by asterisks were identified by the *pre-Implementation* Workshop)

Prior to the 2006 Annual Meeting (the 'First Annual Meeting'):

(1) develop a distribution for F_{ST} for the WNP Bryde's whales to interpret the results of the power analysis;
(2) consider the feasibility of evaluating power using models which explicitly include changes over time in demographics and that can be tailored to the data for the resource under consideration;

[3] The 1W and 1E *Small Areas* are defined to be 130°E-165°E and 165°E-180° irrespective of the true boundary used to define the structure of the populations in the operating model.
[4] This assumption is made because it will lead to the most severe test of conservation performance.

(3) examine the extent to which the priors assumed in Kitakado *et al.* (2005c) are uninformative in terms of model selection;
(4) evaluate the performance of the Bayesian approaches in Kitakado *et al.* (2005c) using the simulation;
(5) evaluate the impact of differences in the age-at-recruitment on MSY;
(6) the *ISTs* in Annex G should be coded and conditioned;
(7) establish a 'blind' calibration exercise based on an experimental design with at least Kato, Ohsumi and Zenitani using earplugs from both commercial and JARPN II whales to examine potential inter-reader differences (Convenor: Miyashita; members: Ohsumi, Perrin, Brownell, SWFC statistician);
(8) Ohsumi will assist Allison in finalising the outstanding issues relating to the catch data.

The Workshop noted that topics (1)-(4) would enhance the ability to assign plausibility ranks to *ISTs* but they may not be needed (e.g. because other approaches, such as the use of the 'simple model filter' and the tagging data, may provide sufficient) and hence that not having them would not mean that it will be impossible to complete the tasks scheduled for the First Annual Meeting. Topic (7) will inform the plausibility of trials in which there is sub-stock structure in sub-area 1 (see Item 2.1.3).

The main tasks for the 'First Annual Meeting' are to review the results of the conditioning runs and finalise the *ISTs*. Plausibility ranks will also be assigned to each simulation trial during the 'First Annual Meeting'.

8.2 Terms of Reference for the intersessional group to facilitate conduct of the work

An intersessional Steering Group comprising Punt, Allison, Donovan, Perrin, Butterworth will assist with any problems that may arise in undertaking the intersessional work.

9. ADOPTION OF REPORT

The Chair thanked the participants, the rapporteurs and the interpreters. The participants thanked the Chair.

REFERENCES

Brandao, A., Butterworth, D.S. and Brown, M.R. 2000. Report of the Scientific Committee. Annex G. Report of the Sub-Committee on the Comprehensive Assessment of Other Whale Stocks. Appendix 8. Maximum possible humpback whale increase rates as a function of biological parameter values. *J. Cetacean Res. Manage. (Suppl.)* 2:192-93.

Butterworth, D.S. and Best, P.B. 1990. Implications of the recovery rate of the South African right whale population for baleen whale population dynamics. *Rep. int. Whal. Commn* 40:433-47.

Cooke, J.G. and de la Mare, W.K. 1994. Some aspects of the estimation and modelling of baleen whale sustainable yields. *Rep. int. Whal. Commn* 44:451-57.

de la Mare, W.K. 1985. On the estimation of mortality rates from whale age data, with particular reference to minke whales (*Balaenoptera acutorostrata*) in the Southern Hemisphere. *Rep. int. Whal. Commn* 35:239-50.

de la Mare, W.K. 1989. On the simultaneous estimation of natural mortality rate and population trend from catch-at-age data. *Rep. int. Whal. Commn* 39:355-61.

de la Mare, W.K. 1990. A further note on the simultaneous estimation of natural mortality rate and population trend from catch-at-age-data. *Rep. int. Whal. Commn* 40:489-92.

Donovan, G.P. 1991. A review of IWC stock boundaries. *Rep. int. Whal. Commn (special issue)* 13:39-68.

International Whaling Commission. 1996. Report of the Scientific Committee, Annex G. Report of the sub-committee on North Pacific Bryde's Whales. *Rep. int. Whal. Commn* 46:147-59.

International Whaling Commission. 1997. Report of the Scientific Committee, Annex G. Report of the sub-committee on North Pacific Bryde's whales. *Rep. int. Whal. Commn* 47:163-68.

International Whaling Commission. 1998. Report of the Intersessional Working Group to Review Data and Results from Special Permit Research on Minke Whales in the Antarctic, Tokyo, 12-16 May 1997. *Rep. int. Whal. Commn* 48:377-412.

International Whaling Commission. 1999a. Report of the Scientific Committee. Annex D. Report of the Sub-Committee on the Revised Management Procedure. *J. Cetacean Res. Manage. (Suppl.)* 1:61-116.

International Whaling Commission. 1999b. Report of the Scientific Committee. Annex F. Report of the Standing Working Group (SWG) on the Development of an Aboriginal Subsistence Whaling Management Procedure (AWMP). *J. Cetacean Res. Manage. (Suppl.)* 1:157-78.

International Whaling Commission. 2000. Report of the Scientific Committee. Annex D. Report of the Sub-Committee on the Revised Management Procedure. *J. Cetacean Res. Manage. (Suppl.)* 2:79-124.

International Whaling Commission. 2004. Report of the Scientific Committee. Annex D. Report of the Sub-Committee on the Revised Management Procedure. *J. Cetacean Res. Manage. (Suppl.)* 6:75-184.

International Whaling Commission. 2005a. Report of the Scientific Committee. *J. Cetacean Res. Manage. (Suppl.)* 7:1-62.

International Whaling Commission. 2005b. Report of the Scientific Committee. Annex D. Report of the Sub-Committee on the Revised Management Procedure. Appendix 2. Requirements and guidelines for *Implementation*. *J. Cetacean Res. Manage. (Suppl.)* 7:84-92.

International Whaling Commission. 2006a. Report of the Scientific Committee. *J. Cetacean Res. Manage. (Suppl.)* 8:1-65.

International Whaling Commission. 2006b. Report of the Workshop on the *pre-implementation assessment* of western North Pacific Bryde's whales. *J. Cetacean Res. Manage. (Suppl.)* 8:337-55.

