Examination of the reliability of catch statistics in the Japanese coastal sperm whale fishery[1]

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ABSTRACT

Catch statistics are important for the assessment of whale stocks. The paper reviews earlier questions over the reliability of statistics from the Japanese land based sperm whale fishery, and presents some new information for the periods 1959-65 and 1983-84. The available data suggest that aspects of post-World War II statistics are unreliable to an unknown extent in terms of total numbers, length and sex ratio. The level of unreliability appears to vary by month, year and whaling company. Suggestions for future work to try to determine the likely levels of unreliability are presented. This is important to enable an accurate assessment of the status of North Pacific sperm whales.

KEYWORDS: SPERM WHALE; REGULATIONS; STATISTICS; WHALING-MODERN; PACIFIC OCEAN; SEX RATIO

INTRODUCTION

Catches of sperm whales by Japanese traditional coastal whaling were negligible (Dainihon-Suisankai, 1896) until large-scale exploitation of sperm whales (*Physeter macrocephalus*), using sailing ships and hand harpoons, began off Japan about 1820. It was probably associated with the breeding schools of the southwestern North Pacific stock (see Kasuya and Miyashita, 1988). The fishery declined in the subsequent 30 years, partly due to a decrease in availability throughout the western North Pacific (Tillman and Breiwick, 1983) and partly due to social factors (Davis *et al.*, 1997). Quantitative assessment of changes in the sperm whale population during this period requires further investigation (Whitehead, 1995).

Modern whaling methods (using steam vessels with harpoon cannons) were introduced to the western North Pacific in 1889 by Russian companies. The whaling company, Nippon Enyogyogyo Kaisha, established in Japan in 1899, was the founder of Japanese modern whaling (Akashi, 1910; Tønnessen and Johnsen, 1982). Japanese catches of sperm whales were low before World War II, but increased in the post-war period (Fig. 1).

Official data for Japanese modern coastal whaling are available from 1910; the total take for the period 1910-1988 was about 88,000 sperm whales (e.g. Kasahara, 1950; Kasuya, 1991). However, as discussed below, the reliability of aspects of these data has been questioned.

Earlier assessments of North Pacific sperm whale stocks by the Scientific Committee of the International Whaling Commission (IWC) were unable to address questions regarding the uncertainty in the data (e.g. Cooke *et al.*, 1983a; Shirakihara *et al.*, 1983), making an interpretation of the results problematic (IWC, 1983). An important advance in the assessment process within the IWC Scientific Committee in recent years has been the explicit decision to take uncertainty into account (e.g. see Donovan, 1995). The aim of this study is to examine the available catch data for the Japanese coastal sperm whale fishery and to discuss their reliability. Any future assessment of North Pacific sperm whale stocks (e.g. see IWC, 1997) must take this uncertainty about historic data into account.

[1] A version of this paper was submitted to the IWC Scientific Committee as SC/50/CAWS10.

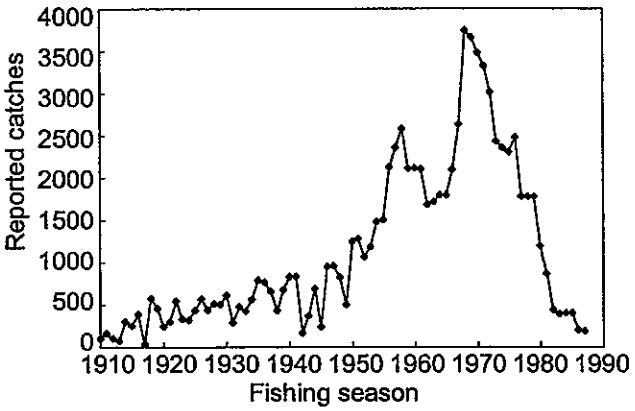

Fig. 1. Official statistics of sperm whales taken by Japanese land based whaling (based on table 1 of Kato, 1996). Regulations in force include minimum length limits (1938-), national catch limits (1959-1966, 1969-1970), agreement by North Pacific whaling countries (1971), IWC limits (1972-) and IWC limits by sex (1973-). The fishery last operated in March 1988.

Previous questions of reliability

Total catches

Tønnessen and Johnsen (1982) reported that considerable differences existed between the catch data published by the Bureau of International Whaling Statistics (BIWS) for the Japanese coastal seasons between 1920-1930 and the records of the Whales Research Institute (WRI) in Tokyo. They presented the correct statistics from the WRI prepared by the late H. Omura, its former director. Table 1 shows the differences in catch totals for each species (over the 10 year period) between the two sets of data. Tønnessen and Johnsen (1982) also commented that the differences for 1911-19 and 1931-40 were 'insignificant'. Gray and right whale statistics present in their table are not analysed here.

A simple comparison of the total catches over the 1920-30 period reveals over-reporting of only 106 sperm whales (2.1%) in the BIWS (Table 1). However, the annual variation is very large for each species, for sperm whales ranging from +277 to –226 in absolute numbers or from +56% to –30% in any one year. Fig. 2 shows the annual percentage of under- or over-reporting by species. There appears to be little pattern, either by species or by year, although significant under-reporting is confined to blue and sperm whales whilst over-reporting occurs for all species. Sei whale catches are over-reported except for 1924-1926.

Table 1

Comparison of Japanese coastal whaling catches (1920-1930) from BIWS and corrected WRI (table 46 of Tønnessen and Johnsen, 1982) data. The percentage difference is the absolute difference (Abs.) expressed as a percentage of the WRI value.

	Blue				Fin				Humpback				Sei				Sperm			
	Catch		Difference		Catch		Difference		Catch		Difference		Catch		Difference		Catch		Difference	
Year	BIWS	WRI	Abs.	%	BIWS	WRI	Abs.	%	BIWS	WRI	Abs.	%	BIWS	WRI	Abs.	%	BIWS	WRI	Abs.	%
1920	35	37	-2	-5.4	438	443	-5	-1.1	83	84	-1	-1.2	393	389	4	1.0	245	251	-6	-2.4
1921	37	53	-16	-30.2	475	470	5	1.1	101	101	0	0.0	477	474	3	0.6	302	301	1	0.3
1922	34	36	-2	-5.6	390	394	-4	-1.0	82	82	0	0.0	391	390	1	0.3	562	567	-5	-0.9
1923	35	35	0	0.0	431	434	-3	-0.7	70	70	0	0.0	488	492	-4	-0.8	364	370	-6	-1.6
1924	33	28	5	17.9	337	342	-5	-1.5	160	156	4	2.6	642	642	0	0.0	336	247	89	36.0
1925	35	31	4	12.9	562	411	151	36.7	230	154	76	49.4	499	491	8	1.6	497	354	143	40.4
1926	36	29	7	24.1	636	408	228	55.9	119	110	9	8.2	568	563	5	0.9	772	495	277	56.0
1927	9	10	-1	-10.0	441	455	-14	-3.1	95	90	5	5.6	531	551	-20	-3.6	450	443	7	1.6
1928	10	16	-6	-37.5	455	417	38	9.1	90	99	-9	-9.1	551	309	242	78.3	482	650	-168	-25.8
1929	16	16	0	0.0	386	386	0	0.0	74	74	0	0.0	364	364	0	0.0	606	606	0	0.0
1930	55	56	-1	-1.8	331	400	-69	-17.3	58	62	-4	-6.5	330	411	-81	-19.7	527	753	-226	-30.0
Total	335	347	-12	-3.5	4,882	4,560	322	7.1	1,162	1,082	80	7.4	5,234	5,076	158	3.1	5,143	5,037	106	2.1

Kasuya and Miyashita (1988) stated their belief that 'significant under-reporting' had occurred in the postwar Japanese coastal sperm whaling operations although they did not have documentary evidence.

Sex ratio in the catch

Questions over the sex ratio of the catches from the Japanese coastal sperm whale fishery were first raised by Gosho (1979), the international observer at the Japanese land stations. He reported a female catch percentage of 67.1% in the 140 animals he observed. He noted that this was very high when compared with the reported value of 19.4% ($n = 1,740$) for the entire 1978 season. However, his sample, despite including some animals from each of the five land stations operating in that season and throughout most (20 October 1978 to 1 April 1979) of the season (September 1978 to March 1979), represented only 8% of the total catch, thus precluding any firm conclusions being reached.

