Report of the Scientific Committee

Bled, Slovenia, 7-19 June 2016

Annex M: Report of the Sub-Committee on Small Cetaceans

**This report is presented as it was at SC/66b.
There may be further editorial changes (e.g. updated references, tables, figures) made before publication.**

International Whaling Commission
Bled, Slovenia, 2016

Annex M

Report of the Sub-Committee on Small Cetaceans

Members: Scheidat and Porter (Convenors), Baker, Baulch, Bell, Bjørge, Brockington, Brownell, Cipriano, Collins, Cosentino, Costa, Currey, Diallo, Donovan, Double, Ferriss, Florez, Fortuna, Fossi, Frey, Fruet, Gallego, Galletti-Vernazzani, Genov, Greig, Hall, Haug, Herr, Hielscher, Hoelzel, Holm, Hrabkovsky, Hughes, Iñíguez, Jaramillo-Legorreta, Jimenez, Joon Park, Kato, Kelkar, Ketele, Lang, Lauriano, Litovka, Long, Louis, Lundquist, Mallette, Marsili, Minton, Moore, Natoli, Øien, Palka, Paniego, Parsons, Reeves, R., Reeves, S., Rendell, Reyes, Ridoux, Ritter, Rodriguez-Fonseca, Rojas-Bracho, Rose, Rosel, Rosenbaum, Rowles, Ryeng, Samaran, Siciliano, Simmonds, Sironi, Slooten, Smith, C., Smith, S., Stachowitsch, Suydam, Thomas, Tiedemann, Torres-Florez, Urban, Vermeulen, Vlckova, Wade, Williams, Wimmer, Woo Kim, Ylitalo, Zerbini, Zharikov

1. CONVENOR'S OPENING REMARKS

Scheidat and Porter welcomed the participants to the meeting.

2. ELECTION OF CHAIR

Scheidat and Porter were elected Chairs.

3. APPOINTMENT OF RAPPORTEURS

Reeves, Cipriano, Collins, Genov, Natoli, Porter, Rosel and Thomas undertook the duties of rapporteurs.

4. ADOPTION OF AGENDA

The adopted agenda is given as Appendix 1.

5. REVIEW OF AVAILABLE DOCUMENTS

The following available documents contained information relevant to the work of the sub-committee:

SC/66b/SM01, SC/66b/SM02, SC/66b/SM04 - SC/66b/SM19, SC/66b/SM21, SC/66b/SM22; SC/66b/SH08; Baretto (2000); Costa *et al* (in press); Costa *et al* (2015); Fruet *et al* (2014); Gaspari *et al* (2015); Jaramillo-Legorreta *et al* (in press); Louis *et al* (2014a); Louis *et al* (2014b); Moura *et al* (2013); Natoli *et al* (2005); Ott *et al* (accepted); Siciliano *et al* (2016); Viaud-Martinez *et al* (2008); and National Progress Reports.

6. REVIEW OF TAXONOMY AND POPULATION STRUCTURE OF BOTTLENOSE DOLPHINS (*TURSIOPS* SPP.) IN THE ATLANTIC OCEAN, MEDITERRANEAN SEA AND BLACK SEA

6.1 Context for and conclusions from the 2015 review

At SC/65b the Small Cetaceans sub-committee decided that its priority topic for the next Scientific Committee meeting would be a review of taxonomy and population structure in the genus *Tursiops*. Because bottlenose dolphins are among the most widely distributed cetaceans, with complex taxonomy and population structure, it was agreed that the review would be completed in stages and over several Scientific Committee meetings, with development of an assessment framework and general reviews of the available information in relatively well-studied regions to be conducted first. Factors contributing to taxonomic uncertainty in this genus include a wide distribution across highly variable environments, variability within locally adapted populations, sympatry of various forms in some regions, a lack of specimens from many regions, and differences in research methods and designs (Wang and Yang 2009).

Worldwide, more than 20 different *Tursiops* species have been described historically but only two (*T. truncatus* Montagu 1821 and *T. aduncus* Ehrenberg 1832) are widely recognized.

Relationships among members of the entire family Delphinidae and in particular the subfamily Delphininae (including *Tursiops*, *Stenella* and *Delphinus*) are complex, and the taxonomy of these species and genera is still unclear (Perrin *et al* 2013). *T. truncatus* has a world-wide distribution from temperate to tropical waters in both hemispheres, whereas *T. aduncus* is confined to the Indo-Pacific region and is principally found in near-shore waters – in addition, *T. truncatus* seems not to occupy inshore areas in the range of *T. aduncus* (although there are areas where the two species can be considered generally sympatric). Among the *T. truncatus* forms in the Atlantic and Pacific, two morphologically and genetically differentiated types have been described – 'coastal' and 'pelagic' (some authors use the terms 'inshore' and 'offshore' or 'oceanic', respectively, for the same distinction). However, the correlation of morphotype with geography is not consistent across regions - for example, in the eastern North Pacific the coastal form is larger than the pelagic (or offshore) form (Perrin *et al* 2013), whereas in the western North Atlantic coastal (or inshore) animals are smaller than pelagic (offshore or oceanic) animals (Mead and Potter 1995). The strong morphological differentiation between coastal and pelagic forms that are sympatric has raised questions about whether these forms represent different subspecies, but these questions have not yet been formally addressed. Strong population structure in coastal *T. truncatus* has been observed in areas where detailed analyses have been conducted (e.g. Florida, Gulf of Mexico, western North Atlantic, Mediterranean) (see Sellas *et al* 2005; Rosel *et al* 2009; Natoli *et al* 2005).

Wang *et al* (1999) examined mtDNA control region sequences from *Tursiops* sampled in Taiwan (and elsewhere) and found the molecular data to be in agreement with the osteological and external morphological characters analysed (Wang *et al*, 2000a, b). This congruence was strong evidence that the sympatric forms of bottlenose dolphins in Chinese waters are reproductively isolated and comprise two distinct species (*T. truncatus* and *T. aduncus*) that are at least partially sympatric in that region. Natoli *et al* (2004), using mtDNA and microsatellite markers, found that coastal *T. aduncus* in South Africa differed significantly from both *T. aduncus* from Taiwan and *T. truncatus* from various locations worldwide (Atlantic Ocean, Gulf of Mexico, Mediterranean Sea, and eastern North Pacific). Therefore, they concluded that the *T. aduncus* in Taiwan may represent a third species. However, Natoli and colleagues did not examine any sequences from Australian *T. aduncus*. Perrin *et al* (2007) re-analysed the *T. aduncus* holotype (specimen from the Red Sea) using genetic and morphological data, and found that it clustered with the 'African' *T. aduncus* specimens. Sarnblad *et al* (2011) compared published *T. aduncus* sequences from China, eastern Australia, and South Africa with their sequences from Zanzibar and found that the African sequences clustered together, confirming the differentiation of African from Chinese and Australian specimens.

At SC/66a the sub-committee reviewed taxonomy and population structure of bottlenose dolphins (*Tursiops* spp.) in the Indo-West Pacific including China, southern Japan, Taiwan, Australian waters, New Zealand and Oceania, the eastern Bay of Bengal, Bangladesh, and the east coast of Africa from the Red Sea to South Africa. The purpose of the review was to clarify understanding of *Tursiops* taxonomy across the region in general, and in particular the relationship of '*T. australis*' to other taxa. In the Indo-West Pacific, *T. aduncus* and *T. truncatus* are clearly distinguishable, and the distinction is consistent across many different areas, studies, and marker types analyzed. However, *aduncus*-type dolphins exhibit considerable regional variability, suggesting that the morphological characters used for diagnosis are subject to convergence, perhaps related to independent adaptation to particular coastal habitats. New *T. aduncus* lineages off Pakistan and India and off Bangladesh have been suggested by recent analyses. The sub-committee at SC/66a found it difficult to reach conclusions on the taxonomic status of '*T. australis'* at least in part because of discordance in results using different genetic markers. Morphometric analyses did not show a difference between putative *T. australis* specimens and *T. truncatus*. However, the lack of morphological distinctiveness relative to *T. truncatus* could be related to the distinctions between species being blurred by convergence.

Thus, some uncertainties remained for taxonomy of *Tursiops* in the Indo-Pacific after the review at SC/66a. The sub-committee therefore advised more consistency in approaches used and in morphological, genetic and behavioral characters employed to allow direct comparisons between areas and study groups. In such efforts, it will be critical to use additional, independent nuclear markers (such as multi-locus genotyping using SNP analysis) as well as both morphological and morphometric characters in analyses, and important for researchers to keep open minds in the search for better understanding of the patterns observed.

At SC/66b the sub-committee reviewed the taxonomy and population structure of bottlenose dolphins (*Tursiops* spp.) in the Atlantic Ocean, Atlantic oceanic islands (Azores, Cape Verdes, Canaries, Saint Peter and Saint Paul Rock), and the Mediterranean and Black Seas.

Specific objectives of this second phase were to clarify:

- Taxonomic status of *Tursiops* spp. in the western and eastern North Atlantic regions with particular attention to the near-shore (coastal) and offshore (pelagic) types.
- Taxonomic status of *Tursiops* spp. in the western South Atlantic considering the different morphotypes reported from this region.
- Distribution and status of *Tursiops* populations in the eastern South Atlantic and of island-associated *Tursiops* populations in the Atlantic.
- Identity of the *Tursiops* population(s) in the Mediterranean in relation to the adjacent eastern North Atlantic population.
- Taxonomic status of Black Sea bottlenose dolphins currently considered a subspecies, *T. truncatus ponticus.*

6.2 Overview of current knowledge and issues regarding the taxonomy of bottlenose dolphins in the Atlantic Ocean, Mediterranean Sea and Black Sea

Natoli and Rosel presented a brief synopsis of the results of last year's meeting and highlighted some of the outstanding taxonomic issues concerning bottlenose dolphins in different regions.

Unlike the situation in the Indo-Pacific, where there are two well-established species of *Tursiops*, only the one recognized species, *T. truncatus*, is present throughout the Atlantic Ocean and the Mediterranean and Black Seas, and the Black Sea population is recognized as a subspecies, *T. truncatus ponticus*. Different local forms have been described, however, based on distribution (offshore vs nearshore differentiation), morphology and genetic profile, and new species and subspecies have been proposed, from time to time, in the western South Atlantic.

Therefore the main challenge when considering the Atlantic Ocean is to understand whether there is consistency of the various local forms across the range and to which taxonomic level(s) these forms (ecotypes/morphotypes) should be assigned.

A map summarizing the areas covered by research on *Tursiops* world-wide was presented as a graphic aid to identify regions where information is lacking. Areas of discussion were divided as follows: western North Atlantic (WNA), western South Atlantic (WSA), eastern North Atlantic (ENA), Mediterranean Sea, Black Sea, eastern South Atlantic (ESA) and oceanic Islands.

It was also clarified that the two independent lines of evidence needed to delimit a species as proposed in Reeves *et al* (2004) could be from two kinds of independent genetic markers.

Before proceeding with a review of what is known about geographic variation in *Tursiops* morphology, genetics and other characteristics within the five geographic regions of the Atlantic, the sub-committee discussed two recent broad-scale studies.

A key objective of Moura *et al* (2013) was to test hypotheses about the role that environmental change, particularly habitat release during interglacial periods, may have played in the radiation of *Tursiops* lineages. Mitogenome analysis was chosen as it has the advantage of high resolution and relatively simple interpretation for mutation rate, but nevertheless represents a single gene tree, subject to problems associated with incomplete lineage sorting and introgression.

The time-calibrated tree in Figure 2 of Moura *et al* (2013) shows three division points between nearshore and offshore populations that overlap with the Eemian interglacial (~130Ma), and one (the nearshore – offshore division in the WNA) that overlaps with the Chromerian and Holstein interglacials (~490 and 420 Ma, respectively). Likelihood analyses showed the strongest increase in the diversification rate to be at the start of the Holocene (Moura *et al*, 2013, Table 2). The dating of nodes was difficult, but the authors used the best-supported model incorporating both biogeographic (opening of the Bosphorus) and fossil calibrations. Biogeographic analyses (Figure 3 in Moura *et al* 2013) suggested origins in coastal habitat followed by an early transition to pelagic habitat (at the base of the *T. truncatus* lineage), and later reversals back to the coastal ecotype.

The tree topology (Figure 2 in Moura *et al* 2013) supports earlier proposals of a division between *T. aduncus* in Australasia from the lineage off South Africa, and between the offshore and coastal populations in the WNA. However, the deepest and best-supported division is between *T. truncatus* and *T. aduncus* lineages. Within the North Atlantic there is reciprocal monophyly between the WNA coastal population and the rest of the *T. truncatus* lineage, but the remainder of the latter lineage shows incomplete lineage sorting. The most recent divisions reflect the founding of the Black Sea population along two more ancient mtDNA lineages, at the time of the opening of the Bosphorus, ~10Ka (timing supported by rate calibration using IMa).

Hoelzel presented a preliminary phylogeny based on genome sampling using the ddRAD method. The phylogenetic tree was created from 4,029,091 bp sequence data in total (26,720 variable sites) using the MrBayes method, with 1,100,000 iterations following 100,000 burnin, and a sampling frequency of 200. Four independent chains were run simultaneously, with one heated chain to reduce the likelihood of local optima. Trees were constructed under the GTR+I+G model of nucleotide substitution, and the final tree was constructed using a 50% majority rule from all retained trees. The topology reveals two well-supported *Tursiops* lineages branching from the same node, and no paraphyly with *Delphinus*, *Lagenodelphis*, *Stenella* and *Steno* outgroups. Three lineages within the *T. aduncus* lineage reflect South African, Australasian and the putative *T. australis* lineages. Within the *T. truncatus* lineage there are four lineages reflecting the WNA coastal, WNA pelagic, eastern Mediterranean, and Black Sea populations. Node support is strong throughout the tree. This tree differs from the Moura *et al* (2013) phylogeny in that *T. australis* is no longer basal to the main *Tursiops* lineage, but instead is found within the *T. aduncus* lineage.

Discussion of these results focused on the importance of fossil and biogeographic calibration points (*e.g.* opening of Bosphorus). The analyses by Moura *et al* (2013) resulted in a well-resolved tree, with high support for the inferred branching points ('nodes'), but most divergence dates largely overlapped and it was noted that even a full mitogenome tree represents only a single gene tree. These types of analyses depend on accurate calibration points; the divergence dates inferred are susceptible to errors in dating and taxonomic uncertainty in fossil designations. In addition, it may be premature to use a single, maternally inherited gene tree as evidence for what a species is. Hoelzel clarified that the species groups used in the analysis were assigned *a priori* (including the Oman specimen) and that the identity of the fossil used for the 5 MYA calibration point has been independently verified (Barnes 1990; Fitzgerald 2005). The sub-committee **agreed** that dependence on single molecular markers for such trees suffers from the possibility that the 'gene tree' may not accurately reflect the true 'species tree' (Doyle 1992) and that 'offshore' and 'inshore' designations are often too simplistic, and in every case require careful morphological characterization. Despite these limitations, the analyses in Moura *et al* (2013), with clarification of those results provided by Hoelzel and his preliminary nuclear data, were considered strongly confirmatory, with *e.g.* two *Tursiops* lineages found in Australia, and suggested a polyphyletic *T. aduncus* (with Pakistan samples in a separate lineage) as well as strong separation of the WNA coastal lineage.

6.3 Bottlenose dolphins in the western North Atlantic

Two distinct morphotypes of common bottlenose dolphins, *T. truncatus*, are present in the WNA and appear to exhibit a parapatric (or possibly sympatric) distribution partitioned into coastal and offshore habitats (Waring *et al* 2015; SM16). These two forms differ in distribution (Kenney 2000), cranial morphology, body size, tooth counts, parasite loads, and diet preferences (Mead and Potter 1995), in hematological parameters (Duffield 1987; Duffield *et al* 1983), and in mitochondrial DNA (Hoelzel *et al* 1998; Moura *et al* 2013; Natoli *et al* 2004; Rosel *et al* 2009) and nuclear markers (Kingston *et al* 2009). The significant ecological differentiation, with corresponding prey preferences and parasite loads, correlates with significant differentiation at multiple independent genetic loci as seen in mtDNA, ALFP loci, MHC and microsatellites.

Rosel (and see SM16) described ongoing genetic research on the two forms of *T. truncatus* in the WNA, including mtDNA sequence data, nuclear data in the form of microsatellites, MHC variability and Y chromosome variability. Bayesian phylogenetic analyses revealed a well-supported clade of offshore mtDNA control region haplotypes while coastal haplotypes were broken into two clades, one well supported and one not. Of note is that when additional coastal and/or offshore haplotypes from the Gulf of Mexico, or elsewhere, were added, the coastal haplotypes did then form a single group. There were fixed differences between the haplotypes representing the coastal and offshore morphotypes. There was strong correlation between haplotype designation of coastal vs offshore and ecological expectation, with offshore haplotypes present in offshore shelf and continental slope waters and coastal haplotypes present in nearshore coastal and estuarine waters. STRUCTURE analysis (Pritchard *et al* 2000) using 19 microsatelllite loci identified 3 genetic clusters: 1) a population restricted to offshore continental slope waters and ranging along the entire United States eastern seaboard, 2) a coastal population found from New York to Florida in water depths of 20m or less and 3) a shelf population found only between Florida and Cape Hatteras, North Carolina. Hybrid analyses found no support for the idea that the intermediate shelf population is a recent hybrid zone between the coastal and offshore groups, though the possibility that it is an ancient hybrid zone could not be ruled out. No differentiation was found in ~1600bp of y-chromosome intron sequences in a small sample of coastal and offshore animals. The nuclear sequences from 2 MHC genes revealed a large number of private alleles for both morphotypes. Every microsatellite locus also exhibited private alleles. What is known to date about the distribution of this coastal morphotype (based on mtDNA haplotypes) suggests a contiguous nearshore coastal distribution in the WNA and Gulf of Mexico and along the Mexican coast at least to the Yucatan Peninsula, the north coast of Cuba (Caballero *et al* 2012), and the Bahamas (Parsons *et al* 2006), all areas with shallow shelf waters. No coastal haplotypes were documented in dolphins from coastal Honduras or Colombia (Caballero *et al* 2012). Overall, significant mtDNA differentiation (fixed differences and good phylogenetic separation) and significant nuclear differentiation (at 2 MHC and at the AFLP dataset of 418 markers (Kingston *et al* (2009)) were seen between the two morphotypes in the WNA. Microsatellites, though not particularly appropriate for taxonomic work, support the other markers. The complete body of evidence, consisting of genetic differentiation at multiple markers coupled with the strong ecological and morphological differentiation, suggests that consideration of the taxonomic status of the coastal morphotype in the WNA is warranted.

Discussion of the results presented in SM16 clarified that most of the specimens used were from biopsy sampling, so that skulls and body size estimates were not available, but efforts are ongoing to match genetic samples to those skulls that are available. In addition, Rosel mentioned that other analyses had shown significant differentiation among individual bays and estuaries along this coastline and there is evidence of seasonal migration by some coastal populations – for example, dolphins found in New Jersey in the summer months migrate to Cape Hatteras later in the year. Hoelzel noted that results from his 1998 study, which covered the same area although it used a smaller sample, were concordant with taxonomic identification of the specimens (skulls examined by Mead and Potter 1995). It would be helpful if such studies were designed to first classify specimens morphologically in order to confirm molecular designations such as ‘offshore’ or ‘inshore’ types.

SM11 reports on a preliminary morphological study using samples of bottlenose dolphins collected in the WNA. The aim was to examine the degree of morphological differentiation between the two known morphotypes (coastal and offshore/pelagic) in the WNA and to compare them with skulls from the WSA. For the WNA, the authors examined 101 physically mature skulls and 34 vertebral columns. For the cranial analyses, they identified the skulls *a priori* from cranial features previously described as useful for identifying the ecotypes in the WSA (Costa *et al* in press), followed by a principal component analysis (PCA) and a discriminant function analysis (DFA) using 19 cranial measurements. The multivariate analyses confirmed the *a priori* classification of the skulls and revealed the presence of two distinct morphotypes, with 57 skulls classified as coastal and 44 as offshore ecotypes. In addition, a PCA of the vertebral data identified two groups corresponding 100% with those defined in the analysis of the skulls. The two morphotypes also exhibited differences in the vertebral formula. Coastal dolphins had smaller skulls and vertebrae, lower vertebral counts, and smaller total body lengths than the offshore (pelagic) morphotype animals. Lastly, the authors compared the WNA data set to 78 skulls from both of the morphotypes in the WSA through a PCA and observed that the offshore ecotype in both locations formed a single unit whereas the WNA and WSA coastal groups appeared to be independent evolutionary units.

Discussion of SM11 primarily centred on the difficulty of associating a unique morphological profile to a specific ecotype as size features vary within ecotypes and across regions. For example, in different regions bottlenose dolphins that occur in coastal or near-shore waters may be larger or smaller than those found in adjacent neritic or pelagic waters.

In fact, the type specimen of *T. truncatus* is from inshore waters of the British Isles and was a relatively large animal. The discussion also stressed that 'larger' and 'smaller' are relative terms, and so for example it is possible that 'offshore' animals are roughly the same size everywhere, but the size of 'inshore' animals might vary. The influence of ocean conditions and water temperature on bottlenose dolphin body size may also be important – in some cases 'offshore' waters are influenced by cold currents and coastal zones are relatively warm, and in other cases coastal waters are influenced by cold currents. Costa clarified that the dolphins in her study area differ in both skull size and total body length. Coastal bottlenose dolphins in the WSA are reported only in coastal waters from central Brazil to Chubut province, Argentina (approximately between 23º and 43º south) and no samples from the Caribbean were included in Costa's study. Vermeulen pointed out that the dolphins found farther from shore off the Argentine coast appear to be larger than those found near shore in that region while the opposite is observed along the Brazilian coast; she added that this difference in size may be influenced by water temperatures along the Argentinian coastline.

6.4 Bottlenose dolphins in the western South Atlantic

Fruet summarized the 'Report of the working group on taxonomy and stock identity of bottlenose dolphins in the Southwestern Atlantic Ocean' held in 2010 (Ott *et al* in press). The aims of this workshop were to compile current information on morphology, genetics, stable isotopes, acoustics and parasites of bottlenose dolphins in the western South Atlantic (WSA) and briefly review the proposed taxonomy of the genus for this region. The report concluded that *Tursiops* occurs as two different forms in the region, a northern and a southern form (or 'inshore' vs. 'offshore'). The two forms differ greatly in skull morphology, and preliminary data show differences in whistle parameters, stable isotope signatures and genetics (mtDNA and microsatellites). However, the data available to the working group were considered insufficient to test taxonomic hypotheses.

Fruet *et al* (2014) combined analyses of 16 microsatellite loci and 457bp of mtDNA control region sequences to investigate genetic diversity, structure and connectivity of 124 biopsy samples collected from six 'communities' of individually photo-identified coastal bottlenose dolphins in southern Brazil, Uruguay and central Argentina. Levels of nuclear genetic diversity were remarkably low. It was suggested that at a large geographical scale, bottlenose dolphins from Bahía San Antonio (BSA), Argentina and southern Brazil-Uruguay (SBU) form two distinct ESUs with negligible contemporary gene flow between them. Additional sub-divisions were also found for the SBU ESU, consisting of multiple management units sharing low to moderate contemporary asymmetric gene flow.

In discussion, Fruet clarified that all of the analyses presented in Fruet *et al* (2014) were of 'resident' animals analyzed from biopsy samples taken in coastal waters of southern Brazil, Uruguay and Argentina. The sub-committee **agreed** that the STRUCTURE analysis in Fruet *et al* (2014) would benefit from re-analysis to ensure that consistent parameters were used and that the samples were re-stratified for different 'K' values, rather than exclusion or pooling of geographically defined sets of specimens. The possibility of isolation-by-distance and its effect on STRUCTURE analyses should also be evaluated.