Kato, H. and Yoshioka, M. 1995. Biological parameters and morphology of Bryde's whales in the western North Pacific, with reference to stock identification. Paper SC/47/NP11 presented to the IWC Scientific Committee, May 1995 (unpublished). 19pp. [Paper available from the Office of this Journal].

Kishiro, T. 1996. Movements of marked Bryde's whales in the western North Pacific. *Rep. int. Whal. Commn* 46:421-28.

Kishiro, T. 1998. Further analysis of the mark-recapture data of the western North Pacific Bryde's whales by a unit of five degree square latitude-longitude. Paper SC/50/RMP18 presented to the IWC Scientific Committee, April 1998 (unpublished). 13pp. [Paper available from the Office of this Journal].

Kitakado, T., Kanda, N. and Pastene, L.A. 2005a. A prospective evaluation of statistical power for population identification under island models. Paper SC/M05/BR3 presented to the Workshop on the *pre-implementation assessment* of western North Pacific Bryde's whales, Tokyo, Japan, March 21-24 2005 (unpublished). 14pp. [Paper available from the Office of this Journal].

Kitakado, T., Shimada, H., Okamura, H. and Miyashita, T. 2005b. Review of abundance estimate and additional variance for the western North Pacific stock of Bryde's whales. Paper SC/57/PFI1 presented to the IWC Scientific Committee, June 2005, Ulsan, Korea (unpublished). 20pp. [Paper available from the Office of this Journal].

Kitakado, T., Kanda, N. and Pastene, L.A. 2005c. Preliminary Bayesian analyses for population identification using mtDNA data in western North Pacific Bryde's whales. Paper SC/M05/BR5 presented to the Workshop on the *pre-implementation assessment* of western North Pacific Bryde's whales, Tokyo, Japan, March 21-24 2005 (unpublished). 5pp. [Paper available from the Office of this Journal].

Martien, K.K. and Taylor, B.L. 2004. Analysis of population structure in western North Pacific Bryde's whales using three clustering methods. Paper SC/56/PFI3 presented to the IWC Scientific Committee, July 2004, Sorrento, Italy (unpublished). 10pp. [Paper available from the Office of this Journal].

Ohsumi, S. 1977. Bryde's whales in the pelagic whaling ground of the North Pacific. *Rep. int. Whal. Commn (special issue)* 1:140-50.

Ohsumi, S. 1995. A review of population studies of the North Pacific Bryde's whale stocks (revised). Paper SC/47/NP14 presented to the IWC Scientific Committee, May 1995 (unpublished). 35pp. [Paper available from the Office of this Journal].

Omura, H. and Fujino, K. 1954. Sei whales in the adjacent waters of Japan. II. Further studies on the external characters. *Sci. Rep. Whales Res. Inst., Tokyo* 9:89-103.

Pastene, L., Goto, M. and Kanda, N. 2004. An update of the mitochondrial DNA and microsatellite analyses in western North Pacific Bryde's whale. Paper SC/56/PFI4 presented to the IWC Scientific Committee, July 2004, Sorrento, Italy (unpublished). 9pp. [Paper available from the Office of this Journal].

Punt, A.E., Kishiro, T. and Allison, C. 2005. Progess of estimating mixing rates for western North Pacific Bryde's whales using a 'simple model filter'. Paper SC/57/PFI2 presented to the IWC Scientific Committee, June 2005, Ulsan, Korea. 16pp.

Shimada, H. 2004. Abundance estimate of the western North Pacific stock of Bryde's whales using sighting data from 1998 to 2002. Paper SC/56/PFI6 presented to the IWC Scientific Committee, July 2004, Sorrento, Italy (unpublished). 8pp. [Paper available from the Office of this Journal].

Shimada, H. and Miyashita, T. 1996. Further estimation of Bryde's whale abundance in the western North Pacific incorporating sighting data in 1995 survey. Paper SC/48/NP17 presented to IWC Scientific Committee, June 1996, Aberdeen (unpublished). 8pp. [Paper available from the Office of this Journal].

Shimada, H. and Miyashita, T. 1999. Report of the Scientific Committee, Annex D. Appendix 13. Sightings and abundance estimates for western North Pacific Bryde's whales. *J. Cetacean Res. Manage. (Suppl.)* 1:108-15.

Wada, S. 1991. Genetic structure of Okhotsk Sea-West Pacific stock of minke whales. Paper SC/43/Mi32 presented to the IWC Scientific Committee, May 1991 (unpublished). 17pp. [Paper available from the Office of this Journal].

Wada, S. 1996. The stability of *Got-1f* frequencies of the western North Pacific stock of Bryde's whales. *Rep. int. Whal. Commn* 46:459-60.

Wada, S. and Numachi, K. 1991. Allozyme analyses of genetic differentiation among the populations and species of the *Balaenoptera*. *Rep. int. Whal. Commn (special issue)* 13:125-54.

Annex A

List of Participants

JAPAN
T. Hakamada
H. Hatanaka
T. Iwasaki
N. Kanda
S. Kawahara
T. Kitakado
T. Miyashita
S. Ohsumi
H. Okamura
L.A. Pastene
H. Shimada
K. Murata (I)
Y. Yamakage (I)
I. Yamasaki (I)
H. Yasokawa (I)

USA
R.L. Brownell, Jr
W.F. Perrin

INVITED PARTICIPANTS
D.S. Butterworth
A.K. Danielsdóttir
A.E. Punt

IWC
C. Allison
G.P. Donovan

(I=Interpreter)

Annex B

Agenda

1. Introductory items
   1.1 Convenor's opening remarks
   1.2 Election of Chair and appointment of rapporteurs
   1.3 Adoption of Agenda
   1.4 Review of documents

2. Hypotheses for inclusion in trials
   2.1 Stock structure and mixing
      2.1.1 Review of hypotheses presented at the *pre-Implementation assessment*
      2.1.2 Results of 'simple model filter'
      2.1.3 Final choice of plausible stock hypotheses for inclusion in trials
   2.2 *g*(0)
   2.3 Maximum Sustainable Yield Rate (*MSYR*)
   2.4 Alternative catch series
   2.5 Interpretation of age data
      2.5.1 Examination of age distributions
      2.5.2 Hypotheses arising

3. Specification of *Implementation Simulation Trial* structure
   3.1 Selection of sub-areas
   3.2 Specification of expected future operations
   3.3 Future survey plans
   3.4 Trials structure

