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Report of the Intersessional Working Group on North Pacific sei whales

Cooke J.G., Palka D., Allison C., Butterworth D.S., Kitakado T., Matsuoka K., Mizroch S.A., Punt A.E., Walløe L., Yoshida H.

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1 INTRODUCTION

The group was appointed last year with the task of continuing progress on developing the North Pacific sei whale Comprehensive Assessment. The work completed up to SC/68B is documented in SC/68B/ISG04.

2 UPDATES TO DATA INPUTS

2.1 Catch series

Allison released version 7.1 of the IWC's Summary Catch Data Base in December 2020 (Allison 2020) and a provisional interim release (7.1+) of the Individual Catch Data Base in March 2021 (Allison 2021), which the group has used for a revised sei whale catch series.

The main changes were improved separation of sei and Bryde's whale catches from the mid-1950s when the species were distinguished by Japanese biologists even though not yet recognized internationally. BIWS data were supplemented using original Japanese sources where found, in particular information from researcher's logbooks supplied by Yoshida and Japanese summaries by land station. A few specific errors in the old series, such as double counting of some catches, were also corrected. The data sources used are documented by Allison (2020, 2021).

The Summary data base contains catch totals by species, year and operation (land station or expedition). The Individual data base contains individual data, such as position, length and sex. Individual data are unavailable or incomplete for the earlier years. In some cases, the individual data do not distinguish between sei Brydes whales.

The catch series was constructed by assuming that the totals by species, year and operation in the Summary data base are correct. Individual data that were not divided between sei and Brydes whales were allocated to species in the ratios required to match the Summary species totals by operation and year.

Catches were allocated to subarea using the individual position data where available, otherwise by approximate position based on the position of the land station or fleet.

For those catches without sex information, catches by sex were estimated from the average sex ratio of catches of known sex in the given subarea: this showed little variation over time.

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The resulting revised catch series by subarea (Table 1) contains approx. 1,700 fewer sei whale catches, a reduction of about 2.5% of the total.

The group considered whether removals in the earlier years may have been underestimated, due to underreporting and high struck and lost rates, as has been considered by the Scientific Committee to have likely been the case for early modern whaling in the North Atlantic. However, modern whaling started later in Japan than in Europe, and the early, unregulated period was shorter. Licensing and reporting regulations were introduced in 1911, only five years after the first known sei whale catches. The effect, if present, likely involved hundreds rather than thousands of whales.

In the pre-modern era, balaenopterids were lumped together, but it is unlikely that were substantial numbers of sei whales caught, due to their offshore distribution (Fig. 1). The group concluded that the catch series can be considered effectively complete for the purpose of the assessment.

2.2 Mark and recovery data

The improved species breakdown of catches compiled by Allison also enabled more complete species breakdown of marked and recovered whales. Previously, species breakdown in areas of sei and Brydes overlap had been considered reliable only from 1962 (SC/68A/IA/03) but this could now be pushed back to 1955. SC/68A/IA/03 defined criteria for various categories of recoveries of marked whales. Category A recoveries are where both the effective number of sei whale marked, in the season and area of marking, and the size of the effective catch of sei whales in the area and season in which the recoveries were found, are both known or considered sufficiently reliable. Category B recoveries are those for which the effective number marked is uncertain, but the effective catch is known. Category C recoveries are those for which the effective catch of sei whales is uncertain. In SC/68A/IA/03 , recoveries prior to 1962 in the area of sei/Brydes overlap (south of 42.5°N) were assigned to category C. In the light of the new information, recoveries prior to 1955 in this zone remain in category C, but marks recovered in 1955 or later are now assigned to category A or B. Otherwise, the categories A, B and C remain as defined in SC/68A/IA03. Category C marks are not used. The sample size of category A and B recoveries was increased from 91 (*JCRM* 21:119) to 101 recovered whales (Table 2). Some of these contained more than one mark. The table of effective catches for recapture samples was updated accordingly.

2.3 Relative abundance data

An error was found in some of the scouting vessel sightings data used for 1965-72 due to incorrect scanning of IWC reports. The regression analysis of the relative abundance series (JCRM 20:193-196) was redone using the corrected inputs. The resulting relative abundance series did not change substantially, but the apparent mid-Pacific gap in the distribution visible in the earlier results was found to be due to the error. The data used, analysis and results are documented in Appendix 1.