SM14 expands on the study described in Fruet *et al* (2014) by adding samples collected in offshore waters. Using a combination of 457bp of the mtDNA control region sequence and 16 microsatellite loci for genetic analysis, strong levels of structuring and contrasting genetic diversity were found between offshore and coastal ecotypes of bottlenose dolphins biopsy-sampled (n=168) or freshly stranded (n=4) in the western South Atlantic. The analyses indicated minimal recent and historical connectivity between ecotypes, suggesting that they are following separate evolutionary trajectories. Based on their findings, which seemed consistent with morphological differentiation recently described for animals in their study area (Costa *et al*, in press), the authors of SM14 recommended that the offshore bottlenose dolphin ecotype be considered a western South Atlantic ESU that differs from the two ESUs proposed by Fruet *et al* (2014) for the coastal ecotype.

Discussion of SM14 again focused on the difficulties of using alternate naming conventions, *e.g.* 'coastal' vs. 'offshore' ecotypes and 'large' vs. 'small' morphotypes. Fruet clarified that cranial characters were not used for specimen characterization, and that the 'inshore' vs. 'offshore' dolphins analyzed in this study were characterized using sampling location (surveys of the outer continental shelf for samples of offshore individuals), dorsal fin shape and coloration to distinguish morphotypes. It was suggested that, given the clear indication that three 'offshore' dolphins had joined the 'inshore' population in Bahia San Antonio, Argentina, additional analyses to test for hybridization ('admixture') could be informative. Positive F_{IS} values were noted and may be indicative of further structure within the offshore group.

Costa *et al* (in press) studied the morphology of bottlenose dolphins collected in the WSA with the aims of improving understanding of the different morphotypes in southern Brazil and helping to resolve the taxonomy of *Tursiops* in the WSA. The authors tested two hypotheses that have been proposed for the WNA: (1) offshore and coastal ecotypes with a parapatric distribution and (2) two species, *T. truncatus* and *T. gephyreus*, living in sympatry. Multivariate analyses (PCA and DFA) were conducted for 24 skull measurements, four alveoli counts and two categorical variables from 100 physically mature skulls. The vertebral formula was determined and five measurements were taken from 7 selected vertebrae. Two well-separated groups were identified and the morphological characters that distinguish the groups corresponded well with ecological habits expected for coastal and offshore ecotypes of common bottlenose dolphins described in other geographic areas. The offshore animals had smaller skulls and vertebrae and shorter body lengths, but higher vertebral counts, with no overlap, than the coastal animals. A parapatric rather than sympatric distribution along the coast of southern Brazil was suggested due to the uneven ratio of strandings of coastal and offshore animals. Visual identification of specimens is possible using a subset of skull characters. The great degree of morphological differentiation revealed through skull and vertebral column analyses were interpreted by the authors as suggesting that the ecotypes represent two subspecies, *T. t. truncatus* (offshore ecotype) and *T. t. gephyreus* (coastal ecotype). However, an additional independent line of evidence would be needed to hypothesize that the two ecotypes represent different species.

In discussion, Costa clarified that differences in patterns in Costa *et al* (in press, Figures 1 and 2) resulted from the use of two different sets of data (skulls and associated measurement characters) for the two analyses. Because a subset of the skulls had missing data, they could not be used in the first PCA that used all 19 characters. Using the 6 characters identified in the first PCA as being most useful for discriminating the two morphotypes, the second PCA (Costa *et al*, in press, Figure 2) was performed to identify the morphotype to which the skulls with missing characters belonged.

Three other papers that examined morphological data from the WSA were briefly considered. Barreto (2000) proposed, based on skull morphology, that bottlenose dolphins along the coast of Brazil north of Santa Catarina comprise a smaller form under the influence of warm waters of the Brazil Current while a larger, southern form is found in cold waters south of 29°S, with a small sympatric zone between 26 and 29°S. Genetic variation observed using a small sample (n = 17) was congruent with the morphological results. Based on the morphological and genetic data together, the author recommended the southern form be recognized as *T. t. gephyreus*. The sample size for the northern form was too small to draw any taxonomic conclusions.

SC/66b/SM07 analyzed the skull morphology of bottlenose dolphins stranded between northern Brazil and the north coast of Chubut (Argentina), with a possible area of overlap of *T. truncatus* and putative *T. gephyreus* in southern Brazil and northern Argentina. The skulls were separated using *a priori* identification following Lahille (1908) and Barreto (2000). A total of 192 adult skulls were analyzed using 52 measurements and 14 morphological characters. However, due to high correlation among the measurements, the multivariate analyses were conducted using only 29 measurements. The multivariate analyses confirmed *a priori* classification of 53 out of 57 specimens initially identified as *T. truncatus* and 72 out of 82 initially identified as *T. gephyreus*. In addition, six morphological characters in the skulls were proposed by the authors as diagnostic for visual species identification. Total vertebral counts of 22 specimens (*T. truncatus* = 13; *T. gephyreus* = 9) revealed no overlap (*T. truncatus* = 62-68; *T. gephyreus* = 57-59). These results led the authors to conclude that, based on the Phylogenetic Species Concept, the two morphotypes represent separate species.

The authors of SC/66b/SM17 conducted a morphological study using 2D-geometric morphometrics with 209 adult skulls photographed in dorsal, ventral and lateral views. The specimens were collected in four different oceanographic areas: WSA, WNA, ESA and eastern North Pacific. The aim of the study was to assess cranial morphological differences among bottlenose dolphins in different ocean areas, as well as to investigate the presence of two putative species in the WSA. Canonical analyses revealed differences between all four areas. However, as pointed out by the authors, there was no *a priori* separation of the data set into coastal and offshore morphotypes before conducting the multivariate analysis. In addition, the authors conducted a PCA for the samples collected in the WSA to verify the presence of putative species. The skulls were classified *a priori* as *T. gephyreus* and *T. truncatus* based on Wickert (2013). Based on the results obtained and using the Phylogenetic Species Concept, the authors concluded that the morphological variation observed in the WSA was a good indication of the presence of different species – *T. gephyreus* and *T. truncatus*.

Discussion of these three papers focused on the difference in results between standard morphological analyses, which revealed little overlap in the two morphotypes, versus the 2D geomorphometric analysis, which showed significant overlap between the two morphotypes. The latter type of analysis should have been performed after removing effects due to size but the sub-committee was unable to determine whether this had been done. Further discussion focused on the conclusions of these papers that the coastal form in the WSA should be elevated to species status. It was noted and stressed, however, that only a single line of evidence had been used and so the criterion that at least two lines of evidence are needed for delimiting cetacean species (Dalebout *et al*, 2004; Reeves *et al*, 2004) was not met. Therefore, the sub-committee concluded that there was not enough evidence to draw firm conclusions about species status for *T. gephyreus*. In addition, it is necessary to evaluate the genetic context before proposing new species. Environmental factors can influence morphology (ecophenotypic variation), even if interbreeding is occurring. So, (i) caution should be exercised when interpreting morphological differences alone and attempting to delimit species, (ii) consideration should be given to whether characters are phenotypically plastic, and iii) behavioral differences should be considered.

The goals of SM10 were to assess the levels of genetic variability and population structure of the bottlenose dolphins in the tropical and subtropical WSA and compare the results with previous morphological studies. The 110 samples analysed came from six areas of occurrence along the coast of Brazil to as far north as the Guyana border, as well as from French Guiana and from Saint Peter and Saint Paul's Rocks – oceanic islands where a resident population of dolphins is known to occur. Analyses of the mtDNA control region and seven microsatellite loci found significant population structure in both markers. Combining these results with previous studies, it was concluded by the authors of SM10 that there are at least four bottlenose dolphin management units in the WSA. Finally, from Santa Catarina state in southern Brazil to at least Uruguay there seems to be a distinct genetic unit of some kind that is not the classical *T.*

truncatus, but partially sympatric with it, and having morphological features that have been attributed to the putative species *T. gephyreus*. However, the authors of SM10 did not consider the available evidence to be sufficiently strong to support a formal taxonomic proposal.

In discussion of SM10, it was again suggested that the STRUCTURE analysis could have been extended with tests for hybridization ('admixture') as this is an important factor for interpreting whether observed differences are species- or subspecies-level. The results reported in SM10 may have been affected by the fact that many specimens were from stranded animals, which can yield low-quality DNA, which in turn can affect the quality of microsatellite data. Siciliano explained that the analyses presented were preliminary and that further details could be included in an update from the primary author, who was not able to attend the current SC meeting.

Costa *et al* (2015) described a preliminary genetic study conducted along the southern Brazilian coast to investigate the level of population structure in ten estuarine resident bottlenose dolphins biopsy-sampled in Laguna, one estuarine resident bottlenose dolphin biopsied in the Mampituba River, and 30 stranded dolphins (29 of unknown origin and one estuarine resident bottlenose dolphin from Tramandaí Lagoon). The study used 316 bp mtDNA control region sequence data and 5 microsatellite loci. STRUCTURE analysis, with no *a priori* information about the data set, revealed three clusters. Cluster 1 was composed mainly of dolphins from Laguna and the Mampituba River, Cluster 2 mainly of dolphins that had stranded close the mouth of Tramandaí Lagoon and one resident dolphin of this estuary, and Cluster 3 of stranded dolphins of unknown origin. There was low to moderate genetic diversity in Clusters 1 and 2, as well as possible gene flow between these two clusters. High genetic diversity was observed in Cluster 3 and no gene flow appeared to exist between Cluster 3 and the other two clusters. These results led the authors to suggest that Clusters 1 and 2 belonged to a possible coastal population while Cluster 3 belonged to a larger offshore population.

In discussion, Costa clarified that only the specimens from Laguna were included in the complementary study by Fruet *et al* (2014), and that the inferred 'overlap' area was defined as the coastal region where stranded specimens of both morphotypes had been collected – although observations of live 'offshore' dolphins moving through the coastal zone in the 'overlap' area are quite rare. Costa also explained that the continental shelf is relatively wide off central and southern Brazil, while to the north the continental shelf is much narrower. Only four resident populations in the coastal zone are known from this region, and all are being monitored in ongoing and cooperative Brazil/Argentina studies, which include analyses of stomach contents and stable isotopes from the same specimens that were used for the genetic analysis.

Available information on the distribution, movement patterns, abundance and population structure of bottlenose dolphins in Argentina was summarized in SM06 and SM08. The frequency of sightings has greatly decreased since the 1980s, such that the species is now essentially absent from the northern coast of Buenos Aires province (Bastida and Rodriguez, 2003) and very rarely seen in the province of Chubut (Coscarella *et al*, 2012). Current estimates suggest there are now fewer than 200 individuals in Argentine coastal waters, mainly between Bahia Blanca and Playa Union (Coscarella *et al*, 2012; Vermeulen and Bräger, 2015). Two apparently sympatric populations occur, differing in external morphology (Bastida and Rodriguez, 2003) and genetic composition (Fruet *et al* 2014; SC/66b/SM14). Genetic data have been interpreted to indicate that the population in Bahia San Antonio is an ESU of the coastal type (i.e. *T. gephyreus*), whereas the other population may belong to the offshore ecotype (SC/66b/SM14) despite its apparently coastal ecology and the lack of evidence of offshore populations in Argentine waters, supported by multiple surveys conducted in offshore waters (SM08). It was noted that no *Tursiops* acoustic detections were made at 100-200 nm off the Argentine coast (Miguel Iñiguez, pers. comm.).

Regarding conservation, Vermeulen and Bräger (2015) suggested that reproductive problems (indicated by the presence of few calves and reproducing females) are having a severe effect on the population dynamics of coastal bottlenose dolphins in Argentina. To date, this situation has been given little attention, apparently because there have been no clear warning signs such as obviously high observed mortality. The sub-committee **recommended** that an updated assessment of population status is obtained. This should include estimation of the rate of decline and investigation of causal factors with the primary focus on the apparently reduced reproductive success.

Further discussion focused on areas of remaining uncertainty regarding distribution of bottlenose dolphin morphotypes in Argentine waters and potential explanations for apparent changes in abundance. Observations in Argentina span over 100 years, so range shifts during that period – perhaps associated with changing oceanographic conditions – may explain the difficulty of establishing consistent boundaries for the two morphotypes. However, a range shift would not likely explain fully the current absence of sightings in the province of Buenos Aires. Therefore, a suggestion was made to stratify specimens and sightings by decade to see if shifts in distribution can explain the observed changes. Caution may be needed when using observed differences in coloration and dorsal fin shape to interpret morphotype distinctions, since consistent associations of coloration and fin shape with skull and body size characters have not been demonstrated. More samples are needed that include all relevant characters – coloration, dorsal fin, skull characters and genetics – with particular focus on the offshore type.

6.5 Overview of studies and observations of island-associated bottlenose dolphins in the Atlantic Ocean

There are a number of offshore island systems in the Atlantic Ocean. This includes the Azores and Madeira, Cape Verdes, Saint Peter and Saint Paul Rock (Castilho *et al*, 2014), the Canary Islands and a number of small islands off

Brazil (Baracho *et al*, 2008; Carvalho and Rossisantos, 2011). Bottlenose dolphins have been reported in the Cape Verdes (Hazevoet *et al*, 2010) and a population genetic study was conducted to compare the populations in the Azores and Madeira (Quèrouil *et al*, 2007) using mtDNA and 10 microsatellite loci. Bottlenose dolphins in this region, where the continental shelf is almost non-existent, occur mostly within 9km of shore. Population structure was found to be minimal among these two island groups based on mtDNA data and even less based on nuclear markers. Quèrouil *et al* (2007) suggested higher male-mediated dispersal among locations. On a broader geographic scale, significant differentiation was observed between the Azores/Madeira dolphins and those in the Black Sea, Mediterranean Sea, eastern North Atlantic, Bahamas, Gulf of Mexico and the coastal western North Atlantic, but no significant differentiation was found between the Azores/Madeira dolphins and the pelagic population of the western North Atlantic. Therefore, Quèrouil *et al* (2007) concluded that *T. truncatus* around the Azores belongs to the offshore type.

6.6 Bottlenose dolphins in the eastern North Atlantic

Louis *et al* (2014a) examined the genetic structure of bottlenose dolphins in the eastern North Atlantic through analyses of 381 biopsy-sampled or stranded individuals using 25 microsatellites and a 682-bp portion of the mitochondrial control region. The authors found hierarchical structure with the greatest genetic differentiation between coastal and pelagic dolphins. Finer-scale structure was found within each group. Coastal dolphins mainly shared haplotypes from one lineage that is separated by 12 bp from the lineage with most of the pelagic haplotypes, but a few haplotypes were shared between coastal and pelagic samples. Coastal populations had lower effective population sizes and less genetic diversity than pelagic populations. Migration rates among populations were low, around 1% at most.

Louis *et al* (2014b) examined the forces shaping population structure and ecotype differentiation in bottlenose dolphins in the ENA through reconstruction of population demographic history using approximate Bayesian computation and the data from Louis *et al* (2014a). These analyses indicated that coastal populations were founded by the Atlantic pelagic population after the Last Glacial Maximum (10,320 yrBP, 95% CI: 4300-47800), likely as a result of the colonization of coastal habitats that became available after sea ice retreated. Louis *et al* (2014b) also characterized the ecology of the two ecotypes to investigate how ecotype differentiation could be maintained. Skin stable isotope values ($\delta^{13}C$, $\delta^{34}S$ and $\delta^{15}N$) and stomach content analyses on a subset of the dataset (21 coastal and 42 pelagic individuals) indicated that coastal and pelagic bottlenose dolphins were feeding on different demersal prey in distinct habitats. Ecological specialization, strengthened by social behaviour, has likely reduced genetic exchange between ecotypes. The external morphology of the two ecotypes was not significantly different, in contrast to other parts of the world such as in the WNA. This might be due to a relatively recent genetic divergence or less contrasted coastal and pelagic habitats. To conclude, the results suggest that ecological opportunity to specialize is a major driver of genetic and morphological divergence.

Discussion of these two papers focused on how the source locations of stranded samples identified as offshores (pelagics) were determined. Clarification of the drift models used to identify source location of offshore samples was provided. Louis clarified that the samples in Louis *et al* (2014b) were identified *a priori* as offshore or coastal (using genetic results) for the stable isotope analysis in Louis *et al* (2014b, Figure 3). However, a clustering analysis using the stable isotope data without any *a priori* designations assigned the individuals to the same cluster as the genetic analysis apart from one individual. Louis noted that the highest density of *Tursiops* sightings is at the shelf break, but some groups may come close to shore occasionally. Fruet suggested that the stable isotope analysis does not suggest that offshore animals spend much if any time close to shore. Louis confirmed that genetically assigned offshore individuals had sulfur values typical of offshore waters.

6.7 Bottlenose dolphins in the Mediterranean and Black Sea

Natoli noted that bottlenose dolphins in the Mediterranean Sea are regarded as *T. truncates truncatus*, whereas those in the Black Sea have been described as a subspecies, *T. t. ponticus* based on morphological data and supported by further recent morphological and genetic analyses (Viaud-Martinez *et al*, 2008). A broad population genetic study of samples from the Mediterranean, Black Sea and eastern North Atlantic using mtDNA and 9 microsatellites showed significant genetic differentiation among the three locations and also revealed population structure within the Mediterranean basin coincident with different habitat regions (Natoli *et al*, 2005).

Gaspari *et al* (2015) investigated population structure and phylogeography of bottlenose dolphins in the Mediterranean Sea, using 12 microsatellite loci and the entire mtDNA control region. Tissue samples were collected from 194 free-ranging adult dolphins between 1992 and 2011 from the five main Mediterranean basins (Tyrrhenian Sea, Adriatic Sea, Ionian Sea, Aegean Sea and Levantine Sea) – 28 from biopsies in coastal waters of the Adriatic and 167 from strandings in various areas. A significant level of genetic differentiation was detected among all basins in the eastern Mediterranean, showing fine-scale population structure, largely a result of stochastic distribution of genetic variation through a series of founder events (either sequential or concurrent) during a recent invasion from the North Atlantic, concurrent with the recent post-glacial expansion. Gaspari *et al* (2015) found significant haplotype sharing between the Mediterranean and Atlantic as well as more broadly across the Atlantic. In spite of this, the dolphins inhabiting shallow-water basins (Adriatic, Tyrrenian and Levantine) within the Mediterranean had a higher number of private alleles and unique mtDNA haplotypes than those in the deeper Ionian Sea which were more similar to the WNA pelagic ecotype, suggesting pelagic versus coastal population differentiation in the Mediterranean Sea.

In discussion of the data from the Mediterranean and ENA, it was noted that the network analysis of mitochondrial DNA data indicated no lineage sorting corresponding with geographic locations, yet the STRUCTURE analysis based on microsatellites strongly supported population structure among the Black Sea, Mediterranean and ENA, and within the Mediterranean. The question was raised of how to interpret the microsatellite data in light of the absence of a signal from the mitochondrial DNA data. It was suggested that incomplete lineage sorting could be one cause of this pattern, possibly indicating that the populations have not been separated long enough or perhaps the populations were large at their founding, explaining the lack of lineage sorting. Recent ddRAD-based analysis supported the separation of the Mediterranean and the Black Sea populations.

6.8 Bottlenose dolphins in the eastern South Atlantic

SM19 reviews information on bottlenose dolphins in western Africa (21 range states, but not the Canary Islands or South Africa). The sources of the data were published reports and unpublished IWC reports. Some information on taxonomy of bottlenose dolphins in this region is available from these sources. No abundance estimates are available, except for some rough estimates for Sao Tome. No estimates of total removals in the region are available.

There are reports of coastal and offshore populations from most range states in the region, but these are often indirectly derived, as there have been few dedicated observation programs and no systematic surveys. ‘Offshore’ bottlenose dolphins seem to be found in relatively large groups, ‘inshore’ dolphins typically in smaller groups. The best evidence for this group size difference comes from Angola. Some stocks of bottlenose dolphins in the region are found associated with large rivers, and there are also some apparently insular stocks. Priorities for additional research identified in the reviewed papers include better attention to fisheries interactions, use of genetic analyses, and more use of platforms of opportunity.

Although not necessarily pertinent to the taxonomic issue, important information was reported in SM11 on takes and bycatch in the region. Reported information on takes is patchy but gillnets are the main cause of bycatch. There are also records of bycatch in industrial trawls in several areas. Recent increases in bycatch and the use of dolphins as bushmeat have been related to the trend of migrant fishermen bringing their own fishing techniques (gillnets) into various areas, instead of adopting the traditional local fishing methods and practices.

Discussion focused on the availability of specimens and opportunities for taxonomic studies in the region. Some skulls and other tissues suitable for genetic analysis have been collected, some biopsy sampling has been conducted in the Congo and Gabon, and some large-scale distributional surveys have taken place off Sierra Leone and Mauritania. There has been no concerted effort on taxonomic studies in the region, but such studies should be encouraged. It was suggested that sharing of information on appropriate molecular markers and help with conducting molecular analyses might encourage the collection of data that would allow wider-range comparisons. At the 2013 SC meeting (Jeju, South Korea), Diallo summarized past efforts to conduct collaborative surveys in the region, and continuation and expansion of such surveys would improve understanding of distribution, abundance, threats, and population structure. The sub-committee **stressed** that compilation of information, including sampling locations, numbers of samples already available, and identification of who is working in particular areas would constitute a good first step.

6.9 Discussion of a proposed framework for making cetacean subspecies distinctions

Rosel presented a summary of guidelines in an unpublished manuscript (Taylor *et al*, in review), which was provided to stimulate the sub-committee’s discussions on how to resolve the taxonomy of *Tursiops* populations around the world. The manuscript is part of a group of related papers intended to be published as a special issue of Marine Mammal Science. The first section of Taylor *et al*’s paper suggests guidelines for which types of data and supplementary information should be included when formulating a taxonomic argument, and is aimed at promoting consistency in what goes into a manuscript that uses genetic data to examine taxonomic questions for cetaceans. The second part focuses on: 1) use of the mitochondrial DNA control region for making taxonomic distinctions at subspecies and species levels and 2) qualitative and quantitative benchmarks for identifying levels of genetic divergence, along the continuum from population to species, that correspond to subspecies- and species-level delineation. Taylor *et al* make use of the large amount of published control region data for many cetacean taxa, which allowed a thorough exploration and evaluation of possible threshold values that might be used to guide and test taxonomic hypotheses. Plotting a measure of divergence against a measure of diagnosability for a large group of well-accepted population, subspecies and species pairs revealed net divergence (d_A) values that minimized classification errors for the available control region dataset. As the paper acknowledges, no threshold values are going to work for every case, but because there is so much control region sequence available for cetaceans, it is a useful example for exploring and evaluating the use of genetic divergence values estimated from the control region to formulate taxonomic hypotheses. The manuscript also provides a flow chart that incorporates these quantitative thresholds with qualitative ones to help evaluate cases that fail to meet the divergence or diagnosability threshold criteria. It allows one to consider and address cases where divergence is low due to very large population size, for example, and it links with the requirement to have two independent lines of evidence to sustain a species-level argument (as laid out in the 2004 workshop report by Reeves *et al* 2004).

The Taylor *et al* guidelines and standards as presented at the meeting elicited discussion of various issues relevant to the current review of *Tursiops* taxonomy, including 1) general considerations for the use of genetic markers for classification (e.g. ‘barcoding’); 2) specific considerations of which markers (i.e. mitochondrial versus nuclear), analytical techniques, and methods of inference are useful for population genetics and taxonomy [see also the Genetic Analysis Guidelines being developed by the Working Group on Stock Definition (ref.)]; and 3) the appropriate sequence of steps that might be followed for developing and then testing taxonomic hypotheses.