More recently, Kasuya and Miyazaki (1997) compared data collected by scientists from the WRI in seven seasons (1959-1965) with corresponding statistics from the Japan Whaling Association (JWA). The latter were the basis for the government statistics reported to the BIWS. At that time, national regulations did not allocate catch limits by gender. The authors found that the percentage of females in the WRI sample was around 67% ($n = 5,287$) whereas it was only about 52% ($n = 13,185$) in the JWA statistics. Earlier analyses (Kasuya and Miyashita, 1988; Kasuya, 1991) found a similar pattern but used smaller data sets.

Catches of sperm whales by small-type whalers

Balcomb and Goebel (1977) reported that the owner of a small-type whaling company taking Baird's beaked whales believed that published records for that species were too high and that this 'may be due to the inclusion of other species in the records'. Statistics for Baird's beaked whales were presented for the 1965-1975 seasons. Kasuya (1995) reported that a past custom of Baird's beaked whale hunters was to report a catch of several sperm whales as one Baird's beaked whale. His belief was that, unless such a misallocation of species occurred, companies could not have continued reporting an annual take of 100-300 Baird's beaked whales for nearly 22 years (1950-1971) from an apparently small stock of the species (Miyashita, 1986; Miyashita and Kato, 1993). The rationale for this misallocation is unknown. It is unlikely to have occurred for product conversion reasons as it would require several Baird's whales to equal the products of a single sperm whale.

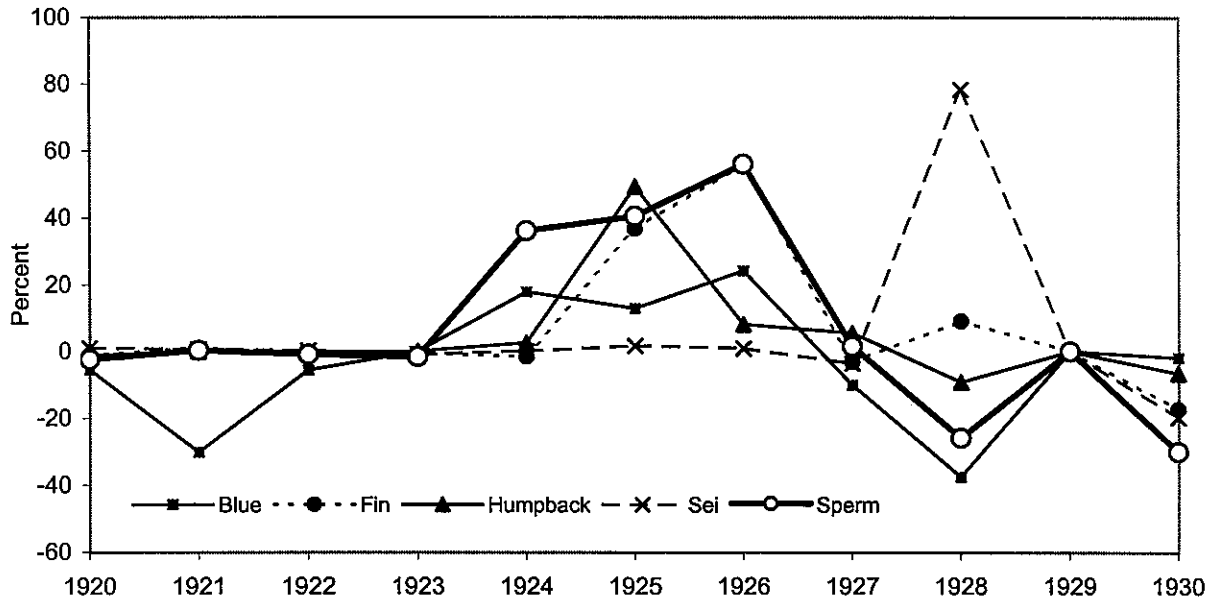

Fig. 2. Annual percentage of over- or under-reporting by species (see text).

An alternative explanation is that the aim was to hide illegal catches of sperm whales.

Kasuya and Miyazaki (1997) reported that a gunner from a small-type whaling company had stated that the company had illegally killed 50-100 sperm whales per year until the middle of the 1970s. The total extent of any illegal sperm whale catches by small-type whalers (around 10 vessels since the 1960s) is unknown.

Length data

Certain authors, including Allen (1980) and Cooke *et al.* (1983b), examining statistics from the North Pacific sperm whale fishery, observed a knife edge distribution of body lengths near the minimum size limit, and questioned the accuracy of these statistics. This distribution of body length implies that either: (1) the gunners were extremely good at estimating lengths at sea; (2) whales near but below the minimum size limit were 'stretched' (Best, 1989) or discarded (see below); or (3) all length data were fabricated.

Discarding of small animals

Watase (1995) reported the existence of some pelagic operations where the number of whales killed exceeded the processing capacity of the whaling vessel, and where smaller whales were later discarded before towing to the factory ship. This may reflect the high level of inspection on the factory ships. The likelihood of such a situation arising in coastal whaling is lower, given the generally lower level of inspection (see below).

Whales accompanied by calves

International whaling regulations prohibit the taking of whales accompanied by calves (e.g. see Donovan, 1992). Evidence to suggest that this regulation was sometimes broken can be found by examining the mammary glands to determine whether the animal was lactating[2]. For the 1983/84 coastal season, Kasuya (1986) reported discrepancies between the proportions of the various reproductive classes reported by the industry when compared to those he obtained directly. In particular, the proportion of lactating females was higher for his data. He suggested that this might reflect the ability of biologists to collect more accurate data than non-biologists, a feature also reported by Best (1984).

MATERIALS AND METHODS

Information collected by scientists, 1959-65

Data and biological samples were collected by scientists from the WRI (including the author) working at the land stations of five Japanese whaling companies under a contract with the Japanese Fisheries Agency, during the whaling seasons 1959-1965. The aim of the programme was to maximise sample size, geographical coverage and species of whale caught. Full coverage was impossible given that the number of scientists was less than the number of whaling stations. It is not clear how a particular whaling station was selected for sampling if several stations nearby were also processing their catches at the same time. Tables 2-4 (pp. 112-13) summarise information on the monthly number of sperm whales by sex examined by WRI scientists[3] (Whales Research Institute, 1961-1966) and the corresponding figures from the JWA (1961-1966) for the Sanriku (Pacific coasts, 38°-41°N) and Hokkaido (Pacific coasts, 42°-44°N) regions (detailed information is given in the Appendix Tables 1 and 2). Further disaggregation of the data is not possible because under the terms of the agreement with the industry, the names of companies or land stations were not recorded. Similar data are available for other species but are not considered in this paper. The WRI statistics are cited after correction of some simple typing errors. The analysis has been restricted to those months where the WRI sample represents ≥20% of the JWA sample and where the reported JWA catch is ≥40 whales, with some allowance if either of these criteria is fully satisfied. Although a somewhat arbitrary choice, it is an attempt to restrict the analysis to those months where one might expect the WRI sample to be reasonably representative. Data for the 1959 season (Whales Research Institute, 1960) are of only limited use because they are not available by month and region.

'A-log' data

The A-log data (Table 5, p. 113, and Appendix Table 3) are a daily summary of the catcher boat operations of a single whaling company (referred to here as Company A) recorded by a gunner during his employment. The log appears to cover all the catcher boats of the company that operated in one specific region (where he worked as a gunner), and includes the recorded noon positions of catcher boats and other data (e.g. whale species and the number of whales sighted and taken). Although A-log also contains records of a small number of vessels from other whaling companies, these data were not used in the present study.

The log covers the three seasons 1959-1961; these were the first three years that Japan set a national quota for the land-based sperm whale fishery. The land station used was only identified for catches off Oshima (Appendix Table 3), but these data are not considered further here as the catch of sperm whales in the region was insignificant. It was impossible to determine from the noon positions of catcher boats in the Sanriku and Hokkaido regions which land stations had been used, as most of the five whaling companies (including Company A) had stations in both regions and the whaling ground was situated at an equal distance from them both. Thus, the catches off Sanriku and Hokkaido have been combined as a single unit (Sanriku/Hokkaido) for this paper (Table 5). The number of land stations that have processed sperm whales (Table 5) is three in Sanriku (Kamaishi, Onagawa and Osawa) and two in Hokkaido (Kiritappu and Kushiro).

