Report of the Technical Advisory Group (TAG) Meeting on the Short and Medium Term Objectives and Plans for the IWC-POWER Cruises

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The meeting was held at the Tokyo University of Marine Sciences and Technology from 26-28 September 2011. The participants were An, Brownell, Donovan, Kelly, Kitakado, Matsuoka (Convenor) and Miyashita.

1. INTRODUCTORY ITEMS

Matsuoka welcomed the participants to the meeting and to Tokyo. He thanked Kitakado for providing excellent meeting facilities.

1.1 Opening remarks and welcoming address

The objectives of the meeting were to complete the work identified in IWC (2012b) and reviewed during SC/63 (IWC, 2012a) i.e. to discuss short-, mid- and long-term objectives for the IWC-POWER programme to provide overall strategy and more detailed 5-year plans for the North Pacific programme, with a focus on the three aspects below:

(1) the overall long-term general objectives (stock structure, abundance, trends) and the priorities agreed;
(2) integration of (1) in a pragmatic way, for the short (<5 years), medium (5-10 years), and long-term (10+ years); and
(3) examine existing data plus environmental data to develop better options (including methods with visual survey mode, acoustics, biopsy, etc.) for strata coverage and likely power to detect trends.

1.2 Election of Chair

Kitakado was elected Chair.

1.3 Adoption of Agenda

The **agreed** Agenda is given as Annex A.

1.4 Appointment of rapporteurs

Donovan and Kelly agreed to serve as rapporteurs.

1.5 Review of documents

Relevant past meeting documents and published papers were made available as necessary.

The Technical Advisory Group (TAG) thanked the authors of the 2011 POWER Cruise Report for producing that document in such a short time since the end of the voyage.

2. OBJECTIVES AND PRIORITIES

2.1 Review of objectives as discussed in IWC (2012b)

The Scientific Committee has been discussing the objectives and priorities of the IWC POWER programme since 2009 (IWC, 2010) and this culminated in the discussions given in IWC (2012b). This section summarises these past discussions.

2.1.1 Long-term (*including information gaps*)

The Committee and the Commission agreed the long-term objectives for the programme in IWC (2011).

> 'The programme will provide information to allow determination of the status of populations (and thus stock structure is inherently important) of large whales that are found in North Pacific waters and provide the necessary scientific background for appropriate conservation and management actions. The programme will primarily contribute information on abundance and trends in abundance of populations of large whales and try to identify the causes of any trends should these occur. The programme will learn from both the successes and weaknesses of past national and international programmes and cruises, including the IDCR/SOWER programme.'

2.1.2 Medium-term (*including information gaps*)

In IWC (2012b), after reviewing current knowledge in the region, and recognising the ongoing work on the current *Implementation Review* for common minke whales in the western North Atlantic, a list of medium-term priorities by species for the programme was developed (IWC, 2012b, table 3). This was agreed by the Scientific Committee in Tromsø and is repeated below with some slight clarifications (see Table 1, overleaf).

2.1.3 Short-term options

In IWC (2012b), there was insufficient time to address the question of short-term objectives although a draft proposal was annexed to the report. The TAG noted that a revised proposal for short-term objectives had been provided (POWER/11/WP8) and that this will form part of its discussions under Item 7.

3. DISTRIBUTION, ABUNDANCE AND TRENDS

3.1 Visual survey methods

3.1.1 Past discussions and IO mode

There has been considerable discussion whether it is necessary to undertake IO mode during the IWC-POWER cruises (e.g. see item 11.1 of IWC, 2012b). IO mode is important for those species for which it is believed that the probability of seeing an animal on the trackline is less than one (i.e. the $g(0)$ issue). It is generally believed that $g(0)$ for blue and fin whales will be around one, while previous work on the western side of the Pacific has shown that $g(0)$ for common minke whales is considerably less than one (Okamura *et al.*, 2009; 2010). There are few good studies for sei and Bryde's whales but $g(0)$ for those species will probably be less than for blue and fin whales. The problem of $g(0)$ for long-diving species such as sperm whales is well-known; as discussed in IWC (2012b), the most promising approach for this species is the use of combined visual/acoustic surveys rather than simple IO mode.

If it can be assumed that $g(0)$ does not vary over time a lack of information will not affect trend analyses, but it will mean that absolute abundance estimates are underestimated.

The researchers participating in the 2010 cruise, where IO mode was used part of the time, stated that it was logistically difficult and tiring for researchers and crew to undertake IO mode (Matsuoka *et al.*, 2011). Unlike in the Antarctic, on the 2010 cruise, two observers were used on both platforms (in the Antarctic it had been two and one).

The TAG noted that in the eastern North Pacific, common minke whales (for which IO mode is of most benefit) are not a high priority species. It also noted that the IO results for

*This report was presented to the meeting as SC/64/Rep1.

Table 1
Priorities for the medium-long term IWC-POWER programme by species.

Initial priority	Rationale
Blue whale	
Low direct, high opportunistic	Depletion level suggests high priority (i.e. highly depleted based on catch history), but feasibility of addressing outstanding issues in short term is low. Continued photo-id work part of US national programme. Little information on stock structure and movements.
Bryde's whale	
Low, direct, high opportunistic	Depletion levels suggest low priority (i.e. low depletion given catch history). Management on western side already dealt with under RMP where a national programme exists. Telemetry not well served given available vessel. Suggest separate study. Stock structure relativel poorly understood in central and eastern North Pacific.
Common minke whale	
Low direct, high opportunistic	Depletion levels suggest low priority on east. Management on western side already dealt with under RMP where a national programme exists. However, if Okhotsk Sea covered for other priority species (e.g. right whales) then would provide valuable information incl. biopsy. Telemetry studies priority for stock structure but not part of this programme with this vessel. Suggest separate study. Weather/*g*(0) a problem if multi-species surveys.
Fin whale	
High direct, moderate opportunistic	Depletion levels suggest high priority. Given major genetic analysis on east then biopsy sampling on offshore east and west high priority to improve overall understanding of stock structure. Co-ordination with US national work in Bering Sea needed. Examination of existing data and coverage of uncovered areas needed to determine survey strategies.
Humpback whale	
Low direct, high opportunistic	Good information already available from SPLASH. Existing programmes sufficient. Opportunistic sightings during cruises may identify new 'SPLASH' areas. Feasibility of collecting biopsy and photo-id data opportunistically high.
Right whale	
Moderate-high direct, high opportunistic	Depletion level suggests high priority, but feasibility of addressing outstanding issues in short term is low. Poor knowledge of stock structure. Continued photo-id work part of US national programme. Feasibility of collecting biopsy and photo-id data opportunistically high. New survey in Sea of Okhotsk has high feasibility to obtain good abundance data provided appropriate permits can be obtained from the Russian Federation. Targeted surveys required.
Sei whale	
High direct, high opportunistic	High priority for in-depth assessment. High feasibility of obtaining abundance estimates and biopsy samples in well-designed surveys. Cover new areas based on available information.
Sperm whale	
High direct, moderate opportunistic	High priority given lack of good information on status but high historic catches. Obtaining abundance estimates for sperm whales can be problematic due to *g*(0) issues but combined acoustic/visual surveys have been successful. Feasibility depends on equipment.

the 2010 survey have not yet been analysed to see if it is possible to obtain an estimate of *g*(0) from them (noting that the sample size is small). It therefore **agrees** that, pending analyses of these data and an examination of any other relevant studies for sei and Bryde's whales, the short-term cruises (see Item 7.1) will not operate in IO mode. However, it may be that after such analyses, further work on the possibility of some proportion of future surveys being in IO mode is proposed.