In discussion, Rosel clarified that specific examples of how taxonomic distinctions using genetic data are made in other taxonomic groups were considered during preparation of the Taylor *et al* manuscript, and although the choice of molecular marker used may vary, valuable lessons on how this has been done are available in the literature for a variety of taxonomic groups. Rosenbaum added that guidance about making taxonomic distinctions is also included in the 'strict diagnosis' literature. Bickham mentioned that his research group is exploring the use of genome size estimation as an additional method for taxonomic inference in cetaceans, and this approach has been used successfully in cetaceans and other taxonomic groups. Hoelzel commented that it should be kept in mind that mtDNA is a matrilineal marker and does not provide information on male-biased dispersal. For example, Waples asked how does one interpret a situation where strong mtDNA divergence is coupled with F_{ST}=0 based on a nuclear marker? As described by Taylor *et al*, in situations where use of benchmarks alone is inadequate, other information (e.g. morphology, ecology, acoustics, behavior, demography) can be used to make an argument for describing new subspecies, but an explanation of why the benchmarks were not met or were met only partially must also be provided.

During discussion, Rosel clarified that the Taylor *et al* manuscript is an attempt to put current classification procedures into context, not an attempt to impose rules on how to make taxonomic distinctions. In addition, the conclusion that there are unidentified cetacean subspecies was inferred from i) a comparison of the number of subspecies generally expected to the number of cetacean species known and ii) their very broad distribution and the fact that many species are found in multiple ocean basins. Brownell emphasized that the Taylor *et al* paper is intended to provide a consistent framework for making taxonomic distinctions at the subspecies level based on what has been the mostly commonly used genetic marker in cetaceans, the mtDNA control region sequence, and to ensure that authors include information pertinent to particular cases. Ultimately, taxonomic changes in cetaceans require a peer-reviewed article which is evaluated by the Society for Marine Mammalogy's Committee on Taxonomy.

Tiedemann pointed out that there is a broad literature on the issues involved in using a single molecular marker (*e.g.* cytochrome oxidase 1 – 'barcoding') to draw inferences about species delimitation. Consideration is also given in the barcoding literature to when incorrect inferences may be drawn. Several members indicated that the qualitative standards proposed by Taylor *et al* are most appropriate for generating taxonomic hypotheses. The sub-committee agreed that the addition of information from other markers, specifically nuclear data, supporting such hypotheses makes the strongest arguments for taxonomic changes. Bickham added that both population genetics analysis and consideration of historical demography can help explain some patterns, and that it is helpful to combine the two when making taxonomic distinctions. Rosel added that the guidelines outlined in the Taylor *et al* manuscript also make this argument. Authors should consider and incorporate all appropriate types of data when making taxonomic arguments.

The sub-committee acknowledged that there has been a shift away from use of mtDNA alone since so many new molecular approaches are now being used. In this changing landscape, the use of mtDNA sequences alone is becoming less common, but is still concordant with current usage by the SMM Committee on Taxonomy (one or two independent lines of evidence for subspecies and species respectively). Mitogenome sequences are being used increasingly, and they have been effective for resolving some species-level distinctions. Use of genomic information is valuable for detection of large numbers of molecular markers that are being used increasingly for population genetics, phylogenetics and taxonomy.

The sub-committee **agreed** that the use of complementary datasets including genetic markers (*e.g.* mitochondrial, Y-chromosome and other nuclear DNA sequence data, SNPs, and microsatellite profiles), morphometrics, demographic analyses, ecological and behavioral data (including acoustics), and discontinuities in distribution provides valuable context for making taxonomic distinctions. However, caution should be used when attempting to combine results from some types of markers (*e.g.* SNPs and microsatellites) across labs.

The sub-committee also **agreed** that the framework provided in the Taylor *et al* manuscript would best be used to make taxonomic distinctions following a stepwise approach, bringing in additional markers in order to resolve ambiguities when necessary. The sub-committee also **agreed** that another valuable approach would be to use mtDNA control region sequence data to formulate a taxonomic hypothesis, then identify an appropriate sample design, marker(s) and analytical tool(s) needed to test that hypothesis.

6.10 Conclusions from the 2016 review

From the SM sub-committee's review of *Tursiops* in the Atlantic Ocean and the Black and Mediterranean Seas, it is clear that minimal data are available on the ecology and taxonomic status of *Tursiops* sp. in the eastern South Atlantic, although it is assumed they are all *T. truncatus*. More work in this region is needed.

In the eastern North Atlantic, convincing evidence was presented of an offshore and coastal ecotype and of population structure, but mtDNA haplotypes were shared and no differences in external morphology were detected (Louis *et al*, 2014, 2015). A morphometric analysis paired with genetics would be useful to improve understanding of *Tursiops* taxonomy in the eastern North Atlantic. Bottlenose dolphins are documented to occur around many oceanic islands of the Atlantic Ocean, although limited data are available from many locations. One publication on genetic differentiation (mtDNA control region) between the Azores and Madeira found no evidence for population differentiation and found haplotypes common to North Atlantic pelagic populations.

Morphological and genetic analyses of samples from the Black Sea, Mediterranean Sea and eastern North Atlantic have been performed (Natoli *et al*, 2005). *Tursiops* in the Black Sea exhibit strong morphological differences from those in the Mediterranean and elsewhere, and these differences formed the underlying basis for the original subspecies designation. A recent re-analysis of morphology confirmed the distinctiveness of Black Sea bottlenose dolphins, while analysis of mtDNA control region haploytpes revealed shared haplotypes among the Black Sea, Mediterranean and eastern North Atlantic (Viaud *et al* 2008). Population structure is also seen within the Mediterranean (Natoli *et al*, 2005) where part of this structure can be explained by differentiation between offshore and inshore populations that matches the difference in oceanographic characteristics between basins (Gaspari *et al* 2015).

Two distinct morphotypes of *Tursiops* are present in the western North Atlantic. Morphological and ecological (diet preferences, parasite loads) differences have been documented between a smaller coastal form and a larger offshore form (Mead and Potter 1995). Ongoing genetic analyses have revealed significant genetic differentiation for mtDNA, microsatellites, major histocompatibility complex genes, and amplified fragment length polymorphism (AFLP) markers. The mtDNA control region and mitogenome sequences, AFLP data, and preliminary genomic data yield reciprocally monophyletic clades. These latter suggest a relatively deep divergence time for the coastal morphotype in the western North Atlantic.

The papers reviewed at this meeting indicated that there is significant morphological differentiation in the western South Atlantic between a large coastal form and a smaller offshore form, indicative of subspecies-level differences. The two morphotypes are parapatric along the coast from southern Brazil to northern Argentina. To date, analyses of mtDNA control region sequence data have not found shared haplotypes between the two morphotypes. However, a network analysis did not reveal complete separation of haplotypes corresponding to *a priori* identification of offshore and coastal samples. Further analysis of nuclear data to examine the possibility of introgression between the two forms, as suggested by microsatellite data, is necessary. In Argentina, the frequency of sightings has decreased since the 1980s, the species is now absent from previously inhabited areas, and current estimates indicate that there could be fewer than 200 bottlenose dolphins in Argentina. How the changes in distribution and/or abundance are related to local ecosystem variability is unknown. In addition, reproductive success appears to be depressed.

7. REPORT ON THE VOLUNTARY FUND FOR SMALL CETACEAN CONSERVATION RESEARCH

In 2015, donations for the Voluntary Fund for Small Cetacean Conservation Research totalling £76,089 were received from the Governments of Italy, the Netherlands, Switzerland, and the United Kingdom as well as from Whale and Dolphin Conservation (WDC), WWF International, World Animal Protection, Pro Wildlife and Campaign Whale. The sub-committee expressed its sincere gratitude for these contributions.

The call for new proposals was circulated to the Scientific Committee and advertised on the IWC web site at the end of March 2016, along with information on the review process and a summary of past recommendations of the sub-committee (*https://iwc.int/sm_fund*).

The Secretariat received 20 project proposals for research projects based in six continents on a number of different species living in a variety of habitats (some highly degraded). Projects ranged from ‘research only’ to ‘research, capacity building and public awareness’. Various scientific approaches were included in the proposals including abundance estimation, assessment of habitat suitability, evaluation of anthropogenic threats including fishing-related mortality, drive hunts, habitat modification, dolphin watching, acoustics and novel approaches such as the use of economic business models and online tools.

The overall review process is explained in detail in Annex L of IWC (2012) and on the IWC website (*https://iwc.int/sm_fund*).

All projects were evaluated by the Review Group (Bjørge, Donovan, Double, Fortuna, Palka, Porter, Reeves, Rojas-Bracho and Scheidat) selected by the Chair of the Scientific Committee and the Chair of the sub-committee on small cetaceans.

During the first step, individual members of the Review Group were asked to evaluate each project using the following criteria (based on the existing approach for reviewing proposals to the Scientific Committee – see the Scientific Committee Handbook):

(1) intrinsic scientific value;
(2) relevance of the scientific outcomes to sub-committee priority topics and previous recommendations;
(3) methodology;
(4) level of involvement and engagement of regional participants;
(5) feasibility; and
(6) capability of the principal investigator and research team.

This phase, conducted intersessionally via email, helped to produce an initial evaluation of each project against the criteria and helped to highlight where there were different views among members of the Review Group concerning specific aspects of some projects that would need to be considered further. Overall the quality of the received projects was high.

The second phase of the evaluation work was concluded in Bled. The Review Group met and agreed final rankings of the projects. The Review Group placed a high priority on the relative contribution to important conservation issues made by each project.

Taking into account the above, the Review Group recommended to the sub-committee seven proposals for potential funding (see Table 1). The sub-committee agreed that the Co-chairs of the sub-committee could forward these recommendations to the Scientific Committee for its consideration.

Should sufficient funds be made available, the Review Group suggested that the next call for proposals should occur in **2018** and that serious efforts should be made in the meantime to build up the fund.

After Scientific Committee approval, these projects will be included in the Scientific Committee's budget as given in its report to the Commission under the heading of a specific request to the Voluntary Research Fund for Small Cetaceans.

Grant contracts, incorporating any suggested modifications and a specification of deliverables, will be developed by the Review Group and the Secretariat after formal approval of the projects by the Commission at its Plenary meeting in October 2016.

Table 1

Summary of projects recommended to be funded by the Voluntary Fund for Small Cetacean Research, and their Principal Investigator (PI).

PI	Project Title
Heinrich	First region-wide estimates of population size and status of endemic Chilean dolphins (*Cephalorhynchus eutropia*) in southern Chile (F)
Lai	Assessment of Online Information as a Tool to Improve the Documentation of the Availability of Marine Mammals for Consumption and Other Uses in Southern China (F)
Weir	Assessing the conservation status of the Atlantic humpback dolphin (*Sousa teuszii*) in the Saloum Delta, Senegal (P)
Sanjurjo	Business model to save vaquita from extinction while improving fishermen livelihoods in the Upper Gulf of California (P)
Khan	Abundance Survey for Indus River Dolphin (P)
de Castro	Unpacking the catfish-dolphin nexus: The social dimension of river dolphin as bait in the Brazilian Amazon and outlooks for a participatory plan for dolphin-safe piracatinga fishing (IA)
Oremus	Implementing a protocol to monitor the drive hunt of dolphins in Fanalei village, Solomon Islands (IA)

Key: F=full funding, P=partial funding, IA=if sufficient funding available.

8. PROGRESS ON PREVIOUS RECOMMENDATIONS

8.1 Vaquita

CIRVA Report

At SC/65b Rojas-Bracho reviewed developments in vaquita (*Phocoena sinus*) conservation in Mexico since SC65a. Participants were advised of a recent dramatic escalation of illegal fishing and trade of totoaba (*Totoaba macdonaldi*), a CITES Appendix I croaker species, in the Upper Gulf of California, Mexico. This fishing involves the use of large-mesh gillnets which present a high entanglement risk to vaquitas. The fishery is driven by the high price of totoaba swim bladders in the black markets of China.

As reported to SC/66a, in May 2015 the President of Mexico announced a set of measures for the protection of vaquitas which followed, to a large degree, the recommendations of the fifth meeting of the International Committee for the Recovery of the Vaquita in July 2014 (CIRVA-5). These included (i) implementation of an emergency two-year partial gillnet ban throughout the vaquita's distribution, (ii) making major new commitments to enforcement by strengthening the team of agencies involved and building coordination across them, providing new high-speed patrol boats, and committing to a greater overall enforcement presence in the region, (iii) establishing a comprehensive program to compensate fishermen and associated workers, and (iv) funding a new survey to estimate vaquita abundance planned to occur in 2015. These measures came into force throughout the remainder of 2015 and continued into 2016.

At this meeting, Rojas-Bracho presented the report of the seventh meeting of the International Committee for the Recovery of the Vaquita (CIRVA-7) which took place in Ensenada, BC, Mexico, 10-13 May 2016 (SC/66b/SM18). CIRVA-7 reviewed the results of the abundance survey (Expedición Internacional Vaquita Marina 2015) that was conducted from 26 September to 3 December 2015 and covered the entire known range of the species. The estimated total abundance of vaquitas in 2015, at the beginning of the emergency 2-year partial gillnet ban, based on the combined results of the visual line transect survey and static passive acoustic monitoring, was 59 (95% CI 22–145). Previous estimates of abundance were 567 (95% CI 177–1,073) in 1997 and 245 (95% CI 68–884) in 2008. This sharp population decline between 1997 and 2015 is best reflected by changes within the core stratum, which was covered in all three surveys. The abundance of vaquitas decreased during this period by 92% (CI 80%-97%). The danger of losing 9 out of 10 individuals of an already endangered species cannot be over-emphasized.

The passive acoustic method has proven to be the most reliable way to monitor trends in the vaquita population. Jaramillo presented the latest results of the passive acoustic monitoring program. These had been presented and reviewed by CIRVA-7. The dataset comprises acoustic information generated yearly (June-September), from 2011 to 2015, at 46 fixed C-Pod sampling sites inside the Vaquita Refuge. Due to unbalanced datasets (both spatially and temporally), the trend was estimated by using two modelling approaches. This work is based on the assumption that acoustic rates are proportional to population size. The metric used to measure acoustic detection rates was clicks/day, which is the rawest form of information and provides statistical advantages. This metric appears to be proportional to other possible options such as encounter rates or time periods with positive indications of acoustic activity. A spatial model and post-stratified mixture model were fitted separately, using a Bayesian framework. The trend estimate was obtained from a model-averaged posterior distribution, using the same weight for both models. Prior to modelling, data were filtered and inspected for potential biases. It was determined that tidal states were similar between years and that using whole days as sampling units averaged out any influences of time of day. Differences in temporal sampling between years were addressed by selecting a 'core' period (19 June – 19 August), when at least 50% of acoustic detectors were operational every day. The final estimate indicates an average yearly rate of decrease of 0.34 (95% CI: 0.21–0.48), and the entire posterior distribution is on negative values, hence a decreasing trend is certain. Over the four years of sampling, the vaquita population decreased by 80% (95% CI: 62–93%). Jaramillo mentioned that, for first time, there is acoustic evidence of constant activity of vaquitas in shallow waters in the northern portion of the distribution area.

Enforcement

The CIRVA-7 meeting heard reports from the Mexican Navy and the Sea Shepherd Conservation Society (SSCS) of extensive continued illegal gillnet fishing for totoaba during the months from December to May in both 2015 and 2016, and particularly during the legal curvina (*Cynoscion othonopterus*) season, which appears to have been used as a cover for illegal fishing. The current level of enforcement effort is inadequate and illegal fishing has continued to undermine the vaquita conservation effort. CIRVA also noted that at least three vaquitas are known to have died in fishing gear in March 2016.

CIRVA reported that, in cooperation with the Mexican Navy and PROFEPA (the environmental enforcement agency), SSCS gathered extensive evidence of totoaba poaching and, between January and May, retrieved 42 gillnets and 16 longlines. The team encountered nets that had been set for very long periods, as well as freshly set nets in recently patrolled areas. Even as the illegal totoaba fishery wound down seasonally in early summer 2016, abandoned nets continued to pose an active risk to vaquitas throughout their range.

CIRVA reviewed the results and recommendations of a WWF/INAPESCA workshop, held in coordination with FAO and ICES, in Mérida, México in April 2016 and stressed the need for continued investment of time and resources by all sectors in alternative fishing technology development and full implementation of the protocols developed in Mérida. CIRVA noted that, given enforcement concerns regarding illegal fishing, any recommendation concerning alternative gear development must be implemented with close and effective monitoring.

In light of the continued and accelerating decline of the vaquita population, CIRVA considered the question of ex situ approaches to conservation. CIRVA recognised that in such a critical situation, every possible conservation option must be considered, but also stressed, once again, that none of the options negates the requirement to remove all gillnets, including those used for curvina, from the range of vaquitas to allow them to increase toward their former levels.

The major recommendations of CIRVA are as follows:

- CIRVA recommends that the Government of Mexico immediately implement and enforce a permanent ban on all gillnets throughout the entire range of the vaquita and seriously consider the closure of all fishing there, if evidence of illegal activities continues to come to light.
- CIRVA applauds the collaboration among SEMAR, PROFEPA, and Sea Shepherd Conservation Society and recommends that such collaboration be continued and strengthened in the 2016-2017 season.
- CIRVA further recommends that efforts to remove gillnets from throughout the vaquita's range be intensified as a matter of utmost urgency.
- CIRVA concluded that fieldwork to determine the feasibility of ex situ conservation actions for the vaquita is warranted.
- CIRVA reiterates that there is no reason for the Government of Mexico to delay the issuance of commercial permits to fish for shrimp with the 'Selective net RS-INP-MX' trawl, which has received adequate testing.

- CIRVA recommends that every effort be made to develop gillnet-free fisheries in the Upper Gulf and to strengthen linkages between the fishermen using alternative gears and the seafood supply chain.
- CIRVA recommends continuation of the acoustic monitoring program to allow annual estimation of population trend. For several years CIRVA and the SC have recommended that secure funding be made available for the continuation of the acoustic monitoring program.

The full text of the CIRVA-7 report (including detailed recommendations) is given in SC/66b/SM18. The sub-committee **welcomed** the CIRVA-7 report and **endorsed** and **adopted** its recommendations.

In particular the sub-committee **strongly reiterated** that the only measure that will save the vaquita is to make the current two-year partial ban on gillnets permanent throughout the species' range.

The sub-committee first became **concerned** about the status of the vaquita more than 40 years ago (IWC, 1975), and has repeatedly recommended elimination of gillnets to reduce bycatch to zero. The sub-committee has become **increasingly concerned** over the imminent extinction of the vaquita due to incidental mortality in the illegal gillnets for totoaba. The sub-committee **agreed** that the choice is simple and stark: either gillnetting in the Upper Gulf ends, or the vaquita becomes extinct very soon.

The illegal fishery and trade in totoaba swim bladders is a major, continuing, and insidious force that is driving the vaquita towards extinction. The sub-committee **viewed with alarm** the recent escalation of the illegal totoaba fishery and illegal international trade of totoaba swim bladders, which has continued despite the strong enforcement efforts in the Upper Gulf of California. The sub-committee **recommended as a matter of utmost urgency** that enforcement efforts be strengthened, against both illegal fishing in Mexico and totoaba smuggling out of Mexico and into transit and destination countries. Furthermore there is an **urgent need to** remove active and ghost gillnets from the range of the vaquita; this is an insidious, invisible and existing threat.

The sub-committee **commended** the Government of Mexico for the major actions it has taken to conserve vaquitas through a two-year partial gillnet ban and associated enforcement and the compensation program to support local fishing communities. The sub-committee also **commended** the Government of Mexico for providing substantial support to the visual and acoustic abundance survey that was completed successfully in 2015 and for offering to fund the acoustic monitoring program through 2018. The sub-committee **reiterated its recommendation** to maintain, properly funded, the acoustic monitoring program as a key action in support of any recovery strategy. And the sub-committee **respectfully requested** that Mexico provide a report to SC67a on further vaquita conservation efforts.

The demise of the vaquita is being driven by the high demand for totoaba swim bladders in international markets. Therefore, the sub-committee **reiterated its recommendation** that the Governments of Mexico and the United States consult closely on the continuing illegal international trade in CITES Appendix I totoaba and noted the opportunity afforded by the CITES Conference of Parties (CoP) later in 2016 to further address the effect of this trade in causing additional losses of the critically endangered vaquita. The sub-committee noted that the illegal trade was also being progressed through the territories of other nations and called on those these nations to do everything in their power to interdict it. The goal should be to enhance both enforcement and awareness. The sub-committee again **requested** that the IWC Executive Secretary send letters to the CITES Secretariat and to appropriate Chinese authorities expressing the Commission's strong concern about the impact of the illegal totoaba trade on the vaquita.

8.2 Yangtze finless porpoise

Recent information was received intersessionally from Wang Ding on *ex situ* conservation efforts for the Critically Endangered Yangtze finless porpoise (*Neophocaena asiaeorientalis asiaeorientalis*). While *ex situ* conservation has been seen as an important strategy for endangered terrestrial animals, it is still controversial for cetaceans. The Tian-E-Zhou Oxbow 'semi-natural reserve' in China is considered to provide seed or source population for future releases when ecological conditions in the porpoises' natural habitat have improved. Finless porpoise have been shown to be capable of surviving and reproducing successfully in the reserve. A census completed in late November 2015 revealed that the population had increased by 108% over the previous five years with 27 new individuals recorded, excluding eight new animals that were introduced into the reserve in 2014 and 2015. The population's fecundity is considered high; of 18 mature females in the oxbow, nine were pregnant (as diagnosed by ultrasound imaging) and 11 were lactating (four of which were also pregnant). There were 17 juveniles younger than two years old and of these, 11 were identified as newborns in 2015.

The capacity of the Tian-E-Zhou Oxbow to support finless porpoises is estimated to be 80 to 100 individuals, limited principally by fish availability. At current rates the population could reach local carrying capacity in 2018, after which periodic removals would be required. Four animals (2 male, 2 female) have been selected to seed a new *ex situ* population in He-Wang-Miao Oxbow, which has an estimated capacity of over 120 individuals. The project team believes that more ex-situ populations will provide a firm basis for the Yangtze finless porpoise conservation project, and ultimately improve the chances to save this Critically Endangered freshwater subspecies.

While the sub-committee welcomed the positive news of the ex-situ breeding program, it reiterated its previous recommendation that every possible effort be made to protect Yangtze River finless porpoises in their natural riverine and lacustrine habitat. Further, the sub-committee recommended that steps be taken to: (a) identify river and lake segments with the highest porpoise concentrations and enforce appropriate, year-round protection measures (including fishing bans); (b) vigorously enforce a basin-wide prohibition of electro-fishing and other fishing activities known to threaten porpoises; (c) vigorously enforce regional and seasonal closures of sand-mining; (d) strengthen pollution control measures; and (e) ensure that before any further modification of the natural flow regime (or other natural features) of the Yangtze ecosystem are allowed to take place, the implications for finless porpoise and other affected species are investigated and taken into account.

8.3 Hector's dolphin

8.3.1 Review of abundance estimates

For several years questions have been brought forward in SM concerning the methods used to derive abundance estimates of Hector's dolphins by New Zealand. The sub-committee agreed at last year's meeting to review the abundance estimates intersessionally (IWC 2016, item 8.3.2). A formal process was established intersessionally following IWC procedures for such review and this included the creation of an Intersessional Expert Group (IEG) and an Intersessional Correspondence Group (ICG). The IEG consisted of independent experts who were asked to review the abundance estimates produced by MacKenzie and Clement (2014a, 2014b, 2016a, 2016b). The ICG was available in an advisory role for the IEG. The terms of reference of the IEG and the ICG are given in the introduction to the IEG report in Appendix 2.

Palka presented a summary of the IEG report, which is given in Appendix 2. The IEG reviewed the MacKenzie and Clement (2014a, b, 2016a, b) papers which estimated the abundance of Hector's dolphins around the South Island, New Zealand (excluding sounds and harbours) to be 14,849 (CV:11%; 95% CI 11,923-18,492). This analysis extended conventional data collection and analytical methods to account for perception bias using data from two teams in an airplane within a mark-recapture distance sampling framework; explored several truncation schemes to account for unequal field-of-view capabilities of the two teams due to the configuration of the aircraft's windows; explored a relatively new and nonconventional analytical method to account for unknown levels of dependence between the two teams (due to heterogeneities); and explored two different methods to collect and analyse data to account for availability bias. As a strategy to incorporate all the information obtained from the various methods and models, model averaging was used to develop the final abundance estimate and associated metrics of variability. In addition, using the same aerial survey data, density surface modelling techniques were used to develop both spatial fine-scale distribution maps and an independent estimate of abundance.