The tables also include the corresponding values from Company A from the JWA (1960-1962). Not all of the A-log data are suitable for comparative purposes as the author was not always present for complete months. Records for 'incomplete' (<90%) months have been excluded from Table 5 and the analysis. The last month of a season when operations ceased as soon as the catch limit had been reached is included. In principle, one can assume that the A-log data will under-represent true catches; as such they are of potential value in identifying under-reporting errors by the industry.

'B-log'data

'B-log' data are from the records of Company B and should thus provide the true data for sperm whales processed at the Taiji whaling station (Table 6, p. 114) during the two seasons (25 January-14 March 1984, and 24 December 1984-31 March 1985) for which data are available.

[2] The discovery of a lactating whale in the catch does not necessarily mean that the whale was accompanied by a calf at the time of capture.

[3] Data from the 1959 season (Whales Research Institute, 1960) are not used since it is not available by month and region.

Table 2

Summary of the information given in Appendix 1, tables 1 and 2 showing the percentage of females in the WRI sample (% F (WRI)), the total reported catch given by the JWA (Total) and the total WRI sample size expressed as a percentage of the total JWA value (% WRI). Only months where % WRI ≥ 20 and Total ≥ 40 are shown (see text). **Bold** type indicates JWA figures that are exceeded in the sample taken by the scientists.

Sex	Month	1960	1961	1962	1963	1964	1965	Total	F (%)	P(%)*
Sanriku										
% F (WRI)	Jun.	85.7	66.7	70.0	73.3	0	75.8	65.8	65.8	<0.1
Total	Jun.	99	139	36	54	48	59	435	40.9	
% WRI	Jun.	21.2	34.5	27.8	55.6	33.3	55.9	36.3		
% F (WRI)	Jul.		64.0	50.0	62.1	30.8	56.0	54.1	54.1	<0.1
Total	Jul.		51	43	69	40	198	450	33.6	
% WRI	Jul.		49.0	65.1	95.7	65.0	46.0	53.8		
% F (WRI)	Aug.	55.3	73.0	74.1	66.7	29.3	49.3	58.2	58.2	1-0.1
Total	Aug.	107	282	87	171	237	326	1210	50.7	
	Aug.	71.0	13.1	**124.1**	61.4	24.5	42.3	43.1		
% WRI	Sep.	65.7		80.6	56.3		58.6	64.1	64.1	>90
Total	Sep.	170		216	312		236	1425	64.2	
% WRI	Sep.	61.8		16.7	15.4		29.7	18.2		
% F (WRI)	Oct.	84.0			62.5	71.7	75.9	72.7	72.7	50-30
Total	Oct.	38			97	111	206	553	61.7	
% WRI	Oct.	65.8			41.2	41.4	26.2	29.8		
% F (WRI)	Nov.	76.2		78.9				76.8	76.8	<0.1
Total	Nov.	40		79				335	51.6	
% WRI	Nov.	**157.5**		24.1				24.5		
Hokkaido										
% F (WRI)	Jul.		78				53.1	58.9	58.9	<0.1
Total	Jul.		208				73	574	39.5	
% WRI	Jul.		24.0				43.8	16.6		
% F (WRI)	Aug.	39.6	70.1		54.5	21.6		50.3	50.3	<0.1
Total	Aug.	253	297		112	140	66	1023	40.7	
% WRI	Aug.	79.8	59.6		39.3	26.4	27.3	48.4		
% F (WRI)	Sep.	73.8	71.8	76.6	69.3	69.9	72.5	72.9	72.9	<0.1
Total	Sep.	825	548	373	308	483	171	2708	59.3	
% WRI	Sep.	68.4	71.2	71.0	32.8	37.9	80.7	60.6		
% F (WRI)	Oct.	76	80.4	76.9	71.9	78		76.9	76.9	<0.1
Total	Oct.	176	80	395	161	188		1237	61.7	
% WRI	Oct.	56.8	**351.3**	52.7	**106.2**	48.4		70.1		
% F (WRI)	Nov.			81.4				78.5	78.5	<0.1
Total	Nov.			165				475	52	
% WRI	Nov.			26.1				19.6		

* Probability at which two sets of sex ratio data (WRI and JWA) represent a common population (chi-square test).

The total number of sperm whales and their body lengths given in B-log are identical to those reported to the government. However, the author of B-log has cast some doubt on the body lengths included therein as well as suggesting that there were a number of sperm whales processed that were not recorded in the actual log. For the purposes of this paper therefore, only the data on gender in B-log are considered reliable.

Inspection and observation

Any consideration of the reliability of the data referred to above must refer to:

(1) any national and international regulations in force at the time;
(2) any national inspection schemes or international observer schemes in force at the time.

Table 7 (p. 115) summarises the available information for the three data sets considered.

Ohsumi (1980) briefly reviewed the regulations affecting North Pacific sperm whales. A minimum length limit was the first regulatory measure applied to the Japanese sperm whale fishery. It came into effect in June 1938 and prohibited the take of animals less than 9.9m (30ft) in length for land based operations and less than 10.6m (35ft) for pelagic operations (Omura *et al.*, 1942). Although the size limits themselves were altered several times (e.g. the size limit for coastal operations was increased to 35ft (10.6m) in November 1945 (Maeda and Teraoka, 1952)), they continued until the sperm whale fishery closed in March 1988. A Japanese national catch limit for the coastal sperm whale fishery was established in 1959 (at 2,100 individuals per season) and changed several times (including no limits at all in 1967 and 1968) until international limits were set. These first came about as part of an agreement reached by the IWC Commissioners of the North Pacific whaling countries (pelagic operations came under control in 1970 and coastal operation in 1971). In 1972, catch limits were included in the Schedule of the IWC for both coastal and pelagic operations. Catch limits by gender began in 1973 and led to a decrease in catches of females.

Table 3

Summary of information from WRI and JWA pooled over months.

	1960	1961	1962	1963	1964	1965	Total
Sanriku							
M	99	47	56	107	90	160	559
F	199	92	145	185	58	226	905
Total (WRI)	298	139	201	292	148	386	1,464
Total (JWA)	572	851	538	839	810	1,173	4,783
% WRI	52.1	16.3	37.4	34.8	18.3	32.9	30.6
F % (WRI)	66.8	66.2	72.1	63.4	39.2	58.5	61.8
F % (JWA)	38.1	51	60.6	62.3	59.3	47.9	53.2
P(%)*	<0.1	<0.1	1-0.1	80-70	<0.1	1-0.1	<0.1
Hokkaido							
M	304	240	130	102	105	76	957
F	574	698	411	224	207	128	2,242
Total (WRI)	878	938	541	326	312	204	3,199
Total (JWA)	1,472	1,194	1,142	874	989	627	6,298
% WRI	59.6	78.6	47.4	37.3	31.5	32.5	50.8
F % (WRI)	65.4	74.4	76	68.7	66.3	62.7	70.1
F % (JWA)	59.3	56.4	65.1	49.3	37.5	39.8	52.9
P(%)*	1-0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

*See footnote to Table 2.

Table 5

Summary of A-log and JWA data for those months for which A-log is believed to cover >90% of total (see text) for Sanriku and Hokkaido.

	Baleen				Sperm			
	A-log	JWA	Diff	%	A-log	JWA	Diff	%
1959								
May	82	78	-4	-4.9	30	38	8	26.7
Jul.	55	63	8	14.5	50	57	7	14.0
Aug	18	23	5	27.8	310	358	48	15.5
Sep.	21	40	19	90.5	249	231	-18	-7.2
Oct.	34	45	11	32.4	123	101	-22	-17.9
Nov.	0	0	0		45	19	-26	-57.8
Total	210	249	39	18.6	807	804	-3	-0.4
1960								
Sep.	7	12	5	71.4	416	443	27	6.5
Oct.	7	7	0	0.0	164	75	-89	-54.3
Total	14	19	5	35.7	580	518	-62	-10.7
1961								
Jun.	73	81	8	11.0	35	33	-2	-5.7
Sep.	18	12	-6	-33.3	293	270	-23	-7.8
Oct.	1	1	0	0.0	125	36	-89	-71.2
Nov.	0	0	0		134	27	-107	-79.9
Total	92	94	2	2.2	587	366	-221	-37.6
1959-61								
Total	316	362	46	14.6	1,974	1,688	-286	-14.5

RESULTS

Total catch numbers, 1960-1966

Information from WRI data (Tables 2 and 3)

Given the logistical constraints, it is clear that the number of whales examined by WRI scientists must be smaller than numbers of whales processed in the region, or at most equal to them. Clearly, it is not possible for the scientific sample to exceed the total number of whales processed, unless there was incorrect reporting by the companies. Examination of Appendix Tables 1 and 2 reveals that in some months and regions, the WRI sample was greater than the reported catch. The total sperm whale catch in those five months was 386 sperm whales in the JWA statistics while the WRI scientists recorded 663 whales (157 males and 506 females). Assuming that the WRI values are the true figures, then the JWA values represented only 58% of the catch for those months.

