Annex F

Report of the Sub-Committee on In-Depth Assessments

Members: Palka (Convenor), Allison, Aoki, Archer, Baba, Baker, Bironga, Brownell, Buss, Butterworth, Charlton, Cipriano, Cooke, de Moor, Debrah, Donovan, Fujise, Goetz, Goodman, Goto, Hakamada, Herr, Hosoda, Hubbell, Iñíguez, Jimenez, Kato, Kishiro, Kitakado, Lang, Lee, Lent, Maeda, Mallette, Matsuoka, Miyashita, Mizroch, Morishita, Morita, Moronuki, Mueni, Murase, Nelson, Nio, Øien, Pastene, Punt, Reeves, Robbins, Seakamela, Sohn, Stack, Suydam, Suzuki, Taguchi, Takahashi, Tamura, Urbán, Walters, Weinrich, Weller, Wilberg, Wilson, Yasokawa, Yoshida, Zerbini.

1. INTRODUCTORY ITEMS

1.1 Introductory remarks
Palka welcomed the participants.

1.2 Election of Chair
For this meeting Palka was elected Chair and Herr co-Chair.

1.3 Appointment of Rapporteurs
Cooke, Herr and Palka agreed to act as rapporteurs.

1.4 Adoption of Agenda
The adopted Agenda is shown in Appendix 1.

1.5 Documents available
The documents considered by the sub-committee were SC/68A/IA/01-IA/04.

2. COMPREHENSIVE ASSESSMENT OF NORTH PACIFIC HUMPBACK WHALES

2.1 Progress on intersessional work
Work towards a Comprehensive Assessment of North Pacific humpback whales began in 2016, and included an intersessional workshop held in April 2017 and summarised in Item 4 in IWC (2018). During 2018 at SC/67b, four potential stock structure hypotheses were proposed that were largely consistent with existing data, in particular with the results obtained by the SPLASH project. However there were still questions about the connections among the proposed breeding and feeding areas. These might be addressed by analyses of photo-ids taken after the SPLASH project.

Over the past year, Cheeseman pursued improvements to the automated photo-identification matching algorithm that is the technical basis for his website *happywhale.com*. Google agreed to sponsor a competition on the Kaggle platform to develop an automated matching program, which attracted a large number of entries. The top performers among responses to this competition achieved matching rates of greater than 97%, and were able to successfully match even highly challenging humpback whale fluke photos. The latter include images with poor orientation towards the camera (much rotation or distortion, or overall poor quality), and the winning entries all successfully matched images based upon shape and/or pigment, including the smallest details of the trailing edge. Tests of the new algorithms (one in particular) have correctly identified matches from calves to adults that were very difficult for the human eye to detect, and have also found many previously unrecognised duplicates in every catalogue available to *Happywhale*, including those that have been manually searched through for (in some cases) literally decades. The algorithm successfully matched other 'difficult' flukes, including the previously problematic all-white tails from Southern Hemisphere animals. The matching rate for good quality photos is better than 99%. This powerful new tool largely eliminates the need for manual matching (certainly at any significant level of effort).

At the same time, Cheeseman developed a collaboration with many of the major contributors of North Pacific humpback whale photos. Together with the new algorithm, this now provides an opportunity to conduct a large-scale updated matching exercise across much of this ocean basin, as was recommended by the Scientific Committee at SC/67b. The results of such an exercise are expected to further refine our understanding of population structure and interchange rates in the North Pacific, including for areas that were under-represented during the SPLASH project (SC/68A/IA/02).

2.2 Preparation of data for assessment
2.2.1 Stock structure hypotheses

The sub-committee **welcomed** the developments of the successful *Happywhale* matching algorithm and the recent collaborations because these could address some of the questions remaining about the stock structure hypotheses. The sub-committee previously noted that because of the lack of general coordination among local research groups one of areas with a data gap is in waters around Japan in the Western North Pacific. Specifically, the waters around southwest Japan, Amami-Ohshima Island, Kikaijima Island and Hachijoijima Island are considered new areas that have major aggregations and are part of the stable migration routes (in addition to Borin Islands and Okinawa Islands that are already known to be along the migration routes). Kato expects Yoshida will be able to coordinate research and possible data sharing among these Japanese regions. The sub-committee **welcomed** this collaboration in light that this contribution will enhance the photo-matching exercise and advance our knowledge on the stock structure of the North Pacific humpback whales.

Attention: SC, G

At SC/67B, the Committee recommended that a large-scale matching effort of recent Pacific humpback whale photo-ids taken after SPLASH be conducted to help clarify the connections among the feeding/breeding areas within the North Pacific. Since then, the Happywhale matching algorithm was improved and a collaboration between many contributors was initiated. To obtain the most robust assessment and thus conservation advice, the sub-committee ***recommended*** *that the large-scale matching effort be conducted using as many photo catalogs that are currently available. The sub-committee also* ***encouraged*** *all catalog holders to participate in this exercise, after the appropriate data sharing agreements are made.*

It was noted that the matched photos may also be used to estimate abundance, subject to consideration of the potential biases and differential survey effort.

During SC/67b the SC recommended to assess the feasibility of a mixed-stock genetics analysis in the feeding grounds to better inform the allocation of catches for the assessment model. After discussion, the sub-committee **agreed** results from this analysis could provide valuable information and **encouraged** the input data be prepared which can only start after the stock structure hypotheses are re-evaluated and the SPLASH project database is re-stratified to follow new definitions of the breeding and feeding grounds. Then, time and funding permitting, the mixed-stock analysis could be conducted by Baker.

2.2.2 Abundance, catch histories and life history parameters

No new information on abundance, catch histories, and life history parameters was presented this year.

If the proposed matching exercise results in modified stock structure sub-areas, then the historical abundance estimates and catch history would also have to be modified to reflect the modified sub-areas. For input into the assessment model it will be necessary to go through the list of abundance estimates previously assembled during the 2017 Workshop and the more recent IWC-POWER abundance estimates (Inai *et al.*, 2018) discussed last year to re-calculate abundance estimates for each sub-area. The sub-committee **agreed** that the abundance estimates should be re-calculated in light of any new stock structure modifications.

Consideration should be given to the time period used in the assessment, and specifically whether historical catches before the modern era should be included.

The life history parameters summarised in Zerbini *et al.* (2010) may be utilised.

2.3 Assessment model

As previously, the sub-committee **agreed** that a simplified age-aggregated model should be used for the assessment. After the matching exercise and re-evaluation of the stock structure hypotheses is completed, the sub-committee **agreed** that previously suggested sensitivity cases will need to be re-evaluated.