The IEG recognized that this study accounted for many difficulties that also affect other small cetacean abundance estimation studies using aerial surveys. The authors addressed several difficult questions, including: how to develop a correction for availability; how to handle the fact that observers cannot easily see the track line; how to incorporate spatial-temporal changes in availability and detection; how to deal with the lack of complete independence between the two observation teams; and what scale is appropriate to display when developing distribution maps. Although these issues have been recognised in many studies, the theoretical and practical methods and guidelines to deal with them have not yet been fully developed. The IEG commended the ambitious and often innovative work undertaken by the authors to attempt to deal with all of those issues. After an in-depth review of the survey design, analyses and results, the IEG endorses the abundance estimates and concluded that the estimates accurately reflected the data, were derived from appropriate data collection and analysis methods, and represented the most current abundance estimates for Hector's dolphins around the South Island. Thus, it follows that it would be reasonable to use them to inform a management plan. The IEG also considered this study to be a step forward in the development of survey methodology more generally. The IEG made a number of suggestions to refine the methods further (see Table 1 in the Appendix 2), including the collection of additional targeted data, additional sensitivity analyses regarding criteria used to make decisions, and the use of simulation and other ancillary studies.

The sub-committee acknowledged and thanked the members of the IEG for their efforts in reviewing the methods used to estimate Hector's dolphin abundance, and for the contributions of members of the ICG to this process.

The sub-committee discussed model selection and model averaging and the arbitrary removal of models that produced unrealistically high abundance estimates ('blowouts'; see section 3.2 of the IEG report). In response, it was noted that it was important to refer back to Buckland *et al* (2010), which indicates that these situations can be expected to occur and that because all models tested represent different types of dependence between the two observer teams, it is impossible for all to be right. The ones that were rejected were those that resulted in unrealistically high numbers. A way to diagnose these models is to assess correlation; blowout models were highly correlated. It was noted that the greatest difficulty is related to models that show high correlation, but produce realistic abundance estimates. There is substantial literature where the criteria for model selection within this context is discussed. Buckland *et al* (2010)'s basic strategy, which is to remove models with high correlation that don't seem to fit the data, is appropriate. The IEG applied a similar approach to that of Buckland *et al* (2010) and the resulting abundance estimates were within the confidence interval of the estimates presented in the MacKenzie and Clement report (see item 3.2 in Appendix 2).

In response to a question regarding potential causes for the drop in the estimated detection probability near the trackline, it was noted that problems of this kind are common in aerial surveys. It primarily results from the physical configuration of the windows on the plane and the fact that observers often need to assume uncomfortable positions for long periods, making it difficult to search consistently on the trackline.

In response to a question concerning whether the issues identified with the surveys could have had cumulative effects on the abundance estimates, it was pointed out that the authors of the study tried to address each of these issues independently. If each was accounted for and corrected for appropriately, there should not be any cumulative or additive effects.

It was asked whether it would not have been better practice when using the 'circle back' to provide estimates of uncertainty when determining duplicate sightings, as was done during the SCANSII surveys. In response it was noted that this has only been done for the shipboard surveys of SCANSII, when a double platform protocol was used. The SCANSII aerial surveys have used the circle back protocol of Hiby (1999).

Palka added that with aerial line-transect surveys there are multiple options for how to define duplicates, not a single universally accepted method. The 'circle back' (or racetrack) method (Hiby, 1999; Hiby and Lovell, 1998) is to resurvey a part of the trackline after an initial sighting is made and to define a probability of duplicates and then use set rules that are carried all the way through the survey. To identify duplicates, MacKenzie and Clement (2014b) included angle, distance and group size as criteria. They state that these criteria 'were used as guidelines, but were not strictly adhered to with experience playing a leading role in the process (note that all matching was done manually).'

There was general agreement in the sub-committee that the determination of availability and observer (detection or perception) bias for aerial surveys is an area that needs more attention and is also of particular interest for surveys of other cetacean species, not just Hector's dolphins.

A concern was raised about how to interpret the abundance estimates in cases during the Hector's dolphin surveys where no sightings were made in a small area even though dolphins are known to occur there. Despite the relatively high survey effort, abundance estimation for low-density areas was a challenge. Palka responded that line-transect surveys merely sample populations and the overall estimates are representative of the data at a larger scale. If there are specific management questions for certain areas, then more targeted or intensive survey effort is needed beyond the sort of survey effort being discussed here.

It was noted that even though the state of aerial survey design and analysis methods have improved dramatically since the 1980s, all of the available approaches still rely on a number of assumptions. Use of simulation data is a potential option for furthering methodological and analytical development and investigating which approach is best,

The SC Chair noted that this was the first time the IEG and ICG process had been used by SM sub-committee and it has been an interesting and valuable experience. It was noted that this is an excellent example of analyzing data in the light of uncertainties and that while there is always more work to be done, the results showed that the estimate was appropriate to inform management. The sub-committee also agreed to the suggestions and recommendations of the IEG which are applicable to both the current study and the general evolution of survey methodology.

The sub-committee **encouraged** further work to consider the recommendations presented in the IEG report. The sub-committee **also endorsed** the abundance estimates produced by MacKenzie and Clement (2014a, 2014b, 2016a, 2016b).

8.3.2 Māui dolphin

SC66b/SM12 is an annual update on New Zealand's research and management approach on Māui dolphins (*Cephalorhynchus hectori maui*). It describes the current management measures as well as data collection and research activities over the past year. Further background on the status of Māui dolphins can be found in SC66a/SM3. The current measures include a range of regulations and prohibitions that cover threats such as set net, trawl and drift net fishing, seismic surveying, and seabed mining. Ahead of the next scheduled review of the Threat Management Plan in 2018, a program of ongoing data collection and research is underway. During the reporting period, there were no observer- or fisher-reported captures in commercial or recreational fisheries, no beach-cast dolphins, and no reported ship strikes. The observer coverage for the set net fishery in Taranaki operating within 7nm from shore from Waiwhakaiho River to Hawera was 98% over the reporting period. For the inshore trawl fishery operating within 7nm from shore from Maunganui Bluff to Pariokariwa Point, observer coverage was 24%, increasing to 32% over the last 5 months of the reporting period. A Māui dolphin Research Advisory Group was established by the New Zealand Government in 2014. This group, comprising researchers, stakeholders and government officials, focuses on identifying and prioritising research on Māui dolphins intended to inform management decisions for the subspecies' continued conservation and recovery. The Research Advisory Group developed a Māui dolphin five-year strategy and research plan, and will review progress towards fulfilling the plan each year.

Regarding current research, one of the highest priorities identified by the group was abundance surveys conducted at intervals of not more than five years. In response to the advice of the group, an abundance project was commissioned, as described in SC/66b/SM13. Another priority identified by the group was offshore distribution. In response to that, a pilot study commenced, exploring the use of passive acoustic loggers (C-PODs) as a means to investigate the offshore extent of Māui dolphin distribution, as well as daily, seasonal and inter-annual variation in habitat use. The results of this pilot study will aid in planning a wider study using the C-PODs. A final priority identified by the group was alongshore distribution in the south of the subspecies range. Monthly aerial surveys were undertaken in Taranaki from January through April 2016. No Māui dolphins were observed on these surveys.

During discussion, the sub-committee noted that the observer coverage over the entire range of Māui dolphins, as described by the IWC in 2015 (i.e. from Maunganui Bluff in the north to Whanganui in the south, offshore to 20 nm and including harbours), was 12.7% for the set net fishery (for vessels greater than 6m in length) and 14.6% for the trawl fishery.

The sub-committee discussed whether the plan to obtain abundance estimates at 5-year intervals had sufficient power to detect changes in the Māui dolphin population. Currey explained that the 5-year frequency represents a trade-off, taking into account whether a given method could be expected to produce sufficiently precise estimates. Photo-identification mark-recapture is unlikely to do so because of the low marking rate in this dolphin population. Consequently, the chosen method was genotype mark-recapture based on biopsy sampling, which however raised some concern over multiple sampling of the same individuals. It was therefore decided that the first year would represent the first sampling occasion (marking), the second year the second sampling occasion (re-capture), and the following three years would constitute a period when the animals are free from any potential disturbance from biopsy sampling.

Currey also explained that the monitoring goal of the observer coverage is not to quantify bycatch but rather to detect it, given that even a single bycatch event would be seen as a threat to the population. Any bycatch event would likely lead to immediate review, and possibly revision, of the Threat Management Plan. The sub-committee **welcomed** the update on research provided but **noted** that no new management actions had been enacted since 2013.

The sub-committee noted that one of the main challenges is how to assess trends, and agreed that further discussion of power analysis and other approaches to reduce uncertainty and minimize the time required to detect population change would be useful.

SC/66b/SM13 reviewed the history of genetic monitoring of Māui dolphins (Baker *et al* 2013; Hamner *et al* 2014a, 2014b) and provided an update on boat-based surveys in the austral summers of 2015 and 2016. These surveys were conducted as a collaborative effort by the New Zealand Department of Conservation, the Ministry of Primary Industries, the University of Auckland, and Oregon State University. The 2016 surveys represented the second field season of a two-year project intended to update the 2010-2011 genotype mark-recapture surveys of Māui dolphins (Hamner *et al* 2014). From 10 February to 5 March 2016, there was a total of 13 small-vessel surveys along the west coast of the North Island from south Kaipara in the north to Tirua Point, south of Kawhia Harbour. During 1,552 km of survey effort, 66 groups of Māui dolphins were encountered, with an average of 5.1 groups per day (ranging from 0-10 groups per day). Group size ranged from 1-15 dolphins (average of 3.6-4.8 dolphins) with calves accounting for 4.3% of the sightings (n = 10). Dolphins were encountered along the coast between south of Kaipara Harbour and north of Raglan. A total of 44 biopsies were collected. As in previous years, the dolphins showed little or no behavioural response to biopsy sampling. The surveys also documented two encounters with a group of 7 killer whales, traveling slowly along the coast in the primary range of Māui dolphins, and six encounters with common dolphins but observed no interactions among these species. After completion of the dedicated biopsy surveys, supplemental funding enabled four additional surveys in late March which focused on photo-identification, with no biopsies collected. During the four surveys, there were 22 encounters with Māui dolphins. Unlike the surveys earlier in the summer, the dolphins were mostly encountered alone or in groups of two or three and showed little interest in approaching the boat or riding the bow. Within the range of the surveys, the dolphins also appeared more dispersed than earlier in the season. This was a notable change in the social behaviour and spatial aggregation from a month previously. Laboratory analysis is currently underway to complete DNA profiling (mtDNA, sex identification and 21 microsatellites) of the 2016 samples and for matching genotypes to the 40 individuals identified in the 2015 surveys. Baker noted that there was no evidence in the data of 'mixed' Hector's/Māui individuals, despite the fact that these would be easy to detect genetically.

New presented a power analysis intended to inform precautionary management and the ongoing scientific monitoring effort. The sub-committee agreed that detecting population change is extremely challenging and will take many years, and that Baker's mark-recapture study is extremely helpful in this regard. Baker noted that the use of minimum population census (i.e. total of distinct genotyped individuals in a season) may reduce the inherent uncertainty around the estimation of trends. He noted that, in fact, the Māui dolphin population is getting dangerously close to the point at which this metric will be the only feasible one that remains. Slooten noted that additional challenges in detecting population trends include the difficulty of detecting range contractions and that population changes are unlikely to be simply linear.

Given the information presented this year, the sub-committee **concluded**, as it has repeatedly in the past, that existing management measures in relation to bycatch mitigation fall short of what has been recommended previously and **expressed continued grave concern** over the status of this small, severely depleted subspecies. The human-caused death of even one individual would increase the extinction risk. The sub-committee **reiterated** its previous recommendation that highest priority should be assigned to immediate management actions to eliminate bycatch of Māui dolphins. This includes closures of any fisheries within the range of Māui dolphins that are known to pose a risk of bycatch to dolphins (i.e. set net and trawl fisheries). It **re-emphasised** that the critically endangered status of this subspecies and the inherent and irresolvable uncertainty surrounding information on most small populations point to the need for precautionary management.

Ensuring full protection of Māui dolphins throughout their known range, together with an ample buffer zone, would minimise the risk of bycatch and maximise the chances of population increase. The sub-committee **noted** that the confirmed current range extends from Maunganui Bluff in the north to Whanganui in the south, offshore to 20 nm, and it includes harbours. Within this defined area, fishing methods other than set nets and trawling should be used. The sub-committee again **urged** the New Zealand Government to commit to specific population increase targets and timelines for Māui dolphin conservation, and again **respectfully requested** that reports be provided annually on progress towards the conservation and recovery goals.

8.4 River dolphins of Amazonia

SC66b/SC/SM21 reviews the biology of the Araguaian boto, which is restricted to a 1,500 km stretch of the Araguaia River, other riverine habitats of the Araguaia-Tocantins Basin and mangrove habitats in the Marajó Bay (Siciliano *et al*, 2016). The Tocantins Basin has been significantly altered over the past few decades by dams, deforestation for cattle ranching, logging, road building and the use of Agent Orange to clear pathways for power lines. Although the consequences of these factors are poorly understood, dams are known to have divided the riverine habitats of Araguaian botos into eight distinct fragments; the implications of such fragmentation are unlikely to be other than detrimental to long-term population viability. Araguaian botos are routinely found in areas of high human population density. The Museu Paraense Emílio Goeldi in Belém has monitored strandings and entanglements of aquatic mammals in the Amazon Delta region since November 2005. Over 700 carcasses have been recovered, of which only three were Araguaian botos, all a result of fisheries bycatch. Araguaian botos are also killed by fishermen who believe they compete for fish resources and individuals have been recovered with gunshot wounds. The putative species *I. araguaiaensis* has only recently been described and (Hrbek *et al*, 2014) and has yet to be formally accepted by the Society for Marine Mammalogy's Committee on Taxonomy. Regardless of its current taxonomic status, of this outcome, the boto population in the Tocantins Basin is believed to be isolated from the Amazon River population and thus constitutes a distinct subpopulation (if not a subspecies or species). Therefore, it was suggested that it be assessed separately for the IUCN Red List. The sub-committee also recommended that this population of botos be given more attention at future meetings and that more information on its status and threats be provided to the next SC meeting.The sub-committee **welcomed** the information in SM21 and encouraged the authors to provide updates on the status of Araguaian botos at future meetings. The sub-committee also **agreed** that relatively little attention had been paid to river dolphins of Amazonia in recent years and that they should be considered as a potential priority topic in the near future.

At SC/66a, the sub-committee had requested that the Brazil Government continue to provide progress reports to the Scientific Committee on its efforts to combat the use of Amazon River dolphins (*Inia geoffrensis* and *Sotalia fluviatilis*) as bait for the piracatinga (*Calophysus macropterus*) fishery in the Amazon Basin. Coutinho provided an update on actions taken since SC66a. In July 2014 the Federal Government published an Interministerial Normative Instruction (Normative Interministerial nº 6/2014) establishing a five-year moratorium on the fishing and marketing of piracatinga in Brazilian waters starting from January 2015. The Ministry of Environment (MMA) is responsible for evaluating the success of the moratorium. A working group was established by the MMA (Decree n° 318/2014) to define procedures and monitor the fishing and marketing of piracatinga during the moratorium period. According to Coutinho, three inspections to assess compliance with the ban were completed in 2016 and included: 'Routine Operation' in the municipalities of Iranduba, Itacoatiara, Manacapuru and Manaus in February, 'Operation Golden Dragon' in the municipalities of Mara, Tefe and Source Good in March-April and 'Operation Federal Rios' in the municipalities of Jutai, Tabatinga, Coari, Fonte Boa and Tefe also in March-April.

Brazil has established a National Action Plan for the Conservation of Small Cetaceans which lists *Inia geoffrensis* as an endangered species. This plan is intended to reduce human impacts and increase knowledge on small cetaceans in Brazil. Furthermore, the Brazil Government is cooperating with Colombia and Peru to support sustainable development of fishing activities. Several meetings and workshops involving these countries have included discussions on the catch and sale of piracatinga. According to Coutinho, the national authority of fisheries and aquaculture in Colombia has scheduled an official meeting with the Brazilian government for July 2016 to further address these matters.

Reeves presented information on botos and tucuxis received intersessionally from A.R. Martin and V. da Silva. The SC has, for several years, expressed concern about levels of fishery-related mortality of these dolphins in much of their range. This concern was heightened in the early years of this century when evidence came to light of a widespread directed hunt for botos, with the carcasses being used as bait in the piracatinga fishery. This hunt added substantially to pre-existing mortality caused by accidental entrapment in monofilament nets. The Data Deficient Red List status of both botos and tucuxis masks what is believed to be an alarming and deteriorating conservation status in at least parts of their range. The first robust evidence of elevated, and probably unsustainable, mortality rates was provided by Mintzer *et al* (2013) in an analysis of annual survival of botos in Mamirauá Reserve, Brazil. This study indicated that mortality had more than doubled after the initiation of the directed hunt, and greatly exceeded the potential biological removal (PBR). Martin and da Silva reported (pers. comm. to Reeves) that their recent study of both *Inia* and *Sotalia* along a fixed transect demonstrates that the numbers of both species in their Mamirauá study area have declined by more than half over the past two decades. There is good evidence that the export trade to Colombia persists, and that dolphins continue to be killed in support of the fishery. Incidental dolphin mortality in gillnets continues as well.

In discussion, the sub-committee **thanked** the Brazil Government for providing the update. It **expressed concern** over the fact that the declines appear more substantial than previously thought, and that rigorous population monitoring has been limited to a single portion of the vast Amazon system (i.e. Mamirauá). There was general agreement within the sub-committee that dolphin abundance had declined, although some members raised questions about the causes and suggested that more evidence was needed before concluding that the declines were linked to a particular fishery. The sub-committee noted that populations of small cetaceans do not recover fast enough for short- or even medium-term measures (such as the 5-year moratorium on the piracatinga fishery) to be reliably effective. Furthermore, monitoring of the entire population of botos (or tucuxis) is almost impossible, and the statistical power of planned monitoring work to demonstrate that the current program is effective and the population is recovering is almost certainly not sufficient. The sub-committee agreed that durations of any bans need to be adequate to the task, and need to be long enough to show measurable effects. It was noted that the sub-committee needs to consider not only the present status of the dolphin populations, but also help develop and promote the use of new tools and methods that can be used to track population change. Finally, the sub-committee **respectfully requested** the Brazil Government to provide detailed information on the piracatinga/*Inia* issue to the next meeting of the Scientific Committee, including, for example, information on where piracatinga are and are not being fished, the effort as well as outcome of inspection and enforcement actions, the geographic scope and methods used to monitor dolphin populations during the moratorium period, and the metrics being used to evaluate how well the moratorium is meeting its objectives. The sub-committee also **encouraged** collaborative efforts among the range states, and **respectfully requested** further information from countries in addition to Brazil (Bolivia, Colombia, Ecuador, Peru and Venezuela). The sub-committee **agreed** to form an intersessional working group to provide guidance to Brazil in preparing its next progress report on river dolphins (table 4).

Finally, the sub-committee **encouraged** the Brazil Government to give serious consideration to extending the ban on piracatinga fishing until there is assurance that it no longer poses a threat to river dolphins.

8.5 Franciscana

SC/66b/SM05 reports on the 8th workshop for research on and conservation of the franciscana (*Pontoporia blainvillei*). At the previous meeting of the Scientific Committee and the joint meeting of the Conservation and Scientific Committees in San Diego, Argentina and Brazil expressed their intention to nominate the franciscana as a potential candidate for an IWC Conservation Management Plan (CMP). The first step to accomplish this was to develop the 8th workshop on franciscanas, which was organized by the Franciscana Consortium and held in Sao Francisco do Sul, Brazil, in October 2015. The goal of the workshop was to update the information and establish priority actions for research on and conservation of franciscanas. An overview of current knowledge on franciscana population structure, abundance, trends, anthropogenic threats, and conservation actions was provided for Argentina, Brazil and Uruguay. The species range has been divided into four 'Franciscana Management Areas' (FMAs I to IV). Based on sufficient evidence (e.g. genetics, morphology) the workshop suggested changes in the boundaries of FMA I, which was subdivided into FMA 1a and 1b, and the boundary between the FMA II and FMA III was moved about 250 km north to the central coast of the state of Santa Catarina. The participants recommended that further studies be conducted to better understand population substructure within the existing FMAs and assess them as management units.

The workshop agreed to focus on the following priority actions: (1) monitor abundance, trends and bycatch; (2) mitigate bycatch; (3) develop and implement protected areas; (4) encourage the adoption and implementation of the National Action Plan to Reduce the Interactions of Marine Mammals with Fisheries in Argentina; (5) develop a strategy to increase public awareness of the franciscana; and (6) include the franciscana in bilateral and multilateral discussions. All these actions will be incorporated into the CMP. The workshop concluded that good progress had been made since the 2004 sub-committee's review of the status of this species and requested that the sub-committee consider holding a new review of the franciscana. Such a review would be particularly valuable to improve research and refine conservation actions under an IWC CMP.

In discussion, the sub-committee **endorsed** the report and **reiterated** that franciscana is a good candidate to be put forward for the CMP process. In line with what was presented, the sub-committee **recommended** that monitoring of bycatch and assessment of the extent and other characteristics of fisheries in the franciscana's range be considered as high priorities.

8.6 *Sousa*

SC/66/SM/WP17 contains a compilation of the recommendations that the Small Cetacean sub-committee has made since 1993 pertaining to the genus *Sousa* or to geographical areas where humpback dolphins are found. References published after 2002 (the year when this sub-committee first reviewed the genus *Sousa* as a priority topic) were reviewed and an attempt was made to match these references to the relevant recommendation(s). Each recommendation was then assigned a progress status of 'none, limited, partial, or significant' (none were considered completed). The exercise highlighted the impressive progress that has been made towards documenting the distribution and range of humpback dolphins through dedicated surveys and compilations of opportunistic records. Many of these efforts have included studies of habitat use and generated abundance estimates. In many cases such studies have helped to build the capacity of local scientists. Furthermore, international collaboration has led to significant progress in clarifying the taxonomy of the genus, which is now resolved into four species: *S. chinensis, S. plumbea, S. teuszii* and, most recently, *S. sahulensis*. Studies of *Sousa* ecology and life history parameters, as well as health and impacts of human activities, are limited primarily to the South China Sea and Australia. The review highlighted gaps where further research and conservation efforts are required. These include a basic lack of information on *S. teuszii,* including distribution, abundance, population connectivity, life history and mortality from bycatch and direct hunting. Although bycatch of *Sousa* spp. is reported to be high and unsustainable throughout much of the range, few robust estimates of mortality from fisheries exist. The ranges of the three known Indo-Pacific species (*plumbea, chinensis* and *sahulensis*) and the putative species *S. lentiginosa* require delineation. The paper concludes that all species in the genus are at risk and would benefit if specified areas could be designated as refuges or be given focused conservation attention.

It was noted that *Sousa teuszii*, in particular, would benefit from a better understanding of population status and population connectivity throughout its known or suspected range. There are parallel processes in the IWC, CMS, and IUCN which are trying to address threats to this species in its coastal habitat, but they are not necessarily as coordinated as they should be.

On a more general point it was noted that the sub-committee often discusses the same threats as they pertain to different species or populations around the world. There is good understanding of the severe consequences of certain threats (e.g. gillnets) to populations of small cetaceans, including humpback dolphins in some areas, but in dealing with specific cases (e.g. West Africa), conservation actions are often postponed until detailed scientific information on causation and level of impact becomes available. It was suggested that this sub-committee could be more assertive in using examples of the impacts of threats on well-studied species or populations to provide advice by analogy for addressing threats to less well-studied areas or populations.