3 ABUNDANCE ESTIMATES

The estimate calculated last year for the EC area was derived as documented in SC/68B/ISG04 Appx 1. While recognizing the Committee's agreement that the evidence for multiple stocks was weak (IWC 2018), the group examined the location and timing of sei whales sightings in the surveys on which the estimate was based (Barlow 2016). Since they were mainly well offshore of the coastal whaling area (Fig 1a), this casts doubt on whether they represent the stock that was then exploited (although this depends partly on how unidentified baleen sightings are handled). Indeed, the continued existence of the suggested eastern

Coastal stock may be in doubt. The fact that it alone exhibited the baleen wasting disease suggests that it was a discrete population. By contrast, recent sightings in the ENP area are well within the grounds of the former Canadian whaling operations, suggesting that they represent a formerly exploited stock. The group recommended that the abundance estimate for both the EC and ENP be considered to belong to the suggested ENP (D) stock. This was implemented by Punt in SC/68C/IA06. This leaves the suggested EC (E) stock rather undetermined in the model but the group reached no conclusion on how to handle it.

4 DISCUSSION OF MODEL FITS

The group discussed at length the lack of fit in the model but was unable to resolve it. An examination of the seasonal pattern of past catches and absolute abundance data did not suggest that seasonal effects would resolve the discrepancies. However, the relative abundance data are not published by month. While a request for access to or analysis of these data could be made, it is not considered very likely that a reanalysis would fundamentally change the picture, given the results of the Committee's previous assessment (IWC 1977; Tillman, 1977).

The basic problem is the apparent major depletion of the Pelagic area during the whaling era coupled with a high current recent abundance estimate, such that the catches would not have been sufficient to deplete such a large stock. The group noted that this problem is not unique to sei whales. Similar problems have been encountered with other species, such as North Pacific gray whales and North Atlantic humpback whales (Butterworth et al. 2002; Punt et al. 2006).

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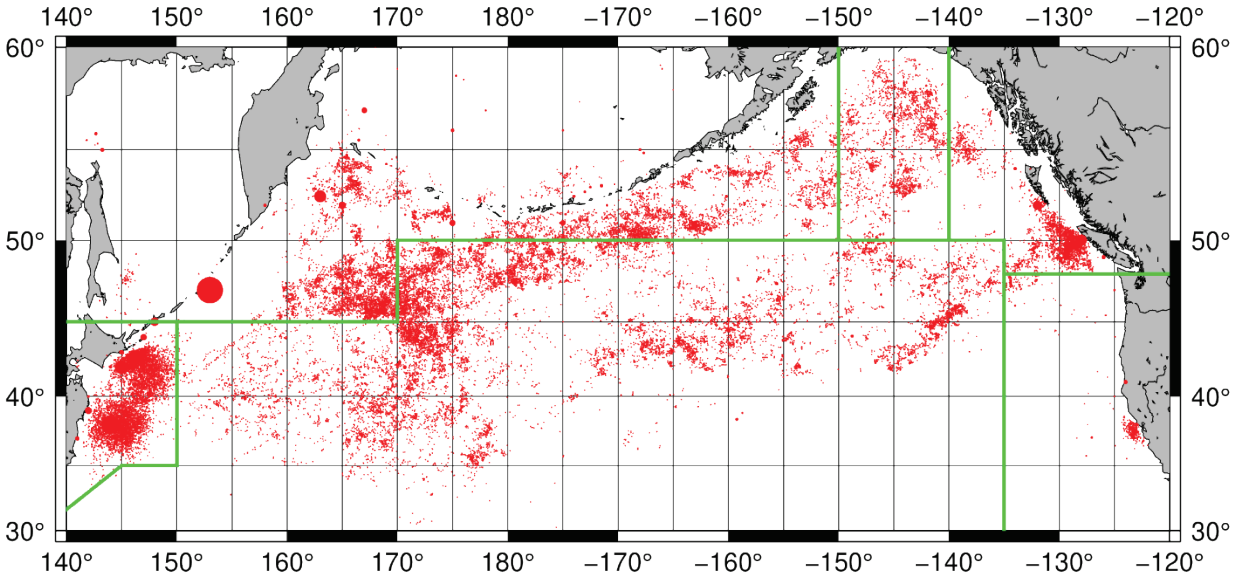


Fig. 1a. Catches of sei whales in North Pacific (catches with exact positions only). IWC Catch Data Base v. 7.1+ (Alison 2021).