3. IN-DEPTH ASSESSMENT OF NORTH PACIFIC SEI WHALES

3.1 Progress on intersessional work

The intersessional group prepared data inputs for the preliminary modelling work. The catch history, relative abundance data, and absolute abundance estimates were used as tabulated in last year's report with minor corrections. A reanalysis of the marking data (presented in SC/68A/IA/03 - see Item 3.2.3) yielded a subset of the marking data that was used for the preliminary assessment model runs.

The assessment model outlined in Punt (2018) was updated to incorporate the features requested by last year's sub-committee. A specification of the revised model and results of preliminary runs using the new data inputs were presented in SC/68A/IA/01 (see Item 3.3).

3.2 Review data for assessment

3.2.1 Stock structure hypotheses

Last year the sub-committee agreed to proceed with two stock structure hypotheses for modelling purposes: (i) a single stock in the entire North Pacific; and (ii) five stocks with some overlap in feeding areas. Last year, the sub-committee had agreed that the evidence for multiple stocks was weak. However, because virtually all the genetic samples had been obtained in just one of the putative sub-areas (the Pelagic sub-area), the sub-committee was not able to reject the hypothesis of multiple stocks at this stage. The sub-committee emphasised that this decision to proceed does not imply endorsement of either hypothesis at this stage.

The preliminary model runs conducted intersessionally and reported in SC/68A/IA/01 (see section 3.3) had failed to fit the 5-stock model, but the sub-committee found that an erroneous stock mixing matrix had been used for this hypothesis. This was a possible cause of the failure to converge. The sub-committee **agreed** to proceed with the 1-stock hypothesis and the 5-stock hypothesis as specified last year (IWC, 2019). A 3-stock model had been fitted in SC/68A/IA/01 as an alternative to the failed implementation of the 5-stock hypothesis, but this was not considered further by the sub-committee. At this meeting, the sub-committee reviewed in detail only the results for the 1-stock hypothesis but expects to review revised results for both the 1- and 5-stock hypotheses intersessionally and at next year's meeting.

Last year, the sub-committee recommended that when feasible, any researcher working in the North Pacific tag sei whales in one or more of the other sub-areas to assist in quantifying the movement patterns of the animals. During the NEWREP-NP 2018 cruise, satellite tags were deployed on 8 sei whales and 1 minke whale, as reported in SC/68A/SP/02 (see fig.10). Sei whales were tracked for up to 40 days and moved up to about 350 n.miles. The sub-committee **welcomed** this contribution that provides the much-needed information on modern movement patterns and **recommended** that further sei whales be tagged by expeditions in the North Pacific whenever the opportunity arises.

3.2.2 Absolute abundance

The agreed positive abundance estimates to be used in the model were tabulated last year (IWC, 2019, Appendix 5) and had been used in the intersessional assessment modelling, but the previous zero estimates could not be used without further information. In addition, the 2018 POWER cruise in the central Bering Sea also yielded zero sightings. The sub-committee noted that in fact 1 sighting had been made in the Aleutian area and corrected the table accordingly. The effort information required to use the zero estimates was extracted. Table 1 of Appendix 2 contains the updated abundance estimates including both zero and non-zero estimates and the extra information needed to use the zero estimates for fitting the assessment model. Intersessionally all the abundance estimates to be used in the assessment should be finalised and documented appropriately.

The sub-committee **agreed** that the sensitivity of the assessment model fits to potential additional variance in the abundance estimates based on the POWER and JARPN-II surveys should be examined. The potential additional variance arises from the fact that the area was not all surveyed within a single year, and there may be shifts of distribution between years within the Pelagic sub-area. In view of the virtual absence of sei whale sightings in the Bering Sea and in the 2013-16 POWER cruises south of 40°N, the sub-committee considered that variance due to movement within the survey season into and out of the area covered by the population estimate (which would lead to a variable negative bias) would probably not be substantial. However, movement between the areas surveyed in 2010-12 could be substantial and would lead to additional variance.

Direct estimation of additional variance in the POWER estimates was not possible due to lack of repeat surveys, but Kitakado conducted a preliminary analysis of additional variance in the JARPN-II abundance estimates (Appendix 3). The sub-committee requested that this be refined intersessionally to constrain the total population size across areas and that the results be provided to the proposed intersessional group.

The sub-committee noted that the 2019 POWER cruise is scheduled to re-survey the US EEZ between 130°W-170°W. This area was surveyed in 2011-12 without any sightings of sei whales. Because the potential movement of whales between areas can make non-synoptic surveys hard to interpret, the sub-committee **agreed** that using data from the 2019 cruise was not a high priority for the assessment modelling, even if sei whales are seen on the 2019 cruise, but agreed that the proposed intersessional group could reconsider this.

3.2.3 Relative abundance

The sub-committee agreed that the relative abundance index from Japanese scouting vessels and dedicated surveys that was compiled last year (Appendix 4, IWC, 2019) contained useful additional information and should continue to be used in fitting the assessment model. However, it was a crude index. The sensitivity of the assessment model fits should be examined with respect to: (i) possible additional variance in this index; and (ii) a possible degree of non-linearity in its relationship to abundance, modelled as a power function.

3.2.4 Marking data

SC/68A/IA/03 contained an analysis of the *Discovery* marks placed during 1949-81, to address the issues that were identified last year regarding uncertainty in the species of whales marked, the number of marks successfully placed, and recovery rates. Whales recorded as multiply marked were significantly more likely to be recovered than singly marked whales, but usually with fewer marks than were recorded as placed. The recovery rate *per mark* was also higher in multiply marked whales, for reasons which are not obvious. Taking account of species uncertainty (between sei, Bryde's and fin whales) each mark was assigned to one of three categories: A (number of marks placed and size of recapture sample known); B (size of recapture sample known but number of marks placed uncertain); and C (both mark and recapture samples unknown). Category A marks convey information about movement and abundance: category B marks provide information only on movement; and category C marks provide only anecdotal information about movements. Category A summer marks were used in the intersessional modelling work.

The sub-committee endorsed this analysis and **agreed** that the assessment model of SC/68A/IA/01 should be extended to make use of: (i) winter marks; and (ii) category B marks.

Because there were virtually no catches in the winter months, and there is no winter abundance data, it is not necessary to model the winter distribution of the sei whale populations(s). It is sufficient to assign the marks placed in winter to putative stocks. Based on recovery positions, it was agreed to assign the Japanese marks placed in winter (1972-75) to the Pelagic stock for the multi-stock hypothesis, or to the single North Pacific stock for the single-stock hypothesis. This is supported by a high recovery rate of these marks and almost all marks were recovered in the Pelagic area.