The sub-committee **emphasized** that virtually all previous recommendations related to the genus *Sousa* are still relevant as none have yet been completely fulfilled.

The sub-committee **recommended** an urgent focus on its previous recommendations which pertain to understanding the conservation status of *Sousa teuszii* throughout its known, and suspected, range so that protection measures can be implemented.

The sub-committee **strongly recommended** that more effort be placed throughout the range of the genus *Sousa* on estimating mortality from by-catch and other anthropogenic sources, and designing and implementing effective mitigation of these sources of mortality. This will require collaboration with the sub-committee for Non-deliberate Human Induced Mortality (HIM).

The sub-committee **recommended** the expansion of the existing network of researchers and NGOs working with *Sousa* spp. to include all such entities who might be able to archive samples for genetic analyses and prioritise dedicated research studies in areas at the edges of suspected population ranges to better define population boundaries, structure and connectivity.

8.7 Killer whales

Annex 2 of SC/66b/SH10 (pp.23-33) summarises progress of the IWC-SORP project: 'Distribution, relative abundance, migration patterns and foraging ecology of three ecotypes of killer whales in the Southern Ocean' since SC/66a. The project has produced 26 peer-reviewed papers since 2010. The IWC-SORP killer whale project involves collaboration among Australia, Italy, New Zealand, South Africa and the United States. In total, since SC/66a, researchers involved in the IWC-SORP killer whale project have collected biopsies from 19 killer whales, and thousands of images for photo-identification have been catalogued. Fieldwork has been undertaken in Terra Nova Bay, the Ross Sea and the western Antarctic Peninsula. Pitman and Durban continued to analyse and write-up data from tagging and photo-identification imagery collected in the Antarctic Sound during four previous field seasons; to date a total of 406 individual type-C killer whales have been identified in the Sound. The team undertook five expeditions around the western Antarctic Peninsula on the vessel National Geographic Explorer. Two type-B2 killer whales were satellite tagged and a total of 4627 photographic images were collected from 10 different groups of killer whales, including 2 Type-A, 1 Type-B1, and 7 Type-B2. The project also received several thousand photographs from other tour vessels operating in the Peninsula area, representing over 25 separate killer whale encounters.

In February 2016, Dalla Rosa and colleagues surveyed the waters of the Bransfield and Gerlache Straits, western Antarctic Peninsula. Approximately 450 nmi of cetacean search effort resulted in 230 on-effort sightings, of which two corresponded to killer whale groups (1 Type-B and 1 unknown type). Another two sightings (1 Type-A and 1 Type-B) were made off-effort. Four biopsies were collected, and acoustic recordings obtained, from a group of Type-B killer whales in Bransfield Strait. Photo-identification data included about 20 individuals from this group, 5 from a group sighted in Gerlache Strait, and another 6 from a sighting made by collaborators in December 2015.

Lauriano and Panigada have submitted a proposal to the Italian National Antarctic Research Programme to support their research in Terra Nova Bay over the coming years. In January 2016, Eisert and colleagues collected 15 biopsies, acoustic recordings, and photo-ID images from Type-C killer whales along the ice edge and in the icebreaker channel in McMurdo Sound. No Type-B killer whales were sighted. Multiple individual whales have been re-sighted in the same area in 2013/14, 2014/15, and 2015/16. At least four adult Type-C killer whales were sighted with tags attached to their dorsal fins, or with characteristic scars resulting from tag deployment.

The sub-committee welcomed the report, echoing prior agreement that the IWC-SORP killer whale project is a valuable example of international scientific collaboration. Of note was the increasing availability of photo-id data for Type-C killer whales in the McMurdo Sound area that may facilitate population assessment (trends, abundance), a stated management concern given the ecological importance of Antarctic toothfish (*Dissostichus mawsoni*) which are the main prey of killer whales in this area. Some data sets may now be sufficiently extensive to complete analyses of killer whale trends more generally in the region. To this end the importance of sharing data and assessing their statistical power was re-emphasised. The sub-committee **reiterated** the value of links between IWC-SORP and CCAMLR that facilitates sharing of images of killer whales (and other species) and results relevant to overall ecosystem assessment in the Antarctic marine environment. The Italian data on Type-C killer whales, both photo-ID and telemetry, have already been shared with colleagues at NOAA, and this will contribute to an abundance estimate. Moreover, killer whale data shared with New Zealand colleagues are included in a working paper provided to CCAMLR.

The sub-committee **encouraged** that all of the work described above be continued.

8.8 Harbour porpoises

The main objective of the Static Acoustic Monitoring of the Baltic Harbour Porpoise **(**SAMBAH) project was to estimate density, abundance and distribution of the critically endangered harbour porpoise population in the Baltic Proper (SC/66b/SM22). The project also aimed to identify hotspots and areas with high risk of conflict with human activities. Data were collected using porpoise click detectors deployed for two full years, from May 2011 to April 2013, at 304 stations throughout the Baltic Sea. Auxiliary data for density estimation were collected through instrumentation ('tagging') of harbour porpoises in Danish waters and through acoustic tracking. A seasonal division into summer (May-October) and winter (November-April) and a division into two sub-areas during summer were established based on visual inspection of detection data. The north-eastern subdivision was considered to represent the Baltic Proper population. Harbour porpoise distribution was modelled using general additive modeling (GAMS). During the summer reproductive season, harbour porpoises aggregate around Hoburg's bank and the Northern and Southern Midsea banks in the Baltic Proper, and there is a clear separation between the Belt Sea and Baltic Proper populations, indicating the presence of a critical breeding ground for the Baltic Proper population. During winter the distribution of animals is wider than previously thought, and there is no clear separation between the two populations. Density was estimated using methods adapted from point transect methods, leading to a summer (May-Oct) abundance estimate of the Baltic Proper population of approximately 500 animals (point estimate 497, 95% confidence interval 80–2091), which confirms that this population is critically endangered. In light of these results, bycatch in fisheries as well as disturbance by anthropogenic underwater noise have to be mitigated, and marine protected areas should be designated for harbour porpoises in the high-density area on and around the offshore banks in the Baltic Proper, as well as south of Öland island, in the Hanö Bight and along the Polish coast.

The sub-committee **recognized** the great importance of this work given the particular concern about the status of Baltic Proper harbour porpoises. The previous survey of this population occurred 20 years ago and there is no indication that abundance has increased since then. A follow-up research project has been planned but regrettably has not been funded. The sub-committee **recommended** that a follow-up research project on this population be funded. The threat of porpoise bycatch in the Baltic remains unaddressed and development of management plans for Natura 2000 sites in the Baltic region continues to lag behind that for other areas such as the North Sea.

The Scientific Committee has continually **expressed serious concern** about the status of the harbour porpoise population of the Baltic Proper. International surveys suggest no recovery of the population, which is estimated at < 500 animals (SAMBAH project, SC/66b/SM22), over the past 22 years, with unsustainable by-catch as the major source of anthropogenic mortality.

In order to save the *critically endangered* harbour porpoise population of the Baltic proper (Hammond *et al* 2008), the sub-committee **recommended** as a matter of urgency that all countries adjoining the Baltic Proper assess and mitigate bycatch and other anthropogenic mortality, including consideration of cumulative effects throughout the range of the population, by:

- implementing independent fishery observer schemes (in compliance with EC 812/2004) and setting in force the JASTARNIA plan developed by ASCOBANS (ASCOBANS 2009);
- monitoring population abundance;
- monitoring the health status of the population through stranding networks and necropsies of collected carcasses;
- developing and finalizing effective management plans for designated Natura 2000 sites in the Baltic Sea and facilitate quick implementation and enforcement;
- banning fishing practices associated with a high risk of cetacean bycatch in Natura 2000 sites;
- immediately implementing management actions to reduce bycatch (i.e. strictly applying a precautionary approach in the absence of bycatch estimates); and

- encouraging, promoting and funding the use of alternative fishing methods throughout the population's range.

9. TAKES OF SMALL CETACEANS

9.1 New information on takes

The sub-committee received the summary of takes of small cetaceans in 2015 extracted from this year's online National Progress Reports and prepared by Hughes of the IWC Secretariat (see Appendix 3, Tables 1-2).

9.1.1 Direct takes

No direct takes of small cetaceans were reported in the 2016 National Progress Reports. The sub-committee noted that it would be helpful if the Secretariat encouraged all member countries and IGOs (e.g. NAMMCO) to submit information on direct takes as a routine procedure.

The content of the Japan Progress Report on Small Cetaceans, a public document available from the website of the Fishery Agency of the Government of Japan[1], was summarised. The report provides catches in small cetacean fisheries in the 2014 calendar year as well as information on research conducted during the 2014 fiscal year (from April 2014 to March 2015) by the National Research Institute of Far Seas Fisheries (NRIFSF) of the Fisheries Research Agency of Japan (FRA) and the Fisheries Agency of the Ministry of Agriculture, Forestry and Fisheries, Government of Japan (FAJ) in cooperation with other organisations. The report covers information on small cetaceans which is not included in the IWC Japan National Progress Report.

The Committee **reiterates** its long standing recommendation that no small cetacean removals (live capture or directed harvest) should be authorised for any population until a complete and up-to-date assessment of sustainability has been completed.

For example, of particular concern to the sub-committee is the longstanding and ongoing hunt for Baird's beaked whales off Hokkaido. Recent scientific research supports the recognition of two distinct forms: the common 'slate gray' form and a smaller, rarer 'black' form (Morin *et al*, In press). The paper by Morin *et al* highlights the need to collect additional information on populations of Baird's beaked whales in the area of Hokkaido where hunts occur. Sightings reports and catch data suggest that the recently described 'black' form is uncommon

9.1.2 Accidental takes

The Terms of Reference for sub-committee on Non-deliberate Human-Induced Mortality (HIM) now include small cetaceans and, as such, some recommendations of the sub-committee on small cetaceans (SM) pertaining to high incidental catches were dealt with in a joint session of HIM/SM (See Annex J). For example, in 2014, the SM sub-committee noted that the bycatch of finless porpoises (*Neophocaena phocaenoides*) in South Korean waters was high and recommended that the Korean Government implement a monitoring and mitigation programme on the 'stow net' fisheries[2] which are responsible for 95% of the bycatch. The Government of Korea provided an update on these efforts at the joint HIM/SM meeting which described a modified net aimed at reducing bycatch (See Annex J Item 7).

9.2 Poorly documented hunts of small cetaceans for food, bait or cash

SC/66b/SM01 and SC/66b/SM02 reported on the consumption and use of small cetaceans in West Africa and Latin America. Hunting of small cetaceans for human consumption and other uses (sometimes referred to as 'marine bushmeat') constitutes a substantial and immediate threat to some species and populations. A recent CMS document introduced the term 'aquatic bushmeat', recognising that the issue extends beyond the marine realm (e.g. river dolphins are used as 'bait' in some areas) and defined this term as 'the products derived from aquatic megafauna (e.g., mammals, sea turtles and crocodiles) that are used for food and non- food purposes, including traditional uses.' The CMS definition further states, 'Aquatic bushmeat is obtained through illegal or unregulated hunts as well as from stranded (dead or alive) and/or bycaught animals'. A literature search of published and unpublished materials available online in English, Spanish and French was conducted. The search included videos, news media and local organization websites. Also, the marine mammal community was approached via the MARMAM mailing list and by directly contacting authors of published papers. Cosentino concluded from her review that the 'aquatic bushmeat' problem has increased in some countries in recent years. While in many cases the practice of consuming cetacean products likely began opportunistically, in some countries it has evolved to include directed catches which are sometimes thought to be at unsustainable levels. Of the 34 small cetacean species recorded in SM01 and SM02 as being consumed, two are IUCN red-listed as 'Near Threatened', two as 'Vulnerable' and two-thirds of them as 'Data Deficient'.

The sub-committee thanked Cosentino for compiling the reports. She indicated that she has funding to continue documenting marine mammal consumption. The discussion that followed focused on the ways in which further documentation, and particularly the establishment of a regularly updated and expanded database, might contribute to understanding of this issue. It was noted that the quality of the information on 'aquatic bushmeat' varies considerably and also that some species and areas of particular concern can be readily identified from the data that Cosentino and

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[1] *http://www.jfa.maff.go.jp/j/whale/w_document/pdf/h25.pdf.*
[2] *http://www.fao.org/fishery/fishtech/1024/en.*

others have already compiled. Also, market surveys were suggested as an alternative approach for determining and illustrating the state of the 'aquatic bushmeat' problem. The sub-committee noted that the Secretariat is developing multiple databases across different sub-committees and working groups and that there might be scope to include a database (or dedicated fields) for the 'aquatic bushmeat' issue. Scheidat offered to communicate with the Secretariat on this matter and report back to the sub-committee in due course.

9.2.1 Follow-up on the workplan for assessing 'poorly documented hunts of small cetaceans for food, bait or cash'
At SM66A, this sub-committee **endorsed** a workplan with three components: (i) continue development of a detailed terms of reference intersessionally through a small working group; (ii) develop a 'toolbox' of investigative techniques to assist in documenting takes of small cetaceans; and (iii) hold a workshop comprising a multi-disciplinary group of biologists, social scientists, managers and NGO's with a global scope. Terms of reference were finalised for the multi-disciplinary workshop which will be held in Singapore in June 2016. A second workshop has been proposed for later in 2016 which will focus on providing a 'toolbox' of investigative techniques. Porter noted that the use of forensic science, online data mining, building of theoretical models, monitoring of pathogens and other methods will be the broad themes under which investigative tools will be developed. This workshop will be funded through a donation by the Netherlands. Parsons informed the sub-committee that a Focus Group Session on the use of social science to explore the consumption and other uses of marine mammal products will be held at the International Marine Conservation Congress in October 2016.

With several intersessional workshops and liaison initiatives underway, it is anticipated that more detailed information will be available to the 2017 Scientific Committee meeting. Realising that there could be value in establishing formal working relationships between the IWC and other international bodies that attempt to address bushmeat issues, such as the Convention on Migratory Species and the Convention on Biological Diversity, the sub-committee **recommended** that further steps are taken to investigate, and then pursue, as appropriate, such relationships.

10. OTHER

10.1 Task Teams and Conservation Management Plans for small cetaceans

Simmonds reported on the first year of work by the Small Cetacean Task Teams. This process allows for swift intersessional action for particularly imperilled populations. . Its terms of reference can be found in IWC (2015, Annex L, Appendix 4). A Task Team Steering Committee (TTSC) was established (Simmonds (coordinator), Donovan, Genov, Porter, Reeves, Scheidat and Thomas) and, further to agreement from the last meeting of the Scientific Committee, the Task Team process was initiated for the franciscana, with Zerbini leading the Franciscana Task Team (FTT) for Franciscana Management Area (FMA) I. The TTSC and the FTT were in the process of finalising the project when significant funding became available from within Brazil and the project was paused to allow this opportunity to be explored. The final steps in the process of assessment and endorsement of the FTT will be concluded shortly.

Zerbini provided an update on the Franciscana Task Team. The task team reviewed research and conservation priorities for franciscanas in FMA I, which corresponds to the northern portion of the franciscana's range in the Brazil states of Rio de Janeiro (RJ) and Espírito Santo (ES) and is geographically isolated from the other FMAs (Siciliano *et al* 2002). There is also a gap in the distribution of franciscanas within FMA I (Siciliano *et al* 2002; Danilewicz *et al* 2012). In fact, recent analysis of mitochondrial DNA indicated that the two groups separated by this gap represent distinct populations (Cunha *et al* 2014). The formal recognition of FMA Ia (the population in northern RJ) and FMA Ib (the population in northern ES) was recommended during the 8th Workshop for the Research and Conservation of the Franciscana held in Brazil in October 2015 (SC/66b/SM05). These two populations were selected by the task team because their abundance is the lowest among all FMAs and because no information on bycatch has become available since the early 2000s.

The task team concluded that the following priority tasks are needed to improve conservation of the species in that management area: (1) Monitor the fisheries and estimate bycatch; (2) Assess areas at risk from coastal and offshore development; (3) Estimate abundance and trends; (4) Plan for long-term conservation efforts.

During the intersessional period, a Brazilian non-profit organization, FUNBIO (Fundo Nacional para a Biodiversidade) announced a request for proposals for franciscana research and conservation projects within FMA I. Funds in the amount of ~US$ 2.7 million were allocated for this. Projects addressing some of the tasks listed above were submitted by members of the task team and also by other scientists working on FMA I population. Because projects addressing fishery-related issues were not funded, the development of studies to monitor the fisheries and to estimate bycatch remain the greatest research priority for this population. A proposal to assess characteristics of the fisheries in FMA Ia and FMA Ib was prepared for the task team as a first step to establish a long-term monitoring plan and estimate bycatch in FMA I. Zerbini warmly thanked the TTSC for its support.

The sub-committee **recommended** supporting the fishery characterization and bycatch monitoring and estimation work identified by the FTT.

In discussion, the sub-committee noted that several different Task Teams can operate simultaneously, and that lessons learned can be applied successively to future Task Teams. Moreover, Conservation Management Plans (CMPs) and Task Teams can function synergistically, with a clear distinction maintained between the two: CMPs are formal, lasting agreements between governments, while Task Teams are more immediate and informal initiatives led by researchers and other interested individuals.

In light of the information provided by Kelkar concerning India's recently approved National Waterways Act, the sub-committee **expressed concern** over the potentially severe impacts of developments pursuant to this Act on the conservation status of South Asian river dolphins. The sub-committee **agreed** that the situation facing South Asian river dolphins is a matter of grave concern and requires immediate attention. It further **agreed** that the South Asian river dolphin should be the next candidate for development of a Task Team, given the ongoing and new threats to the survival of the species. The Steering Committee therefore, will establish an appropriate team of experts to develop a project description and it will report back on progress to the next meeting of the Scientific Committee.

10.2 Other scientific information

10.2.1 South Asian river dolphin Platanista gangetica

South Asian river dolphins (*Platanista gangetica*) face serious threats across their range. These include, most obviously, fishery impacts (bycatch or targeted killing) and altered and declining river flows. However, the effects of various threats have been considered largely in isolation.

Kelkar described recent studies testing the hypothesis that fishery impacts on river dolphins are aggravated by declines in water availability (river flows) in two highly distinct ecological settings: the Ganga River (India) and the Karnali River (Nepal). At both study sites, there was a clear negative correlation between dolphin abundance and fishing intensity when river depths were lower than long-term averages. In the Ganga, dolphins appeared to avoid sites with high fishing intensity when water flow was poor and in the Karnali, some recorded dolphin bycatch events coincided with periods of rapidly declining flows. These results illustrate the need to estimate and manage basin-wide flow regimes that are considerate of ecological needs, including recognition of the link between river dolphin population status and fishing intensity. This should be more widely regarded as a high priority for river dolphin conservation in the South Asian subcontinent. The Gangetic basin currently is currently experiencing serious and prolonged water scarcity, exacerbated if not caused by existing dam operations and water abstractions that do not allow adequate river flows, and in addition by failed monsoons over the last three years.

It is paradoxical that at a time when water levels are at historic lows (especially in 2015-16), ecologically threatening interventions such as river interlinking and waterways development are progressing apace in India. India's National Waterways Act (2016) plans to convert 111 river reaches into waterways for inland navigation and goods transport (for coal, fuel, bulk cargo, hazardous goods, etc.). Waterways have been designated to cover 18,240 km of rivers across India. This development will involve capital and maintenance dredging and the construction of ports, large embankments, navigation locks and barrages (although there has been strong local opposition to barrage construction and therefore this aspect of the plans may not come to fruition). Preliminary observations reported by Kelkar suggest that river dolphins tend to move downstream from preferred habitat where dredging is carried out. In his Ganga study site, dive-times increased approximately threefold when compared to 'undisturbed' rates and periods of high dolphin activity (e.g. feeding peaks). In addition, dolphins were highly vocal when undisturbed but exhibited reduced acoustic activity during dredging. These preliminary observations indicate the potential for physiological stress, possibly caused by dredging of river sediment and vessel noise. Kelkar reported that just prior to this meeting, a month of intensive dredging had caused abundance in a 12km long 'hotspot' to be reduced from around 22-25 to 6-7 dolphins.

The South Asian river dolphin was declared the National Aquatic Animal of India in 2010. However, the species now appears to be in grave danger. All rivers inhabited by dolphins in the Indian part of the range could end up being modified by the waterways project, with no obvious refuge areas. Most funding for the waterways development will be provided through public-private partnerships, though it remains unclear how much overseas funding will also be required. There appears to be little scope for detailed environmental impact assessments, although some have been completed, and the implementation process still requires clarification. According to Kelkar, there is a widespread perception in India that vessels constitute an environmentally benign means of transport and therefore that waterways development is a preferable path to economic and social improvement. Some rivers already serve as waterways for vessels and when water levels are high, there is likely less overt effect on dolphins. However, water levels over the past few years are much reduced given poor rainfall, and this increases the risks to dolphins from additional habitat modification. The immediate outlook is thus bleak, raising concern for the species in general; abundance in Nepal is very low and the only populations that appear to be relatively secure for the moment are in Bangladesh. Although populations of the Indus subspecies in Pakistan (*P. gangetica minor*) have been persisting despite a series of barrages, they are also under potential threat from a recently proposed commercial waterway on the Indus River.

Letters of concern were sent recently to the Government of India's Ministry of Environment, Forests and Climate Change by the International Union for Conservation of Nature and the Society for Marine Mammalogy. These letters emphasized the need to conduct detailed ecological assessments and encouraged re-thinking of the proposed scale of waterways development plans, given the threats to South Asian River dolphins and other endangered aquatic species in India. It was **proposed** that the Secretariat of the IWC would be consulted with regards to issuing a letter of concern to the Government of India.

The sub-committee **expressed serious concern** for the survival of river dolphins in India and **encouraged** the India Government to ensure greater and more regular scientific representation at SC meetings. It agreed to elevate consideration of *P. gangetica* (and other river dolphins) as a potential priority topic for future sub-committee meetings.

In light of the information provided by Kelkar concerning India's recently approved National Waterways Act, the sub-committee **expressed concern** over the potentially severe impacts of developments pursuant to this Act on the conservation status of South Asian river dolphins. The sub-committee agreed that the situation facing South Asian river dolphins is a matter of grave concern and requires immediate attention. It further agreed that the South Asian river dolphin should be the next candidate for development of a Task Team, given the ongoing and new threats to the survival of the species. The Steering Committee therefore, will establish an appropriate team of experts to develop a project description and it will report back on progress to the next meeting of the Scientific Committee.

10.2.2 Artisanal fisheries and cetaceans in Kuching Bay, Sarawak, East Malaysia
SC66b-SM-09 provided details of surveys using line-transect and photo-identification methodology that were conducted in Kuching Bay, Sarawak, Malaysia between 2011 and 2013. During surveys fishing activity was recorded and described to quantify the scale and nature of artisanal fishing activity in the bay. During a total of 3670 km and 248 hours of survey effort, gillnets (with a predominance of attended vs unattended nets) were the most commonly observed fishing gear. Boat–based observations were complemented by interview surveys with fishermen in villages surrounding the study site. Both interviews and direct observations show a clear post-monsoon (March-May) seasonal peak in the presence of attended gillnets, while encounter rates for unattended gillnets peaked in September to October. Relative density of observed fishing activity depicted in 2km × 2km grid-cells indicated a strong overlap between the primary fishing areas and the preferred habitats of Irrawaddy dolphin and finless porpoises, which are both concentrated in rivers, river mouths and close to the shore. This overlap suggests that the impact of artisanal fisheries to the cetacean population through bycatch could be high, and interview data confirm that accidental bycatch is prevalent, with 93% of fishermen reporting that they had heard of between one and five cases of bycatch in their village in the past year, and 35% of respondents reporting that they personally had found at least one dolphin accidentally entangled (either live or dead) in their net in the past year. The species most often caught is the Irrawaddy dolphin. However, the high proportion of attended vs. unattended nets, the fishermen's reported positive perception of cetaceans, and their reported willingness to release dolphins from nets give cause for optimism in the potential effectiveness of targeted action with fishermen to reduce cetacean mortality from by-catch. The project was funded by the Voluntary Fund for Small Cetaceans and a full report can be found on the webpage.