Table **1. Revised catch series**

Table 4. Historical catch series for North Pacific sei whales[1]

Year	Western coastal		Aleutian		Northeastern		Eastern coastal		Pelagic		Mixing area		Total	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F
1906	8	8	0	0	0	0	0	0	0	0	0	0	8	8
1907	21	22	0	0	0	0	0	0	0	0	0	0	21	22
1908	49	52	0	0	0	0	0	0	0	0	0	0	49	52
1909	28	30	0	0	0	0	0	0	0	0	0	0	28	30
1910	49	52	0	0	0	0	0	0	0	0	0	0	49	52
1911	106	110	1	0	0	0	0	0	0	0	0	0	106	111
1912	76	79	0	0	0	0	0	0	0	0	0	0	76	79
1913	116	120	0	0	2	1	0	0	0	0	0	0	117	122
1914	90	93	0	0	8	6	1	1	0	0	0	0	99	100
1915	273	284	0	0	0	0	0	0	0	0	0	0	273	284
1916	144	151	0	0	14	11	0	0	0	0	0	0	159	161
1917	195	203	0	0	85	62	0	0	0	0	0	0	280	265
1918	289	302	0	0	78	56	0	0	0	0	0	0	367	358
1919	181	189	0	0	44	32	2	3	0	0	0	0	227	224
1920	147	154	0	0	97	71	6	7	0	0	0	0	251	231
1921	178	185	13	9	0	0	0	0	0	0	0	0	191	194
1922	92	95	0	0	1	1	0	0	0	0	0	0	93	96
1923	204	213	0	0	33	18	0	0	0	0	0	0	237	231
1924	258	270	0	0	70	30	1	1	2	1	0	0	331	302
1925	182	189	1	4	36	32	18	8	2	1	0	0	238	235
1926	207	215	3	1	14	12	22	21	4	3	0	0	250	252
1927	207	216	2	1	5	2	23	22	2	1	0	0	239	242
1928	112	117	0	1	8	5	6	9	0	0	0	0	126	132
1929	152	148	0	0	39	28	6	8	0	1	0	0	197	185
1930	166	173	2	1	51	37	0	0	4	3	0	0	222	215
1931	137	143	2	2	0	0	0	0	1	1	0	0	140	146
1932	129	134	0	0	0	0	0	0	2	1	0	0	130	136
1933	122	127	2	1	1	0	0	0	7	6	0	0	131	135
1934	106	110	1	2	0	0	0	0	2	1	0	0	108	114
1935	140	145	0	0	0	0	5	1	6	6	0	0	151	152
1936	119	124	0	0	0	0	0	0	11	10	0	0	130	134
1937	132	137	1	1	0	0	5	7	26	25	0	0	163	171
1938	163	207	0	0	0	0	0	0	11	11	0	0	175	217
1939	230	227	0	0	0	0	0	0	14	14	0	0	244	241
1940	139	147	2	1	0	0	0	0	16	13	0	0	157	161
1941	223	227	11	8	0	0	0	0	17	10	0	0	251	245
1942	93	126	0	0	0	0	0	1	8	7	0	0	101	134
1943	125	121	11	8	0	0	1	1	27	31	0	0	164	161
1944	242	292	16	10	0	0	1	1	55	67	0	0	314	370
1945	30	32	0	0	0	0	0	0	0	0	0	0	30	32
1946	140	199	0	0	0	0	0	0	8	8	0	0	149	207
1947	116	176	0	0	0	0	0	3	48	45	0	0	163	224
1948	172	186	23	16	1	1	0	0	33	32	0	0	229	235
1949	264	260	49	32	2	1	0	0	19	19	0	0	335	312
1950	94	145	38	20	10	14	0	0	0	0	0	0	142	179
1951	186	179	33	32	5	0	0	0	2	1	0	0	226	212
1952	160	251	143	72	17	5	0	0	0	0	0	0	320	328
1953	267	216	114	96	2	12	0	0	0	0	0	0	383	324
1954	266	229	160	109	74	60	0	0	4	4	0	0	505	402
1955	174	211	112	60	84	55	0	0	4	1	0	0	374	327
1956	406	347	134	101	12	25	0	0	0	0	0	0	551	473
1957	191	230	141	140	36	57	0	1	20	11	0	0	387	439
1958	188	267	271	332	15	24	1	1	35	47	0	0	510	671
1959	576	439	125	127	116	69	10	27	2	2	0	0	829	664
1960	124	116	234	130	0	0	19	28	17	23	0	0	394	297
1961	281	288	80	29	0	0	24	27	8	1	0	1	393	346
1962	277	246	312	243	211	128	5	18	80	64	18	18	903	717
1963	291	294	73	62	309	126	34	63	275	263	324	268	1 307	1 075
1964	385	391	614	388	409	294	4	9	330	310	279	175	2 021	1 568
1965	264	182	595	438	390	287	7	15	350	350	188	122	1 795	1 393
1966	59	139	599	464	179	187	22	38	596	501	560	328	2 015	1 657
1967	197	276	1 150	740	34	55	2	1	1 431	1 129	13	5	2 827	2 207
1968	403	404	1 257	791	0	0	5	9	1 070	900	78	37	2 813	2 141
1969	227	220	850	416	0	0	4	6	1 561	1 500	0	0	2 642	2 142
1970	222	254	326	288	187	132	23	19	1 195	1 118	32	20	1 985	1 831
1971	126	132	269	212	35	27	51	33	848	984	9	5	1 338	1 393
1972	117	85	63	57	0	0	1	1	962	1 010	9	6	1 152	1 159
1973	20	11	13	8	0	0	9	11	938	838	4	4	984	872
1974	16	22	35	43	18	20	16	32	528	543	2	5	615	665
1975	16	12	0	0	2	1	5	13	236	221	1	1	260	248
2001	1	0	0	0	0	0	0	0	0	0	0	0	1	0
2002	0	0	0	1	0	0	0	0	16	23	0	0	16	24
2003	3	2	0	0	0	0	0	0	20	25	0	0	23	27
2004	0	0	15	13	0	0	0	0	32	40	0	0	47	53
2005	0	0	1	0	0	0	0	0	50	49	0	0	51	49
2006	2	3	0	0	0	0	0	0	47	49	0	0	49	52
2007	5	1	0	0	0	0	0	0	49	45	0	0	54	46
2008	0	0	3	3	0	0	0	0	41	53	0	0	44	56
2009	0	0	0	0	0	0	0	0	47	54	0	0	47	54
2010	5	5	0	0	0	0	0	0	38	52	0	0	43	57
2011	0	0	13	3	0	0	0	0	42	38	0	0	55	41
2012	0	0	0	0	0	0	0	0	44	56	0	0	44	56
2013	0	0	6	3	0	0	0	0	38	53	0	0	44	56
2014	0	0	0	0	0	0	0	0	38	52	0	0	38	52
2015	0	0	0	0	0	0	0	0	29	61	0	0	29	61
2016	2	2	0	0	0	0	0	0	36	50	0	0	38	52
2017	1	2	17	28	0	0	0	0	45	41	0	0	63	71
2018	1	2	1	0	0	0	0	0	62	69	0	0	64	71
2019	5	20	0	0	0	0	0	0	0	0	0	0	5	20
2020	9	16	0	0	0	0	0	0	0	0	0	0	9	16
Total	11 919	12 430	7 934	5 550	2 734	1 984	341	444	11 485	10 954	1 517	995	35 930	32 357