The US whale marking program marked sei whales in 1962 and 1965. All marks were placed south of 36°N. One of these marks was recovered in the Eastern North Pacific sub-area and another was recovered near the northeastern line of the Pelagic sub-area. It was agreed to assign these marks to the Eastern North Pacific migratory stock for the multi-stock hypothesis, or to the single North Pacific stock for the single-stock hypothesis.

The category B marks were incorporated into the assessment model by modifying the likelihood to condition on such marks being recovered (somewhere), while the sub-area of recovery (and the catches in that sub-area) contribute information to the likelihood.

The revised table of marks and recoveries for use in the assessment model is given in Appendix 4, along with revised estimates of the 'reporting rate' (which depends on both the proportion of marks recorded as hits that are effectively lodged and the detection rate of marks in captured whales). These were accepted by the sub-committee.

The sub-committee **agreed** that the marking data and their mode of use in the assessment model are now finalised.

3.2.5 Catch history

The catch history compiled last year (Appendix 5, IWC, 2019) was extended to 2018 and the sub-area breakdown for 2016-17 was corrected.

3.2.6 Life history parameters

SC/68A/IA/04 presented a summary of an analysis of biological parameters for North Pacific sei whales by Ishikawa (2013) originally submitted as their Master's thesis. This was based on samples from commercial pelagic whaling (1962-75) and JARPN-II (2002-10). The length at first ovulation showed no significant trend over the entire period, averaging about 13.7m. The apparent pregnancy rate also showed no trend, remaining around 70-80%. The proportion mature by age appeared to show higher proportions (i.e. lower age at maturity) during 1971-75 as compared with 1966-70 or JARPN-II (2002-10), which was attributed to the effects of exploitation. The age at 50% maturity was about 5 years in the middle period and 7 years in the earlier and later periods. The mean age at maturity from transition layer readings was somewhat higher, but also suggested a decline followed by an increase over the same period.

The sub-committee recalled a value of 10 years for the age at 50% maturity of animals from the Eastern Coastal area that had been reported by Rice (1977) and recalled there were caveats over the interpretation of transition layer data, as discussed in previous Committee discussions (IWC, 1984). The sub-committee noted that nevertheless the broad trends in the indices were generally consistent with the response expected in at least some demographic parameters from a population impacted by initially high and then substantially reduced catches, and therefore provided auxiliary support for the assessment model results.

The age at maturity of 5 years used in the assessment model was roughly consistent with the proportion at 50% maturity in the whaling data for the middle period. The sub-committee did not expect that the results from the assessment model would be sensitive to the age at maturity, but noted that a sensitivity test based on the observed values by time period and/or stock area could be performed if time permitted and data were available.

3.3 Assessment model

SC/68A/IA/01 specified the updated age-, sex-, and season-structured population dynamics model developed to conduct an assessment of North Pacific sei whales based on the recommendations of the IA sub-committee in 2018.

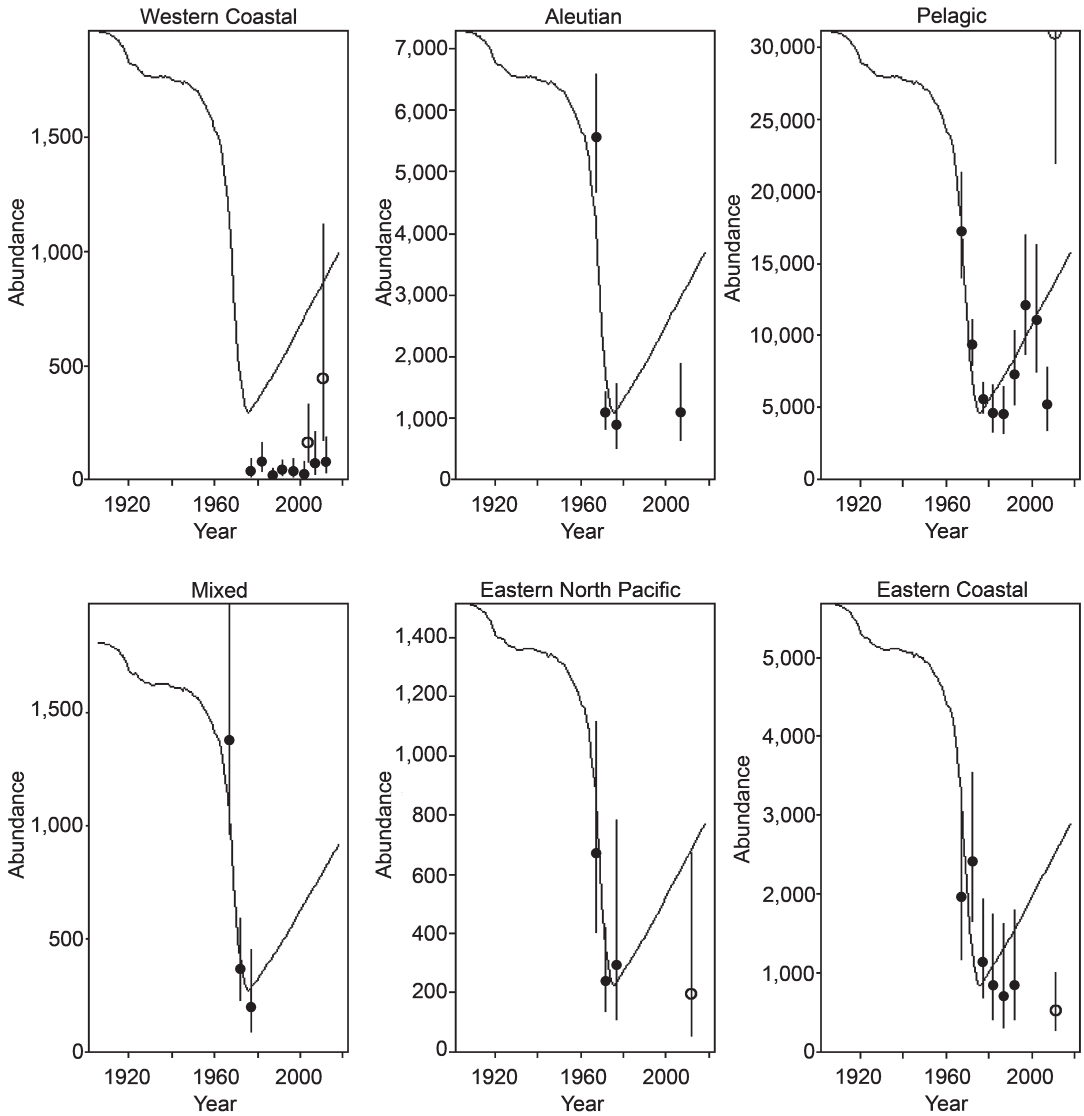

Fig. 1. Time-trajectories of summer 1+ abundance by sub-area with the estimates of absolute (open circles) and relative (closed circles) abundance. The vertical lines denote 95% confidence intervals based on the sampling CVs. The lines are the model predictions from the single-stock model where the reporting rates are set to the default values (Model A0).