4. Conditioning
   4.1 Abundance estimates and covariances
   4.2 Biological parameters
   4.3 Other

5. Specification of management options
   5.1 Potential *Small Area* definitions
   5.2 Potential management options

6. Performance statistics and presentation of results

7. Consideration of ways to distinguish among competing stock hypotheses

8. Work required prior to 2006 Annual Meeting
   8.1 Schedule
   8.2 Terms of Reference for the intersessional group to facilitate conduct of this work

9. Adoption of report

Annex C

Documents

SC/O05/BWI

1. PUNT, A.E. Initial (straw man) trial specifications for the western North Pacific Bryde's whales.
2. PUNT, A.E. Distribution proportions for western North Pacific Bryde's whales and their implications for the performance of the RMP.
3. PASTENE, L.A. Comments on the hypotheses on stock structure presented at the *pre-implementation assessment* of the western North Pacific Bryde's whale.
4. HAKAMADA, T., BANDO, T. AND OHSUMI, S. Estimation of the lower bound of *MSYR* for western North Pacific Bryde's whales.
5. BANDO, T., HAKAMADA, T. AND OHSUMI, S. Estimation of true pregnancy rate of western North Pacific Bryde's whale.
6. KITAKADO, T., SHIMADA, H., OKAMURA, H. AND MIYASHITA, T. Update of additional variance estimate for the western North Pacific stock of Bryde's whale.
7. BANDO, T., KISHIRO, T., OHSUMI, S., ZENITAN, R. AND KATO, H. Estimation of some biological parameters of western North Pacific Bryde's whale by age distribution.

Annex D

Extract from 'Requirements and Guidelines for *Implementations*'

The following is an extract from 'Requirements and Guidelines for *Implementations*' (IWC, 2005).

2. First intersessional Workshop

The primary objective of the first intersessional workshop is to develop an appropriate *Implementation Simulation Trials* structure and to specify the associated conditioning so that it can be carried out before the following Annual Meeting. The aim of such trials[1] is to encompass the range of plausible scenarios involving *inter alia* stock structure, MSY rates (*MSYR*), removals and surveys. These trials are used to investigate the implications of various choices of RMP variants such as *Catch-cascading* from a risk- and catch-related perspective, with a view to recommending an appropriate variant for implementation of the RMP for a specific species/area.

Workshop discussions will include the items listed below.

(1) A final review of the plausible hypotheses arising from the *pre-Implementation assessment* (and, if appropriate, elimination of any hypotheses that are inconsistent with the data) – this will take into account the probable management implications of such hypotheses to try to avoid unnecessary work in the precise specifications of hypotheses for which these are very similar;
(2) An examination of more detailed information in expected operations, including whether coastal, pelagic, on migration, on feeding, on breeding or combinations of these. When providing such information, users and scientists may provide options or suggest modifications to the pattern of operations;
(3) The determination of the small geographical areas ('sub-areas') that will be used in specifying the stock structure hypotheses and operational pattern;
(4) The development of (options for) potential *Small Areas*[2] and management variants;
(5) The specification of the data and methods for conditioning the trials that will be carried out before the next annual meeting (an e-mail correspondence group will be established to make revisions should any problems arise);
(6) Further consideration of experimental ways to distinguish amongst competing stock hypotheses.

It is **important** to note that after this stage:

(1) there shall be no changes to the agreed trials structure that implements the agreed plausible hypotheses;
(2) no new data will be considered, although new analyses of existing data may be presented to the First Annual Meeting (see below).

[1] A trial is the combination of a set of 'hypotheses' (e.g. about stock structure, *MSYR*).

REFERENCE

International Whaling Commission. 2005. Report of the Scientific Committee. Annex D. Report of the Sub-Committee on the Revised Management Procedure. Appendix 2. Requirements and guidelines for *Implementation*. *J. Cetacean Res. Manage. (Suppl.)* 7:84-92.

[2] *Small Areas* cannot be smaller than sub-areas.

Annex E

Report of updated SMF results

André E. Punt

The 'simple model filter' calculations of SC/O05/BWI2 have been updated to reflect the revised estimates of abundance in SC/O05/BWI3 (Table 1). The model formulation for these calculations is identical to that of SC/O05/BWI2 except that the tag-loss rate (S in Equation 7 of SC/O05/BWI2) is treated as an estimable parameter. The results in this working paper therefore correspond most closely to stock structure hypothesis 4.

The results corresponding to the maximum likelihood estimates for the distribution proportions are listed in Table 2. The model is able to fit the abundance estimates and the tag-recaptures almost exactly (Fig. 1; Table 2). However, the estimate of tag-loss is considerably higher than the value of 0.07 assumed in SC/O05/BWI2 (0.29 for r=0.013 and 0.34 for r=0.053). The results in Table 2 suggest that stock/sub-stock 2 is found exclusively in sub-area 1W while stock/sub-stock 1 mixes between sub-areas 1W and 1E (35% in sub-area 1W and 65% in sub-area 1E). Stock/sub-stock 3 is only found in sub-area 2. Stock/sub-stock 2 is more depleted (47% of K) than the stock/sub-stocks found in sub-areas 1E and 2 (70 and 83% of K respectively), which is broadly consistent with the information from the ageing data (see Fig. 2 for the time-trajectories of exploitation rate by stock/sub-stock for r=0.013).

Table 3 shows negative log-likelihood values for 289 combinations for the two distribution proportions. Roughly, the 95% confidence intervals for the distribution proportions are those for which the negative log-likelihood differs by 3.00 units from the 'best' values reported in Table 2. Table 4 lists the estimated depletion of the two stocks in 2003 for each combination of the two distribution proportions. Note that some combinations of distribution proportions lead to values for K for one of the stocks/sub-stocks in sub-area 1 that are very small (<100), i.e. effectively a single stock hypothesis.