There are clearly problems with the data for those months and areas, at least before 1964, and this gives rise to some concern about the overall reliability of the total catch numbers. Several land stations and companies operated at that time, but given the level of disaggregation of the data, it is not possible to determine if the errors can be directly linked to all or a few of these.

Information from A-log

Table 5 shows reasonably good correlation (±10) between the A-log and JWA data for most months for baleen whales. Where the values were not identical, in all but two cases, the JWA values were slightly higher. The total catch was 316 baleen whales (A-log) and 362 whales (JWA) for these selected months. Table 5 also summarises the WRI and JWA catch data for sperm whales. There were two instances where the JWA data were higher than the A-log data, three instances where they were similar (±10) and seven instances where they were considerably lower. Lower values occurred later in the season, with the degree of apparent under-reporting (expressed as a percentage of the A-log values) increasing from September onwards and from 1959-1961.

The lower values for A-log can probably be attributed to the use of some months with less than 100% coverage, or to some missed vessel records by the gunner. There are a number of possible causes for the higher values in A-log, including: recording errors by the gunner; carry over of catch records to the subsequent month (e.g. sperm whales taken in March 1960 or a day before the season opened seemed to be processed in April); or under-reporting by the company.

Table 4

Summary of information from WRI and JWA pooled over region and years for Sanriku and Hokkaido.

	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Total
WRI									
M	0	19	62	150	464	537	245	39	1,516
F	0	17	104	187	553	1,363	787	136	3,147
Total	0	36	166	337	1,017	1,900	1,032	175	4,663
F%	-	-	62.7	55.5	54.4	71.7	76.3	77.7	67.5
JWA									
M	101	190	378	646	1,203	1,612	686	390	5,206
F	31	171	220	378	1,030	2,521	1,104	420	5,875
Total	132	361	598	1,024	2,233	4,133	1,790	810	11,081
F%	23.5	47.4	36.8	36.9	46.1	61	61.7	51.9	53
% WRI	0	10.0	27.8	32.9	45.5	46.0	57.7	21.6	42.1
P(%)*	-	>90	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

*See footnote to Table 2.

Table 6

Body length composition constructed from individual records in B-log, indicating manipulation of gender of sperm whales at Taiji whaling station during 1984 and 1985 seasons. M: male, F*: female reported as male, F: female reported as female.

Body length (feet)	I-III,1984				XII,84-III,85				Total			
	M	F*	F	Total	M	F*	F	Total	M	F*	F	Total
31	6	6	2	14	12	2	3	17	18	8	5	31
32	5	3	8	7	6	2	15	12	9	2	23	
33	3	5	4	12	13	7	7	27	16	12	11	39
34	6	3	3	12	4	1	3	8	10	4	6	20
35	5	3	3	11	12	6	1	19	17	9	4	30
36	6	2	3	11	7	2	3	12	13	4	6	23
37	3	2	1	6	2	1	5	8	5	3	6	14
38	2	1		3	10	3	1	14	12	4	1	17
39	4		2	6	4		2	6	8	2	2	12
40		1		1	7			7	7	1		8
41	1	1		2	5	1		6	6	2		8
42		1		1	1		1	1	1		2	
43				2			2	2			2	
44				3			3	3			3	
55				1			1	1			1	
61	1			1				1				1
Total	42	28	18	88	90	31	25	146	132	59	43	234
True F%	52.3				38.4				43.6			
Rep. F%	20.5				17.1				18.4			-

Table 7

Summary of regulations and inspection pertinent to the data sets examined in this paper.

Year (s)	Catch limit	Total (JWA figures)	Length limits		National inspection	International observation
1959	2100	2104	Min. length	35ft (10.6m)	Partial	No
1960	2100	2107		10.6m	Partial	No
1961	2100	2101		10.6m	Partial	No
1962	1800	1685		10.6m	Partial	No
1963	1800	1714		10.6m	Partial	No
1964	1800	1800		10.6m	Partial	No
1965	1800	1800		10.6m	Partial	No
1984	400 males*	400	Min: 30ft (9.0m); Max: 45ft (13.6m) March-June incl.		**	8.4% of all sperm whale landings were observed.
1985	400 males*	400	As above		**	

* Although the catch limit for females was zero, a bycatch of not more than 11.5% females (i.e.46) was allowed in recognition of the difficulty in identifying the sex of animals at sea.

** To supplement insufficient coverage by national inspectors, local personnel were allocated the task of observing flensing. They visited the land stations at the invitation of the station masters.

Whilst the first two reasons may be sufficient to explain the differences for baleen whales, it seems clear that for the large differences seen for sperm whales, under-reporting was occurring. One interpretation of the A-log data is that Company A: (1) correctly reported baleen whales throughout most of the period; (2) correctly reported catches of sperm whale in early months; and (3) under-reported[4] sperm whales in the later part of the season. The magnitude of under-reporting appears to increase as a season progresses.

Table 8 represents an attempt to develop a 'corrected' catch series based on the A-log data. If one assumes that the need for under-reporting did not occur until the latter part of the season (September-November), and that the A-log values are correct, then in 1959 the under-reporting for the latter 3-month period is 66 whales (15.8% of A-log), in 1960 it is 83 (13.5%) and in 1961 it is 219 (39.6%). If one wishes to approximate this to the whole season, one approach is to assume that the JWA data are correct data for the May-August period (this is not inconsistent with the available data). Under this assumption the percentage under-reporting for the 1959 season is 7.5%, for 1960 is 8.4% and for 1961 is 21.4%.

Although this assumes that the A-log values are correct, they are in fact underestimates of the true catch to an unknown extent (for example around 10-15% for the pooled baleen whale data discussed above).

[4] The purpose of this paper is to examine the reliability of the available statistics, not to apportion blame. However, for the purposes of determining how much uncertainty one needs to take into account in any catch history dataset, it is worth noting that a senior staff member of a whaling company, who was unaware of the identity of Company A, had agreed that some under-reporting of total catches had occurred in the past. He had suggested the names of three companies who he believed might be the worst offenders; these did not include Company A.

Percent females in the catch

Information from WRI data (Tables 2 and 3)

Table 2 presents the WRI and JWA data on the percentage of females in the catch by month and by year, as well as the percentage of the reported JWA total catch observed by the

Table 8
Reconstruction of the sperm whale catch data for company A based on the assumptions given in the text for Sanriku and Hokkaido.