'Stocks' in this model may correspond to different biological populations or may merely reflect differences in data spatially, and are hence 'movement strategies' or a lack of complete mixing within a biological population. The model is fitted to estimates of abundance (relative and absolute), and mark-recapture data. It can now utilise minimum abundance estimates, account for differential probabilities of tag reporting as a function of number of hits, and better handle situations in which catches in some years are high relative to the estimates of available numbers. A key assumption of the model is that the proportionality for the relative abundance indices is constant over time and area. Preliminary base-case models were undertaken for single-stock, 3-stock, and 5-stock hypotheses. The base-case model for the 5-stock hypothesis did not converge because it appears to be over-parameterised. Results are shown for various sensitivity analyses based on the single and 3-stock hypotheses, including those in which the weights assigned to the various data sources are changed. The 3-stock model fit the data better than the single-stock model according to the negative log-likelihood but both models have poor model diagnostics. In particular, the models could not simultaneously match the estimate of abundance of 30,919 (CV 0.208) and the trend in relative abundance for the Pelagic area. In addition, the models predict the stocks increased after the reduction in catches, but this was not consistent with the trends in abundance for the Western Coastal, Aleutian and Eastern North Pacific areas. To illustrate this problem, the fits to the base-case single-stock model are shown in Fig. 1.

The sub-committee thanked Punt for running these assessment models and his patience when promoting us to provide input data and feedback.

As noted above, the failure of the 5-stock model may have been due to an erroneous mixing matrix, and the 3-stock alternative was not considered further by the sub-committee. The sub-committee's discussion focussed on the results for in the 1-stock model.

The sub-committee discussed the lack of fit of the model to the available data. It was difficult to reconcile the high recent estimate of absolute abundance in the Pelagic area from the POWER cruises (2010-12) with a historical depletion of the pelagic sub-area, as evidenced by the relative abundance data from scouting, the mark-recapture data, and the catch per unit effort used in the Committee's previous assessments (Tillman, 1977). The low abundance and apparent lack of recovery of sei whales in the western coastal, Aleutian and eastern areas was also hard to reconcile with the 1-stock hypothesis.

Table 1

Work plan for IA.

Topic	Intersessional 2019/20	2020 Annual Meeting (SC/68b)	Intersessional 2020/21	2021 Annual Meeting (SC/69a)
Comprehensive Assessment of North Pacific sei whales	Re-establish the ISG (Annex T) to further data preparation and development of the assessment model	Review progress of intersessional work and continue/finalise the assessment	If needed finalise/ continue preparation of assessment	As needed, review progress of intersessional work and finalise assessment
Comprehensive Assessment of North Pacific humpback whales	Re-establish the ISG (Annex T) to further data preparation, development of the assessment model and hold a Workshop	Review progress of intersessional work and continue the assessment	Finalise/continue preparation of assessment	Review progress of intersessional work and continue/finalise the assessment

The sub-committee noted that the lack of fit could be ameliorated somewhat by allowing some additional variance in the absolute abundance estimates and relative abundance index, as discussed in Item 3.2.2, and **agreed** that appropriate sensitivity runs incorporating additional variance be conducted. However, the sub-committee recognised that a more fundamental problem remained, and that alternative model structures need to be considered.

The contradiction between a historical decline and high abundance in the pelagic area could potentially be reconciled with a changing *K* (carrying capacity). A changing *K* is best modelled as random effects, possibly allowing changes only at fixed intervals, such as 10 years, either stepwise or piecewise linear, if this facilitates computation and fitting. The variation in *K* can be modelled either as variation in density-dependent recruitment or variation in density-dependent mortality.

The lack of recovery in the western coastal, Aleutian, and eastern area may be easier to fit with the multi-stock model, but could also potentially be fitted with a single-stock model that allowed for a relatively slow, density-dependent redistribution of whales between areas following depletion. Concerns were expressed that a full redistribution among feeding areas may be implausible given prey, sea surface temperature and other oceanographic differences among the areas.

4. REVIEW OF BUDGET REQUESTS IN LIGHT OF THE TWO-YEAR BUDGET AGREED LAST YEAR

There are no new budget requests this year.

5. WORK PLAN

5.1 Comprehensive assessment of North Pacific humpback whales

In light of the development of the new matching algorithm, the following work plan was **agreed** to progress this assessment:

(1) Provide 'dummy' datasets of abundances and catches to Punt to allow the development of the framework of the assessment model. Timeline: 15 July 2019.
(2) Revise abundance estimates using 2010-18 POWER survey data; led by Kitakado. Timeline: complete by October 2019.
(3) Update North Pacific photo-id matching using the new matching algorithm with as many photo data collections as possible including the 2019 IWC-POWER data; develop report with technical details and performance diagnostics; led by Cheeseman. Timeline: complete by January 2020.
(4) Review the results of the photo-identification matching exercise in Step (3), and revise stock structure accordingly during a one-day intersessional meeting in Seattle, WA (and call-in as needed) involving the appropriate intersessional steering group members and chaired by Clapham. Timeline: winter 2020, perhaps January, after the matching in Step (3) is complete. No funding is requested.
(5) Revise and document whaling catch allocations in light of any changes arising from Step (4); led by Ivashchenko. Timeline: winter 2020 after Step (3).
(6) Revise and document sampling strata for the abundance estimates, and estimate interchange rates using the updated comprehensive mark-recapture analysis model; led by Wade. Timeline: winter/spring 2020.
(7) Initiate and document genetics-based mixed stock analysis in the feeding grounds to better inform the allocation of catches for the assessment model in light of any changes arising from Step (4); led by Baker. Timeline: dependent on funding to support analysis.
(8) Using results from Steps (1)-(5), conduct and document preliminary assessment runs; led by Punt. Timeline: spring 2020.
(9) Review revised input data (Steps 1-5) and analyses (Steps 6-7) to develop work plan to further assessment during a 1-day pre-meeting to the SC/68B meeting in May 2020. Discussions may need to continue during SC/68B.