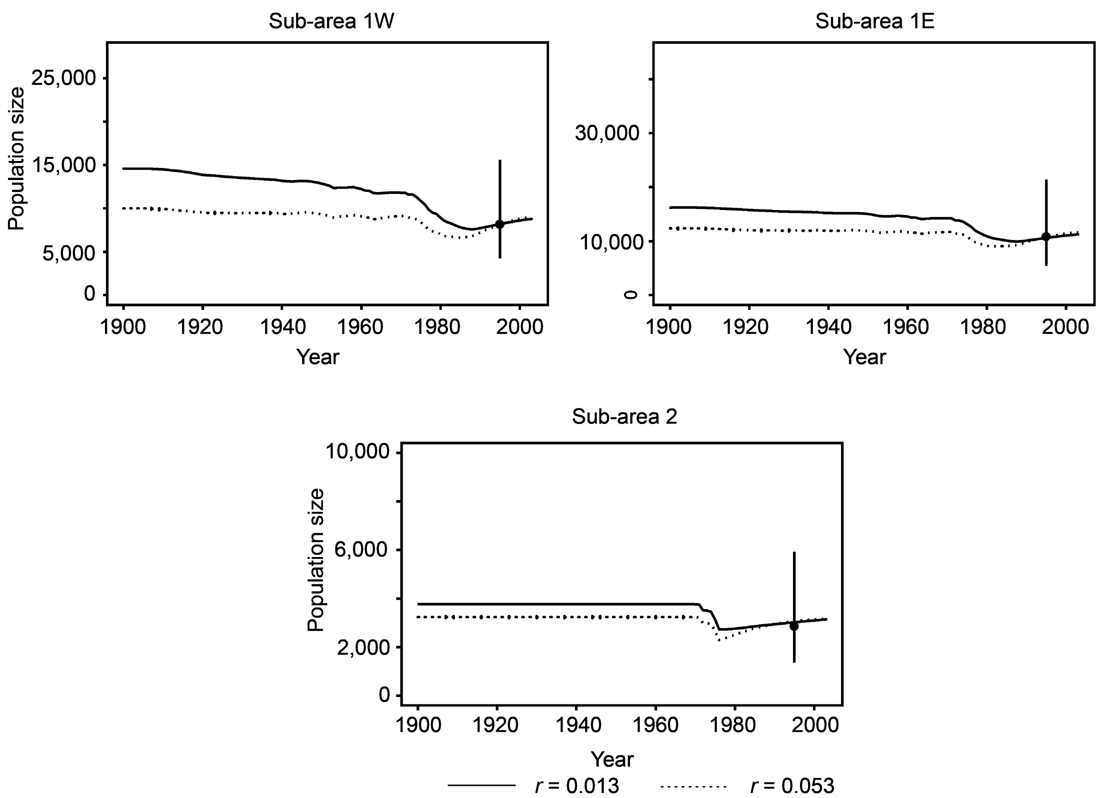

Fig. 1. Time-trajectories of population size by region for the two assumed values for r. The solid dots denote the abundance estimates used for conditioning and the vertical bars indicate the 95% confidence intervals for the data.

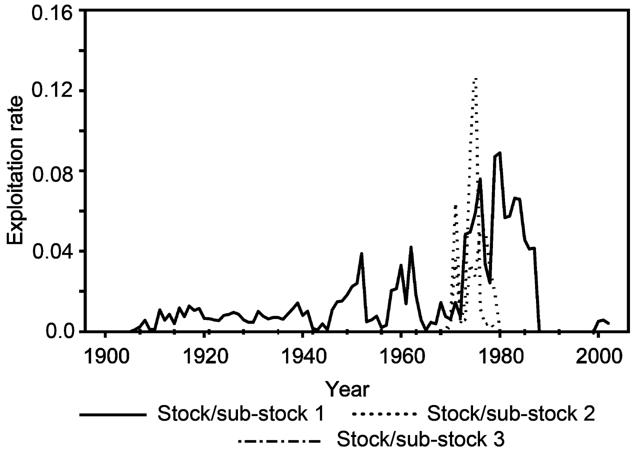

Fig. 2. Time-trajectories of population size by stock/sub-stock for r=0.013.

Fig. 3 shows time-trajectories of population size by stock/sub-stock for four variants of the RMP for the case r=0.013 (results are not shown for r=0.053 because they are not very informative regarding the conservation performance of variants of the RMP). The four variants are:

(1) Sub-area 2 is taken to be a *Small Area* and the complete sub-area 1 is treated as a *Small Area*. For this management option, all of the catches in sub-area 1 are taken from sub-area 1W.
(2) Sub-area 2 is taken to be a *Small Area* and sub-area 1 is taken to be a *Combination area*. Sub-areas 1W and 1E are *Small Areas*, with *catch-cascading* applied.
(3) Sub-areas 1 and 2 (combined) are taken to be a *Combination area*, and sub-area 2 and sub-areas 1W and 1E are *Small Areas*, with *catch-cascading* applied; and
(4) Sub-areas 1W, 1E and 2 are treated as *Small Areas* and catch limits are set by *Small Area*.

Table 1

Abundance estimates by sub-area used in the analyses of this document. The abundance estimates are assumed to pertain to 1995.

Area	Estimate (CV)
Sub-area 1W	8,152 (0.329)
Sub-area 1E	10,814 (0.342)
Sub-area 2	2,860 (0.372)

Table 2

Summary of the results when the distribution parameters (i.e. w_1 and w_2 in Table 5 of SC/O05/BWI2) are treated as estimable.

	r=0.013	r=0.053
Negative log-likelihood	6.47	6.46
Pre-exploitation size (% depletion in 2003)		
Stock/sub-stock 1	24,029 (70.2)	18,728 (93.7)
Stock/sub-stock 2	6,758 (47.1)	3,633 (84.2)
Stock/sub-stock 3	3,781 (83.2)	3,240 (97.8)
Distribution proportions (sub-areas 1W, 1E, 2)		
Stock/sub-stock 1	0.35; 0.65; 0	0.35; 0.65; 0
Stock/sub-stock 2	0.91; 0.09; 0	0.96; 0.04; 0
Stock/sub-stock 3	0; 0; 1	0; 0; 1
Tag-loss rate	0.286	0.341
Predicted recaptures		
Marked 1W; recaptured 1W (observed = 17)	16.92	17.1
Marked 1W; recaptured 1E (observed = 1)	0.57	0.64
Marked 1E; recaptured 1W (observed = 4)	4.21	4.25
Marked 1E; recaptured 1E (observed = 1)	0.90	0.98
Marked 2; recaptured 2 (observed = 0)	0.34	0.38