Year/month	A-log	JWA	Difference	% under
1959				
May	38	38		
Jun.	7	7		
Jul.	57	57		
Aug.	358	358		
Sep.	249	231	-18	-7.2
Oct.	123	101	-22	-17.9
Nov.	45	19	-26	-57.8
Total (Sep.-Nov.)	417	351	-66	-15.8
Total (all months)	877	811	-66	-7.5
1960				
Apr.	18	18		
May	23	23		
Jun.	51	51		
Jul.	116	116		
Aug.	165	165		
Sep.	416	443	27	6.5
Oct.	164	75	-89	-54.3
Nov.	34	13	-21	-61.8
Total (Sep.-Nov.)	614	531	-83	-13.5
Total (all months)	987	909	-83	-8.4
1961				
Apr.	6	6		
May	37	37		
Jun.	33	33		
Jul.	132	132		
Aug.	261	261		
Sep.	293	270	-23	-7.8
Oct.	125	36	-89	-71.2
Nov.	134	27	-107	-79.9
Total (Sep.-Nov.)	552	333	-219	-39.7
Total (all months)	1,021	802	-219	-21.4

WRI scientists, for those cases where the WRI sample represents over 20% of the JWA reported total, or otherwise where the JWA (Total) is well above 40 individuals. In terms of annual data, apart from the Sanriku region in 1961 and 1964, WRI scientists observed over 30% of the reported catch (Table 3). Fig. 3 plots the annual WRI and JWA percentages for both regions. Although the differences vary annually and by region, in all but the year 1964 for Sanriku (when the sample size was less than 20%), the percentage females was either very similar (e.g. 1963 for Sanriku) or significantly higher for the WRI data. It is interesting to note that for Sanriku the agreement between the JWA and WRI values improves over the 6-year period, whereas almost the opposite is true for Hokkaido. The proportion of females in the 1959 season is 63.1% ($n=582$) in the WRI sample, while it is 56.2% ($n=2,104$) in the JWA statistics. Thus, inclusion of the 1959 season does not alter the disparity in sex ratio between the two sources.

In terms of monthly data, the WRI coverage was generally reasonable (>20%, total catch *ca* 40+) for the months of June, July, August and October for Sanriku, and August to October for Hokkaido. These data (WRI) are plotted by year in Figs 4 and 5. Inspection of these figures reveals that for both locations, the percentage of females within a month can vary considerably by year (e.g. Hokkaido-August, from 21.6-70.1%), although the range, particularly for Hokkaido, is generally smaller towards the end of the season (September to November). This will relate to some degree to greater sample sizes in September ($n=171$-825) and October ($n=80$-395) than in August ($n=66$-297) in Hokkaido. The WRI sample suggests some monthly changes in female proportion, which is lower in July and August compared with September-October and perhaps June (Figs 4 and 5, overleaf, and Table 4).

The WRI sample is likely to give a less biased sex ratio of sperm whales processed by Japanese coastal whaling in 1959-1969. However, given the variability apparent within and between the regions of Hokkaido and Sanriku using the WRI data, it is not clear how they are representative of the entire catch, or if it is reasonable to pool these data in an attempt to derive a correction factor or a set of monthly correction factors for the JWA series that includes seasons not covered by WRI samples. A more appropriate response might be to note that there is considerable doubt over the reliability of the sex ratio data, noting that for the 1960-65 period the percentage of females was consistently under-estimated. If one does pool the monthly data over years, in some months the difference might be over 25% (Table 4).

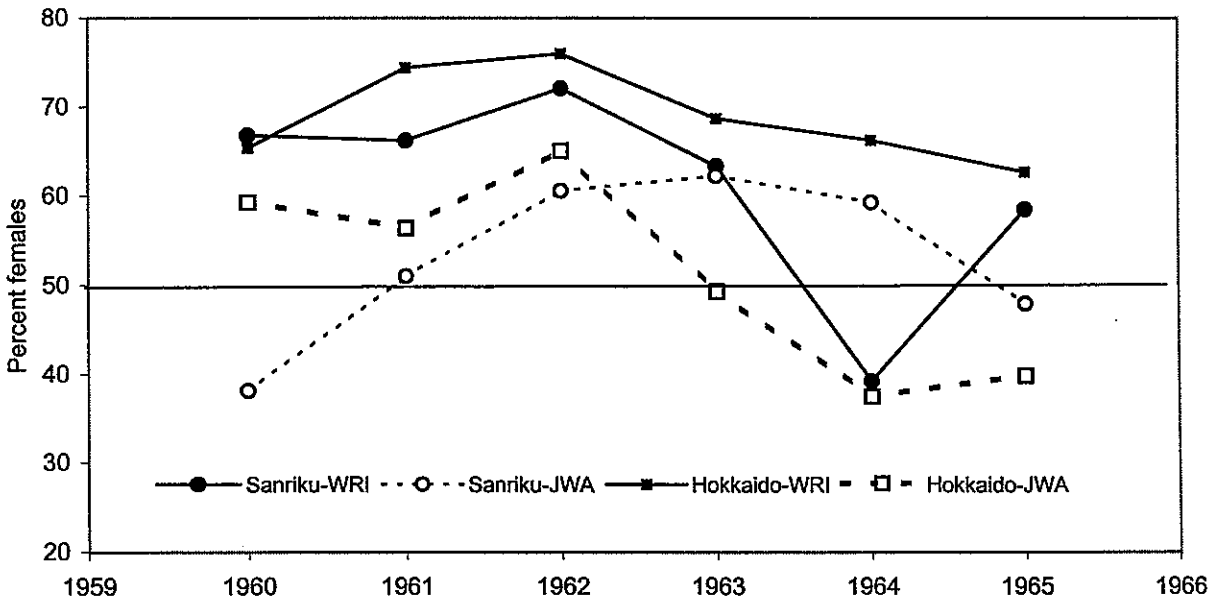

Fig. 3. Percentage of females reported in the WRI and JWA series for Sanriku and Hokkaido by year.

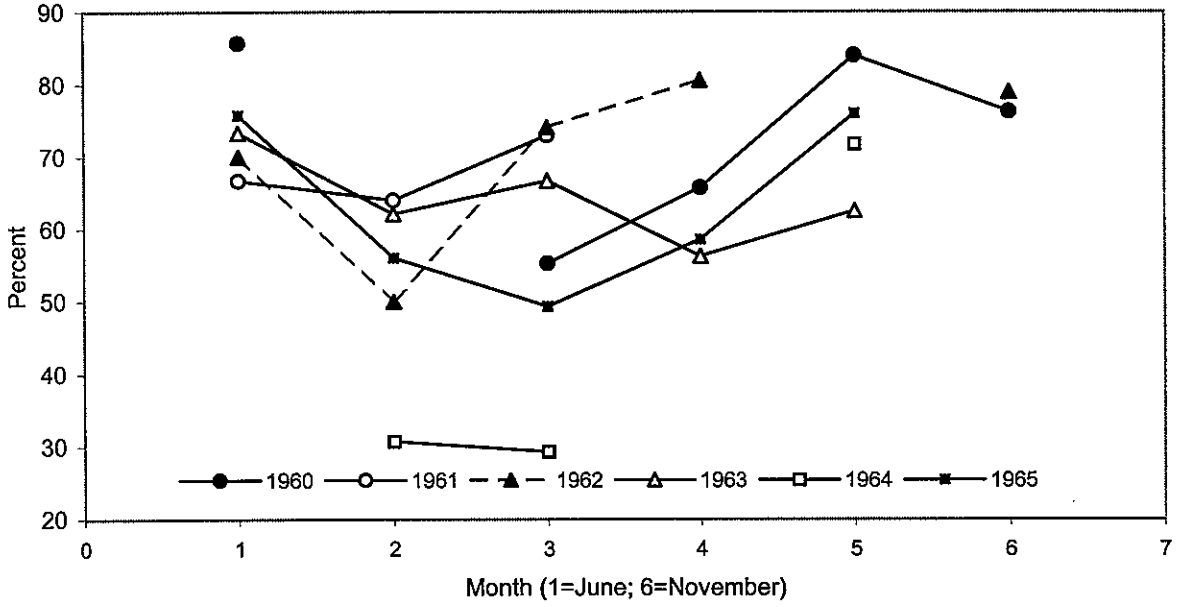

Fig. 4. Percentage of females in the WRI samples for Sanriku by month.