To oversee this work plan the sub-committee **agreed** to re-establish an intersessional steering group under Clapham (see Annex T). To ensure progress of this Comprehensive Assessment, the sub-committee **agreed** that a 1-day intersessional workshop and a 1-day pre-meeting was necessary to further progress of this Comprehensive Assessment. No funding was requested.

5.2 Comprehensive assessment of North Pacific sei whales

In light of the intersessional work and further progress made during this meeting, the following work plan was **agreed** to ensure progress on this assessment:

(1) review the estimates of additional variance to be provided by Kitakado and incorporate them into the assessment model inputs;
(2) finalise input data for the assessment model;
(3) conduct and review model fits runs for the 1- and 5-stock models incorporating the following optional features:
    (a) additional variance in absolute and relative abundance estimates/index;
    (b) non-linearity in the relative abundance index;
    (c) slow density-dependent mixing within the single stock (for the 1-stock hypothesis);
    (d) any alternative, easily implementable, hypotheses that could explain the lack of fit that the group can think of; and
    (e) appropriate combinations of the above (need not be exhaustive);
(4) report results to next year's meeting.

To oversee this work plan the sub-committee **agreed** to re-establish the intersessional steering group convened by Cooke (see Annex T).

6. ADOPTION OF REPORT

The report was adopted at 1833 on 18 May 2019.

REFERENCES

Inai, K., Matsuoka, K. and Kitakado, T. 2018. Preliminary report of abundance estimation for the North Pacific humpback whales using IWC-POWER data. Paper SC/67b/NH04 presented to the IWC Scientific Committee, April-May 2018, Bled, Slovenia (unpublished). 14pp. [Paper available from the Office of this Journal].

Ishikawa, Y. 2013. Long term trend of some biological parameters of the North Pacific sei whales, Master's thesis, Graduate School at Tokyo University of Marine Science and Technology, Tokyo. 104pp.

International Whaling Commission. 1984. Report of the Scientific Committee. *Rep. int. Whal. Comm.* 34:35-181.

International Whaling Commission. 2018. Report of the Scientific Committee. Annex F. Report of the Sub-Committee on In-depth Assessments. *J. Cetacean Res. Manage. (Suppl.)* 19:174-82.

International Whaling Ccommission. 2019. Report of the Scientific Committee. Annex F. Report of the Sub-Committee on In Depth Assessment. *J. Cetacean Res. Manage. (Suppl.)* 20:183-99.

Punt, A.E. 2018. Updated progress report: A multi-stock model for North Pacific sei whales, with preliminary results. Paper SC/67b/IA01 presented to the IWC Scientific Committee, April-May 2018, Bled, Slovenia (unpublished). 21pp. [Paper available from the Office of this Journal].

Rice, D.W. 1977. Synopsis of biological data on the sei whale and Bryde's whale in the eastern North Pacific. *Rep. int. Whal. Comm. (special issue)* 1: 92-97.

Tillman, M.F. 1977. Estimates of population size for the North Pacific sei whale. *Rep. int. Whal. Comm. (special issue)* 1: 98-106.

Zerbini, A.N., Clapham, P.J. and Wade, P.R. 2010. Assessing plausible rates of population growth in humpback whales from life-history data. *Mar. Biol.* 157(6): 1225-36.

Appendix 1

AGENDA

1. Introductory items
    - 1.1 Convenors' opening remarks
    - 1.2 Election of Chair
    - 1.3 Appointment of Rapporteurs
    - 1.4 Adoption of Agenda
    - 1.5 Documents available
2. Comprehensive Assessment of north pacific humpback whales
    - 2.1 Progress of intersessional work
    - 2.2 Preparation of data for assessment
        - 2.2.1 Stock structure hypotheses
        - 2.2.2 Abundance, catch histories and life history parameters
    - 2.3 Assessment model
3. In-depth assessment of North Pacific sei whales
    - 3.1 Progress on intersessional work
    - 3.2 Review data for assessment
        - 3.2.1 Stock structure hypotheses
        - 3.2.2 Absolute abundance
        - 3.2.3 Relative abundance
        - 3.2.4 Marking data
        - 3.2.5 Catch history
        - 3.2.6 Life history parameters
    - 3.3 Assessment model
4. Review of budget requests in light of the two-year budget agreed last year
5. Work plan
    - 5.1 Comprehensive Assessment of North Pacific humpback whales
    - 5.2 Comprehensive Assessment of North Pacific sei whales
6. Adoption of Report

Appendix 2

ABUNDANCE ESTIMATES FOR USE IN THE SEI WHALE IN-DEPTH ASSESSMENT

J.G. Cooke, T. Hakamada and T. Kitakado

Table 1 is an update of table 1 in Appendix 5 of last year's IA report (IWC, 2019). The abundance estimates and associated data in the table will be reviewed by the intersessional correspondence group, and any required corrections made, before use in the assessment. The sub-area definitions are given in Appendix 2 of last year's report.

Table 1

Provisional table of abundance estimates for use in the In-depth Assessment.

Sub-area	Surveys	Year span	*ns*	*nw*	*L* nm	½*esw*	Area nm²	α	β = 2*Lw*/*A*	Estimate (P)	CV(*w*)	CV(P)
Alt (E of 170°E)	POWER	2010-11	1	1	1,200.3	1.899	349,101	4.0	0.01306	(1)	0.067	(1)
Alt (W of 170°E)	JARPNII	2008-12	2	3	1,610.3	1.807	158,030	3.4	0.03683	(1)	0.055	(1)
Mix	POWER	2012	0	0	624.6	1.899	209,945	4.0	0.01130	(1)	0.067	(1)
ENP	POWER	2012	2	4	402.2	1.899	88,390	4.0	0.01728	(1)	0.067	(1)
Pel (E of 170°E)	POWER	2010-12	159	295	3,803.1	1.899	1,148,196	4.0	0.01258	23,450	0.067	0.234
Pel (W of 170°E)	JARPNII	2008-12	155	290	10,099.6	1.807	526,331	3.4	0.06935	3,869	0.055	0.198
WC	JARPNII	2006-07	11	11	1,969.9	1.602	175,978	-	0.03587	416	0.158	0.482
WC	JARPNII	2008-12	18	23	4,651.2	1.807	175,978	-	0.09552	444	0.055	0.561

[1]No explicit abundance estimate, but the log-likelihood for the modelled abundance is given by formula (1).

ESTIMATES WITH ZERO OR VERY FEW SIGHTINGS

Usually, the Committee treats abundance estimates as log-normally distributed with the estimated CV. When the number of animals sighted, n, is zero, the log-normal assumption fails. When n is low (e.g. 1, 2 or 3) the log-normal assumption can be inaccurate.