3.1.2 Cruise track design

During previous planning discussions for IWC-POWER surveys, it was recommended that a random start point for tracks be used, instead of using the corner of the pre-survey stratum, which had been the method used for IWC-SOWER cruises. This can be easily implemented in DISTANCE (Thomas *et al.*, 2009). A random start point for survey tracks was used successfully during both 2010 and 2011 IWC-POWER cruises.

The TAG **recommends** that cruise tracks continue to be designed using the program DISTANCE following the principles outlined in the IWC Scientific Committee's Requirements and Guidelines for Surveys (IWC, 2005).

The question of appropriate strata and survey blocks is discussed further under Item 7.

3.1.3 Angle and distance experiments

Accurate estimates of angle and distance to whale sightings are fundamental to the estimation of effective strip width which, in turn, is highly influential in the ultimate abundance estimate. The 2010 and 2011 cruises followed the same training process and angle and distance experiments used in the IWC-SOWER programme. Training usually takes up to two hours, and at some time within the cruise, the angle and distance experiment occurs that takes some 4-5 hours in total. Results of the experiment are used to calibrate observations taken during survey effort and play an important part in the development of a final abundance estimate.

The TAG recognised that in delayed closure survey mode, in practice, observers receive feedback on their distance estimation (i.e. they know the speed of the vessel and the time it takes to close to the sighting) and that this can be considered part of training.

For the 2010 and 2011 IWC-POWER cruises, angle and distance training and an experiment were each undertaken once every survey. However, it has previously been recommended that angle and distance experiments be repeated twice during a survey (IWC, 2005). This second experiment phase is important to help determine if there have been any changes in the ability to estimate distance over the duration of the survey. Fortunately, some of the IWC-POWER crew had already participated in angle and distance experiments on another research cruise, about a month prior to IWC-POWER cruises; although on two separate surveys, these experiments can assist towards quantifying any changes in observer performance should these occur.

The TAG, recognising the importance of angle and distance estimation, **recommends** that**:**

(1) in accordance with the IWC guidelines, every effort is made at least to conduct an angle and distance experiment at the start of a cruise and during the middle of the cruise (in some cases it is not necessary to conduct the experiment near the start of the cruise if the observers have undertaken an experiment on a national cruise undertaken immediately prior to a POWER cruise); and
(2) the IWC-POWER Steering Group continue to monitor the development and feasibility of using newer technology to improve estimated angle and distance (this may ultimately allow the automatic recording of angle and even distance into an onboard recording system).

3.1.4 Survey methods and modes given resources and priority species

The question of the use of IO mode is discussed under Item 3.1.1.

Previous studies have shown the general advantages of passing mode surveys versus closing mode surveys including issues of 'skipping', sample size and problems in high density areas, often with a focus on the IDCR/SOWER surveys where the primary target species was the Antarctic minke whale

However, in the POWER research area, the use of passing mode would result in very high proportions of unidentified cetaceans, since priority species such as fin, sei and Bryde's whales are difficult to identify unambiguously unless close to the vessel. Given this, the TAG **recommends** that 'NSP' (passing with abeam closing as was used in 2011) is the most appropriate survey mode, both with respect to confirming species identity and school size.

What comprises acceptable survey conditions, particularly with respect to sea state, varies with species. For instance, in the North Pacific and the North Atlantic, common minke whale blows are rarely seen (unlike Antarctic minke whales where the blow is a common cue). In the case of surveys where common minke whales are the priority species, then surveying should not occur above sea state 4. However, for larger species with conspicuous blows, surveys can continue in sea states <6 (and also wind speed <20 knots and visibility over 2 n.miles). For multispecies surveys, therefore, compromises must sometimes be made. According to the priority species agreed by the Committee, common minke whales (and, indeed, Bryde's whales) in the eastern Pacific are of lower priority than sei and fin whales, as they were rarely hunted.

Given that, the TAG **recommends** that at least for the short-term plan (see Item 7), 'acceptable' conditions include sea states <6. Experience from the earlier surveys also suggests that the time spent on effort would decrease considerably (e.g. by 1/3 in 2011[1]) if surveying stopped at sea state 4. In taking this decision, it is recognised that a higher proportion of common minke whale sightings will be missed. This will need to be taken into account when determining the medium-term strategy.

3.1.5 Initial power analyses

The power to detect a trend in abundance depends on the magnitude of actual change over time, and the variation around the estimates and the level of the test; variation around abundance estimates depends *inter alia* on the actual abundance and the amount of survey effort/number of sightings. As one of the aims of the IWC-POWER programme is to assess and monitor large whale populations in the North Pacific, it is essential to estimate the power of survey designs (in the broadest sense) to detect the presence of a trend in these populations, should trends occur. It should be noted that reference in this section is being made here to abundance estimates derived using line-transect methods; power can also be calculated for other methods to estimate abundance, such as mark-recapture, and this is referred to under Item 3.2.

A simple initial analysis of the power to detect a range of trend magnitudes in sei whale abundances across the 2010 and 2011 IWC-POWER survey areas indicated that a substantial increase in effort (i.e. up to x10) was required to approach reasonable levels of power to detect changes in that population. Details of these analyses are given in Annex E (which was completed after the meeting and not discussed). These calculations will be refined in the future to provide guidance about medium-term survey design (see Item 7.2). There is no recommendation to increase survey effort in the short-term (i.e. up to 2015), based on these power calculations, given the objective of the short-term plan (see Item 7.1).

[1]Sea states 1-2, 14%; sea state 3, 26%; sea state 4, 28%; and sea state 5, 32% - no effort in sea state 6.

3.2 Mark-recapture methods

Mark-recapture methods allow the use of photo-ID and genetics to match individuals over time, which can inform animal movement and stock structure studies as well as provide data for abundance estimation. Survey designs for mark-recapture methods can be a lot more relaxed than those required for line-transect approaches; more opportunistic sampling is possible, and searching for animals can be non-random.

Although not considered practical in the short-term to obtain information on abundance and trends for priority species in the POWER region[2], data from the short-term plan (Item 7.1), may result in areas being identified that may warrant targeted mark-recapture work in the medium-term[3]. The Committee has agreed that high priority be given to opportunistically obtaining photographs/biopsy samples from rare species such as the blue whale and right whale. The importance of collaborative photo-identification studies is well known and photographs collected from the IWC-POWER programme should be made available (see Item 6). The value of both photo-identification and genetic catalogues increases with time. For humpback whales, the programme SPLASH already exists to both archive photographs of animals and to process these to check for matches. The TAG **recommends** that humpback photo-identification data be supplied to SPLASH, to take advantage of pre-existing methods and to foster collaboration. Programmes such as SPLASH demonstrate the enormous benefits that can be yielded from collaborative work

The feasibility of obtaining photographs and biopsy samples is addressed under Item 4.

3.3 Acoustic methods

As noted above, to best estimate the abundance of sperm whales requires the use of acoustic techniques combined with visual surveys, as shown for example by Barlow and Taylor (2005). However, this requires towing a hydrophone array (perhaps up to 600m) behind the vessel. This approach is not compatible with methods such as biopsy sampling, which require the vessel to stop and turn at tight angles.

Towed array methods require specific equipment, expertise and training. It was noted during discussions that US researchers could potentially make this equipment available for IWC-POWER programme, but that this needed further investigation.