The sub-committee **commended** this work and hopes to see it further developed to test the effectiveness of the bycatch mitigation measures proposed in the paper.

10.2.3. Genetic structure of the beaked whale genus <u>Berardius</u> in the North Pacific, with genetic evidence for a new species
Morin *et al* (in press) summarizes new and previously published information supporting recognition of a new species of beaked whale in the North Pacific. Japanese whalers traditionally recognized two forms of Baird's beaked whales: the common 'slate gray' form and a smaller, rarer 'black' form. This genetic study of samples from across the North Pacific examined individuals of both forms, including eight of the enigmatic 'black' form. The authors found a greater divergence between the two North Pacific forms than exists between them and the most closely related species, Arnoux's beaked whale (*B. arnuxii*), found only in the Southern Ocean. The primary evidence for recognition of a new species includes:

- Genetic distance similar to other congeneric beaked whale species.
- Very low intra-specific diversity for each type, based on a range-wide sample.
- 16-26 diagnostic sites in the control region sequence between the 'black' form and the two recognized *Berardius* species.
- Apparently clumped distribution of the 'black' form specimens in the Okhotsk and Bering Seas.
- Smaller adult body size of the 'black' form (~2/3 that of the 'gray' form, based on 2 specimens).

Efforts to formally describe this new species on the basis of genetic and morphological characteristics are underway. It was noted that the current domestic quota in Japan is set at 60 Baird's beaked whales to be shared among a few small-type whaling villages. Some unknown number of 'black' form individuals could be taken, as has happened in the past.

10.2.4 Lagonorhynchus
At the last meeting, the sub-committee received a report on population parameters for Pacific white-sided dolphins (*Lagenorhynchus obliquidens*) (SC/66a/SM20) as well as information on a workshop to review *Lagenorhynchus* taxonomy and conservation status expected to be held at the December 2015 Biennial Conference of the Society for Marine Mammalogy. At this meeting, Cipriano provided a summary of the workshop's outcomes and follow-up plans. The 27 participants collated data from past and current studies and identified priority areas for conservation and management, research needs, and funding opportunities to support work on *Lagenorhynchus* reclassification and conservation.

The sub-committee **encouraged** taxonomic revision of the genus *Lagenorhynchus*, continued work to clarify the systematics of species currently assigned to *Lagenorhynchus* and close relatives within the genera *Cephalorhynchus* and *Lissodelphis*, and efforts to fill significant data gaps in acoustics and genetics for these species, especially *L. cruciger* and *L. australis*.

10.2.5 Survey programs

Herr presented information on the Small Cetaceans in European Atlantic Waters and the North Sea (SCANS-III) project to be carried out in the summer of 2016. A series of large-scale surveys for cetaceans in European Atlantic waters was initiated in 1994 (SCANS; Hammond *et al* 2002) and continued in 2005 (SCANS-II; Hammond *et al* 2013) and 2007 (CODA 2009) to obtain estimates of abundance and place bycatch levels in a population context and to enable EU Member States to discharge their responsibilities under the Habitats Directive. The frequency of such surveys was intended to be approximately decadal, thus the third survey to take place in 2016.

Given the rapid changes taking place in the European Atlantic, EU Member States are seeking up-to-date information on the status of key species so that mitigation and future monitoring can be directed to achieve and maintain favourable conservation status. Consequently, the objective of SCANS-III is to estimate the abundance of all cetacean species in shelf and oceanic waters of the European Atlantic in summer 2016. This will be achieved through a large-scale multi-national aerial and shipboard survey of all European Atlantic waters. SCANS-III aims to survey waters covered by both the SCANS-II and the CODA projects but extended to the 200nm limit in waters of the whole European Atlantic. Continental shelf waters (including areas surveyed in SCANS-II) will mostly be covered by aerial survey. Offshore waters (including areas surveyed in CODA) and the Skagerrak, Kattegat and Belt Seas will be covered by ship survey.

The representative of the Agreement on the Conservation of Cetaceans in the Black Sea Mediterranean Sea and Contiguous Atlantic Area (ACCOBAMS) informed the sub-committee of progress on the ACCOBAMS Survey Initiative, a synoptic survey programme to be conducted in the ACCOBAMS area to estimate cetacean density and abundance. The survey has been discussed and endorsed by this sub-committee over the last few years and is considered one of the top priorities under the ACCOBAMS workplan. The ACCOBAMS Secretariat has received funding from private foundations and from Countries and fieldwork is planned in summer of either 2017 or 2018. Contact has been established with the SCANS III coordinator to ensure consistency of data collection protocols across Europe.

11. WORKPLAN

The sub-committee agreed on a general plan for next year’s priority topic: a review of taxonomy of bottlenose dolphins in the remaining areas – northeast Pacific, southeast Pacific, northwest Pacific and oceanic islands, plus any newly available information on *Tursiops* from areas covered in 2015 and 2016.

In addition, intersessional work will be undertaken to prepare for a worldwide comparison of *Tursiops* taxonomy to be reviewed at SC/67a and then further explored at an intersessional workshop in 2017. Ideally this would include: (1) a mtDNA database of all available sequences and quality checking of every sequence to ensure that it is appropriate and well-documented, (2) a table with every region where studies have been conducted, including markers used, morphological information available, and evaluation of the strength of existing evidence for each region, and (3) a database of samples for those areas already recognized as understudied in order to evaluate what is currently available.

In addition, a workplan that takes account of the two-year reporting period to the commission will be developed and the convenors will notify the sub-committee of details no later than 1 November 2016. For 2017, the agenda will prioritize populations of critical concern that are being immediately impacted by human activities. Input is welcomed concerning populations or issues that might be discussed, whether these are ‘new’ or previously considered.

12. ADOPTION OF REPORT

The report was adopted at 10:20 on 16 June 2016.

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Table 2
Summary of the work plan for the Small Cetacean sub-committee.

Item	Intersessional 2016/17	2017 Annual Meeting (SC/67a)
Global *Tursiops* Taxonomy	Email group to synthesise information presented at SC/66a; SC/66b and any new information	Report to Committee
Poorly documented takes	Email group to plan and conduct South East Asian workshop	Report to Committee
Task Team Steering Committee	Continue work on Fransiscana and explore other taxa	Report to Committee

Table 3
Summary of the work plan for the Small Cetacean sub-committee.

Item	Intersessional 2017/18	2018 Annual Meeting (SC/67b)
Global *Tursiops* Taxonomy	Intersessional Workshop *Tursiops* taxonomy	Report to Committee
Poorly documented takes	Email group to plan and conduct African workshop	Report to Committee
Task Team Steering Committee	Continue work on Fransiscana and explore other taxa	Report to Committee

Table 4

E-mail Intersessional Correspondence Groups, Steering Groups, Working Groups and Terms of Reference.

Group		Committee	Terms of Reference	Membership
(1)	Poorly documented takes of small cetaceans	SM	Develop a 'toolbox' of investigative techniques to assist in documenting more clearly takes of small cetaceans; and hold a workshop comprising a multi-disciplinary group of biologists, social scientists, managers and NGO's with a global scope. Increase formal liaison with other MEA	Porter (convenor), Baker, Brownell, Collins, Cosentino, Frey, Jiminez, Ritter, Scheidat, Simmonds
(2)	Small Cetacean Task Team	SM	Assist the Scientific Committee in providing timely and effective advice on situations where a population of cetaceans is or suspected to be in danger of a significant decline that may eventually lead to its extinction; the ultimate aim being to ensure that extinction does not occur.	Simmonds (convenor), Donovon, Genov, Porter, Reeves, Scheidat
(3)	Tursiops Taxonomy Review	SM	Provide an overview of evaluation of Tursiops conducted in SC/66a; SC/66b and other, relevant new information	Natoli (convenor), Hoelzel, Rosel
(4)	Reporting from Brazil on piracatinga/*Inia*	SM	Provide Guidance to Brazil on Committee reporting concerning the piracatinga/*Inia* issue	Zerbini (convenor), Brichta, Coutinho, Fruet, Luna, Marmontel, Martin, Porter, Raseira, Reeves, Scheidat, Silva, Thomas

Appendix 1

AGENDA

1. Convenor's opening remarks
2. Election of Chair
3. Appointment of rapporteurs
4. Adoption of agenda
5. Review of available documents
6. Taxonomic status of *Tursiops spp*. for the North Atlantic and South Atlantic**]**
7. Status of the Voluntary Fund for Small Cetacean Conservation Research
8. Review progress on previous recommendations
   - 8.1 Vaquita
   - 8.2 Yangtze finless porpoise
   - 8.3 Hector's dolphin*
     - 8.3.1. *Maui's dolphin*
   - 8.4 Amazon River dolphin and tucuxi
   - 8.5 Franciscana*
   - 8.6 Sousa
   - 8.7 Killer whales
   - 8.8 Harbour porpoise*
9. Review takes of small cetaceans
   - 9.1 New information on takes
     - 9.1.1. *Direct takes*
     - 9.1.2. *Accidental takes*
   - 9.2 Poorly documented hunts of small cetaceans for food, bait or cash
10. Other
    - 10.1 *Task team and Conservation Management Plans for small cetaceans*
    - **10.2** *Other scientific information**
11. Workplan
12. Adoption of report

*Some joint sessions with HIM.

Appendix 2

REPORT OF THE INTERSESSIONAL EXPERT GROUP TO REVIEW HECTOR DOLPHIN ABUNDANCE ESTIMATES

Members: D. Palka (convenor); A. Cañadas; G. Donovan; C. Fortuna; M. Scheidat; A. Zerbini

ABSTRACT

An independent expert group (IEG) reviewed the MacKenzie and Clement (2014a, b, 2016a, b) papers which estimated the abundance of Hector's dolphins around the South Island, New Zealand (excluding sounds and harbours) to be 14,849 (CV:11%; 95% CI 11,923-18,492). This analysis extended conventional data collection and analytical methods to account for perception bias using data from two teams in an airplane within a mark recapture distance sampling framework; explored several truncation schemes to account for unequal fields of view capabilities of the two teams due to the configuration of the aircraft; explored a relatively new non-conventional analytical method to account for unknown levels of dependence between the two teams (due to heterogeneities); and explored two different methods to collect and analyse data to account for availability bias. As a strategy to incorporate all the information obtained from the various methods and models, model averaging was used to develop the final abundance estimate and associated metrics of variability. In addition, using the same aerial survey data, density surface modeling techniques were used to develop both spatial fine scale distribution maps and an independent estimate of abundance.

This study accounted for many difficulties that also affect other studies that estimate abundance of small cetaceans using aerial surveys. The authors addressed several difficult questions that do not have easy answers. These include: how to develop a correction for availability; how to handle the fact that observers cannot easily see the track line and thus results show a dip in the detection function at the track line; how to incorporate spatial-temporal changes in availability, detection, and g(0); how to deal with lack of complete independence between the two observation teams; and what scale is appropriate to display when developing distribution maps. Although these issues have been recognised in many studies, the theoretical and practical methods and guidelines to deal with them have not yet been fully developed. The IEG commended the ambitious and often innovative work undertaken by the authors to attempt to deal with all of these issues. After an in-depth review of the survey design, analyses and results, the IEG **endorses** these abundance estimates and **concludes** that the estimates accurately reflect the data, were derived from appropriate data collection and analysis methods, and represent the most current abundance estimates for the Hector dolphins around South Island, New Zealand. Thus, it follows that it is reasonable to use them as one component in developing a management plan.

The IEG considers that this study is also a step forward in the general evolution of survey methodology development. The IEG has made a number of suggestions to refine further the methods, including the collection of additional targeted data, additional sensitivity analyses sensitivity analyses regarding criteria used to make decisions, and use of simulation and other ancillary studies.

1. INTRODUCTION

Within its areas of interest and expertise when it comes to conservation and management of stocks and species, the primary objective of the IWC Scientific Committee (SC) is to review and endorse (or otherwise) existing abundance estimates produced outside it, which may be suitable for management purposes. To this end, in the intersessional period 2015-2016, with the help of the IWC Secretariat, the IWC SC Chair set up a formal process along the lines of another process that has been agreed by the SC and endorsed by the Commission (i.e. Annex P). This review process involves the creation of an Intersessional Expert Group (IEG) and an Intersessional correspondence Group (ICG).

This process was used to review abundance estimates of Hector's dolphins. The compositions of the IEG and ICG are in Annex A.

The Terms of References to the IEG were:

- Review the MacKenzie & Clement (2014a, b) East Coast South Island (ECSI) Hector's dolphin abundance estimate, and
- Review the MacKenzie & Clement (2016a, b) results of the West Coast South Island (WCSI) Hector's dolphin survey and the updated ECSI and South Coast South Island (SCSI) abundance estimates.

The terms of reference also indicated that if the IEG could not complete its work in time for the 2016 Scientific Committee meeting, a workshop could be convened in New Zealand in 2016 to finalise its evaluation; in which case the IEG's final report would be submitted to the 2017 Scientific Committee meeting. The IEG was able to complete its work intersessionally and so this workshop was not required.

The MacKenzie & Clement reports were provided by the New Zealand representatives to the ICG on 8 April 2016. The IEG discussed these documents via Skype conference calls during the rest of April and May and asked the ICG two sets of questions. The questions and responses are in Annex B and C.

As a brief introduction to the MacKenzie & Clement papers the executive summary for the 2016 paper was reproduced below. Following this are the comments and conclusions from the IEG.

2. EXECUTIVE SUMMARY FROM MACKENZIE AND CLEMENT (2016A)

'The Ministry for Primary Industries and the Department of Conservation are currently reviewing the Hector's dolphin Threat Management Plan. For this review, up-to-date abundance and distribution estimates of Hector's dolphin are required. A survey programme was specifically designed for sampling the WCSI population using two separate aerial surveys over summer 2014/2015 and winter 2015. The WCSI surveys constitute the last abundance estimate of the three regional South Island Hector's dolphin sub-populations; following on from the east and north coast (ECSI) aerial surveys in 2013 (MacKenzie & Clement 2014) and south coast (SCSI) aerial surveys in 2010 (Clement et al. 2011). This report summarises the results from the recently completed WCSI surveys.

The WCSI survey area (~ 26,333 km^2 between Farewell Spit and Milford Sound) was stratified into six coastal sections, which were further divided into offshore substrata of 0–4 nmi (inner), 4–12 nmi (middle) and 12–20 nmi (outer). This design was expected to encompass the offshore limits of Hector's dolphin distribution along the South Island's west coast. Double observer, line-transect methodology was used with transect lines orientated in the offshore direction and spaced parallel at equal intervals (according to strata-specific effort allocation) using systematic-random line placement.

WCSI abundance was estimated using an extension of mark-recapture distance sampling (MRDS) techniques that accounts for differing field of views between observer positions in the plane; similar to the approach developed for the ECSI survey (MacKenzie & Clement 2015). These methods also allow for a lack of independence between the observer detections. Availability bias is a fundamentally important component for obtaining a reliable estimate of total abundance. As in the ECSI survey, we utilise two availability methods; helicopter observations of dive cycles and circle-back redetection.

These aerial surveys constitute the only abundance study to date with substantial effort in offshore regions (more than 4 nmi from the coast) for Hector's dolphin along the entire west coastal waters of the South Island. Summer sightings results consisted of 250 dolphin groups (115 of which were seen by two observers) sighted within 0.3 km either side of the plane along 4001 km of transect lines. In winter, 272 dolphin groups (115 of which were seen by two observers) were sighted within 0.3 km either side of the plane along 4307 km of transect lines. Hector's dolphins were observed as far offshore as 12 km (6.5 nmi) and 17.7 km (9.5 nmi) in summer and winter, and in waters as deep as 160 m and 200 m, respectively. However, the majority of animals in both seasons occurred close to shore (< 3 nmi) and within relatively shallow depths (<40 m).

Regional variation in dive cycle data was similar in both survey periods with slightly lower surface availability off the Okarito Lagoon region. Availability estimated from the circle-back data exhibited less regional variation than dive-profiles, although both the effects of region and offshore (0-4 nmi or 4-20 nmi) factors were incorporated into model average estimates of circle-back availability.

The WCSI Hector's dolphin summer abundance was estimated to be 5,490 (CV: 26%; 95% CI: 3,319-9,079) and 5,802 (CV: 21%, 95% CI: 3,879-8,679) in winter. These estimates were obtained by averaging the four sets of results for each season; from two different data sets using different truncation distances and two methods of estimating availability (dive cycle and circle-backs). These estimates are very similar to the previous 2000/2001 WCSI estimate of 5,388 Hector's dolphins (CV: 21%; 95% CI: 3,613-8,034), even after accounting for differences in offshore survey areas.

Following a reanalysis of the ECSI and SCSI survey data, our estimate for the total Hector's population around the South Island (excluding sounds and harbours) is 14,849 (CV: 11%, 95% CI 11,923-18,492). This estimate is approximately double the previous estimate from surveys conducted in the late 1990s – early 2000s (7,300; 95% CI 5,303-9,966), with the difference primarily due to a much larger estimated population along ECSI, distributed much further offshore than previously thought. Densities are similar along ECSI and WCSI. This new estimate has implications regarding the conservation, potential fisheries-related impact and our general understanding of the species.'

3. COMMENTS BY THE IEG

McKenzie and Clement's overall analysis strategy was to analyse the data using a suite of good fitting models and two totally different data collection methods to estimate availability bias, then use model averaging to incorporate the uncertainties inherent to these different models and methods. The authors are commended at taking this approach which is time consuming but incorporates model selection into the variance estimates (which is not commonly done, although often desired) and thus this approach recognises the pros and cons of the different methods/models.

Comments by the IEG are divided into general aspects of the data collection, analyses and results.

3.1 Survey design

To account for the animal density gradient that had higher *a priori* density close to shore, the surveys were designed using tracklines that were perpendicular to the coast line or as nearly as possible given the study area is all around the

South Island. Also, to account for the onshore-offshore density gradient, the survey area was divided into 3 strata: inner (< 4nmi), middle (4 – 12 nmi), and outer (12 – 20 nmi offshore). Coverage was greatest in the inner, nearshore strata with the highest *a prior* density. The IEG **concludes** that the survey design was appropriate for the study area and *a priori* density gradient of the Hector dolphins.

The surveys were designed following the two team techniques where two 'independent' teams of people simultaneously search the waters for animals and both teams record all sightings detected. Unfortunately, though common, the plane had different types of windows for the two teams, so one team was not able to survey the entire region that could be surveyed by the other team. Consequently, more complex analytical techniques were appropriated used to account for these asymmetric viewing regions (see section 3.2). The IEG **recommends** that when possible in future surveys, to reduce the variability due to this asymmetry, efforts be made to have windows that allow for symmetric viewing regions for the two teams or utilize analytical techniques that account for the asymmetry.

3.2 Detection function models

Abundance of Hector's dolphins was estimated using mark-recapture distance sampling (MRDS) methods (e.g. Laake and Borchers, 2004). These methods integrate sighting data from the front and rear platforms to compute detection probability and to estimate perception bias. In addition to distance from the survey platform, the effect of group size was considered). The work by McKenzie and Clement was unique because it extended the MRDS conventional methods by utilising two sets of data to account for differing fields of view by the two teams and by using an alternate approach to address potential varying levels of lack of independence between the two teams that was developed by Buckland *et al*. (2010). In addition, they expanded the published approach following recommendations by one of the authors (JL) of Buckland *et al.* (2010). Finally, a simulation study was conducted to assess the performance of the extended MRDS method used in the analyses for the various Hector's dolphin populations.

Detection probability was estimated for two sets of data: 'full' and 'truncated'. In the full set, perpendicular distance was right-truncated at 0.3km for both front and rear observers and left-truncated at 0.071km for the front observers (those searching through flat windows). In the truncated set, the same right and left truncation distances were used, but the left truncation was not only applied to the front, but also the rear observers (those searching through bubble windows). Therefore, perpendicular distance sample sizes were always lower for the truncated dataset. Detection probability models were developed for each survey separately. The IEG **concludes** that investigating the two data sets was appropriate given differences between the view ranges of the two teams and the potential differences among the observers, surveys characteristics and environmental conditions.

Model selection was conducted based on the Akaike Information Criterion (AIC) and model averaging was performed taking into consideration the AIC weights. Goodness of fit of the detection functions was assessed using quantile-quantile (q-q) plots and through Komolgorov-Smirnov and Cramer-von Mises tests. Based on the results of their simulations and those in Buckland *et al.* (2010), the authors expressed concerns with models producing (a) invalid standard errors for the abundance estimates (singular or nearly singular Hessian matrix) or (b) over-estimation of abundance. Over-estimation was particularly problematic for models with constant dependence and limiting independence and extreme negative correlation (<-0.95) of the intercept of the detection function and the dependence components of the model. However, extreme correlations do not necessarily result in unstable over-estimations. For these reasons, the authors followed the general recommendations made in Buckland *et al*. (2010) by adopting the following criteria to exclude problematic models (pg. 15, WCSI Report): 'models that resulted in abundance estimates that were greater than twice as large as the estimates from similar models (approximately) and with a correlation value between the intercepts of the detection and dependence components of the model approaching -1, were excluded from the set used for final inferences. Models that failed to produce a standard error (singular Hessian) or very large standard errors (nearly-singular Hessian) were also excluded.'

In general, the IEG **concludes** that the methods employed by MacKenzie and Clement (2014a, b, 2016a, b) to estimate detection probability of Hector's dolphin and the procedures adopted to assess model fit and model performance were appropriate. However, the IEG discussed some issues in more detail and provided the following comments:

(1) The IEG was pleased to see that a simulation was conducted to assess the performance of the estimators in the methods proposed by the authors to estimate detection probability. Simulations are often useful to understand potential biases and limitations of new methods and appear to have been useful in these analyses.

(2) Estimates of abundance using line transect methods often pool sighting data across regions, years and/or seasons to estimate a common global detection function. This is usually done to increase sample size and compute more robust estimates of detection probability. In this study, data were pooled within each survey, which represents a region and season. The IEG **concludes** that the estimate of survey-specific detection functions was appropriate given that sufficient sample sizes were available within each survey and given the possible differences in data collection methods, observers and survey conditions between the surveys.

(3) The use of non-conventional functional forms for the detection function were questioned in previous reviews of the reports, but appear not to have significant effects on the Hector's dolphin abundance estimates. MacKenzie and Clement (2014b, Tables O.1 and O.2, p. 75) demonstrated that estimates of abundance in the covered region using

the method they developed were not statistically different than those computed with conventional and multiple covariate distance sampling methods (e.g. hazard rate and half normal models with and without covariates). The IEG was pleased to see this comparison and **concludes** the different methods should result in similar estimates of overall Hector's dolphin abundance. This is because the non-conventional functional forms are a generalisation of the conventional forms (Buckland *et al.,* 2010) and allows for the complete range of levels of dependence, within which the conventional forms fall.

(4) The application of the criterion to remove certain detection function models (MacKenzie and Clement, 2016a, p. 15) was not completely clear. It was evident that models with high correlations between the intercepts of the detection and dependence components of the model are potentially unstable resulting in large estimates of abundance and measures of variability, and therefore, can be removed (see recommendations by Buckland *et al.,* 2010). However, it was not evident how to best determine which models with high correlations should be removed. In addition, it was not clear what correlation value should be considered as 'high'. Buckland *et al.* (2010) investigated the effects of defining high as values ranging from 0.9 to 0.99 and concluded that 'lowering the correlation criterion provides a more conservative approach to avoid overestimation with the only cost being potential underestimation due to the unmodelled dependence'.