[1] Replaces Table 1 published in *JCRM* 20(Suppl.):198-199120.

Table 2. Revised Table of recaptures.

Table 2. Recoveries of type A and B[2]

Category	Year marked	Nat marked	Winter/ summer	SubArea marked	Year recov.	SubArea recov.	number of marks placed in the whale (hits only) 0 U	0 M	0 F	1 U	1 M	1 F	2 U	2 M	2 F	3 U	3 M	3 F	Total U	Total M	Total F	Grand total
A	1952	J	S	WC	1955	WC						1			1						2	2
A	1952	J	S	WC	1957	WC						1									1	1
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	1961	J	S	Alt	1963	Mix					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	W	ENP	1969	Pel							1						1			1
A	1966	J	S	Mix	1968	Pel				1									1			1
A	1966	J	S	Mix	1971	Alt				1									1			1
A	1966	J	S	Alt	1968	Pel					1									1		1
A	1966	J	S	Alt	1969	Alt				1									1			1
A	1967	J	S	Alt	1968	Alt					1									1		1
A	1967	J	S	Alt	1971	Pel								1						1		1
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	Pel					1	2								1	2	3
A	1970	J	S	Pel	1971	WC								1						1		1
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	3			1	1	4	4	9
A	1972	J	W	Pel	1972	Alt					1									1		1
A	1972	J	W	Pel	1973	Pel						1	1					3	1		4	5
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	1950	J	S	WC	1955	WC			1												1	1
B	1951	J	S	Pel	1961	WC					1									1		1
B	1952	J	S	WC	1959	WC		1			1									2		2
B	1952	J	S	Pel	1955	WC						1		1	1					1	2	3
B	1952	J	S	Pel	1957	WC												1			1	1
B	1952	J	S	Pel	1958	WC											1			1		1
B	1952	J	S	Pel	1961	WC									1						1	1
B	1953	J	S	WC	1955	WC								1						1		1
B	1953	J	S	WC	1958	WC						1									1	1
B	1953	J	S	Pel	1962	WC					1									1		1
B	1954	J	S	Alt	1958	Pel			1	1									1		1	2
B	1954	J	S	Alt	1964	Alt		1												1		1
B	1954	J	S	Alt	1965	Mix				1									1			1
B	1954	J	S	Alt	1965	Alt			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	Pel	1964	Alt	1												1			1
B	1962	J	S	Pel	1969	WC			1												1	1
B	1962	USA	W	ENP	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	Pel		1												1		1
B	1970	J	S	Pel	1971	WC		1												1		1
B	1972	J	W	Pel	1972	Pel			1												1	1
	Totals																		18	45	38	101