As there will probably be a lead-in time of a few years, the TAG **recommends** a desktop feasibility study of the approach in the context of the IWC-POWER programme and its priorities (biopsy sampling is a high priority action for a number of species at present). The idea that a whole survey season be dedicated just to line-transect acoustic methods (i.e. no biopsy sampling) should also be explored. This feasibility study could also include consideration of using sonobuoy technology to detect blue and fin whales.

[2]Apart from the very successful SPLASH programme for humpback whales and for studies on blue and humpback whales off California (Calambokidis, 2009; Calambokidis *et al.*, 2008).

[3]When and if such areas are identified, power analyses to estimate required sample sizes/effort will need to be conducted.

4. STOCK STRUCTURE AND MOVEMENTS

4.1 Genetics
The value of genetic studies to address stock structure issues is well known and is not discussed here.

4.1.1 Available genetic samples
For the most part, there are low numbers of genetic samples for all species in the central and eastern North Pacific (i.e. beyond those collected within the JARPN II area). Collection of biopsy samples to inform stock structure studies is thus a high priority for several species (see Table 1). The TAG was particularly encouraged by the successful biopsy work during the 2010 and 2011 surveys (see Table 2). Genetic analyses of samples from sei whales from the 2010 cruise are described in Kanda *et al.* (2011).

4.1.2 Efficiency of approaches to obtain sufficient samples
Table 3 provides a simple summary of the biopsy sampling results from the 2011 survey. Overall, the biopsy sampling effort seemed to be quite efficient, with roughly half of the whales encountered being successfully sampled except for fin whales where it was about 1/3. Times spent with fin and sei whales (24 and 18 minutes) were somewhat less than with blue and humpback whales. As noted in the legend to Table 3, there may be some confounding between the time spent biopsying and the time spent photographing (the times for blue, fin and sei whales are similar to the values in Table 4).

4.2 Individual identification (photo-id and genetic)
Individual identification data from both photo-identification and genetics can provide valuable information on movements to inform discussion of stock structure. The 2010 and 2011 cruises have successfully obtained large numbers of photographs for photo-identification studies for a number of species including blue, fin, and humpback whales. A large number of photographs of sei whales were also taken during biopsy work that may prove suitable for photo-identification. It was noted that photo-identification for sei whales is not a well-developed technique. The TAG **recommends** that an expert in fin whale photo-identification be contacted in regards to assessing the amount of information in sei whale photographs and the potential to develop identification methods.

Table 2

Number of biopsy samples, by species, for each IWC-POWER cruise.

Species	2010	2011
Sei whale	13	31
Fin whale	2	12
Blue whale	1	4

4.2.1 Efficiency of approaches
Table 3 (below) summarises the situation for obtaining genetic samples based on the 2011 cruise. Table 4 below provides a simple summary of the photo-identification effort from 2011. In general, for the large whales the success rate is high with over 75% of fin and sei whales encountered being successfully photographed during biopsy sampling (although see need above for evaluation of the use of photo-identification for sei whales) and over 90% for humpback and blue whales.

Encounter durations were shortest for humpback and killer whales (around 10 minutes) and longest for blue whales (around 40 minutes), although as noted for the biopsy sampling times, there may be some confounding between the time spent biopsying and the time spent photographing (the times for blue, fin and sei whales are similar to the values in Table 4).

4.3 Telemetry
In the past there has been interest in exploring telemetry methods to address stock structure and movement questions during IWC research cruises. However, current tags used in telemetry can best be deployed from small boats, a resource not current available on the vessels used for IWC-POWER cruises (and of course would involve considerable investment of time).

It is not feasible for the IWC-POWER programme to make a substantial commitment to tag development (including deployment and subsequent data analysis) in the short-term. However, the TAG **agrees** that the IWC-POWER steering group should monitor developments in this field for possible targeted studies in the medium term.

Table 3

Summary of 'average' biopsy encounters by species (including encounters where there were no hits and/or shots). Note that the number of whales sampled can be lower than the number of hits as in some cases two samples were taken from the same animal. The encounter duration may be governed by the need for getting photo-id photographs rather than biopsy samples in some cases but this has not been evaluated in this simple summary.

Species	*N*	Group size	Number of whales sampled/encounter (% each group)	Shots	Hits	Encounter duration
Blue whale	8	1.00	0.50 (50%)	1.25	0.88	00:42
Fin whale	31	1.45	0.45 (31%)	1.10	0.71	00:24
Humpback whale	2	1.00	0.50 (50%)	3.00	1.00	00:45
Sei whale	37	2.03	0.92 (45%)	2.38	1.11	00:28

Table 4

Summary of 'average' photo-identification encounters by species. Note that the number of individuals identified has not been fully evaluated for sei whales (see report). The encounter duration may be governed by the need for getting a biopsy sample rather than a photograph in some cases but this has not been evaluated in this simple summary.

Species	*N*	Group size	Number of individuals photographed	% of each group	Encounter duration
Blue whale	9	1.00	1.00	100.00	00:40
Fin whale	22	1.91	1.27	77.95	00:18
Humpback whale	35	1.69	1.37	92.43	00:10
Killer whale	5	10.80	3.80	68.57	00:11
Sei whale	21	2.48	1.57	76.39	00:32

5. OTHER POTENTIAL ASSOCIATED STUDIES

The meeting considered the potential to undertake other data recording during the survey, either to assist other research programmes or to augment available data that could be of value to the IWC-POWER objectives.

5.1 Oceanographic studies

There is no plan to conduct oceanographic studies as part of IWC-POWER at this time (at the correct scale, such studies can assist in spatial modelling approaches). Previously, there had been a request to deploy Argo floats in the IWC-POWER survey area, but that request was not repeated this year. After some discussion, the TAG **agrees** that it would be appropriate for the IWC-POWER Steering Group to investigate whether other surveys (e.g. oceanographic, fisheries research, marine mammals) are running at a similar time and place to IWC-POWER surveys for possible future collaboration with mutual benefit. Oceanographic data from the Argo programme and other similar programmes can be requested[4]. It would also be valuable to examine new and developing technology to enable data to be collected whilst the IWC-POWER vessel is underway to aid in data analysis and modelling.

5.2 Marine debris

After the Japanese earthquake and resultant tsunami in March 2011, a large increase in marine debris in the North Pacific has been observed; for example, under the IWC-POWER programme, there were 33 pieces of debris reported during the 2010 cruise compared to 130 pieces during the 2011 cruise. However, as recording of debris is highly dependent on the weather and the amount of debris itself, effort to count it is not constant or systematic, particularly given it has a low priority compared to surveying for whales. Clearly, the amount of data collected by the cruises alone is insufficient to address the issue of marine debris. The TAG therefore **recommends** that relevant agencies (to be determined by Miyashita, An and Brownell), be approached to gauge the usefulness of the type and quality of marine debris data that is or could be collected during IWC-POWER cruises. Data collected should be sent to the relevant agencies.

5.3 Other

There is the potential to collect data on the presence and distribution of other sea life, such as turtles and pinnipeds during the IWC-POWER surveys. These data may be useful to other agencies and research programmes, who may then respond in kind with collection/provision of data that will assist the IWC-POWER programme. However, as with marine debris, collecting these data may be distracting and must not be allowed to interfere with the high priority activities of the cruise. Therefore, as long as it does not interfere with collecting data on whales, the TAG **recommends** recording the presence of other species (birds should not be considered as they are too distracting). Any data collected should be made available to relevant research groups.