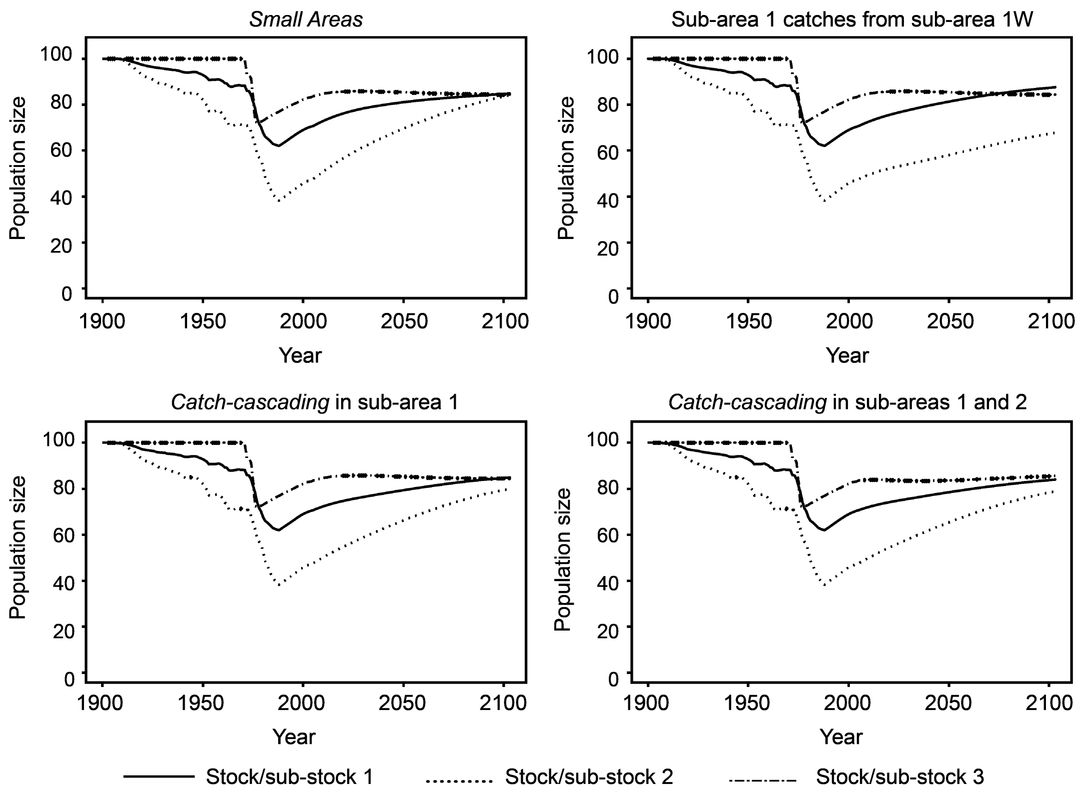

Fig. 3. Time-trajectories of population size by stock/sub-stock relative to K (1900-2103) for the four variants of the RMP for r=0.013.

Table 3

Negative log-likelihood values for 289 combinations of the distribution proportions for stocks/sub-stocks 1 and 2. The shaded areas identify the sets of distribution proportions for which the negative log-likelihood differs by less than 3 units from the lowest negative log-likelihoods in Table 6.

Proportion stock/sub-stock 1 in sub-area 1W	Proportion stock/sub-stock 2 in sub-area 1W																
	1.00	0.95	0.90	0.85	0.80	0.75	0.70	0.65	0.60	0.55	0.50	0.45	0.40	0.35	0.30	0.25	0.20
r = 0.013																	
0.00	87.06	11.74	10.27	8.81	7.88	7.31	6.94	6.69	6.53	6.47	6.48	6.56	6.73	6.98	7.45	8.21	9.46
0.05	11.53	10.58	9.28	8.25	7.57	7.12	6.82	6.62	6.51	6.47	6.48	6.58	6.73	6.98	7.44	8.22	9.49
0.10	10.26	9.47	8.47	7.79	7.27	6.94	6.71	6.57	6.49	6.47	6.51	6.60	6.74	6.98	7.44	8.22	9.47
0.15	8.90	8.30	7.73	7.31	6.99	6.76	6.61	6.51	6.47	6.47	6.52	6.61	6.75	6.98	7.46	8.22	9.46
0.20	7.76	7.44	7.18	6.94	6.76	6.62	6.53	6.48	6.47	6.49	6.55	6.63	6.75	6.97	7.44	8.21	9.45
0.25	7.03	6.90	6.77	6.66	6.58	6.52	6.48	6.47	6.48	6.52	6.58	6.65	6.76	6.98	7.44	8.22	8.21
0.30	6.64	6.59	6.54	6.51	6.48	6.47	6.47	6.49	6.52	6.57	6.61	6.68	6.77	6.97	7.43	7.44	7.44
0.35	6.49	6.48	6.47	6.48	6.49	6.49	6.51	6.54	6.57	6.61	6.65	6.70	6.79	6.98	6.97	6.98	6.97
0.40	6.51	6.52	6.53	6.55	6.56	6.58	6.60	6.62	6.64	6.67	6.71	6.73	6.75	6.79	6.77	6.76	6.75
0.45	6.65	6.66	6.68	6.69	6.70	6.71	6.72	6.72	6.73	6.75	6.74	6.73	6.73	6.70	6.68	6.65	6.63
0.50	6.89	6.90	6.89	6.90	6.90	6.90	6.90	6.89	6.90	6.89	6.89	6.74	6.71	6.65	6.61	6.58	6.55
0.55	7.24	7.24	7.24	7.23	7.24	7.24	7.24	7.24	7.24	7.24	6.89	6.75	6.67	6.61	6.57	6.52	6.49
0.60	7.77	7.78	7.77	7.77	7.77	7.77	7.77	7.77	7.77	7.24	6.90	6.73	6.64	6.57	6.52	6.48	6.47
0.65	8.54	8.53	8.53	8.53	8.53	8.53	8.53	8.53	7.77	7.24	6.89	6.72	6.62	6.54	6.49	6.47	6.48
0.70	9.57	9.57	9.56	9.57	9.57	9.58	9.55	8.53	7.77	7.24	6.90	6.72	6.60	6.51	6.47	6.48	6.53
0.75	10.97	10.98	10.96	10.98	10.96	10.96	9.58	8.53	7.77	7.24	6.90	6.71	6.58	6.49	6.47	6.52	6.62
0.80	12.94	12.93	12.93	12.93	12.92	10.96	9.57	8.53	7.77	7.24	6.90	6.70	6.56	6.49	6.48	6.58	6.76

Table 4

2003 depletion for stocks 1 and 2 for 289 combinations of the distribution proportions for stocks 1 and 2. The shaded areas identify the sets of distribution proportions for which the negative log-likelihood differs by less than 3 units from the lowest negative log-likelihoods in Table 2.