For survey blocks or sub-areas with small n, we propose to use an over-dispersed Poisson form for the likelihood, with the overdispersion parameter α estimated from the data pooled across blocks. The esw (w) is also estimated from the pooled data. For the purpose of using the data in the assessment model, the log-likelihood, ignoring constant terms, is given by:

$$\Lambda = \alpha^{-1} \left(n \log(\beta P) - \beta P \right) \tag{1}$$

where:

P is the abundance from the population model; and

$\beta = 2Lw/A$, where L is track length and A is the surface area.

α is estimated from the pooled data, or from blocks with many sightings, by:

$$\hat{\alpha} = CV(\hat{P}) \sqrt{n} \tag{2}$$

n is the number of animals (not schools), so that the mean school size and its variance is taken into account. When n is very small, the variance of w (estimated from pooled data) is generally a negligible contribution to the total uncertainty, and is subsumed here into the estimate of α.

This approach is based on the method recommended in the RMP for zero estimates (IWC, 2012).

REFERENCES

International Whaling Commission. 2012. The Revised Management Procedure (RMP) for Baleen Whales. *J. Cetacean Res. Manage. (Suppl.)* 13:483-94.

International Whaling Commission. 2019. Report of the Scientific Committee. Annex F. Report of the Sub-Committee on In Depth Assessment. *J. Cetacean Res. Manage. (Suppl.)* 20:183-99.

Appendix 3

PRELIMINARY REPORT ON THE ESTIMATION OF ADDITIONAL VARIATION IN ABUNDANCE ESTIMATION FOR THE NORTH PACIFIC SEI WHALES USING JARPNII DATA

T. Kitakado

In this appendix, the additional variance was estimated using JARPNII abundance estimates over three areas (conventionally mentioned as Sub-areas 7-9) to provide with some proxy values possibly used for the IWC-POWER abundance estimates.

Underlying abundance estimates and their associated variance-covariance matrix were provided by Japanese scientists (see Table 1 for the estimates etc.). Some estimates are combined ones across multiple years (and therefore we need to refine this analysis to account for this data handling). For 2006-07 abundance estimates, we set a time stamp as 2006. Also, for 2011-12 estimates, it was set at 2011 in this preliminary analysis. No sensitivity analyses were conducted to see the influence of this treatment of time-stamping.

A total of six different cases were considered as combinations of the following factors:

(1) Time trend:
   (a) Model 1: no time trend;
   (b) Model 2: common time trend between early and late surveys;
   (c) Model 3: different time trends between early and late surveys;

(2) Additional variance: common and different between early and late seasons.

In all the cases, the area (SAs 7-9) and season (early and late) effects were incorporated. Linear mixed effects models were used to account for inter-annual variation of whale distribution, which extent is the additional variance. An integrated likelihood approach was used for the REML treatment not to underestimate the additional variance.

The results are shown in Table 2. The estimate of additional CV was a range of 0.312-0.368 when assuming a same extent of the additional variance. On the other hand, when assuming separate additional variances between early and late seasons, which might be basically a better assumption, there is a problem in the estimate; a very small estimate for the late season was drawn. This might be due to higher CVs of estimates in the late season, and therefore it seems that the inter-annual variation among estimates were mostly explained by the sampling errors.

Further investigation will be continued to address this difference and refine the underlying abundance estimates.

Table 1

Underlying abundance estimates used in this analysis.

Year	2006-07								
Sub-area	SA7	SA8	SA9	SA7	SA8	SA9			
Early/late	Early	Early	Early	Late	Late	Late			
Abundance	570	2,341	4,735	205	1,400	3,765			
CV	0.529	0.334	0.371	1.148	0.541	0.352			
Year	2008			2009			2011-12		
Sub-area	SA7	SA8	SA9	SA7	SA8	SA9	SA7	SA8	SA9
Early/late	Late	Late	Late	Early	Early	Early	Early	Early	Early
Abundance	60	908	4,119	364	614	3,756	599	215	2,174
CV	1,130	0.635	0.444	0.938	0.683	0.182	0.673	0.852	0.376

Table 2

Summary of estimation results. Note that the area*season effects are the actual scale of abundance in 2006 when estimating the time trend(s).

	Common additional CV between two seasons						Different additional CVs between two seasons					
	Model 1 (no trend)		Model 2 (common trend between 2 seasons)		Model 3 (different trends between 2 seasons)		Model 1 (no trend)		Model 2 (common trend between 2 seasons)		Model 3 (different trends between 2 seasons)	
Parameter	Est	SE	Est	SE	Est	SE	Est	SE	Est	SE	Est	SE
Trend (log space) Early	-	-	-0.114	0.062	-0.128	0.070	-	-	-0.105	0.063	-0.130	0.075
Trend (log space) Late	-	-			-0.057	0.143	-	-			-0.040	0.115
Area effect in SA7 Early	521	231	641	268	627	281	520	256	609	278	631	296
Area effect in SA8 Early	1,130	488	1,253	482	1,234	489	1,012	496	1,197	507	1,195	508
Area effect in SA9 Early	3,964	1,114	5,164	1,502	5,277	1,643	3,879	1,347	4,966	1,602	5,518	1,764
Area effect in SA7 Late	110	93	111	93	110	93	109	88	112	90	110	89
Area effect in SA8 Late	1,145	558	1,130	529	1,140	547	1,157	476	1,137	468	1,152	475
Area effect in SA9 Late	3,834	1,431	3,780	1,342	3,846	1,426	3,809	1,049	3,694	1,018	3,805	1,062
Additional CV Early	**0.368**	0.239	**0.312**	0.215	**0.344**	0.230	**0.510**	0.296	**0.380**	0.262	**0.403**	0.270
Additional CV Late	-	-	-	-	-	-	**0.001**	0.237	**0.001**	0.385	**0.001**	0.383

Appendix 4

DISCOVERY MARKING DATA FOR USE IN THE SEI WHALE IN-DEPTH ASSESSMENT

J.G. Cooke, S.A. Mizroch and H. Yoshida

These tables update those given in SC/68A/IA/03. The sub-areas are as defined in Appendix 2 of last year's IA report (IWC, 2019). As discussed in the sub-committee, marks placed in winter are assigned to a stock (in the case of the multi-stock hypothesis) or to the single North Pacific stock (NP) (in the case of the 1-stock hypothesis). For these marks, the sub-area column refers to the putative stock to which they are assigned. All the US marks were treated as winter marks for this purpose (although they were placed during Nov.-Jun.), and assigned to ENP (or NP). The Japanese marks placed in Jan.-Mar. were assigned to Pel (or NP).