6. DATA COLLECTION, STORAGE AND ANALYSES

6.1 On board recording

The TAG noted that at present, although some progress had been made (e.g. with direct automatic input of GPS data and some environmental data), much of the data and information required is initially put onto paper forms and then entered by the researchers and validated by the IWC Secretariat (who re-enter the data from the paper forms and compare with the electronic files). Previous discussions have noted the value of moving to direct data entry but it has been agreed that until standard procedures and data requirements have been developed for the IWC-POWER programme, it is better to wait with respect to full onboard electronic data input. With the methodological clarifications discussed under Items 2-5, the TAG believed that it was now time to begin work on an IWC-POWER electronic data entry system, noting the need to consider this also in the light of Item 6.2.

As a first stage, it is important to review systems available elsewhere in the context of the IWC-POWER programme in order to minimise developmental costs and to build upon existing experience. The TAG **agrees** to establish an intersessional group (at least Matsuoka, Miyashita, Hammond, Palka and Barlow, convened by Donovan) to begin to examine this and to meet at the SC/64 meeting in Panama. Systems to be examined include the shipboard programmes used during the SCANS and CODA surveys in the eastern North Atlantic, the aerial survey programmes used in the Mediterranean and Greenland, the shipboard programmes used on the east and west coasts of the USA and the shipboard system used in JARPN II. The group will also develop a list of desired features of the onboard system to assist with the management of the cruise, ease of entry and efficient validation and backup. It is hoped that an appropriate system can be in place for the cruises in either 2013 or 2014.

The TAG also **agrees** that a small group should examine the existing data forms (essentially those developed for the SOWER programme) in the light of discussions at this workshop and the experiences of 2010 and 2011 to see if these could be simplified and a recommendation be developed for the Planning Meeting of the 2012 cruise[5].

6.2 Long-term database

It is essential that any large-scale monitoring programme has a fully functional relational database to enable efficient storage of the several kinds of data collected and to facilitate analyses of the data (including a more effective mapping option). This is especially the case as data collected under IWC programmes are publicly available within the Data Availability Guidelines (*cf* the IDCR/SOWER data). IWC-DESS was developed for the IDCR/SOWER programme but it is now somewhat old, restricted to sightings/effort data and is rather limited. It is important to learn from the strengths and weaknesses of IWC-DESS and other similar databases in developing a new database that meets the present and likely future needs of the IWC-POWER programme. It was agreed that Donovan would consult with users of IWC-DESS and similar databases, recognising the discussions at the present workshop, to develop a document for IWC/64 that provides an outline for an IWC-POWER database that might also be used to store sightings, biopsy, photo-identification, effort and other data from other past, present and future IWC (and some national) programmes. This may lead to a budget proposal request for the 2012/13 research budget.

6.3 Logistics of data analysis

When developing the IWC-POWER programme, it is important to consider mechanisms to ensure the prompt

[4]See, e.g. *http://www.jamstec.go.jp/ARGO/argo_web/argo/index_e.html*; and *http://www.jamstec.go.jp/ARGO/argo_web/MapQ/Mapdataset_e.html*.

[5]This was undertaken during the planning meeting – see SC/64/Rep2.

analyses of data at an early stage, and ensure that they are considered an integral part of the programme with appropriate resources made available (work undertaken under Items 6.1 and 6.2 will also assist in this regard). In retrospect, this was not always the case for the IDCR/SOWER programme, apart from the more standard line-transect analysis updates.

6.3.1 Sightings data

There are many potential analyses of sightings data, for example:

(1) analysis of annual cruise data to obtain abundance estimates for the research area (including analysis of angle and distance experiments);
(2) where necessary, integrated analyses of data over years to obtain abundance estimates by management unit (including consideration of additional variance/process error);
(3) spatial modelling analyses to examine the distribution and relative abundance of cetaceans with respect to environmental variables; and
(4) analyses of particular experiments if they occur.

The TAG **recommends** that the Scientific Committee identifies the analyses of the IWC-POWER sightings data each year and makes arrangements for the necessary resources for the work to be undertaken promptly (this includes 'voluntary' analyses being undertaken by individuals or research groups as well as the potential for contract studies).

6.3.2 Photo-identification data

At present, it is likely that photo-identification data will be collected opportunistically, although as more information becomes available, targeted studies may be developed within the programme. In any event, the TAG **stresses** that it is important that resources are made available so that the photographs are regularly examined and archived within the IWC database (see Item 6.2), added to any existing catalogues (e.g. SPLASH) and also shared with researchers working within the region under the IWC Data Availability Agreement. Should sufficient data become available in the future, the Scientific Committee should identify analyses and make arrangements for the necessary resources to be made available.

6.3.3 Biopsy samples

IWC biopsy samples are presently stored and archived on IWC's behalf at the Southwest Fisheries Science Center, La Jolla, California. Given the limited volume of tissue, a protocol was developed for applications for use from the SOWER cruise samples (see the Scientific Committee Handbook, available on the IWC website); this should continue.

Analyses of biopsy samples can be extremely valuable in addressing the POWER objectives, including:

(1) stock structure studies that are essential to defining appropriate management units and thus to understanding the status of populations (information on stock structure is lacking for most large whales species, especially in the central and eastern Pacific);
(2) other studies (e.g. related to pollutants and feeding ecology) that may assist in understanding any trends in abundance that are detected as well as contribute to an understanding of stock structure; and
(3) individual identification studies including the possibility of targeted studies to obtain estimates of abundance if the short-term programme suggests that it is appropriate for certain species/populations.

The TAG **recommends** that as samples become available, the Scientific Committee should identify priority analyses and make arrangements for the necessary resources to be made available for these to be completed in a prompt manner.

7. INTEGRATED STRATEGY TO ACHIEVE SHORT-MEDIUM TERM GOALS

7.1 Short-term plan (up to 2015 or 2016)

In order to develop fully a medium-term monitoring plan (see Item 7.2), it is essential to have good data on distribution and density for the little understood regions of the North Pacific, as well as develop an understanding of stock structure to determine management units. The completed 2010 and 2011 surveys have begun that process successfully, especially for fin and sei whales, and the 2012 survey will continue that process. Fig. 1 shows the North Pacific and the TAG **recommends** the proposed strategy to cover most of the remainder of the central and eastern North Pacific by 2015. The cruises will combine systematic visual line-transect methods (for distribution, density and abundance) with targeted and opportunistic photo-identification and biopsy sampling studies (for stock structure and movements). In addition, in co-operation with US scientists, efforts will be made to investigate the feasibility of incorporating a towed array on the cruises within the programme to allow estimation of the abundance of sperm whales. If this can be done then it may be introduced in perhaps 2014 or 2015.

As can be seen in Fig. 1, there is as yet no planned coverage north of the Aleutian Islands, south of 30°N, or along the west coast of North America. The southern boundary of 30°N for the POWER cruises was chosen based on oceanographic features, primarily the position of the sub-tropical front (see Annex B). It is expected that at least parts of these areas will be covered by national surveys (much of them lie within the EEZs of the USA, Canada and the Russian Federation) – e.g. a survey of Hawaiian waters is expected in around 2014 or 2015. It is important that efforts are made to bring the IWC-POWER programme to the attention of the appropriate national bodies in order to co-ordinate work (see Items 7.3.2 and 7.3.3). In order to synchronise with any national surveys, it may be appropriate to change the order of the surveying of the IWC-POWER cruises from that shown in Fig. 1.

In addition, the TAG was pleased to hear that Japan was expecting to undertake a major survey in the Okhotsk Sea in the next two years. This is a very important area, especially for right whales and common minke whales. The TAG **strongly urges** collaboration between Japan and the Russian Federation with this survey, particularly with respect to (a) allowing access to survey vessel(s) in territorial waters; and (b) facilitating the necessary CITES permits for biopsy sampling (see Item 7.3.1).