The IEG investigated the effect of removing all models with negative or positive correlation greater than 0.8 and concluded that the removal of these models would result in changes to the estimate of abundance of the ECSI and WCSI populations ranging from 0 to 5% and -1 to -8%, respectively. These changes are small considering the precision of the estimates provided in the original analysis. Removal of highly correlated models would have a greater effect (18% increase) in the estimate of the abundance of the SCSI population. While greater, this increase would also be within the confidence intervals of the estimates presented in the report.

In conclusion, the IEG **concludes** that the 'multiple prong' criteria used in this study is an appropriate way to eliminate the truly unreasonable unstable models. The IEG also **suggests** that the issue of appropriate selection criterion (a) is an area that still needs theoretical development and **recommends** simulation studies as a valuable way to determine the most appropriate set of criteria and correlation values considered as 'high'.

3.3 Availability estimate

One of the assumptions of line transect distance sampling is that all sightings on the transect line are detected – that is, $g(0)$ is equal to 1. However, for cetaceans this is generally not the case. Animals on the transect line are missed for two reasons: (1) they may be unavailable for detection because they are underwater ('availability bias'), or (2) observers may fail to detect them even though they are available ('perception bias').

In case of the work done by MacKenzie and Clement (2016a, b), two approaches were followed to take into account the availability bias for Hector's dolphins: a modification of the Hiby & Lovell circleback method and a method collecting dive and surface times from a helicopter. The IEG **commends** the authors for exploring and using two totally different methods. The two methods each have their own pros and cons, and the IEG **agrees** that it is appropriate to use model averaging to develop availability estimates from both methods.

In general, the IEG **concludes** that the methods employed by MacKenzie and Clement (2014a, b, 2016a, b) to estimate availability were appropriate. However, the IEG discussed some issues in more detail and provided the following comments:

(1) An advantage of the modified circleback method (similar to the original circle-back of Hiby & Lovell) is that the data can be collected during the actual survey and thus represents the variability of the sighting conditions and potentially changes in behaviour of animals. Thus in theory, values obtained are more reflective of the actual conditions and survey area. After asking for additional information from the authors (Annex C), it was determined that indeed, the animals used to determine availability bias during the circlebacks were representative of the animals detected during the regular line transect abundance survey.

(2) As the authors note, a disadvantage of the circleback method is the assumption that dolphins are remaining, and are thus possibly detectable within the strip during the subsequent circleback. Attempts were made to minimise the chances that an animal could be outside the possible detection area by limiting circlebacks to only animals close to the track line and allowing a duplicate sighting to be within a reasonable range of the original location, thus allowing for potential movement. The IEG **concludes** that these safeguards should be sufficient to result in unbiased estimates. It also **agrees** that more detailed information on dolphin dive patterns and swimming speed should be obtained to definitively confirm that this is the case – as a minimum, obtaining more circlebacks in future surveys will provide information on the degree of robustness.

(3) As the authors also noted, another situation that could bias the circleback results was if the circleback was conducted in a high density area where a second group of animals that was not seen on the first pass was detected on a subsequent pass and was mistakenly assigned as a duplicate. The IEG noted that situations with several groups being present in the area of a circleback may not be a problem; the important factor is the locations of those groups within the search area of the circleback relative to each other. The IEG was pleased to see the authors investigated the potential effect of a bias due to a misidentification of duplicates during the circlebacks on the

overall abundance estimate. This study indicated that a potential bias could be caused in cases where there were more than 5% mismatches. This could cause an over- or under-estimate depending on the type of mismatch, and the IEG **concludes** that given the above mentioned safeguards, the potential mismatches would be negligible for the overall abundance estimate and thus not cause a large bias.

(4) The IEG **recommends** that simulations be used to investigate the effects of dolphin movement on the determination of duplicates and the resulting abundance estimate. Or in other words, determine how much movement would be needed to cause a level of bias that would not be negligible.

(5) As already mentioned there is uncertainty in determining duplicate sightings during the circlebacks, in addition to the regular line-transect survey. The current analysis method did not explicitly account for this source of uncertainty. It would be desirable to incorporate this uncertainty into the variance of the abundance estimates, although exactly how this can be done using non-subjective methods is unclear. One possible way would be to incorporate the idea behind the original Hiby and Lovell circleback analysis method, which did not depend on a determination of duplicates. Instead they determine the probability of all possible pairs of sightings within the circleback search area that could be a duplicate sighting. This depends on parameter estimates of swimming speed and other factors. Another possible approach is to designate the level of confidence in a duplicate determination into categories, such as definite, possible, unlikely – but this involves a degree of subjectivity. This issue extends beyond the particular Hector's dolphin case and the IEG **recommends** further theoretical development of methods to incorporate uncertainty in the determination of duplicates into the estimates of uncertainty of the abundance.

(6) The IEG commended the authors for estimating survey- and area-specific availability estimates, realising there could be spatial and temporal true variability. However, the IEG noted that a few average predicted strata-specific values from the circleback method were likely unreliable outliers (0.09 and 0.94, for example), although the associated standard errors were quite large. In many of these cases these outliers were associated with models with low weights so they contributed little to the final abundance estimate. In addition, in many of these cases the circleback estimated abundances were comparable to the dive time estimated abundance from the same strata, which used totally different data for the availability estimate. The IEG **concludes** that, although these rare outliers may be incorrect and are probably due to overfitting due to small samples, their overall effect is probably minor. For future surveys, the IEG **recommends** collecting more circleback data that could be used to eliminate the outlier values (if they are caused by insufficient sample sizes) or to improve our understanding as to why these strata have outlier values of availability.

(7) The IEG was pleased to see that two methods (circleback and helicopter dive cycle methods) produced similar results for the availability estimate, although there were fine scale differences. The reasons for these fine scale differences are not clear, although factors that appear to be influential are the type of platform (helicopter versus plane and even models within each of these types of aircraft), limited sample sizes, and true differences in areas due to perhaps environmental conditions such as water turbidity. The IEG noted the confidence intervals of the estimates from the two methods generally overlapped, so the differences appear to not be highly influential and model averaging is appropriate. The IEG **concludes** that the results suggest that future studies should: use 'quiet' helicopters; avoid sharp turns as these will increase disturbance; collect as much data as is possible; and collect behavioural and environmental data to determine if there are significant covariates to be considered when estimating availability.

3.4 Duplicate identification

As has been seen in other studies and was discussed in item 3.3 in the context of duplicates during the circleback availability portion of the survey, misidentifying duplicates can bias the resulting abundance estimate. The authors investigated the possible consequences of misidentification, where the result was as expected: the level and type of misidentification affect the level and direction of the bias. Thus, it is important to as accurately as possible determine which groups of animals were seen by both the front and back teams. This is a potential problem for any study using the two team approach and no definitive guidance has been suggested by the many investigators that use this approach. In the case of these surveys, three criteria were used to determine a duplicate sighting: sighting time (within ± 5 seconds), sighting angle (within ± 5 degrees) and group size (± 1 individual). These criteria apparently have been used for all of the surveys for this species that used the two team approach. The IEG **concludes** that the criteria are appropriate and since they are consistent over the various surveys, they are not a reason for differences between the present surveys and previous surveys.

3.5 Density surface modelling

Separate density surface models (DSMs) were developed to estimate the summer- and winter-time distribution of Hector's dolphins using statistical software R with a combination of custom code and the package *dsm*. The tracks were divided into segments of 1km length and 0.6km width, and the covariates were associated according to the grid cell (5×5 km) in which the middle point of the segment fell.

Then they estimated abundance for each segment with what seems to be a Horvitz-Thompson estimator including the estimated detection function and estimates of regional availability. These segment-specific abundance estimates were then modelled with GAMs and several covariates to predict dolphin density across the study region using the prediction grid of 5×5 km cells. The covariates used were geographical coordinates (Easting and Northing), distance from shore and depth in one survey. These covariates were used in the model whether they had an effect or not. They attempted to use depth in all surveys but rejected it in one case because it led to unrealistic results. Standard errors were obtained using a parametric bootstrap to accommodate uncertainty in both the detection function and DSM. The authors recommended the use of coarser scales for the purpose of robust inferences about distribution as the resulting maps, with a 5×5 km grid, because the DSM were sensitive to the exact location of the detections.

The IEG **concludes** that the overall DSM process was appropriate. In general, the DSM models appeared to fit the data and the resulting abundance estimates were similar to the estimates using other methods. Because the description of the methods and results were lacking some details, the IEG requested more details from the authors (Annex C). After obtaining the requested details, the IEG discussed some issues in more detail and provided the following comments:

(1) The segment-specific abundance estimates were used as response variables. This means that segments with detections were corrected according to the detection functions and availability bias, but not the segments without detections. Theoretically the process should not cause a bias. However, a more conventional method that could be considered is to use the actual counts of detections as the response variable and then use as predictors the effective search area as an offset term, the segment specific effective strip width (*esw*) and further correcting each segment with the availability bias. This alternative way of processing is especially useful when effort-related covariates are used in the detection function (such as sea state), so that the *esw* changes with such conditions and therefore the effective search area of all segments can be corrected accordingly. This could potentially avoid over or under-compensating the correction of only the segments with detections.

(2) The IEG noted that a variable selection process was not used for the DSM model to remove covariates that did not contribute to a better fit. The authors explained this was because the goal was to have a spatially stratified model and map. This approach is considered appropriate by some statisticians. However, the IEG **recommends** investigating the robustness of excluding model selection. This may help explain why depth had to be removed from the WCSI and not the ECSI survey data and perhaps it would determine there may be overfitting in some cases; see the next comment related to potential overfitting these models.

(3) As the authors stated, the IEG **agrees** that it is true that the finer the scale of the prediction grid, the more sensitive it is to the positions of the detections. But the sensitivity also depends on the level of model overfit. That is, the more overfitted the model is, the more chance of problems noted by the authors. In general, if the model is not overfitted and the grid cells are not extremely small in comparison with the total study area, then the effect of the size of the prediction grid size is minimal. In general the optimal size of the prediction grid cell is related to the total surface area of the study region as well as the resolution of the covariates used in the DSM. That is, a too coarse scale may diffuse the covariates too much and yield meaningless results.

3.6 Results

In general the new 2016 estimates are larger than the previous estimates. The 2016 estimate for the total Hector's population around the South Island (excluding sounds and harbours) was 14,849 (CV: 11%, 95% CI 11,923-18,492). This estimate is approximately double the previous estimate from surveys conducted in the late 1990s – early 2000s (7,300; 95% CI 5,303-9,966; Slooten *et al.,* 2004). Most of the difference is in the summer east coast South Island (ECSI) area. This difference appears to be largely due to the abundance estimated in the two offshore strata which was only surveyed in the recent time period. Because the same areas were not surveyed during both the earlier and 2016 surveys and depending on the level of small scale (4 – 8 nmi) animal movements, it is difficult to compare these two sets of estimates - the recent estimates cover a larger area and found animals where they were not expected earlier. The IEG **concludes** the 2016 estimates are appropriate and represent the most current abundance estimates for the Hector dolphins around South Island, New Zealand.

		Abundance estimates	
Area	Season	Earlier 2000's	2016
ECSI	summer	1600-1900	9728
	winter	NA	8208
SCSI	summer	628	177
	winter	NA	299
WCSI	summer	5388	5490
	winter	NA	5802
TOTAL		7300	14,849

4. OVERALL CONCLUSIONS AND COMMENTS

The reports provided to the IEG were comprehensive and thorough in describing the methods and in presenting results, thus greatly facilitating the review process.

This study accounted for many difficulties that also affect other studies that estimate abundance of small cetaceans using aerial surveys. The authors addressed several difficult questions that do not have easy answers. These include: how to develop a correction for availability; how to handle the fact that observers cannot easily see the track line and thus results show a dip in the detection function at the track line; how to incorporate spatial-temporal changes in availability, detection, and g(0); how to deal with lack of complete independence between the two observation teams; and what scale is appropriate to display when developing distribution maps. Although these issues have been recognised in many studies, the theoretical and practical methods and guidelines to deal with them have not yet been fully developed. The IEG commended the ambitious and often innovative work undertaken by the authors to attempt to deal with all of these issues. After an in-depth review of the survey design, analyses and results, the IEG **endorses** these abundance estimates and **concludes** that the estimates accurately reflect the data, were derived from appropriate data collection and analysis methods, and represent the most current abundance estimates for the Hector dolphins around South Island, New Zealand. Thus, it follows that it is reasonable to use them as one component in developing a management plan.

The IEG considers that, this study is also a step forward in the general evolution of survey methodology development. The IEG has made a number of suggestions to refine further the methods, including the collection of additional targeted data, additional sensitivity analyses sensitivity analyses regarding criteria used to make decisions, and use of simulation and other ancillary studies. Specific suggestions/recommendations for possible future developments are detailed in the report and summarised below.

Summary of suggestions and recommendations for future developments

Section	Suggestion/Recommendation
3.1	In future aerial surveys attempt to use planes with windows that allow for more symmetric viewing regions for the two teams.
3.2	Use simulation studies to determine the most appropriate set of criteria and correlation values considered as ‘high’ as a possible way to develop the appropriate selection criteria to eliminate the truly unreasonable unstable models when using the Buckland *et al.* (2010) methodology.
3.3	Use simulations to investigate the effects of dolphin movement on the duplication identification and availability estimate. Or in other words, determine how much movement would be needed to cause a level of bias that would not be negligible.
3.3	More fully develop methods to incorporate the variability in determining duplicates into the estimates of variability of the abundance estimate.
3.3	Collect more circleback data to attempt to eliminate the outlier estimates of availability, if the outlier values are caused by insufficient sample sizes. At the least the additional data may provide more understanding as to why some strata have what seem like outlier estimates of availability.
3.5	Investigate the robustness of not including model selection in the density surface models. This investigation may help explain why depth had to be removed from the WCSI and not the ECSI survey model, and it may determine if the model is overfit, at least in some cases.

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ADJUNCT 1

Membership of the Intersessional groups

Membership of the Hector's dolphin Intersessional Correspondence Group (ICG)
Darryl MacKenzie
Deanna Clement
Dave Lundquist
Nathan Walker
Rohan Currey
Liz Slooten
Steve Dawson
Will Rayment
All IEG members (Meike Scheidat convenor)

Membership of the Hector's dolphin Intersessional Expert Group (IEG):
Ana Cañadas
Greg Donovan
Caterina Fortuna
Debra Palka (convenor)
Meike Scheidat
Alex Zerbini

ADJUNCT 2

IEG's first question and response

A. The IEG asked the following question
Dear ICG members,

As you know the IEG is currently looking at the technical details of the reports provided to us by Rohan Currey. The IEG would like to make sure that they are considering all potential problems that might be associated with the abundance estimates. To do this, I would like to ask those members of the ICG that have concerns with the results presented in the reports, if they could provide us with their input.

More specifically, if there are any particular points in the report that you believe cause a problem with the resulting abundance estimates (only referring to the latest, March 2016 report), could you please provide us with a list of these? It would be great if you could keep the list concise & make sure that it clearly describes what the issues are you would like to highlight. And, if possible at all, it would be great if we could have such an overview available by the end of this week (no 'nice' format needed).

B. Response provided by Slooten, Dawson, and Rayment on 29 April 2016.

Hector's dolphin surveys carried out in 2013 and 2015
Professor Elisabeth Slooten, Professor Stephen M. Dawson, Dr William J. Rayment, University of Otago, P.O. Box 56, Dunedin, New Zealand, 29 April 2016

Introduction
MacKenzie and Clement were set the challenging task of designing a survey to estimate abundance of Hector's dolphin as well as gather data on offshore and alongshore distribution. They completed a comprehensive series of surveys, representing a considerable input of effort and funding.

The abundance estimates for the WCSI and SCSI populations were broadly similar to the previous estimates, while the estimate for the ECSI population was significantly larger. The offshore distribution information from the new surveys was consistent with previous surveys, with most sightings in water less than 100 m deep.

In terms of alongshore distribution, the survey confirmed there were two high density areas on the ECSI, around Banks Peninsula and in Cloudy Bay – Clifford Bay. However, the recent surveys were less effective in low density areas. For example, in Golden Bay, on the north coast of the South Island, no sightings were made in summer and one sighting was made in winter. This resulted in an estimate for this area of 0 in summer and 187 (95% CI 32–1,087) in winter. In other words, Hector's dolphins are present on the north coast of the South Island, but estimating abundance for such low density areas was essentially a 'hit or miss' process based on a small number of sightings (e.g. 0, 1, 2 or 3). In another low density area off the Otago coastline, no sightings were made in summer or winter despite the year-round presence of a small local population of Hector's dolphins (N = 42; 95% CI 25-75; Turek *et al*. 2013).

The survey protocols and analyses have been discussed in a series of stakeholder meetings organised by DOC and MPI. We welcome the IWC process, aiming to reduce the uncertainty concerning the current abundance of Hector's dolphin.

Below, we present a summary of potential issues with the surveys and analyses that we believe warrant further discussion and clarification.

Models with unrealistic abundance estimates ('blow outs')
In several cases, models with relatively high AIC scores (among the 10 best fitting models, of a total of 72 models fitted) produced unrealistically high abundance estimates ('blow outs'). These were excluded from model-averaged estimates. The blow-out problem was worse in the 2015 reanalysis of the 2013 survey data. The table below shows which of the 10 best fitting models produced unrealistically high abundance estimates and the corresponding estimates of the number of dolphin groups within the area surveyed (total transect line length x 2ESW).

ECSI	Original analysis			Re---analysis				
Summer								
Models that blow out (of top 10)	#4			#8	#9	#10		
Estimated # sightings in surveyed area	1,515,113			27,822	7,845,615,214	49,718		
Winter								
Models that blow out (of 72)	#4	#5	#6	#1	#2	#3	#7	#9
Estimated # sightings in surveyed area	13,819	2,289	260,702	759,060	37,183	6,337	809	134,132

The number of models that blow out in the summer analysis of the ECSI survey has increased from one to three (Table T.3), and the extent of overestimation also increased. Models fitted to the 0.071-0.3 km data set (left and right truncated) blow out more frequently than models fitted to the 0-0.3 km data (only right truncated), as in previous analyses. Left and right truncation resulted in removing 34% of the sightings for both observers, and 42% for bubble window observer in the back of the plane.

Re-analysis of the SCSI survey data resulted in a decrease of the abundance estimate from 628 to 238 (section S in the Supplementary Material). Again there seem to be issues with this analysis. Models 3 and 8 resulted in estimates of 550 and 826 dolphins, respectively, in the surveyed area (Table S.2). Excluding models 3 and 8, results for the 10 best fitting models range from 107 to 196 in the area surveyed.

Clearly, inclusion of blown-out models in the model averaging process would result in overestimates of abundance. Therefore a two-part decision rule (estimates > 2 x estimates from similar models, correlation between intercepts of detection and dependence components approaching -1) was used to exclude some models from final inferences (although, in fact the CV of the abundance estimate was also used). This rule seems somewhat subjective and relies on the analyst's assessment of what might be a sensible estimate (see table 7).

Can we come up with a more objective decision rule?

Given that some combinations of covariates were particularly troublesome, is there grounds for excluding those combinations entirely from the model set?

It would be useful to explore, quantitatively, why the re-analysis resulted in more serious problems with model fitting than the original analyses.

Does excluding models with large CVs underestimate the true uncertainty around the abundance estimates?

Circle backs
Circle-back methodology may more accurately represent the view observers have from a fixed-wing aircraft and therefore could, in certain circumstances, be a useful way of estimating availability bias. However, MacKenzie & Clement appear to have devised their own methods rather than using methods which already appear in the literature (e.g. Hiby 1999; Thomsen *et al*. 2005). Both these studies use methods which account for animal movement. Without accounting for movement, there is the potential for dolphins to move out of the survey strip and therefore be undetectable on the second pass.

Other potential issues which require further discussion include:

Large differences between areas, years and methods for estimating availability.

For example, see tables T.9, T.15 and T.21 in the supplementary material.

In Table T.21 circle-back estimates of availability range from 0.09 (Kaikoura 0-4 nmi offshore) to 0.96 (Pegasus Bay 4-12 nmi offshore).

Dive cycle estimates show a strong North-South pattern (e.g. Table T.9) with availability declining from 0.63 in the North to 0.40 in the South.

Circle back estimates either show no obvious North-South pattern (e.g. Table T.15) or the opposite pattern, with availability increasing from 0.20 in the North to 0.58 in the South (Table T.19).

Unmodelled heterogeneity can cause serious problems in circle-back analyses (e.g. Thomsen *et al*. 2005). For example, with increasing distance from the trackline both observers may see an increasing proportion of highly detectable dolphin groups (e.g. larger groups, fast moving, jumping). This may be worse if observers do not concentrate on the trackline.

As pointed out by Hiby (1999), in high density areas a higher number of non-duplicate sightings will occur close to the locations expected for duplicates, biasing abundance estimates and increasing the CV on the ESW estimate. In high density areas, Hector's dolphins groups are strongly clustered which may aggravate these problems.

The vast majority of the circle backs were carried out in the two areas of high density and multiple groups were often sighted during a circle back. All advice on circle backs is to avoid this practice in areas of high density.

The relatively small number of circle backs (e.g. 27 in summer and 46 in winter on the WCSI; 41 in summer and 43 in winter on the ECSI) may be contributing to the high variability in the estimates of availability bias and population size.

The relative weighting of circle back and dive cycle data in the final abundance estimates deserves some discussion.

Duplicate identification
An apparently subjective method was used for identifying duplicates in both circle back and normal survey sightings.

The sensitivity of the abundance estimates to duplicate identification could be quantified, following the approach of the SCANS survey (estimating abundance using only definite duplicates vs definite, likely and possible duplicates).

Covariates
Sea state, glare and water clarity information were collected during the survey, yet these environmental covariates are not included in the analysis.

If stratum-specific availability was not estimated for similar conditions to those during the surveys within that stratum, they could potentially be biased. It would be useful to explore the proportion of effort by sea state, cloud cover and other environmental variables during the surveys and availability estimation.

Detection functions
The detection functions for the summer 2013 ECSI survey peak at around 100-200m from the trackline (e.g. Figure T.3). In contrast, the winter 2013 detection function for ECSI and those for the WCSI are highest on the trackline and relatively flat from the trackline to a distance of about 120m (e.g. Figures 4 and T.5)

Some discussion of the apparent change in field protocol over time, and any possible effect on abundance estimates, would be useful.

Uncertainty
In comparing the 2013 summer and winter estimates or comparing the 2013 estimates with published abundance estimates, it appears that MacKenzie and Clement may have underestimated uncertainty (e.g. by failing to include duplicate uncertainty)

Survey design
The survey was not an equal coverage design (inshore and offshore areas within the same strata received different effort levels).

The standard advice on survey design is that transect lines should be oriented so they cross contours of density. Lines oriented alongshore should have been avoided.

Conclusion
Many of the issues with survey protocol, data management (e.g. decisions on which sightings are duplicates) and data analysis concern correction factors (e.g. for availability and perception bias) which could have a substantial impact on the abundance estimates. Bias could be non-trivial for any one of these factors. There is potential for considerable bias if multiple factors are acting simultaneously.

It would be very useful to discuss the issues with the analysis, and correct them if possible. If that cannot be done because data are lacking, it will be important to estimate the associated uncertainty around sources of bias and include them in the overall variance estimates.

ADJUNCT 3

IEG's Second Question and Response

A. The IEG asked the following questions to the authors MacKenzie and Clement

Question 1: Our general question is related to how these model selection criteria for the detection function were applied. Could you please clarify why you did not remove all models with a high correlation value between the intercepts of the detection and the dependence components of the model that was approaching -1? That is, why only remove the large estimates with large correlations, why not also the low estimates with large correlations? And how was 'approaching -1' defined? Is it too naive to remove all models with a value less than -0.95 or some other value? In particular, could you provide us with more discussion on what were the decisions made to remove and keep models from the WCSI winter reduced dataset (Table 11; see below)?