As specified in SC/68A/IA/03, recoveries were placed into categories A, B and C. The numbers of effectively marked animals (see Table 1) apply only to category A. Recoveries in categories B and C are listed in Table 2. For category B recoveries, the number of marks placed is treated as unknown: inference for population modelling is conditional on the mark being recovered. Category C recovered are not used for population modelling. The effective catches for recovery modelling purposes are listed in Table 3. These are the catches for which the species is considered reliable and from which marks are considered to be reliably returned.

REFERENCE

International Whaling Commission. 2019. Report of the Scientific Committee. Annex F. Report of the Sub-Committee on In Depth Assessment. *J. Cetacean Res. Manage. (Suppl.)* 20:183-99.

Table 1

Sample sizes of effective marks placed.

Year	Nat	Summer/ winter	Sub-Area	No. of hits in whale 1	2	3	Effective total[1]	Year	Nat	Summer/ winter	Sub-Area	No. of hits in whale 1	2	3	Effective total[1]
1952	J	S	WC	4	2	0	4.2	1968	J	S	Pel	5	0	0	3.2
1954	J	S	WC	1	0	0	0.6	1969	J	S	Alt	4	0	0	2.5
1954	J	S	Pel	0	2	0	1.7	1969	J	S	Mix	2	0	0	1.3
1957	J	S	Alt	9	0	0	5.7	1969	J	S	WC	7	0	0	4.4
1958	J	S	Alt	5	0	0	3.2	1969	J	S	Pel	19	2	0	13.7
1959	J	S	Alt	4	2	0	4.2	1970	J	S	Alt	1	0	0	0.6
1960	J	S	Alt	10	0	0	6.3	1970	J	S	WC	1	0	0	0.6
1961	J	S	Alt	5	0	0	3.2	1970	J	S	Pel	17	2	0	12.4
1961	J	S	Pel	4	1	0	3.4	1971	J	S	Alt	6	0	0	3.8
1962	J	S	Alt	5	0	0	3.2	1971	J	S	Pel	12	0	0	7.6
1962	J	S	Pel	6	0	0	3.8	1972	J	W	Pel	22	15	9	35.4
1963	J	S	Alt	9	0	0	5.7	1972	J	S	Alt	7	0	0	4.4
1963	J	S	Mix	10	0	0	6.3	1972	J	S	Pel	10	0	0	6.3
1963	J	S	Pel	7	0	0	4.4	1973	J	W	Pel	17	2	0	12.4
1964	J	S	Alt	5	1	0	4.0	1973	J	S	EC	4	0	0	2.5
1964	J	S	EC	6	0	0	3.8	1973	J	S	Pel	21	3	0	15.8
1964	J	S	ENP	17	1	0	11.6	1974	J	S	Pel	14	1	0	9.7
1964	J	S	Mix	1	0	0	0.6	1975	J	S	Pel	8	0	0	5.0
1964	J	S	Pel	1	0	0	0.6	1976	J	S	Mix	1	0	0	0.6
1965	USA	*W*	*ENP*	8	1	0	5.9	1976	J	S	Pel	8	0	0	5.0
1965	C	S	EC	2	0	0	1.3	1977	J	S	EC	3	0	0	1.9
1965	J	S	Alt	3	0	0	1.9	1977	J	S	ENP	3	0	0	1.9
1965	J	S	Mix	3	1	0	2.8	1977	J	S	Mix	1	0	0	0.6
1965	J	S	Pel	2	0	0	1.3	1977	J	S	Pel	23	0	0	14.5
1966	J	S	Alt	21	0	0	13.2	1978	J	S	Alt	1	0	0	0.6
1966	J	S	Mix	7	0	0	4.4	1978	J	S	EC	1	0	0	0.6
1966	J	S	Pel	5	0	0	3.2	1978	J	S	Pel	24	0	0	15.1
1967	J	S	Alt	17	1	0	11.6	1979	J	S	Alt	1	0	0	0.6
1967	J	S	Pel	12	1	0	8.4	1979	J	S	Pel	17	0	0	10.7
1968	J	S	Alt	4	0	0	2.5	1980	J	S	Pel	3	0	0	1.9
1968	J	S	Mix	2	1	0	2.1	1981	J	S	Pel	2	0	0	1.3

[1]Effective based on recovery efficiencies per whale of: 0.63 (singly marked whales); 0.86 (doubly marked); 0.95 (triply marked).

Table 2

Recoveries of type A and B.