7.2 Medium-term plan (6-10 years)

The TAG has identified considerable work that needs to be undertaken over the next five years before a final medium-term plan can be finalised; this is an iterative process that depends on prompt analyses of the data collected during the short-term cruise programme. In addition, as shown in the preliminary power analysis given in Annex B, the ability to identify trends will depend on the amount of research effort that can be expended. At present, the IWC-POWER programme is dependent upon the generous provision of a vessel by Japan. The TAG **thanks** Japan for this and

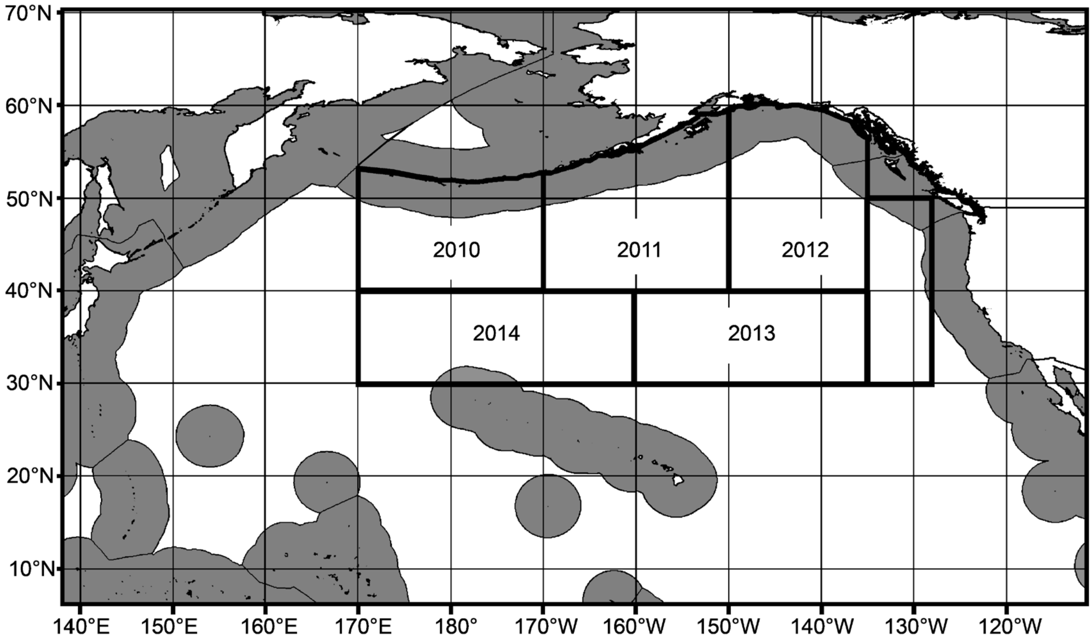

Fig. 1. Proposed research blocks for the short-term plan (see text). The grey shading refers to EEZ areas.

recognises that the provision of a Japanese vessel cannot be guaranteed in the future. However, it also **stresses** the value of other range states contributing vessel time either directly as part of IWC-POWER or by synchronising national surveys with the IWC-POWER programme (see Item 7.3). This will not only contribute to the agreed long-term goals of the programme throughout the North Pacific but will also greatly support conservation and management within national waters, since large whale populations rarely if ever occur only within national waters.

Choice of appropriate survey blocks and strata for a long-term monitoring plan will depend on the results of the short-term plan. *Inter alia* the results of the short-term plan will allow the essential undertaking of a more specific power analysis of the effort required to detect trends in abundance should they occur. This should also incorporate comparison of the strategy of undertaking a large-scale synoptic survey approximately every 5-6 years (with requisite resources) with 5-6 partial area surveys with a single vessel each year.

In addition, it may be appropriate in some years to focus resources on addressing a particular topic (e.g. a targeted mark-recapture programme or a focussed telemetry effort if technological advances show that sufficient sample sizes can be reached to address specified questions).

7.3 Co-ordination and logistics

7.3.1 Permits including CITES

In general, during the 2010 and 2011 POWER cruises, permission to conduct research with a Japanese vessel in the US EEZ has not encountered any major obstacles. This is thanks in great part to the cooperative efforts of the Embassy of Japan and the US State Department in Washington, DC. The TAG was pleased to hear that this cooperation is expected to continue.

As noted in previous IWC-POWER discussions, the main permitting issue relates to CITES permits for biopsy samples. The TAG noted that the absence of appropriate CITES permits/certificates again created problems in collecting the maximum number of biopsy samples during the 2011 survey; this is particularly problematic given that resolving stock structure issues is an important objective of IWC-POWER for many species. This is despite the fact that USA and Japanese responsible persons have been continuing to work to resolve this issue since 2010. The TAG was informed that it seems most likely that no progress can be made on this issue because of different views of the subject by Japan and the USA (the USA can only address this problem via the 'Institutional Permit' approach whereas representatives of the Japanese Fishery Agency have noted in the past that the issue of 'Institutional Permits' is outside the FAJ's mandate in that CITES permits are issued by METI, the Ministry of Economy, Trade and Industry). Similar problems exist with respect to surveys in Russian waters.

Despite this, the TAG **stresses** the great importance of obtaining biopsy samples throughout the region if IWC-POWER is to meet its objectives. For example, it notes that the issue would be a major problem for any future POWER survey in the US EEZ in the Bering Sea or within Russian waters within the Okhotsk Sea. Recognising that this is a bureaucratic rather than a scientific issue, it **strongly requests** the appropriate authorities to continue to try to resolve this matter expeditiously. It **stresses** that the exchange of biopsy samples from living whales for scientific purposes in order to improve conservation and management advice, is clearly **not** the objective of the CITES system; every effort should be made to resolve this issue which is of broader significance than simply the IWC-POWER programme.

In the meantime, it **strongly encourages** national programmes to take biopsy samples in the IWC-POWER region wherever possible and make these available for use within the IWC scientific community under the Data Availability Agreement.

7.3.2 Participation of other range states in IWC-POWER

The discussions earlier in this report emphasise the importance of the North Pacific range states to co-operate with and participate in the IWC-POWER programme. This will greatly increase the ability to meet the long-term objectives of the programme that have been agreed by the Commission.

Collaboration can range from participating in the planning of the cruise programme, providing scientists for the cruises, assisting with analyses of the results, co-ordination of national surveys with the international cruises, to providing vessels. The TAG is pleased to note the contributions thus far from Japan, Korea, the USA and Australia and **strongly requests** other range states to consider more active participation in IWC-POWER.

In order to encourage this, the TAG is pleased to note that the new IWC website will have a section dedicated to the IWC-POWER programme that will highlight its objectives, proposed cruises and results. The IWC-POWER steering group will assist the Secretariat in the development of these web pages and their maintenance.

7.3.3 Co-ordination with other research activities

In addition to encouraging collaboration with cetacean researchers in the region, the website will also assist with encouraging collaboration with other research activities in the North Pacific that can assist with meeting the long-term objectives of the programme, particularly with understanding any identified changes in distribution and/or abundance overtime. For example, there is considerable oceanographic and fisheries research being undertaken in the area, as effort in ecosystem modelling. These programmes and IWC-POWER can be mutually beneficial.

The TAG **encourages** members of the Scientific Committee and the Commission to draw the attention of the IWC-POWER programme (and the website) to marine mammal, fisheries, oceanographic and other research groups operating within the North Pacific region.