[2] Replaces Table 2 published in *JCRM* 21(Suppl.):119.

Appendix 1

Revised[2] analysis of North Pacific sei whale summer density 1965-2015 from Japanese scouting and research vessel sightings

J.G. Cooke

Sightings and effort by Japanese scouting and research vessels in the North Pacific in summer, summarized by 10° square were taken from the following sources:

- seasons 1965-79: published by Wada in *Rep. int. Whal. Commn* 25-36 (1975-81).
- seasons 1980-96: Progress Reports Japan published in *Rep. int. Whal. Commn* (1982-98)
- seasons 1997-99: Progress Reports Japan, unpublished SC documents
- seasons 2000-05: Progress Reports Japan, published on-line (iwc.int/scprogress)
- seasons 2006-15: supplied by T. Miyashita (email 24.7.2017).

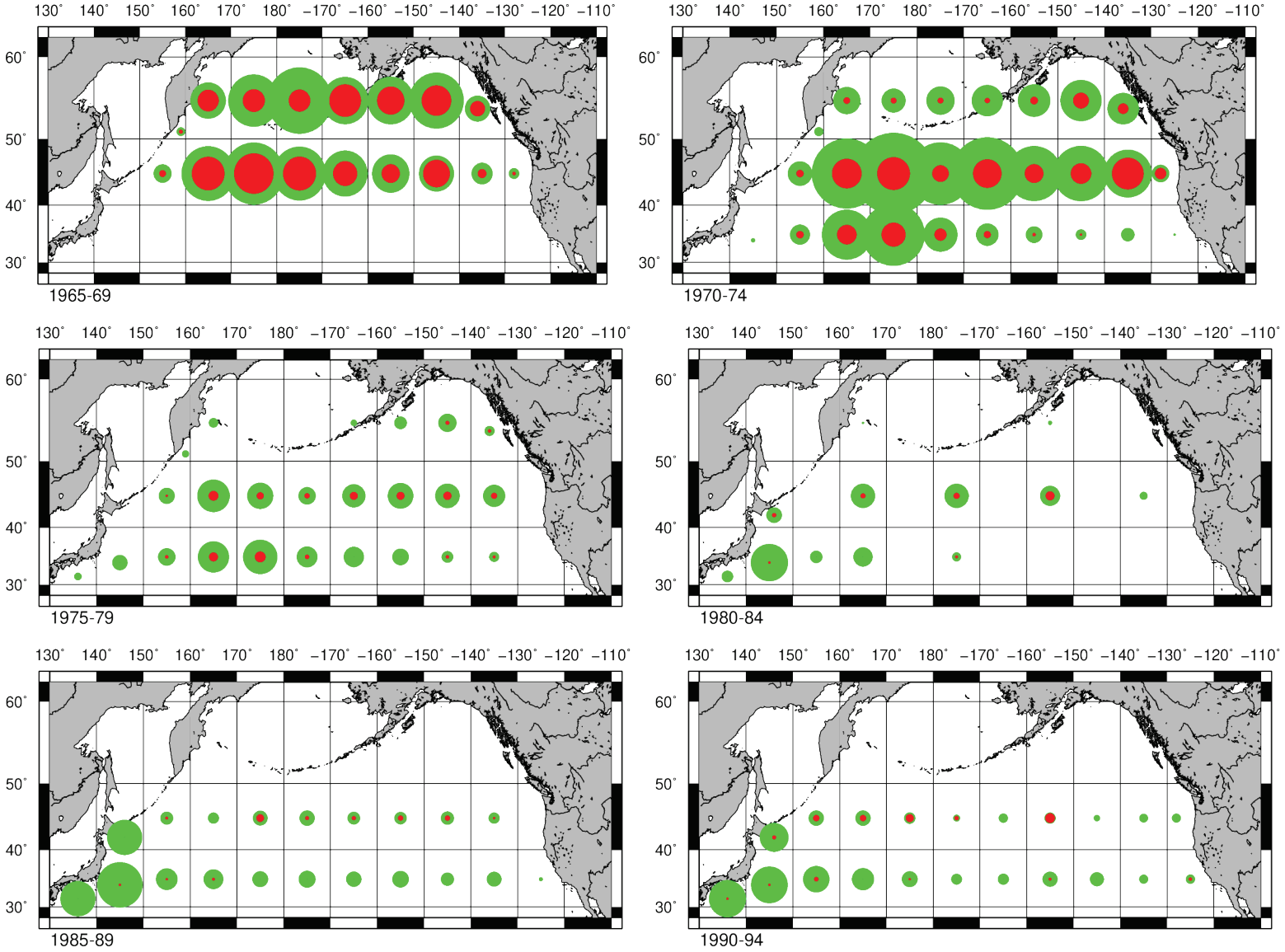
The sightings of sei whales (animals) and effort (nm of track) are summarized in Table 1. All sightings of sei whales were in series M, N and P (30°-60°N) except for 42 whales in series L (20°-30°N) but the latter were in the early years (up to 1975) and may have been Bryde's whales. There were no sightings in the Okhotsk Sea (OS) or Sea of Japan (JS). This analysis used sei whale sightings and effort in series M, N and P in the North Pacific and Bering Sea, making a total of 7,324 sei whales for 1,167,517 nm of track.