							No. of hits in whale															
							0			1			2			3			**Total**			
Category	Year marked	Nat marked	Winter/ summer	Sub Area marked	Year recov.	Sub Area recov.	U	M	F	U	M	F	U	M	F	U	M	F	U	M	F	**Grand total**
A	1952	J	S	WC	1955	WC						1			1						2	2
A	1957	J	S	Alt	1967	Pel				2									2			2
A	1958	J	S	Alt	1967	Alt				1									1			1
A	1959	J	S	Alt	1965	Mix				1									1			1
A	1960	J	S	Alt	1962	ENP					1									1		1
A	1962	J	S	Alt	1964	Alt					1									1		1
A	1963	J	S	Alt	1964	Mix					1									1		1
A	1963	J	S	Alt	1965	Alt						1									1	1
A	1963	J	S	Alt	1966	Alt					2									2		2
A	1964	J	S	Alt	1973	Pel					2									2		2
A	1964	J	S	EC	1966	Mix				1									1			1
A	1965	J	S	Mix	1970	Pel									1						1	1
A	1965	J	S	Pel	1967	Alt					1									1		1
A	1965	USA	S	EC	1969	Pel							1						1			1
A	1966	J	S	Alt	1968	Pel					1									1		1
A	1966	J	S	Alt	1969	Alt				1									1			1
A	1966	J	S	Mix	1968	Pel				1									1			1
A	1966	J	S	Mix	1971	Alt				1									1			1
A	1967	J	S	Alt	1968	Alt					1									1		1
A	1967	J	S	Alt	1971	Pel					2									2		2
A	1967	J	S	Pel	1974	Pel					1									1		1
A	1968	J	S	Mix	1970	ENP						1									1	1
A	1969	J	S	WC	1971	WC						1									1	1
A	1969	J	S	WC	1973	Pel					1									1		1
A	1969	J	S	Pel	1971	Pel					1									1		1
A	1969	J	S	Pel	1972	Pel						1									1	1
A	1969	J	S	Pel	1973	Pel					1									1		1
A	1969	J	S	Pel	1975	Pel					1									1		1
A	1970	J	S	WC	1972	Pel						1									1	1
A	1970	J	S	Pel	1971	WC								1						1		1
A	1970	J	S	Pel	1971	Pel					1	1								1	1	2
A	1970	J	S	Pel	1972	Pel					1									1		1
A	1970	J	S	Pel	1973	Pel						1									1	1
A	1970	J	S	Pel	1974	Pel					1									1		1
A	1971	J	S	Pel	1972	Pel						1									1	1
A	1972	J	W	Pel	1972	Pel					3		1	1	2			1	1	4	3	8
A	1972	J	W	Pel	1972	Alt					1									1		1
A	1972	J	W	Pel	1973	Pel							1					3	1		3	4
A	1972	J	W	Pel	1974	Pel									1		2			2	1	3
A	1972	J	W	Pel	1974	Alt				1									1			1
A	1972	J	W	Pel	1975	WC											1			1		1
A	1973	J	W	Pel	1973	Pel						1									1	1
A	1973	J	W	Pel	1974	Pel				1		2							1		2	3
B	1952	J	S	WC	1959	WC		1			1									2		2
B	1953	J	S	Pel	1962	WC					1									1		1
B	1954	J	S	Alt	1958	Pel			1												1	1
B	1954	J	S	Alt	1958	Alt				1									1			1
B	1954	J	S	Alt	1964	Alt		1												1		1
B	1954	J	S	Alt	1965	Alt			1												1	1
B	1954	J	S	Alt	1965	Mix				1									1			1
B	1956	J	S	Alt	1964	Alt			1												1	1
B	1959	J	S	Alt	1966	Pel		1												1		1
B	1961	J	S	Alt	1963	Mix					1									1		1
B	1961	J	S	Pel	1964	Alt	1												1			1
B	1962	J	S	Pel	1969	WC			1												1	1
B	1962	USA	W	EC	1966	ENP	1												1			1
B	1963	J	S	Alt	1966	Alt		1												1		1
B	1963	J	S	Pel	1966	Alt		1												1		1
B	1965	J	S	Mix	1966	Alt		1												1		1
B	1965	J	S	Pel	1967	Pel		1												1		1
B	1965	J	S	Pel	1967	Alt		1												1		1
B	1967	J	S	Alt	1968	Pel	1												1			1
B	1969	J	S	Alt	1970	Pel			1												1	1
B	1969	J	S	Pel	1971	Pel			1												1	1
B	1970	J	S	Pel	1971	WC		1												1		1
B	1970	J	S	Pel	1971	Pel		1				1								1	1	2
B	1972	J	W	Pel	1972	Pel			1						1						2	2
B	1972	J	W	Pel	1973	Pel						1									1	1
																			18	**42**	**31**	**91**

Table 3
Effective catches for recovery samples.

	Western Coastal		Aleutian		Pelagic		Mixed		ENP		Eastern Coastal		Total	
Year	M	F	M	F	M	F	M	F	M	F	M	F	M	F
1950	16	33	0	0	0	0	0	0	10	14	0	0	26	47
1951	0	0	0	0	0	0	0	0	5	0	0	0	5	0
1952	53	57	8	6	0	0	0	0	17	5	0	0	78	68
1953	92	60	51	47	0	0	0	0	2	12	0	0	145	119
1954	120	113	74	50	2	3	0	0	74	60	0	0	270	226
1955	41	65	12	9	0	0	0	0	84	55	0	0	137	129
1956	63	68	28	20	0	0	0	0	12	25	0	0	103	113
1957	48	54	74	65	17	10	0	0	36	57	0	0	175	186
1958	43	50	109	140	35	46	0	0	15	24	0	0	202	260
1959	62	57	10	22	0	0	0	0	116	69	0	0	188	148
1960	20	23	114	51	17	23	0	0	0	0	0	0	151	97
1961	54	92	0	3	8	1	0	1	0	0	0	0	62	97
1962	366	358	104	69	33	19	18	18	211	128	5	18	737	610
1963	324	319	36	36	1	1	324	268	309	126	34	63	1,028	813
1964	397	402	589	378	13	8	279	175	409	294	4	9	1,691	1,266
1965	264	182	566	402	23	36	188	122	390	287	7	15	1,438	1,044
1966	71	154	563	421	206	146	556	327	179	187	22	38	1,597	1,273
1967	203	283	1,031	607	1,058	768	13	5	34	55	2	1	2,341	1,719
1968	402	402	1,257	791	911	749	78	37	0	0	5	9	2,653	1,988
1969	227	220	850	416	1,194	1,150	0	0	0	0	4	6	2,275	1,792
1970	222	254	326	288	1,148	1,072	32	20	187	132	23	19	1,938	1,785
1971	126	132	269	212	832	967	9	5	35	27	51	33	1,322	1,376
1972	117	85	63	57	933	983	9	6	0	0	1	1	1,123	1,132
1973	20	11	12	8	896	795	4	4	0	0	3	0	935	818
1974	13	16	35	43	520	534	1	2	18	20	13	23	600	638
1975	12	9	0	0	237	221	1	1	2	1	0	0	252	232
2001	1	0	0	0	0	0	0	0	0	0	0	0	1	0
2002	0	0	0	1	16	23	0	0	0	0	0	0	16	24
2003	3	2	0	0	20	25	0	0	0	0	0	0	23	27
2004	0	0	15	13	32	40	0	0	0	0	0	0	47	53
2005	0	0	1	0	50	49	0	0	0	0	0	0	51	49
2006	2	3	0	0	47	49	0	0	0	0	0	0	49	52
2007	5	1	0	0	49	45	0	0	0	0	0	0	54	46
2008	0	0	3	3	41	53	0	0	0	0	0	0	44	56
2009	0	0	0	0	47	54	0	0	0	0	0	0	47	54
2010	5	5	0	0	38	52	0	0	0	0	0	0	43	57
2011	0	0	13	3	42	38	0	0	0	0	0	0	55	41
2012	0	0	0	0	44	56	0	0	0	0	0	0	44	56
2013	0	0	6	3	38	53	0	0	0	0	0	0	44	56
2014	0	0	0	0	38	52	0	0	0	0	0	0	38	52
2015	0	0	0	0	29	61	0	0	0	0	0	0	29	61
2016	2	2	0	0	36	50	0	0	0	0	0	0	38	52
2017	1	2	17	29	45	40	0	0	0	0	0	0	63	71
2018	1	2	0	0	62	69	0	0	0	0	0	0	63	71