Proportion stock/sub-stock 1 in sub-area 1W	Proportion stock/sub-stock 2 in sub-area 1W																
Stock/sub-stock 1- r = 0.013																	
	1.00	0.95	0.90	0.85	0.80	0.75	0.70	0.65	0.60	0.55	0.50	0.45	0.40	0.35	0.30	0.25	0.20
0.00	81.5	83.7	80.8	81.8	82.9	83.6	84.5	85.5	86.0	86.9	87.5	87.9	88.5	89.3	90.5	91.5	92.5
0.05	84.7	82.7	80.9	81.4	81.9	82.7	83.0	83.7	84.2	84.4	84.9	85.3	85.5	86.1	86.6	86.8	87.4
0.10	82.0	81.5	80.6	80.6	80.8	81.0	81.4	81.6	81.8	82.1	82.3	82.6	82.4	82.5	82.5	82.2	81.7
0.15	80.0	79.4	79.2	79.0	79.0	79.2	79.3	79.3	79.4	79.3	79.7	79.6	79.5	79.2	78.8	78.1	76.9
0.20	77.1	77.2	77.7	77.2	77.3	77.3	77.2	77.0	77.1	77.0	77.1	77.1	76.8	76.0	75.2	74.0	71.1
0.25	74.8	74.7	74.9	74.8	74.7	74.8	74.9	74.6	74.9	74.5	74.5	74.4	74.0	73.0	71.4	69.2	69.8
0.30	71.9	72.3	72.3	72.3	72.4	72.6	72.1	72.2	72.2	71.8	71.7	72.1	71.3	70.0	67.9	67.8	68.0
0.35	69.9	70.0	70.0	69.8	70.3	70.0	70.0	70.1	69.6	69.8	69.5	69.1	68.3	66.9	67.0	66.8	66.7
0.40	68.2	68.4	67.9	68.7	68.2	68.6	68.1	67.8	67.7	67.6	66.9	66.6	65.9	65.6	65.9	66.0	65.8
0.45	66.9	66.6	66.9	66.3	66.5	66.4	65.8	66.1	65.5	65.9	65.9	65.4	64.1	64.1	64.8	64.3	64.3
0.50	65.4	65.5	65.4	65.3	65.2	65.3	65.1	65.1	65.2	65.3	65.1	63.8	62.1	62.4	61.9	62.1	62.3
0.55	65.6	65.5	65.5	65.5	65.5	65.5	65.0	65.3	65.6	65.5	63.4	61.7	60.8	60.4	59.8	60.3	60.4
0.60	65.9	65.8	66.0	66.0	65.7	65.9	65.6	65.9	65.8	64.0	61.5	59.0	58.9	58.1	58.5	59.1	58.9
0.65	66.1	66.7	66.3	66.3	66.2	66.1	66.2	66.2	64.6	62.1	59.5	57.8	56.9	56.9	56.6	56.5	57.0
0.70	67.1	66.8	67.2	67.9	67.8	66.8	67.1	65.2	63.0	60.3	57.7	55.5	55.3	54.7	54.1	55.3	56.0
0.75	68.7	67.9	68.3	68.4	68.3	68.6	66.1	64.1	62.1	59.3	56.2	54.4	54.5	52.8	52.9	53.2	54.2
0.80	70.4	70.1	70.6	69.9	70.2	68.0	66.4	63.2	60.6	57.8	54.3	52.7	51.7	51.4	50.9	51.2	53.1
Stock/sub-stock 2 – r = 0.013																	
0.00	53.2	51.6	56.8	56.9	57.8	58.3	58.9	60.4	60.2	61.7	62.6	63.6	65.2	66.8	68.0	69.6	71.1
0.05	46.5	50.7	54.2	56.2	56.8	57.7	57.7	59.3	60.0	61.0	62.3	64.5	65.3	66.9	68.1	69.3	72.0
0.10	44.6	48.7	51.8	53.9	55.1	56.3	57.8	58.1	59.6	60.8	62.2	64.4	65.4	66.6	67.7	69.1	71.3
0.15	44.4	47.1	49.8	51.4	53.6	55.5	56.3	57.6	59.0	60.3	62.3	63.8	65.3	66.6	67.8	69.6	71.8
0.20	41.6	44.9	48.6	50.4	53.1	54.2	56.0	57.0	58.9	60.4	62.3	64.3	65.8	66.7	68.0	69.8	71.1
0.25	41.7	43.9	47.3	49.4	51.2	53.2	55.3	56.5	59.1	60.3	62.1	64.3	66.0	66.8	67.8	69.2	74.0
0.30	41.1	44.5	46.4	48.4	50.9	52.9	54.1	56.6	58.5	59.8	61.9	64.8	65.9	67.0	67.9	71.4	75.2
0.35	42.9	45.1	47.0	48.5	51.4	52.8	54.7	56.9	58.1	60.4	62.4	64.1	65.6	66.9	70.0	73.0	76.0
0.40	44.8	46.7	47.8	50.9	51.7	54.5	55.3	56.9	58.9	60.8	62.1	64.1	65.9	68.3	71.3	74.0	76.8
0.45	46.8	48.0	50.1	50.6	52.7	54.4	55.5	57.8	59.0	61.7	63.8	65.4	66.6	69.1	72.1	74.4	77.1
0.50	48.2	49.7	51.2	52.8	54.3	56.2	57.7	59.5	61.5	63.4	65.1	65.9	66.9	69.5	71.7	74.5	77.1
0.55	52.2	53.4	54.9	56.3	57.8	59.3	60.3	62.1	64.0	65.5	65.3	65.9	67.6	69.8	71.8	74.5	77.0
0.60	55.9	57.0	58.4	59.6	60.6	62.1	63.0	64.6	65.8	65.6	65.2	65.5	67.7	69.6	72.2	74.9	77.1
0.65	59.1	60.8	61.3	62.3	63.2	64.1	65.2	66.2	65.9	65.3	65.1	66.1	67.8	70.1	72.2	74.6	77.0
0.70	62.8	63.3	64.4	65.8	66.4	66.1	67.1	66.2	65.6	65.0	65.1	65.8	68.1	70.0	72.1	74.9	77.2
0.75	66.8	66.4	67.1	67.7	68.0	68.6	66.8	66.1	65.9	65.5	65.3	66.4	68.6	70.0	72.6	74.8	77.3
0.80	70.4	70.1	70.6	69.9	70.2	68.3	67.8	66.2	65.7	65.5	65.2	66.5	68.2	70.3	72.4	74.7	77.3