The nominal stock areas are defined in *JCRM* 19:180. Each 10° square was assigned to the nominal stock area with the largest area of overlap with that square (Table 2). The distribution of effort and sightings by period is summarized visually in Fig 1.

The years of data were divided into 10 five-year periods, except that the last period (2010-15) was six years. The fitted model was log-linear with number of sei whale sightings as a negative binomial NB(p,k) dependent variable with constant k and with the offset log(Effort) where Effort is measured in nm of track. The models fitted with their AIC are listed in Table 3. All terms except the intercept were included as random effects. Further terms did not improve the fit. The best-fitting model was model D.

The Abundance Index for each square in a period is the fitted encounter rate for that square multiplied by the area of that square. The Abundance Index represents a relative index of sei whale abundance scaled to a nominal track half-width of 1 nm. The calculated Abundance Indices are given in Table 4 by Period, summed by Subarea, using the boundaries specified in *JCRM* 20(Suppl.):192, and the values are plotted on Fig. 2. The covariances (expressed as correlations) between Abundance Indices are given in Table 5. All period/subarea combinations were used in the analysis, but only those period/subarea combinations with more than 500nm or track are listed in the results.

[2] An earlier version of this analysis was published in *JCRM* (suppl.) 20:193-196. Due to an OCR error, sightings in square N25 (40°-50°N, 170°-180°E) were erroneously assigned to square N23 for the years 1965-73.


130° 140° 150° 160° 170° 180° −170° −160° −150° −140° −130° −120° −110°
60°
50°
40°
30°
1965-69
1970-74
1975-79
1980-84
1985-89
1990-94