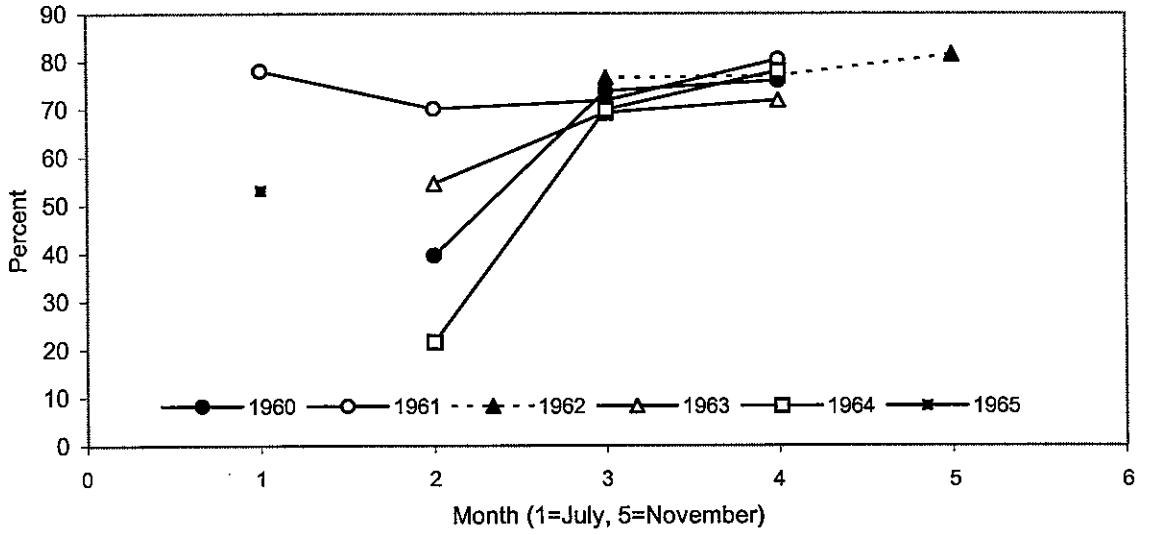

Fig. 5. Percentage of females in the WRI samples for Hokkaido by month.

Information from the B-log

At the Taiji land station, Company B (B-log) recorded a total catch of 234 sperm whales (132 males and 102 females) in the two whaling seasons 1984 and 1985 (Table 6, Fig. 6). The absence of sperm whales smaller than 31ft (9.3m) probably relates to the minimum size limit at the time (30ft). Best (1989) had noted a similar phenomenon for South African data. It is not possible to determine whether such a length distribution is a result of highly efficient size selection by gunners, 'stretching' of whales by the company, or discarding of smaller animals before towing them to the land station (see above). However, it seems unlikely that there would be a true peak at 31ft (31 whales representing 13% of individuals listed in the B-log) with no whales below that body length.

Assuming the validity of the B-log data, then all 132 males were correctly reported as males, while only 43 females out of 102 were reported with the correct gender, thus the true percentage of females in the catch (43.6%) was reported by the company as only 18.4%. Although still greater than the 11.5% allowed for the total catch, this value excludes data for the Ayukawa station for which there are no independent data.

DISCUSSION

The present paper is not the first to examine the reliability of catch data submitted to the Bureau of International Whaling Statistics. For example, Best (1989) made a number of observations on the reliability of the BIWS data based on his experiences of both pelagic and coastal whaling. Several of his concerns are echoed here.

Total catches

The first documented instance of differences between the 'official' statistics and those of biologists are those given in Tønnesen and Johnsen (1982) for the 1920-1930 period. However, the analysis of the data in this paper reveals little pattern: over-reporting as well as under-reporting was

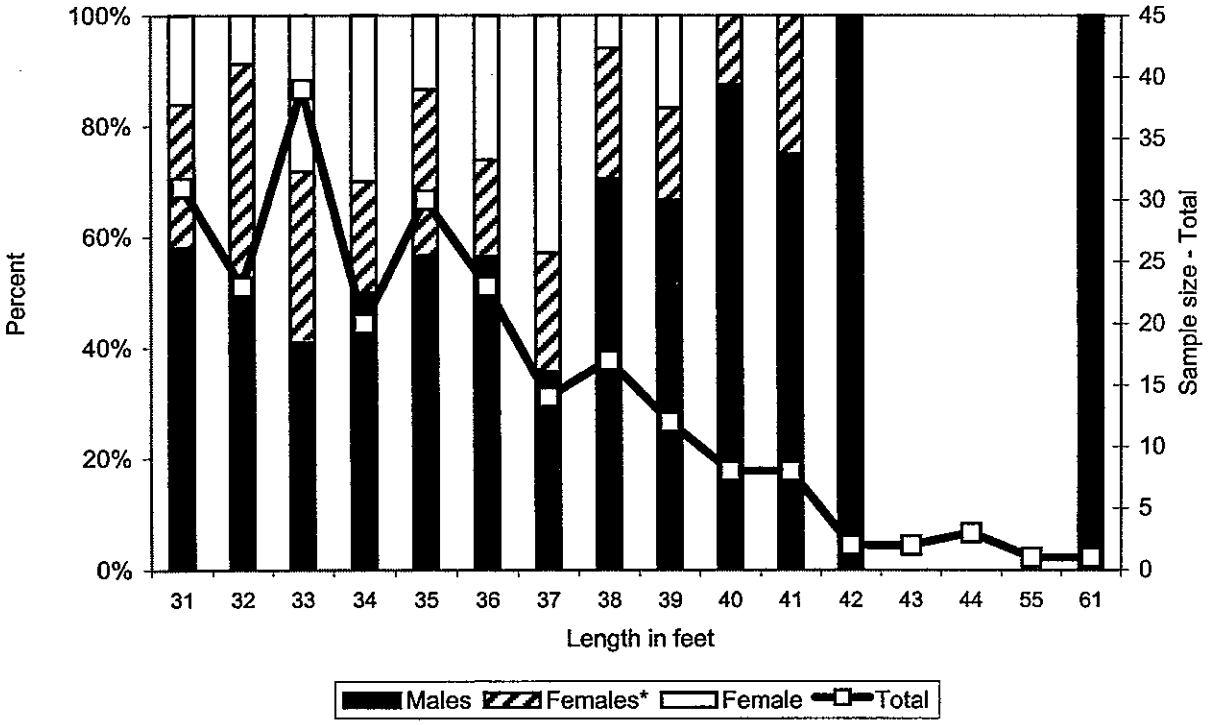

Fig. 6. Percentages of males, females and females reported as males using the data from B-log. Total sample size is also shown.

common and the reason for the disagreement between the WRI and BIWS data is unclear. At that time, there were no regulations controlling the number of whales taken (Omura *et al.*, 1942). Some local governors taxed land stations in their administrative area based on the number of whales processed (e.g. Ayukawa Village: N. Kimura pers. comm.) but whilst one might interpret this as an incentive to under-report the catch it does not explain over-reporting. It may be that investigation of the original data used by Omura can help to resolve this question.

The WRI data for the 1959-65 period also revealed some instances of under-reporting of catches, as did the A-log data for the period 1959-61. In four of the five instances in the WRI data, the confirmed under-reporting occurred late in the season (October in 1961 and 1963, November in 1960 and 1961). The A-log data revealed an increasing trend in under-reporting as the season progressed (Tables 5 and 8). Catch limits were first introduced in 1959 and it is not difficult to speculate why a company might increasingly under-report catches during a season when catch limits are in operation: for example it would enable catching to continue for an entire season, even after completion of the quota; and it might reflect a decline in inspector coverage in the later part of a season due to budgetary or other logistical constraints. It may be possible to address the latter at least by further inspection of records detailing the national inspection programme.

Interestingly, the A-log data do not preclude the possibility of over-reporting, especially in the case of baleen whales (Table 5). Over-reporting also occurred in the 1920-30 period (Fig. 2). It is more difficult to speculate why this should happen.

There were no catch limits or minimum size limits in force in the 1920-30 period and no baleen whale catch limits in the 1959-61 period. It is not obvious, therefore, why under-reporting should occur. Although there is no direct evidence to support this, one might perhaps speculate that a company might wish to hide its fishing grounds from competitors or to reduce its tax payments.

H. Omura (pers. comm.) knew of a custom in Japanese coastal whaling before World War II to classify small whales as 'unlisted' and exclude them from the catch statistics, rendering these unreliable to an unknown extent. Length regulations were first introduced to the coastal sperm whale fishery in June 1938 (Omura *et al.*, 1942). It is unknown whether 'unlisting' was a result of this regulation, due to size limits or whether there were some other reasons.

While working for the National Research Institute of Far Seas Fisheries of the Japanese Fisheries Agency, the author had an opportunity to examine library records of individual sperm whales processed by the coastal fishery. Some of the whales had a hand written note of '*bangai*' (i.e. unlisted) in red ink. Investigation of these records should help to clarify this issue.