Annex F

Catches

[See Scientific Committee Report, Annex D, Appendix 7, this volume p. 125]

Annex G

The Specifications for the *Implementation Simulation Trials* for western North Pacific Bryde's whales

[See Scientific Committee Report, Annex D, Appendix 6, this volume p. 114]

Annex H

An integrated approach for the estimation of abundance through a random-effects model

T. Kitakado, D.S. Butterworth and H. Okamura

Method

Let N_{ay} be the true abundance in the a-th survey block in the year y, and let $\hat{N}^{(P)}_{ay}$ and $\hat{N}^{(C)}_{ay}$ denote estimates of N_{ay} obtained from passing-mode and closing-mode surveys respectively. If abundance estimates in different blocks or years include common parameters such as effective search half-width, then any two of them are correlated, and the method following takes this into account. It is assumed that the abundance estimates are multivariate normally distributed as follows:

$$\begin{cases} \log \hat{N}^{(P)}_{ay} = \log N_{ay} + \varepsilon^{(P)}_{ay}, \\ \log \hat{N}^{(C)}_{ay} = \log R_a N_{ay} + \varepsilon^{(C)}_{ay}, \end{cases}$$

where the vectors of survey error terms, $\varepsilon^{(P)} = (\cdots, \varepsilon^{(P)}_{ay}, \cdots)'$ and $\varepsilon^{(C)} = (\cdots, \varepsilon^{(C)}_{ay}, \cdots)'$ have multivariate normal distributions $N(0,\hat{\Sigma}^{(P)})$ and $N(0,\hat{\Sigma}^{(C)})$, respectively. The variance-covariance matrices $\hat{\Sigma}^{(P)}$ and $\hat{\Sigma}^{(C)}$ are estimated using standard line transect methods. It is assumed that the true abundance level varies randomly as

$$\log N_{ay} = \mu_a + \rho_{ay}$$

where μ_a is a mean block-specific log-abundance for the middle year for the period for which data are available, and ρ_a is a random effect accounting for inter-annual changes in the distribution of the whale population in the surveyed area. The random effect is assumed to be independent and identically distributed according to the normal distribution $N(0, \sigma_A^2)$. Let $\mu = (\mu_1, ..., \mu_A)$ be a vector of the block effects. Then, the unbiased estimator for μ given σ_A^2 is derived from

$$\mu(\sigma_A^2) = (X' \ V(\sigma_A^2)^{-1} X)^{-1} X' \ V(\sigma_A^2)^{-1} y$$

where X is a design matrix, y is the vector of the abundance estimates, and $V(\sigma_A^2) = \sigma_A^2 I + \hat{\Sigma}$. The additional variance σ_A^2 is estimated by the REML method (McCulloch and Searle, 2001; Pawitan, 2001; Punt *et al.*, 1997; Skaug *et al.*, 2004), which maximise

$$l_{REML}(\sigma_A^2) = -\frac{1}{2}\log|D| - \frac{1}{2}\log\left|X' \ V(\sigma_A^2)^{-1} X\right| - \frac{1}{2}(y - X\beta(\sigma_A^2))' \ V(\sigma_A^2)^{-1}(y - X\beta(\sigma_A^2))$$

The confidence interval for σ_A^2 can be calculated using the profile of the function above. Once σ_A^2 is estimated, then the estimate $\hat{\mu} = \mu(\hat{\sigma}_A^2)$ becomes available. At the same time, the covariance matrix of $\hat{\beta} = \beta(\hat{\sigma}_A^2)$ can be evaluated as

$$Cov(\hat{\beta}) = (X' \ V(\hat{\sigma}_A^2)^{-1} X)^{-1}$$

The estimation of abundance in areas defined as FGH=F+G+H, IJK=I+J+K and LM=L+M (see Fig. 1) is now considered. For this purpose, option (a) in SC/O05/BWI6, where block K is included, is used. The abundance in each area is estimated by

$$\tilde{N} = \sum \exp(\hat{\mu}_a + Var(\hat{\mu}_a)/2)$$

and its variance by

$$V\hat{a}r(\tilde{N}) = \sum_a \exp(2\hat{\mu}_a) \ \ V\hat{a}r(\hat{\mu}_a)$$

$$+ \sum_{a \neq a'} \exp(\hat{\mu}_a)\exp(\hat{\mu}_{a'})\, c\hat{o}v(\hat{\mu}_a, \hat{\mu}_{a'})$$

The block-effects μ_a are estimated under the assumption that R_a is common across all blocks a.

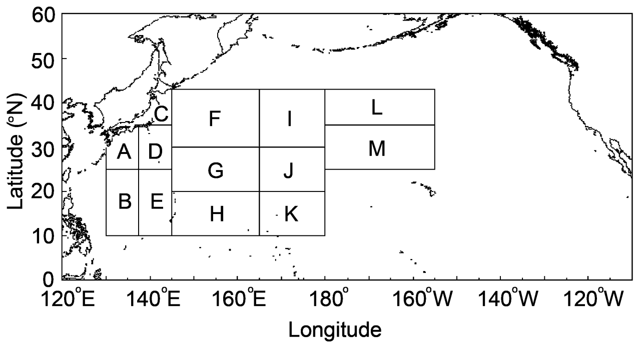

Fig. 1. Survey blocks defined for 1998-2002 surveys.