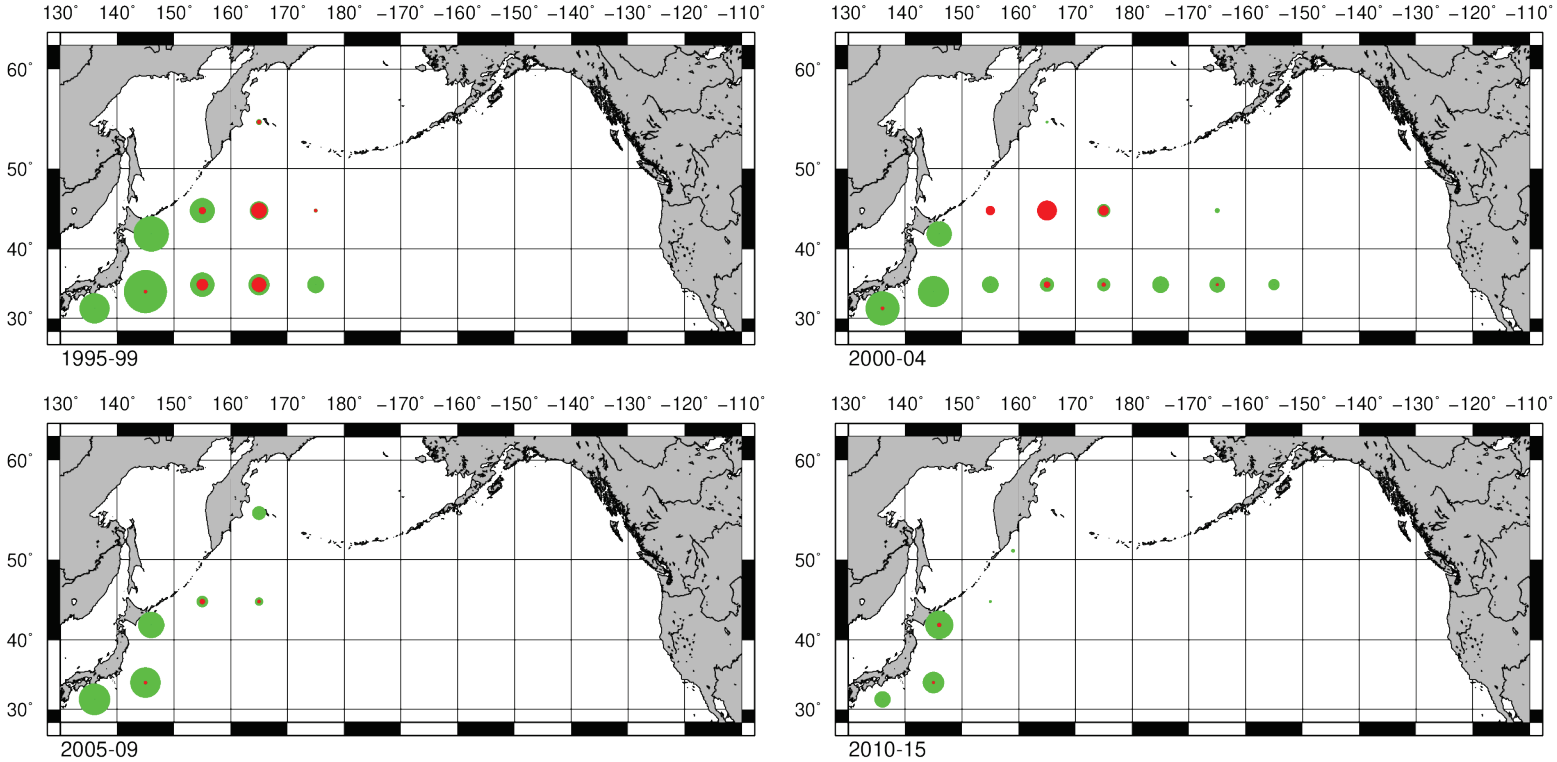


Fig. 1. Distribution of survey effort (nm of track) and sei whale sightings (animals counted) by 10° square by period. The ares of the green circles are proportional to the survey effort. The areas of the red circles are proportional to the sei whale counts.

Table 1. Summary of effort and sei whale sightings

Series	Sea	Track (nm)	Sei
J	NP	7 630	0
K	NP	24 608	0
L	NP	91 942	42
L	ECS/NP	16 042	0
M	NP	323 355	665
M	ECS	10 252	0
N	NP	597 189	4 722
N	JS	14 909	0
N	OS	3 065	0
P	NP	183 107	1 838
P	OS	12 669	0
P	BS	63 866	99
Q	OS	240	0
Q	BS	832	0

Table 2. Assignment of 10° squares to nominal stock areas

Series	Squares	SubArea
M	20-21	WC
M	22-28	Pel
M	29-31	EC
N	21	WC
N	22-28	Pel
N	29-30	EC
P	22-27	Alt
P	28	Mixed
P	29-30	ENP

Table 3. Results of fitting various models

Case	LogLike	DF	AIC	Model
A	-1661.1	26.9	3376.1	Const + Series*Square
B	-1528.7	58.7	3174.8	Case A + Year
C	-1449.4	106.7	3112.1	Case B + Series*Square*Period
D	-1368.6	173.9	3085.1	Case C + Series*Square*Year