8. ADOPTION OF THE REPORT

The report was adopted at 15.30 on 28 September 2011. Final proofreading and the addition of references took place at the IWC Secretariat. Natalie Kelly is thanked for her hard work in producing Annex C after the meeting. The TAG thanked the Chair for his efficient and effective handling of the meeting and the Chair thanked the participants, especially the rapporteurs, for their hard work.

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Annex A

Agenda

1. Introductory items
   1.1 Opening remarks and welcoming address
   1.2 Election of Chair
   1.3 Adoption of Agenda
   1.4 Appointment of rapporteurs
   1.5 Review of documents
2. Objectives and priorities
   2.1 Review of objectives as discussed in SC/63/Rep5
      2.1.1 Long-term (incl. information gaps)
      2.1.2 Medium-term (incl. information gaps)
      2.1.3 Short-term options
3. Distribution, abundance and trends
   3.1 Visual survey methods
      3.1.1 Past discussions and IO mode
      3.1.2 Cruise track design
      3.1.3 Angle and distance experiments
      3.1.4 Survey methods and modes given resources and priority species
      3.1.5 Initial power analyses
   3.2 Mark-recapture methods
   3.3 Acoustic methods
4. Stock structure and movements
   4.1 Genetics
      4.1.1 Available genetic samples
      4.1.2 Efficiency of approaches to obtain sufficient samples
   4.2 Individual identification (photo-id and genetic)
      4.2.1 Efficiency of approaches
   4.3 Telemetry
5. Other potential associated studies
   5.1 Oceanographic studies
   5.2 Marine debris
   5.3 Other
6. Data collection, storage and analyses
   6.1 On board recording
   6.2 Long-term database
   6.3 Logistics of data analysis
      6.3.1 Sightings data
      6.3.2 Photo-identification data
      6.3.3 Biopsy samples
7. Integrated strategy to achieve short-medium goals
   7.1 Short-term plan (up to 2015 or 2016)
   7.2 Medium-term plan (6-10 years)
   7.3 Co-ordination and logistics
      7.3.1 Permits including CITES
      7.3.2 Participation of other range states in IWC-POWER
      7.3.3 Co-ordination with other research activities
8. Adoption of the report

Annex B

Environmental data

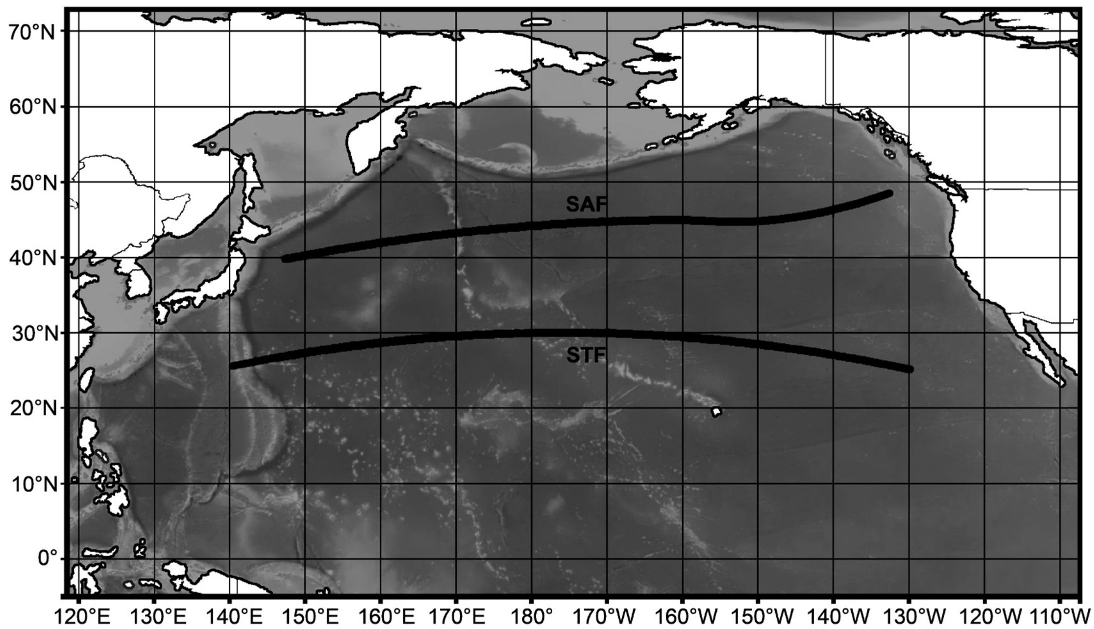

Fig. 1. Ocean floor topography and schematic positions of the subarctic front (SAF) and subtorpical front (STF). The 2-minute gridded global relief data (ETOPO2v2) (US Department of Commerce, National Oceanic and Atmospheric Administration, National Geophysical Data Center, 2006) was used as the topography data.

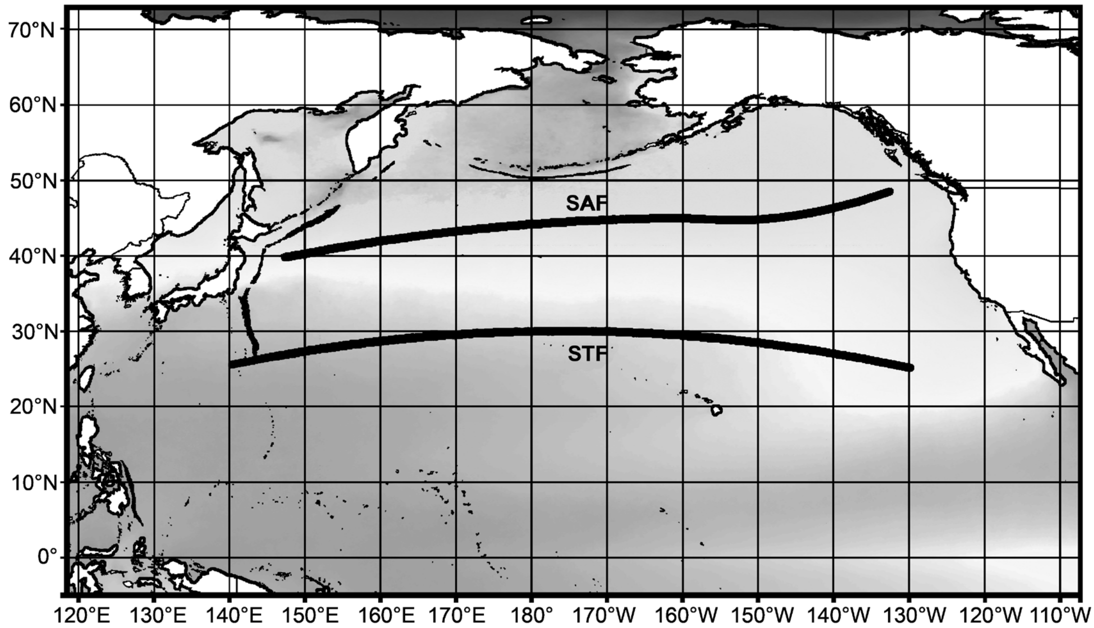

Fig. 2. Climatologcal sea surface temprature (SST) in summer from 2002 to 2010 and schematic positions of the subarctic front (SAF) and subtorpical front (STF). SST data derived from a satellite, the Moderate Resolution Imaging Spectroradiometer (MODIS) Aqua (11 µ daytime, 9km resolution) are used. The data are downloaded from Ocean Color Web, NASA Goddard Space Flight Center (*http://oceancolor.gsfc*).