Results

Table 1

(1) Estimates of block-effects

	F	G	H	I	J	K	L	M
μ	7.89	7.89	7.57	8.46	8.41	6.03	6.97	7.25
SE	0.443	0.459	0.539	0.455	0.480	0.662	0.488	0.566

(2) Estimate of *R* (ratio of closing to passing mode estimates of abundance)

	R
Estimate	0.727
CV (%)	36.4

(3) Estimates of additional standard error and additional variance

	Estimate	95% CI
σ_A^2	0.453	(0.170, 1.041)
σ_A	0.673	(0.412, 1.020)

(4) Abundance estimates and their CVs (assuming passing mode estimates to be unbiased)

	FGH	IJK	LM	F-M
N-tilde	8,152	10,814	2,860	21,826
CV (%)	32.9	34.2	37.2	29.5

REFERENCES

McCulloch, C.E. and Searle, S.R. 2001. *Generalised, Linear and Mixed Models*. Wiley and Sons Inc., New York.

Pawitan, Y. 2001. *In All Likelihood: Statistical Modeling and Inference Using Likelihood*. Oxford University Press, New York. 528pp.

Punt, A.E., Cooke, J.G., Borchers, D.L. and Strindberg, S. 1997. Estimating the extent of additional variance for Southern Hemisphere minke whales from the results of the IWC/IDCR cruises. *Reports of the International Whaling Commission* 47:431-34.

Skaug, H.J., Øien, N., Schweder, T. and Bothun, G. 2004. Abundance of minke whales (*Balaenoptera acutorostrata*) in the northeastern Atlantic; variability in time and space. *Canadian Journal of Fisheries and Aquatic Sciences* 61(6):870-86.

Annex I

Life History Models

In the past, we have assumed

$$P/L = G/W$$

where P = pregnant, L = lactating, G = gestation period (months) and W = weaning age (months).

Based on this, we estimated calving interval as the reciprocal of pregnancy rate.

However, this ignores foetal mortality (and similarly, using L to estimate weaning age ignores nursing-calf mortality).

A better model is

$$P/L = a(G)/b(W)$$

where a = average number of gestations/birth (always >1) and b = average number of complete weanings/birth (always <1).

Even if we know P, G, L and W, we cannot estimate birth rate (or calving interval), because we do not know a or b. Using pregnancy rate as a proxy for birth rate injects a positive bias (and negative bias on CI) of unknown size, depending on extent o f seasonality of breeding and time of sampling.

Annex J

Natural Mortality Coefficient for the Bryde's whale estimated from Commercial and JARPN II samples

T. Hakamada, S. Ohsumi, A.E. Punt and D.S. Butterworth

The method of Chapman and Robson (1960) is applied to age distribution data for commercial whaling and from JARPN II to estimate survival rate. The fishing mortality rate is assumed to be 0.015 and natural mortality estimated by subtracting this value from the logarithm of the survival rate obtained from the Chapman and Robson estimator. The sensitivity of the results to basing the estimate of (total) survival rate on ages 1+, 10+ and 15+ is examined.

Age range	Quantity	Sub-area 1E	Sub-area 2	Sub-areas 1E+2	JARPN II
1+	*M*	0.044	0.036	0.042	0.068
	SE (*Z*)	0.003	0.004	0.002	0.008
10+	*M*	0.087	0.070	0.080	0.126
	SE (*Z*)	0.006	0.006	0.004	0.018
15+	*M*	0.104	0.087	0.097	0.131
	CV (*n*)	0.088	0.009	0.006	0.027

REFERENCE

Chapman, D.G. and Robson, D.S. 1960. The analysis of a catch curve. *Biometrics* 16:354-68.

Annex K

Some Thoughts on the Inter-Reader Comparison Exercise

G.P. Donovan

OBJECTIVE

To examine whether the differences in age distributions identified under Agenda Item 2.5 can be explained by differences in the age reading process and/or sampling issues in the commercial data.

INFORMATION NEEDS

As full a description as possible of the reading process for the various samples (commercial 1971-74, 1975+; JARPNII 2000-03) needs to be developed. This should include *to the greatest extent possible*:

(1) names of readers and number of earplugs they read;
(2) whether the earplugs were read 'blind' in some way (e.g. by either two readers or by the same reader twice; were read with or without knowledge of biological information on the animal);
(3) how differences in readings of the same earplug were handled if they were found;
(4) how many collected earplugs were considered 'unreadable' (and if it exists, any associated information on the animals involved e.g. length, sex, position etc);
(5) for the commercial hunt, is there any information on whether there was any 'selection' for which animals had earplugs collected (e.g. larger animals, smaller animals because they were easier to get the earplugs etc.).

EXPERIMENT

Readers: Ohsumi, Kato, Zenitani + any other identified readers for the commercial catches

Sample: The samples should be taken from the existing commercial earplugs that have already been read. There is a need to ensure sufficient samples from various age-classes – given the results of the χ^2 test it may be appropriate to give more emphasis to younger and older animals. Ideally one would carry out some kind of power analysis to determine appropriate sample sizes but in practice the necessary information is not available. At this stage therefore the following sample sizes represent a 'best guess' for consideration.

Original age reading	5-9	10-14	15-20	21-25	26-30	31-35	35+
Sample size	20	15	15	20	20	20	20

Reading procedure: Given the objective of the exercise, it is important that the readers try to follow the same procedures that they would have originally followed (if they remember)! For example, if two readers always read together and reached a joint conclusion, they must do so again. If they were allowed to have biological information on the animal when they read the earplug, this is also to be done again. The objective is not to define 'best practice' but rather to try to determine whether the differences in age distributions are real.

It is also important to record:

(1) ease of readability e.g. unreadable, difficult, moderate, easy;
(2) comments on condition of earplug (e.g. complete, base damaged, top damaged, part obscure)

ANALYSIS

A non-parametric test (e.g. Friedman's rank-sum test) can be used to examine whether there is a tendency to over- or under-estimate amongst any of the readers or whether there has been a 'drift' in readings by the same reader over time.

STEERING GROUP

It would be useful to establish a small Steering Group to oversee the experiment and present an agreed final report for the next annual meeting. It was suggested that this comprise Ohsumi, Perrin, Pastene, Zenitani and Kato.