Table 4. Fitted Indices of Abundance by subarea and period

Period	SubArea	IA	CV
1965-69	Alt	17 512	0.130
1965-69	EC	11 490	0.337
1965-69	ENP	2 494	0.392
1965-69	Mixed	4 449	0.306
1965-69	Pel	65 204	0.144
1970-74	Alt	4 315	0.185
1970-74	EC	8 088	0.269
1970-74	ENP	951	0.414
1970-74	Mixed	1 304	0.373
1970-74	Pel	32 629	0.118
1975-79	Alt	3 076	0.290
1975-79	EC	4 079	0.320
1975-79	ENP	878	0.567
1975-79	Mixed	824	0.493
1975-79	Pel	20 193	0.129
1975-79	WC	130	0.475
1980-84	EC	3 608	0.438
1980-84	Pel	18 274	0.265
1980-84	WC	200	0.424
1985-89	EC	2 652	0.451
1985-89	Pel	15 385	0.252
1985-89	WC	82	0.485
1990-94	EC	3 525	0.424
1990-94	Pel	23 371	0.235
1990-94	WC	147	0.439
1995-99	Pel	45 477	0.234
1995-99	WC	193	0.473
2000-04	Pel	35 629	0.249
2000-04	WC	155	0.531
2005-09	Alt	3 843	0.363
2005-09	Pel	21 738	0.312
2005-09	WC	208	0.546
2010-15	WC	256	0.482

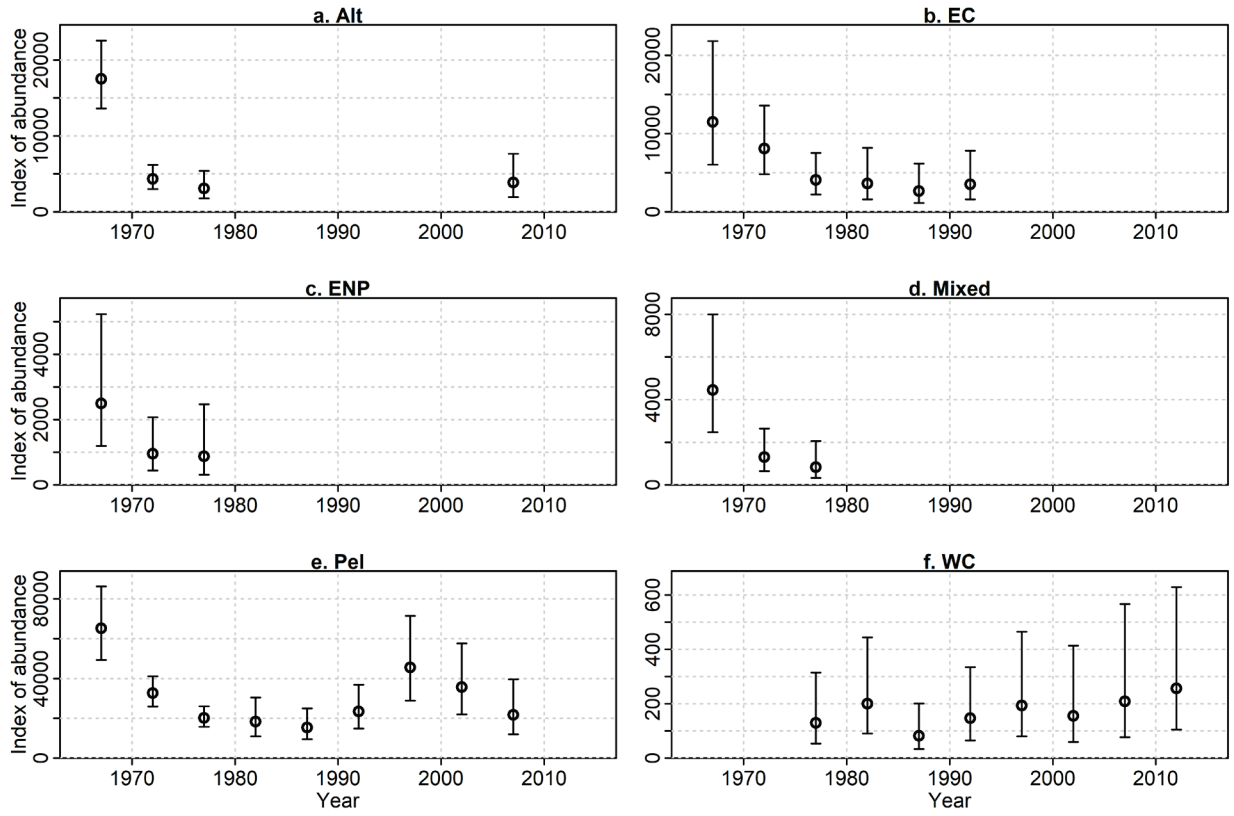


Fig. 2. Fitted indices of abundance by subarea and period, with 95% confidence intervals. the points are plotted at the mid-year of each period.