Percentage of females in the catch

The Japanese coastal sperm whaling grounds covered the entire Japanese Pacific coast (25-45°N) (Ohsumi, 1981). Although information on stock identity is equivocal, the most recent hypothesis, which considers evidence from historical changes in the fishing grounds, the movement of marked whales and monthly changes in blood type composition (Kasuya and Miyashita, 1988) is that Japanese coastal waters include nursery schools (i.e. females, calves, immature males) from two putative populations, each breeding to the north and south of the Kuroshio/Oyashio front, and that the two stocks alternate seasonally off Sanriku (38°-41°N) and Hokkaido (42°-43°N) regions following the seasonal shift of the front.

Nursing schools from the northwestern North Pacific stock, which lack ju-2 positive individuals, summer mainly in northern waters east of the Kuril Islands and Kamchatka Peninsula (44°-55°N). In autumn, their range moves south and reaches 36°N. Thus, off Kushiro and Akkeshi (*ca.* 43°N) on the east coast of Hokkaido, the proportion of ju-2 positive individuals in a whaling sample declined from 53% (August/September) to 14% (October/November).

Wintering nursing schools were confirmed by a whaler (Shino, 1932) off Akkeshi (*ca.* 43°N) in January-March 1932 and at *ca.* 36°N by research whaling (Ohsumi and Satake, 1977) in January and February 1976. Nursing schools from the southwestern North Pacific stock, which are characterised by a high proportion of ju-2 positive individuals (>53%), winter in the western North Pacific south of 35°N, but their summer range extends north to the east coast of Hokkaido. Adult males apparently segregate, after the breeding season, to the north of the nursing schools (Kasuya and Miyashita, 1988). This explains the high female proportion in the catch off Sanriku/Hokkaido throughout the year with this ratio even possibly increasing in the winter months. Sperm whales are sparse in the southwestern North Pacific (10-25°N) as observed in Townsend (1935) and Miyashita *et al.* (1996).

If the industry was allowed to operate without regulations or self imposed length selectivity, one would expect a high proportion of females and animals <30ft of both sexes in the catch whatever the month. Thus the high female proportions found in the various non-JWA records are not particularly surprising. The introduction of catch limits by sex in 1977 and of a maximum percentage of females of 11.5% from 1979 might provide an incentive for an under-reporting of females, either by not reporting them at all or by mis-classifying females as males. The former approach would also result in an under-reporting of the total catch. For example, in order to maintain consistency between total catch numbers and production statistics, several small whales could have been converted into a larger whale.

What is surprising, is the extent of apparent under-reporting of females in the 1959-65 JWA statistics relative to the WRI sample. At that time, catch limits were not set by sex. However, a catch of large numbers of females might have invited suspicion of violation of the minimum size limit at the time (35ft), so this might have been one incentive to under-report them. The variability by month and the lack of any apparent pattern might suggest that the companies were not bothering to record sex information accurately rather than deliberately under-reporting. The situation was clearly somewhat different for the B-log data (1984 and 1985) when catch limits were in force by sex.

Detection of incorrect reporting

Although not strictly a scientific matter, an understanding of the social situations that surround fishing operations is critically important for the management of fishery resources. It would be remiss not to comment on the fact that three groups of people should perhaps have been in a position to detect any mis-reporting by the industry, but apparently did not report it: scientists; national inspectors; international observers. During the five year period (1961-1966) when the author worked for WRI as a scientist, although aware of the possibly low reliability of the sperm whale statistics, conclusive evidence was hard to accumulate from partial samples of multiple land stations. However, the availability of such evidence might not necessarily have resulted in prompt disclosure due to social constraints. Further discussion on the matter is available in Kasuya (1999).

From the scientists' perspective, two factors are relevant. The first is that the WRI scientists did publish their sample sizes, even though they did not personally comment on the differences with the official statistics. It should also be noted that the companies imposed a condition that the names of companies and land stations could not be included, only the geographical area (e.g. Sanriku or Hokkaido), making precise comparison of data considerably more difficult. The second and perhaps most important factor, is also applicable to inspectors and observers and relates to the fact that the number of personnel was insufficient for all stations to be continuously monitored throughout the season.

The fact the inspectors/observers were not assigned to each land station but that a single inspector/observer must cover several stations meant that it was at least possible for companies to choose to land whales at land stations without inspection. For example, the international observer at the Japanese land stations commented that the national inspection for sperm whales in coastal operations was as little as 7-10% (Gosho, 1979). Table 7 illustrates whaling regulations and availability of inspectors/observers to the whaling operation. Falsification may have been easier for the coastal fishery than for pelagic operations, since government inspectors were only present at the former for a small period of each fishing season.

CONCLUSION

The above analyses, even though they cover only a relatively short time series, clearly cast doubt on the reliability, particularly for post-World War II operations, of some of the BIWS data for the Japanese coastal sperm whale fishery in terms of total catches, length distribution and sex ratio. The data reveal that the degree of unreliability appears to differ considerably by month and year, and perhaps between companies.

The assessment of whale stocks requires information on historic catch levels. Where accurate data are not available, then it is important that the uncertainty in the data is incorporated into the analyses. This paper has begun the process of attempting to quantify the levels of uncertainty that may be present. However, further work is required to better determine this and perhaps to try and construct a corrected series.

A number of areas for future work are apparent:

(1) examine the additional data collected by the WRI to further elucidate the true age composition and sex ratio of catch by region, months and years, and to compare this with the equivalent JWA data - if it is possible, a comparison of JWA data and WRI data at a finer level might prove instructive - for example, one might expect the companies' data to be more rigorous on days when a biologist (or national inspector) was present;
(2) examine existing, but unanalysed, records of whaling operations (including small-type whaling operations), such as those kept in government laboratories and whaling companies;
(3) examine the prevailing legal and economic aspects of coastal sperm whaling in more detail, to try and determine any rationale for possible incorrect reporting;
(4) try to trace any private records that might have been kept by people involved in past operations.

Finally, it is important that this exercise is seen as a way to improve knowledge of the status of sperm whale stocks and not as an attempt to assign blame to individuals. Whaling is certainly not the only industry where companies have attempted to avoid national and international regulations and sometimes succeeded in avoiding detection. What is important is to use our best efforts to try to determine levels of reliability for past data and to learn from the past and ensure that inspection of any future operations is at a level which makes avoidance of regulations impossible.

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APPENDIX

Appendix Table 1

Sanriku Region, percentage of females and sample size for data collected by WRI scientists compared with JWA statistics. JWA figures that are exceeded in the sample taken by the scientists are in **bold**.

Item	1960	1961	1962	1963	1964	1965	Total	F (%)
April								
Males	0	0	0	0	0	0	0	
Females	0	0	0	0	0	0	0	
Total (WRI)	0	0	0	0	0	0	0	
Total (JWA)	50	20	1	4	11	1	87	28.7
May								
Males	2	12	0	3	2	0	19	
Females	0	17	0	0	0	0	17	
Total (WRI)	2	29	0	3	2	0	36	47.2
% F (WRI)	0	58.6	-	0	0	-	47.2	
Total (JWA)	19	120	9	96	38	6	288	50.7
% WRI	10.5	24.2	0.0	3.1	5.3	0.0	12.5	
June								
Males	3	16	3	8	16	8	54	
Females	18	32	7	22	0	25	104	
Total (WRI)	21	48	10	30	16	33	158	65.8
% F (WRI)	85.7	66.7	70.0	73.3	0	75.8	65.8	
Total (JWA)	99	139	36	54	48	59	435	40.9
% WRI	21.2	34.5	27.8	55.6	33.3	55.9	36.3	
July								
Males	5	9	14	25	18	40	111	
Females	1	16	14	41	8	51	131	
Total (WRI)	6	25	28	66	26	91	242	54.1
% F (WRI)	16.7	64.0	50.0	62.1	30.8	56.0	54.1	
Total (JWA)	49	51	43	69	40	198	450	33.6
% WRI	12.2	49.0	65.1	95.7	65.0	46.0	53.8	
August								
Males	34	10	28	35	41	70	218	
Females	42	27	80	70	17	68	304	
Total (WRI)	76	37	108	105	58	138	522	58.2
% F (WRI)	55.3	73.0	74.1	66.7	29.3	49.3	58.2	
Total (JWA)	107	282	87	171	237	326	1,210	50.7
% WRI	71.0	13.1	**124.1**	61.4	24.5	42.3	43.1	
September								
Males	36	0	7	21	0	29	93	
Females	69	0	29	27	0	41	166	
Total (WRI)	105	0	36	48	0	70	259	64.1
% F (WRI)	65.7	-	80.6	56.3	-	58.6	64.1	
Total (JWA)	170	166	216	312	325	236	1,425	64.2
% WRI	61.8	0.0	16.7	15.4	0.0	29.7	18.2	
October								
Males	4	0	0	15	13	13	45	
Females	21	0	0	25	33	41	120	
Total (WRI)	25	0	0	40	46	54	165	72.7
% F (WRI)	84.0	-	-	62.5	71.7	75.9	72.7	
Total (JWA)	38	34	67	97	111	206	553	61.7
% WRI	65.8	0.0	0.0	41.2	41.4	26.2	29.8	
November								
Males	15	0	4	0	0	0	19	
Females	48	0	15	0	0	0	63	
Total (WRI)	63	0	19	0	0	0	82	76.8
% F (WRI)	76.2	-	78.9	-	-	-	76.8	
Total (JWA)	40	39	79	36	0	141	335	51.6
%WRI	**157.5**	0.0	24.1	0.0	0.0	0.0	24.5	
Total								
Males	99	47	56	107	90	160	559	
Females	199	92	145	185	58	226	905	
Total (WRI)	298	139	201	292	148	386	1,464	61.8
Total (JWA)	572	851	538	839	810	1,173	4,783	53.2
% WRI	52.1	16.3	37.4	34.8	18.3	32.9	30.6	
F % (WRI)	66.8	66.2	72.1	63.4	39.2	58.5	61.8	
F % (JWA)	38.1	51	60.6	62.3	59.3	47.9	53.2	