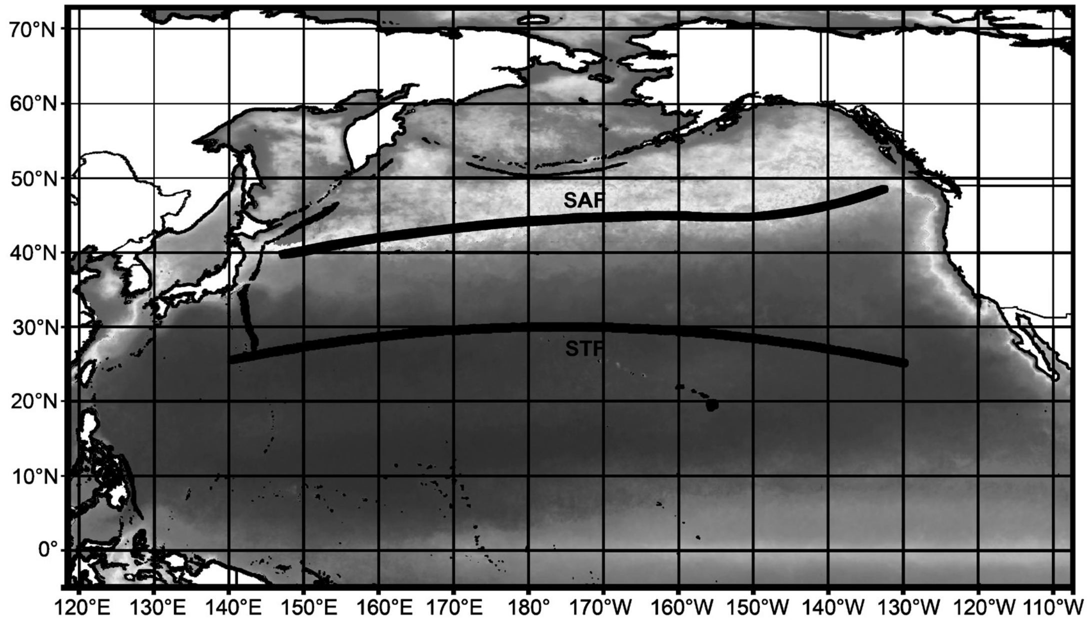

Fig. 3. Climatologcal chlorophyll concentration in summer from 2002 to 2010 and schematic positions of the subarctic front (SAF) and subtorpical front (STF). Chlorophyll concentration data derived from a satellite, the Moderate Resolution Imaging Spectroradiometer (MODIS) Aqua (9km resolution) are used. The data are downloaded from Ocean Color Web, NASA Goddard Space Flight Center (*http://oceancolor.gsfc.nasa.gov/*) on 27 September 2011.

Annex C

Power to detect changes in sei whales abundances (estimated using line-transect methods) for 2010 and 2011 POWER survey areas[1]

Natalie Kelly

INTRODUCTION

The following is a simplified analysis of power to detect increases or decreases in sei whales abundance, over medium- and long-term time frames, across the combined 2010 and 2011 POWER survey areas. Here we consider the power to detect a trend between the first abundance estimates (i.e. from a combined 2010-11 abundance estimate) and putative future surveys (i.e., those forming part of the medium- and long-term plan for IWC-POWER surveys), centred around 2016 and 2021, respectively.

STARTING ABUNDANCE ESTIMATE

For the 2010 IWC-POWER survey area we have an abundance estimate of 9,286 (CV=0.35); see Hakamada *et al.* (2011) for further details. An abundance estimate for sei whales in the 2011 survey area has yet to be estimated. To cover this, we used the encounter rates (of individual animals) from both surveys - 0.059 and 0.040 animals per n.mile, respectively - to estimate an abundance of sei whales in the 2011 area of around 6,232. Combined, this would be an abundance estimate of around 15,518, and a CV of 0.35 might be reasonable.

PROJECTING ABUNDANCE INTO THE FUTURE

In addition to estimating circumpolar abundance for Antarctic blue whales from the three circumpolar IDCR/ SOWER surveys, Branch (2007) provides some guidance on how to estimate the annual rate of change for (with the example of Antarctic blue whales) using an exponential growth model,

$$\hat{N}_t = N_0(1+r)^t ,$$

where t is the number of years after the starting year; N_t is the projected population at time t; N_0 is the estimated population at time 0 (i.e. the first time point for which there is an abundance estimate); r is the estimated annual rate of change.

Although the values of the parameters in this model can be estimated relatively simply, , Branch (2007) recognised that the geographical distribution of whales changes from year to year, generating what is known as 'additional variance' or 'process error'. To account for this additional variance (assumed to be equal for all abundance estimates, Branch, 2007) derived a convenient negative log likelihood expression for generating maximum likelihood parameter estimates,

$$-\ln L = \sum_t \left[\ln\sqrt{CV_t^2 + CV_{add}^2} + \frac{(\ln N_t - \ln \hat{N}_t)^2}{2(CV_t^2 + CV_{add}^2)} \right],$$

[1]Completed after the Workshop.

where CV_{add} is the additional variance, and CV_t is the variance of each survey.

This maximum likelihood approach can be used to estimate the power to detect a positive or negative rate of change in abundance of North Pacific sei whales given the combined 2010 and 2011 abundance and a range of nominated annual rates of change to create projected abundance estimates.

POWER TO DETECT A TREND

Power is the probability that a test will detect departures from the null hypothesis if there is, in fact, a departure (in this study, a departure will represent a non-zero trend of some magnitude). The power depends on the size of the trend (i.e. the actual value of the slope of the trend line), the variance around the point estimates of trend, and on the chosen significance level at which the test; a significance level of 0.05 is standard and has been selected here. A power of 0.8 is considered reasonable in experimental design (e.g. Thomas and Juanes, 1996) and is the benchmark used here. The power of a test (1-β; one sided at the 95% level) for comparing point estimates is approximately equal to:

$$1-\beta = \varphi(-1.64 + \frac{|\Delta|\sqrt{n}}{\sigma})$$

Where:

$\varphi(z)$	is the area under the curve to the left of z on a Standard Normal curve;
$\lvert\Delta\rvert$	is the difference between the two point estimates;
$\sqrt{n}$	is the sample size; and
σ	denotes the standard error of the difference between the two point estimates.

Employing a one-sided test inherently increases the power, but you have to assume that a population has either increased or decreased; just testing for a 'different' population abundance would be a two-sided test.

As abundance estimates are log-normally distributed, an algebraic method to calculate power would introduce bias (Zhou and Gao, 1997) therefore we used Monte Carlo simulation. First, abundance estimates for future surveys (i.e., in 2016 and 2021) were generated for a range of annual rates of change (3, 5, and 7% in the positive; -5, -10 and -15% as a population decline); see Fig. 1 for projected abundance estimates in 2016 and 2021.