Question 2: Ideally the availability estimates should be derived from a representative sample of the population, where group characteristics could affect the chances of determining duplicates and high density areas could adversely affect the estimates. So what are the general characteristics of the groups that were involved in the circle-backs? Specifically, what is the distribution of group sizes detected in the circlebacks? What is the distribution of the numbers of groups seen on each subsequent circle within a set of circlebacks? How many times were the circlebacks aborted due to high density? And how was high density defined in these abortions?

Question 3: As the authors stated, movement of the animals between the circles should be accounted for. This was dealt with developing what we will call 'movement zones' of 250m and 500m to provide an indication of the potential distance a group could have moved on average. Good idea. We would like to clarify what was done when a 'movement zone' was mostly outside of the search area so that there was little to no chance of a re-detection on a subsequent circle? Were these situations removed? Did this even occur? If yes, how many times?

Question 4: Given group characteristics like group size and unrecorded behavioral characteristics that can influence the group's chances of being detected, did you consider modeling the circle-back data using groups as a random effects variable to account for possible unspecified correlations within groups that could account for group specific behaviors affecting detectability and diving characteristics?

Question 5: In general the availability estimates were fairly variable. Variability is expected because animals are after all individuals and so they do their own thing (not the average like we want them to) and many natural factors affect the amount of time that they spend at the surface and below the surface. However, particularly for ECSI winter (in Section T in the 2016 supplement document), some average predicted values seem unlikely (0.09 and 0.94 for example). Could you speculate why you think this is? Are these extreme values and the general level of variability driven by the statistical models or are there physical/biological reasons for the variability? Such as: very clear or murky waters? Prey species are found only deep down or at the surface in different areas or seasons? Group sizes differed? Small samples sizes, so one circle back has forced these extreme values? What do the Hector's feed on? Is there significant variability in what is eaten from place to place, inshore versus offshore, summer versus winter? Any light you can shed on this issue would be helpful to validate the results.

Question 6: As is stated on page 37 of the 2016 WCSI paper there appear to be spatial differences in the availability estimates, which seems feasible. Okarito Lagoon is particularly different when using the helicopter (0.38-0.4) versus circle-back (0.5-0.6). Could you speculate why? Could it be the sample size, group characteristics, area, data collection methods, behavioral responses to the helicopter or airplane? In general the helicopter method results in lower availability estimates and thus higher abundance estimates. Could you speculate why? You discussed behavioral responses in the 2014 report. Could this be part of the explanation? It would have been helpful if you had specified if these behavioral differences were statistically different, using even simple tests. They do not appear to be.

Question 7: It interesting that estimates of availability decreased towards the southern areas in the summer ECSI survey (e.g. is near ~0.6 in 'Cloudy' and 'Kaikoura' and ~0.4 in 'Sth Banks' and 'Otago', Table 15, p. 43 and Fig. 19, p. 44 of the 2014 Report; see below) and increased in the winter (e.g. Table 16, p. 45 and Fig. 20, p. 45; see below). Such geographic variability was not as evident in the estimates of availability computed with the circle-back method. What could be driving the differences observed in the helicopter-based estimates? Are there spatial/seasonal differences in group size or in the environment that would make animals more or less difficult to see or dive deeper in some areas? It's interesting that no regional pattern was observed in the WCSI estimates of availability from the helicopter.

Question 8: The estimates of availability bias with the helicopter relies on the dive cycles of dolphin groups. Was there any attempts to investigate the effects of covariates in the dive duration? For example, large groups are likely more available at the surface than small groups. Other potential covariates affecting availability could be sea state, water transparency, tide, presence of calves in the group and others.

Question 9: The question is how were the quantities in the set of criteria (5 seconds, 5 degrees, 1 individual) decided upon? Were other quantities (7 seconds, 3 seconds, etc) investigated and did they have a big effect on the results?

Question 10: Another common, but not universal strategy to determine duplicates and incorporate the uncertainty in this determination is to use the definite-possible duplicate strategy. This is of course also using possible subjective criteria to determine if the duplicate is definitely or possibly a duplicate. Was this strategy considered? If you had used this strategy, given the reasons why you chose the values you used and your particular data, what would you consider to be appropriate criteria for a possible duplicate?

Question 11:

A) What error distribution was used in the GAM: Tweedie? Poisson?

B) Please describe the GAM model structure in more detail: what were the response variables and covariates; was an offset used? If so, what was used as offset?

C) Why wasn't a model variable selection process used to remove covariates that did not contribute anything?

Question 12: The text stated depth was explored in a different analysis as a covariate but was found to be unrealistic. Could you provide a little more information on this investigation? Was depth a continuous variable or were the three depth categories used? Why do you think this did not work? Was there a problem of edge effect?

B. Response provided by D.I. MacKenzie and D.M. Clement on 27 May 2016.

General comment to IEG
Thank you very much for your efforts in reviewing our work. Below we have responded to your questions as well as we can within the limited time available to us; we hope that you find our responses satisfactory. However, we would like to take this opportunity to note that we are aware improvements could be made to certain aspects of the study, as is the case with any similar undertaking, particularly in terms of accounting for availability bias. As commented on below, reliable estimation of availability is something that we raised during the early design phase for the ECSI survey and we still feel that this is an area that needs further development; not only in terms of analytic methods, but also field trials of different technologies, especially for collecting accurate information offshore. The dive-cycle and circle-back approaches were identified as the best available options given the logistical and budgetary constraints of these projects. While each have their own drawbacks, it is certainly encouraging that they provide broadly similar results. Finally, we would not be surprised if alternative analyses of the data yield abundance estimates that could differ from ours by 500 or even 1,000 animals. That would be completely in-keeping with the level of precision associated with our estimates. Regardless, this would not alter the inescapable conclusion that these recent surveys suggest the population size of Hector's dolphin is much larger than previously thought.

Question 1
While one could take the approach of excluding all models with a high negative correlation between the intercept terms, our experience from fitting models to real and simulated data sets is that the magnitude of the correlation is typically suggestive of a potential problem rather than definitive.

That is, in some cases there may be a high correlation but the methods still produce an acceptable abundance estimate. This is why we used multiple indicators to determine whether a model would be retained in the model set or not. Only models with high estimates were excluded because of the skewed distribution of the estimated abundance. No specific value was used to define 'approaching - 1' although any model that had a correlation that was more extreme than -0.9 (approximately) would be examined further.

Specific to the WCSI winter reduced dataset:

Model 1 was excluded because of high negative correlation, very large abundance estimate and standard error. The abundance estimate is almost twice as large as the second-ranked model, and much larger than any of the other top 9 models. The standard error is also much larger than what was obtained from most of the other top ranked models. In combination, this suggests the estimate may be unstable.

Model 3 was excluded for similar reasons. While the abundance estimate is not as extreme as for model 1, the standard error is still relatively large (in comparison) and the correlation is much closer to -1.

Model 4 was retained even though the correlation is -0.95 as the abundance estimate is similar to that obtained from the point independence models (models 2, 6 and 9) and the standard error is not unreasonably large. Note also that models 1 and 3 (and model 10) have a quadratic relationship between detection and distance, and estimate an intercept term for the correlation component, while model 4 has a simpler linear relationship between detection and distance. Hence, for this particular data set it may be that while the more complex detection models are a better fit to the data, they are producing unstable estimates.

Models 5 and 7 were excluded for similar reasons to models 1 and 3, and again the modelled relationship between detection and distance used a more complex spline function.

Model 8 was also excluded primarily on the basis of the large abundance estimate and standard error, rather than on the size of the correlation term (although it contributed). Note that it also is a constant dependence model which simulations suggested produced excessively high estimates most frequently (MacKenzie and Clement, 2014).

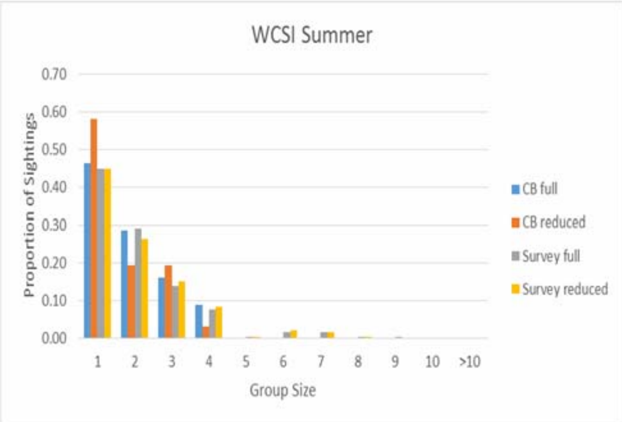
Model 10 was obviously excluded because of the correlation of -1 and completely unrealistic abundance estimate and standard error.

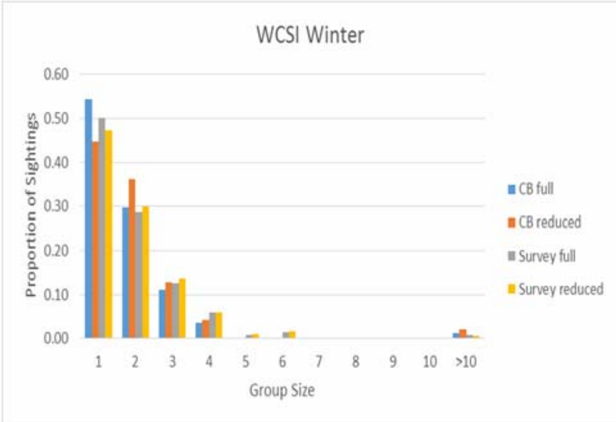
Question 2
As circle-backs were done on the actual on-effort sightings as the survey was underway, the group size characteristics are fairly representative of survey group sizes.

For example, WCSI Table 4 demographics compared to WCSI circle-back demographics:

	Summer			Winter		
	Verified	Full	Reduced	Verified	Full	Reduced
On-effort sightings						
Average Group Size	2.06	2.05	2.10	1.94	1.91	1.93
SD Group Size	1.41	1.39	1.40	1.48	1.47	1.28
Range Group Size	1–9	1–9	1–8	1–16	1–16	1–11
Circle-backs						
Average Group Size		1.88	1.68		1.89	2.19
SD Group Size		0.99	0.91		2.39	3.07
Range Group Size		1-4	1-4		1-22*	1-22*

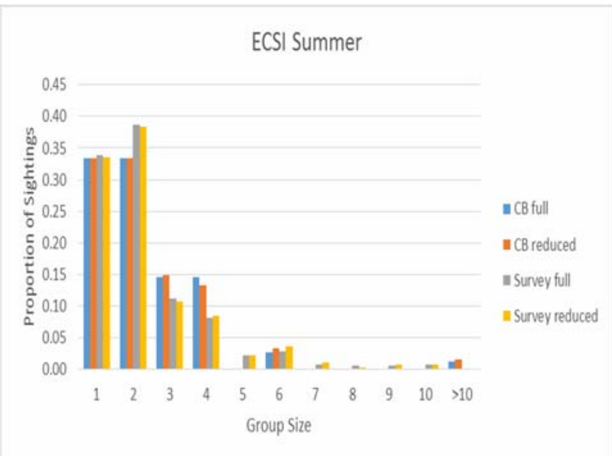
One anomalously large group that started originally as sighting of group of 5 but by 2 circle, was 20-22 animals (all clustered together and pointed similar direction) but as had a few of these larger groups in actual surveys (i.e. groups of 16 and 11), we kept as representative.

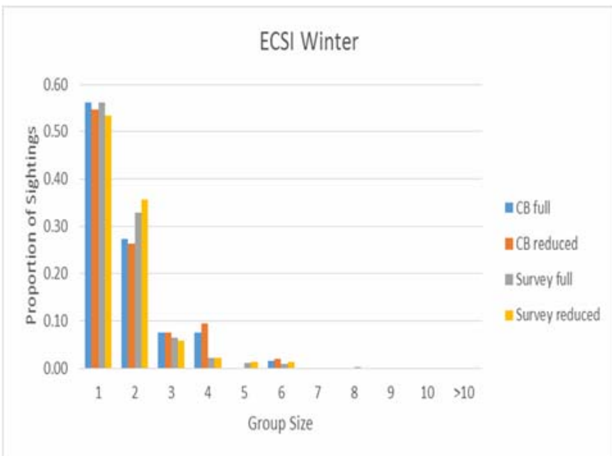




And for ECSI:

	Summer			Winter		
	Verified	Full	Truncated	Verified	Full	Truncated
On Effort Sightings						
Average Group Size	2.3	2.3	2.3	1.6	1.6	1.7
SD Group Size	1.6	1.6	1.6	1.0	1.0	1.0
Range Group Size	1–10	1–10	1–10	1–8	1–8	1–6
Circleback Sightings						
Average Group Size		2.4	2.4		1.7	1.8
SD Group Size		1.7	1.9		1.1	1.1
Range Group Size		1-13	1-13		1-6	1-6





Observers attempted to select sightings for circle-backs attempts that were:

Not further than ~30° angle out from window (front or back), as good chance dolphin group could move out of viewing zone on subsequent circles.

Specifically targeted on-effort sightings in more offshore regions (as deemed unusual and harder to get good sample size on) or in strata in which we weren't expecting many sightings; otherwise try and attempt at least 1-2 circle-back attempts on each flight.

If other observers (particular one on same side as availability call) had more than 2 other sightings just prior or within 20 secs of original call (at this point pilot would ask for decision before turning off-effort), they would abort availability. We had no criteria related to group size or behaviours (as difficult to accurately discern given limited viewing time and when multiple groups present, so not recorded).

Unfortunately we did not keep records on how many circlebacks were aborted as observers continued surveying until the pilot called off-effort (approximately 20 secs after call and only if no one called the circleback off). However from memory, we aborted an attempt every few flights (e.g. WCSI took 29 flights to complete), more usually in strata with high concentrations of groups or areas where we already had plenty of previous attempts (i.e. close to shore, etc). Circlebacks were rarely aborted once the pilot had started circling, even if extra groups popped up later into the availability. We figured it would be easier to deal out any problematic attempts in post-processing at that point. Our most complicated circleback had 5 different sightings occur.

Question 3
The situations in which a group was most likely to move out of the search area (i.e. higher angles) were vetted in 2 ways initially; 1) observers were encouraged to call circle-back attempts on deep sightings mainly, and specifically asked to consciously try not to call any circleback attempts on sightings at angles higher than 30° and 2) all sightings (including any other groups sighted other than original circleback sighting) were truncated to 300m (27°) regardless, by the method's protocol, prior to analyses. In additional and prior to truncation for analyses, each circleback was manually analysed through visualisation in GIS.

For example with WCSI summer full data, approximately 4 out of the 15 sightings removed by manual analyses or truncation were due to the initial location of the sighting. Out of the 56 sightings used, ~21% had a 50/50 chance of the group remaining in or out of the search area by the last circle. We left 10 of these in the analyses while 2 had the last circle dropped due to deteriorating plane or track conditions.

Question 4
No, including a random effect was never considered. It is an interesting idea, although off the top of our heads we're not sure how easily that would then be to incorporate into the abundance estimation.

Question 5
While there could certainly be some biological factors at play in some situations, in this case we suspect it may be a case of some availability models over-fitting the data due to small number of circle-backs in some regions and off-shore strata. This was briefly discussed at an AEWG meeting and it was decided that the models should be retained for consistency.

Question 6
It is not clear why the different methods produce different availability estimates. It could be due to any combination of the factors that you list, or others. The behavioural responses discussed in the 2014 report only occurred when the helicopters (twin or single) made a quick sidewise turn to circle back on a spotted group (animals quickly dove or speed off). Once noticed, we instructed the helicopter pilots not to use such maneuvers. No further behavioural reactions were noted after that and we did not record behavior as part of the CB/survey sightings. Both single and twin-engines (noisier helicopters) were used in the ECSI summer Cloudy Bay strata. Twins were not used in any other ECSI strata or at all in the WCSI due to their lack of availability and cost. R44 single engines were used.

We fail to see how testing whether any difference is 'statistically different' would be helpful given the objectives of this project, especially as it is unknown which might be more accurate. How would the result of a statistical test be incorporated into the abundance estimation process, and how would that be an improvement over our present approach?

We recognise that accurate estimation of availability is a critical component of estimating total abundance and we voiced some concerns about how it had been previously estimated for Hector's dolphin, and the limited ability to properly assess it as part of these projects, in the early design phase of the ECSI survey.

Question 7
We are unsure as to why given that in both surveys, the helicopter data was not collected in any regular or systematic direction (i.e. north to south or vice versa) that could account for seasonal differences (i.e. summer – cloudy, N & S Banks in combination and dependent on weather, Otago, kaikoura; winter – Kaikoura, N & S Banks in combination and dependent on weather, Cloudy) Otago animals were generally harder to locate and keep track of despite sampling over several different days and slightly larger group sizes. But there was nothing noticeable different at time to other strata (calf presence, initial behavioural states, water types, Beaufort, etc.), other than that they were found in same general area each day.

	Cloudy	Kaikoura	N Banks	S Banks	Otago
Summer Helicopter sightings					
Average Group Size	2.76	2.23	2.19	2.36	3.92
SD Group Size	1.09	0.75	0.75	1.22	1.88
Range Group Size	1-5	1-4	1-4	1-5	1-7
Winter Helicopter sightings					
Average Group Size	2.06	2.83	1.94	2.31	NA
SD Group Size	0.57	0.98	1.03	0.95	NA
Range Group Size	1-4	1-4	1-5	1-4	NA

Given the relative small sample sizes and general overlap in confidence levels, it is unlikely that these patterns are as strong as they might appear from the graphs.

In WCSI, Okarito was consistently lower than other strata and it was the stratum with very murky inshore waters due to glacier melt.

Question 8

No attempt was made to incorporate covariates into the analysis of the dive-cycle data. This was briefly considered but would have required a multi-variate analysis (as both time near and below the surface are response variables), which tend to be sensitive to non-normality of the data. There is also the issue of how a more complex analysis of the availability data would be incorporated into estimating total abundance. When availability is specific to a certain set of covariate values then abundance must be estimated at those covariate values. Such an approach would be possible (provided the covariate was measured for the sighting data), although would be more complicated than the present analysis.

It should be noted that a more complex approach would only be beneficial if the range of values for any covariate that is having a substantial effect on availability, is markedly different from the range of values for that covariate in the sighting data. Just because a covariate has an important effect on availability does not invalidate the use of an estimate that ignores that covariate as an 'average' estimate.

Question 9

Criteria for matching duplicates came from previous experience on several earlier aerial surveys for Hector's dolphin (i.e. Rayment *et al* 2010, Rayment & DuFresne 2007, DuFresne & Mattlin 2009, DuFresne *et al*. 2010) and these were originally based on Slooten *et al*. (2004).

We didn't play around with quantities too much other than during training at the beginning of the first survey. Since we decided upon allowing some flexibility in the criteria and general agreement needed in 2 out of 3 criteria (or some other obvious sighting cue, like presence of calf or birds at surface), we felt the final criteria quantities represented the average situation.

Note that all duplicates were matched for each flight immediately after landing and transcribing data. Then the observer leader and myself went through each again. If we were unsure of any matches, these were discussed with both observers again and they had final word.

Rayment, W.; Clement, D.; Dawson, S.; Slooten, E.; Secchi, E. (2010). Distribution of Hector's dolphin (*Cephalorhynchus hectori*) off the west coast, South Island, New Zealand, with implications for the management of bycatch. *Marine Mammal Science 27*: 398−420

Rayment, W.; DuFresne, S (2007). Offshore aerial survey of Maui's dolphin distribution 2007 Final report to Department of Conservation - Auckland Conservancy. 6p

DuFresne, S.; Mattlin, R. (2009). Distribution and Abundance of Hector's Dolphin (*Cephalorhynchus hectori*) in Clifford and Cloudy Bays (Final report for NIWA project CBF07401). Marine Wildlife Research Ltd.

DuFresne, S.; Mattlin, R.; Clement, D. (2010). Distribution and Abundance of Hector's Dolphin (*Cephalorhynchus hectori hectori*) and Observations of Other Cetaceans in Pegasus Bay. Final Report to the Marlborough Mussel Company, Baseline Monitoring for Environment Canterbury Consent CRC21013A.

Slooten, E.; Dawson, S.; Rayment, W. (2004). Aerial surveys for Hector's dolphins: abundance of Hector's dolphins off the South Island west coast, New Zealand. Marine Mammal Science 20, 477–490.

Question 10

We did not consider this strategy, but we did briefly investigate the possible consequences of misidentifying groups as a resight of an already sighted group (so too many duplicate sightings) and of misidentifying a group sighted by both observers as two unique groups in response to a ESCI review question by Prof Phil Hammond (Section Q, MacKenzie and Clement 2014, supplemental material). We concluded that in the former case abundance is likely underestimated, and overestimated in the latter. The level of bias depended on the misidentification rate, and also the detection probability (see below).

Table Q.1: Effect of incorrectly assigning sightings of groups by different observers as duplicate sightings of a group. Duplicates is the number of groups recorded as sighted by both observers, Front only is the number of groups recorded as sighted by the front observer only, Rear only is the number of groups recorded as sighted by the rear observer only, Unique is the recorded number of groups sighted at least once, *N* is the estimated abundance, *p* is the apparent detection probability for each observer and *p is the apparent probability of a group being detected at least once. *p* and *p** are similar to perception bias.**

	Misidentification Rate				
	0.00%	1.00%	5.00%	10.00%	20.00%
Duplicates	125	126	131	138	150
Front only	125	124	119	113	100
Rear only	125	124	119	113	100
Unique	375	374	369	363	350
N	500	495	476	455	417
p	0.50	0.51	0.53	0.55	0.60
*p**	0.75	0.75	0.77	0.80	0.84

Table Q.2: Percent relative bias in estimated abundance for different true levels of detection and misidentification rates.

	Misidentification Rate				
p	0.00%	1.00%	5.00%	10.00%	20.00%
0.3	0.00%	-2.00%	-10.00%	-19.00%	-32.00%
0.5	0.00%	-1.00%	-5.00%	-9.00%	-17.00%
0.7	0.00%	0.00%	-2.00%	-4.00%	-8.00%

Table Q.3: Effect of incorrectly assigning duplicate sightings as unique group sightings for each observer. Duplicates is the number of groups recorded as sighted by both observers, Front only is the number of groups recorded as sighted by the front observer only, Rear only is the number of groups recorded as sighted by the rear observer only, Unique is the recorded number of groups sighted at least once, *N* is the estimated abundance, % RB is the percent relative bias, *p* is the apparent detection probability for each observer and *p is the apparent probability of a group being detected at least once. *p* and *p** are similar to perception bias.**

	Misidentification Rate				
	0.00%	1.00%	5.00%	10.00%	20.00%
Duplicates	125	124	119	113	100
Front only	125	126	131	138	150
Rear only	125	126	131	138	150
Unique	375	376	381	388	400
N	500	505	526	556	625
% RB	0.00%	1.00%	5.00%	11.00%	25.00%
p	0.50	0.50	0.48	0.45	0.40
*p**	0.75	0.74	0.72	0.70	0.64

Question 11
According to documentation of R package *dsm*: family=Quasi-Poisson.

Response variable was the estimated abundance along a segment. Covariates were a bivariate spline using easting and northing, with additive distance from shore and (for ECSI) depth effects. In R notation, Nhat~s(easting,northing)+depth+dist.

No offset was used for the estimation (from package documentation), although an offset was used to predict density for each cell when creating the surface. The offset in this case was cell area.

Variable selection wasn't used as the purpose of the DSM was to provide a descriptive surface of estimated abundance indicating the possible distribution of Hector's dolphin around the South Island, and not to identify which factors are most important to adequately describe that surface.

Question 12
This is for WCSI and it was found that when depth was included in the DSM (as a continuous covariate) the predicted density surface was a very poor match to where sightings occurred. It is not clear why there was a problem with the depth covariate for the WCSI, but not ECSI; possibly it's related to the relative range and distribution of values on each coast, or possibly the degree of correlation with the distance from shore covariate on each coast (depth increases much more rapidly along the west coast with distance offshore than the east coast).

[APPENDIX 3 – DATA TABLES FROM NATIONAL PROGRESS REPORTS - TO COME]