Appendix Table 2

Hokkaido Region, percentage of females and sample size for data collected by WRI scientists compared with JWA statistics JWA figures that are exceeded by the sample taken by the scientists are in **bold**.

Item	1960	1961	1962	1963	1964	1965	Total	F (%)
April								
Males	0	0	0	0	0	0	0	
Females	0	0	0	0	0	0	0	
Total (WRI)	0	0	0	0	0	0	0	
Total (JWA)	1	10	6	21	2	5	45	13.3
May								
Males	0	0	0	0	0	0	0	
Females	0	0	0	0	0	0	0	
Total (WRI)	0	0	0	0	0	0	0	
Total (JWA)	42	2	17	8	3	1	73	34.2
June								
Males	0	0	8	0	0	0	8	
Females	0	0	0	0	0	0	0	
Total (WRI)	0	0	0	0	0	0	0	
Total (JWA)	8	31	23	48	30	23	163	25.8
July								
Males	10	11	0	2	1	15	39	
Females	0	39	0	0	0	17	56	
Total (WRI)	10	50	0	2	1	32	95	58.9
% F (WRI)	0	78	-	0	0	53.1	58.9	
Total (JWA)	158	208	8	37	90	73	574	39.5
% WRI	6.3	24.0	0.0	5.4	1.1	43.8	16.6	
August								
Males	122	53	4	20	29	18	246	
Females	80	124	13	24	8	0	249	
Total (WRI)	202	177	17	44	37	18	495	50.3
% F (WRI)	39.6	70.1	76.5	54.5	21.6	0	50.3	
Total (JWA)	253	297	155	112	140	66	1,023	40.7
% WRI	79.8	59.6	11.0	39.3	26.4	27.3	48.4	
September								
Males	148	110	62	31	55	38	444	
Females	416	280	203	70	128	100	1,197	
Total (WRI)	564	390	265	101	183	138	1,641	72.9
% F (WRI)	73.8	71.8	76.6	69.3	69.9	72.5	72.9	
Total (JWA)	825	548	373	308	483	171	2,708	59.3
% WRI	68.4	71.2	71.0	32.8	37.9	80.7	60.6	
October								
Males	24	55	48	48	20	5	200	
Females	76	226	160	123	71	11	667	
Total (WRI)	100	281	208	171	91	16	867	76.9
%F (WRI)	76.0	80.4	76.9	71.9	78.0	68.8	76.9	
Total (JWA)	176	80	395	161	188	237	1,237	61.7
% WRI	56.8	**351.3**	52.7	**106.2**	48.4	6.8	70.1	
November								
Males	0	11	8	1	0	0	20	
Females	2	29	35	7	0	0	73	
Total (WRI)	2	40	43	8	0	0	93	78.5
% F (WRI)	100	72.5	81.4	87.5	-	-	78.5	
Total (JWA)	9	18	165	179	53	51	475	52
% WRI	22.2	**222.2**	26.1	4.5			19.6	
Total								
Males	304	240	130	102	105	76	957	
Females	574	698	411	224	207	128	2,242	
Total (WRI)	878	938	541	326	312	204	3,199	70.1
Total (JWA)	1,472	1,194	1,142	874	989	627	6,298	52.9
% WRI	59.6	78.6	47.4	37.3	31.5	32.5	50.8	
F % (WRI)	65.4	74.4	76	68.7	66.3	62.7	70.1	
F % (JWA)	59.3	56.4	65.1	49.3	37.5	39.8	52.9	

Appendix Table 3

Comparison of A-log and JWA statistics (in parentheses).

	No. captured				Listed in A-log	
Month	Sperm	'Sei'	Fin	Blue	Day	Vessels
1959 Land station/Region: Oshima						
Apr.	25 (25)	0 (0)	0 (0)	0 (0)	1-25	2
May	(4)	(2)	(0)	(0)		
June	0 (0)	48 (70)	0 (0)	0 (0)	5-23	4
July	(1)	(70)	(0)	(0)		
Aug.	(6)	(6)	(0)	(0)		
Total[1]	25 (36)	48 (148)	0 (0)	0 (0)		
1959 Region: Sanriku/Hokkaido						
May	30 (38)	79 (74)	3 (4)	0 (0)	1-31	8
June	10 (7)	56 (113)	0 (1)	1 (1)	1-10, 23-30	7
July	50 (57)	51 (58)	4 (5)	0 (0)	1-31	5
Aug.	310 (358)	18 (23)	0 (0)	0 (0)	1-26	9
Sep.	249 (231)	21 (37)	0 (3)	0 (0)	1-29	10
Oct.	123 (101)	31 (43)	1 (2)	2 (0)	1-31	12
Nov.	45 (19)	0 (0)	0 (0)	0 (0)	1-7	4
Total[1]	817 (811)	256 (348)	8 (15)	3 (1)		
1960 Region: Sanriku/Hokkaido						
Mar.	10 (0)	0 (0)	0 (0)	0 (0)	30-31	1
Apr.	8 (18)	0 (0)	0 (1)	0 (0)	2-24	6
May	22 (23)	30 (43)	1 (2)	0 (0)	9-31	8
June	0 (51)	4 (80)	0 (0)	0 (0)	1-2	4
July	(116)	(39)	(4)	(0)		
Aug.	19 (165)	5 (17)	0 (0)	0 (0)	19-29	8
Sep.	416 (443)	7 (12)	0 (0)	0 (0)	1-30	9
Oct.	164 (75)	7 (7)	0 (0)	0 (0)	3-31	7
Nov.	34 (13)	0 (0)	0 (0)	0 (0)	7-22	4
Total[1]	673 (904)	53 (198)	1 (7)	0 (0)		
1961 Region: Sanriku/Hokkaido						
Apr.	6 (6)	0 (0)	0 (0)	0 (0)	17-20	2
May	31 (37)	39 (43)	0 (0)	0 (0)	6-30	10
June	35 (33)	72 (80)	0 (0)	1 (1)	1-27	9
July	(132)	(83)	(7)	(0)		
Aug.	122 (261)	4 (17)	0 (2)	0 (0)	22-31	9
Sep.	293 (270)	18 (12)	0 (0)	0 (0)	1-30	9
Oct.	125 (36)	1 (1)	0 (0)	0 (0)	2-31	4
Nov.	134 (27)	0 (0)	0 (0)	0 (0)	1-30	4
Total[1]	746 (802)	134 (236)	0 (9)	1 (1)		

[1] Two corresponding figures in the total are not directly comparable, because A-log is incomplete in some months.