Then the CV for the estimate was calculated based on the assumption that if the new survey has similar effort to past surveys then the only factor affecting the CV of a new survey is abundance itself; as such, the CV will be some function of 1/√(abundance) (Burnham *et al.*, 1980; Gerrodette, 1987). Therefore, using the CV of the first abundance estimates,

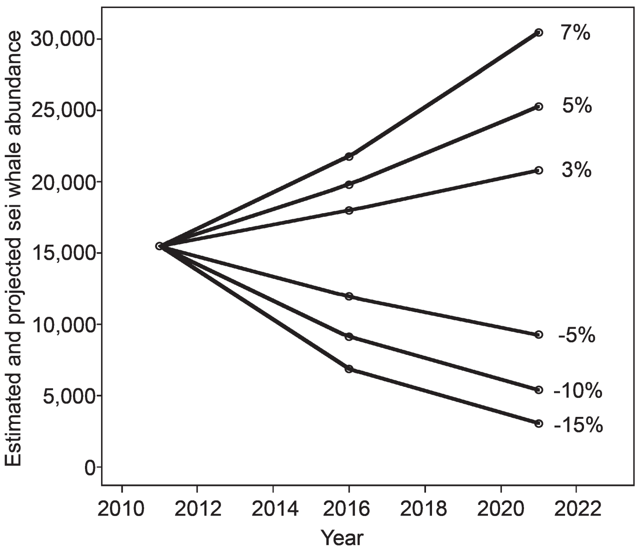

Fig. 1. Estimated and projected abundance estimates of sei whales across the 2010 and 2011 IWC-POWER survey areas, for a range of annual rates of change. For clarity, confidence interval information has not been included in plot.

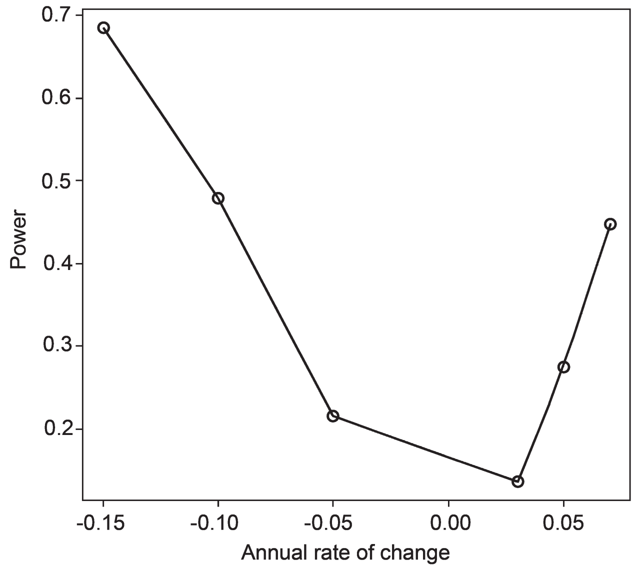

Fig. 2. Estimated power to detect an annual rate of change in sei whale abundance after 10 years (future survey years: 2016 and 2021) across 2010 and 2011 survey areas for a logistic growth curve, where α = 0.05.

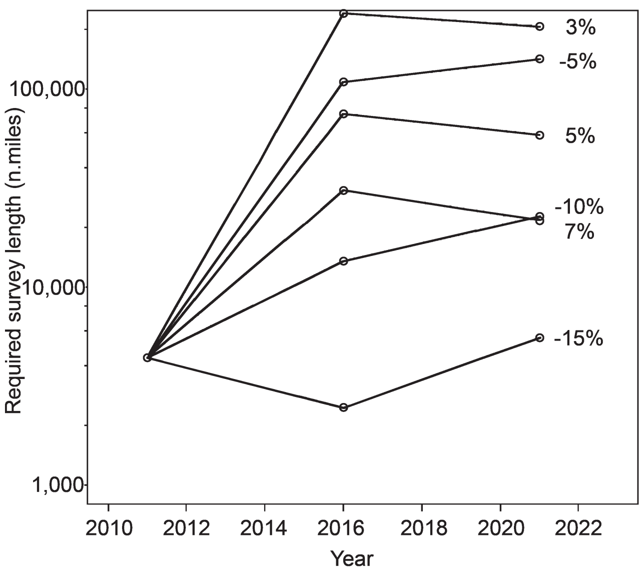

Fig. 3. Effort (in n.miles) required to detect a range of annual rates of change with a power of 0.8. Note that required survey length is represented on a log scale. The realised survey effort for the 2010 and 2011 surveys was 4,383 n.miles.

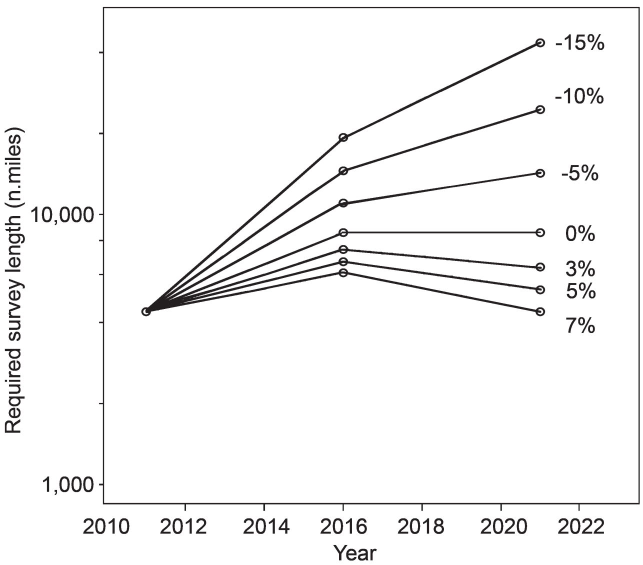

Fig. 4. Effort (in n.miles) required to estimate abundances with a CV of 0.25, for a range of annual rates of change. Note that required survey length is represented on a log scale. The realised survey effort for the 2010 and 2011 surveys was 4,383 n.miles.

we crudely estimated the CVs of a future survey given the projected abundance at the time of that survey.

Finally, the simulated abundance estimates, along with their associated projected CVs, were then fed into the negative log likelihood expression (together with the abundance estimates and CV from the 2010 and 2011 survey area) to derive estimates of *r*. Out of the above maximum likelihood analysis, we can also derive a hessian matrix which allows the standard errors of the parameter estimates to be calculated. With each estimated *r*, and its standard error, we can then perform a simple Wald test to formally check whether *r* is significantly greater than zero (i.e. a one-sided test). Compared against a standard Normal distribution, the *p*-value of this test is returned. Over a large number of simulation runs (say, ~ 5,000), the proportion of *p*-values that are less than a nominated significance level (0.05 is a reasonable Type I error level) is an estimate of the power of the future survey.

Fig. 2 shows the relationship between power and a range of annual rate of change up to 2021 using a logistic growth curve. Assuming that allocated survey effort does not change substantially in 2016 and 2021 from that in 2010 and 2011 surveys, the power to detect a range of annual rates of change are substantially below 0.8.

This process can also be used to estimate the maximum allowable CV that will still deliver a power of 0.8 for a set annual rate of population increase (*r*). Again this approach assumes the operational behaviour of new survey is comparable to the previous surveys. Then, given an estimate of the maximum allowable CV, the sample size required to attain this can be estimated by:

$$\textit{Sample size required for survey 2} = \textit{Sample size survey } 1 \times \left(\frac{CV1}{CV2}\right)^2$$

where *CV1* is 0.35, *CV2* is the maximum allowable CV for a subsequent abundance estimate, and sample size of the first survey is 4,383 n.miles.

The required survey effort to attain a power of 0.8, for a range of annual rates of change, is given in Fig. 3. All represent a substantial increase in the survey effort undertaken in the 2010 and 2011 IWC-POWER surveys.

OTHER BENCHMARKS

Perhaps an alternative target should be an abundance estimate of reasonable precision, say with a CV of 0.25. Using the equation above, we can estimate the effort required to deliver a CV of 0.25 in 2016 and 2016, given a range of estimated rates of increase after 2011. These required amounts of effort are reported in Fig. 4. For example, assuming sei whale abundance does not change too much over the next 10 years, this would require survey effort of around 8,595 n.miles in the 2010 and 2011 survey areas.

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