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Incidental capture of *Phocarctos hookeri* (New Zealand sea lions) in New Zealand commercial fisheries, 2002–03

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EXECUTIVE SUMMARY

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Of the 28 vessels targeting squid (*Nototodarus* spp.) in SQU 6T during February-April 2003, 11 carried observers. Data from observed tows where no Sea Lion Exclusion Device (SLED) was used or a SLED was used with the cover net closed were used to estimate the total capture of New Zealand sea lions (*Phocarctos hookeri*). This coverage represented 23% of the 1368 tows made in the season. Observers reported 10 New Zealand sea lion captures (all landed dead), 9 (6 females, 3 males) for the main fishery during February-April and 1 male from a vessel targeting squid (and fishing on its own) in June. All sea lions were caught in separate tows: four were caught in nets without a SLED and five were caught in nets with SLEDs with the cover net tied down. The mean catch rate for observed tows that used midwater nets was substantially higher than for bottom nets.

The nine captures observed during February-April 2003 resulted in a seasonal mean catch rate of 0.027 sea lions per tow (s.e. = 0.009) and an estimated total of 39 New Zealand sea lion captures (deaths) (c.v. = 30%). With the addition of the 1 capture in June, the total captures for the squid fishery in 2002–03 is 40 sea lions. The mean catch rate for 2003 was more similar to that in 1999 than in more recent seasons.

One female New Zealand sea lion was landed dead from an observed midwater hoki (*Macruronus novaezelandiae*) tow in waters off the eastern edge off the Auckland Islands Shelf in October 2002.

1. INTRODUCTION

Statutory obligations require the Ministry of Fisheries (MFish) to monitor the bycatch of associated or dependent species during commercial fishing operations in New Zealand waters. The MFish Observer Programme collects data on the incidental catch of New Zealand (Hooker's) sea lions (*Phocarctos hookeri*) as part of its monitoring programme.

The proximity of the southern squid (*Nototodarus sloanii*) trawl fishery to the foraging grounds of New Zealand sea lions has resulted in incidental catches of these marine mammals. Vessels operate under a code of practice designed to minimise marine mammal capture and are restricted to fishing outside a 12 n. mile zone around the Auckland Islands. In recent squid fishing seasons, mitigation devices known as Sea Lion Exclusion Devices (SLEDs) (Anon. 2002) have been used in the trawl nets as part of at-sea trials to test the effectiveness of the device in ejecting live sea lions. When a SLED is in place, the net has a cover net that provides a potential escape route for the animals when it is left open.

New Zealand sea lions are nearly always caught singly and are usually landed dead. A maximum allowable level of fishing related mortality (MALFiRM) for New Zealand sea lions has been in place since 1993. The observed capture of sea lions during the squid fishery season is monitored to provide weekly within-season estimates of the total capture of sea lions, based on Ministry of Fisheries observed captures and commercial tow data from the Seafood Industry Council (Doonan 2001). The fishery is closed if this within-season estimate nears the MALFiRM determined for that year (Annala et al. 2004). As part of the operational plan to monitor the incidental capture of New Zealand sea lions in the 2003 squid fishery at SQU 6T, the Ministry of Fisheries and Department of Conservation set a MALFiRM of 70 sea lions.

This report addresses Specific Objective 1 of ENV2001/02: "to estimate and report the total numbers of captures, releases, and deaths of *Phocarctos hookeri* caught in fishing operations, including separate estimates for SQU 6T and other areas, as appropriate, during the 2002/03 fishing year, including confidence limits and an investigation of any statistical bias in the estimate".

2. METHODS

2.1 Data sources and treatment for 2002–03

Data required for the analyses undertaken to estimate the total numbers caught included observed New Zealand sea lion capture data, observed fishing effort data, and total fishing effort data. The observer data were extracted from the MFish *obs* and *obs_lfs* databases compiled from the observer logbooks, and the commercial data were extracted from the MFish Trawl Catch and Effort database for those vessels that completed Trawl Catch Effort Processing Return forms (TCEPR).

Data were extracted for the target fisheries in which incidental captures of New Zealand sea lions were recorded by MFish scientific observers during the fishing year (1 October–30 September) 2002–03 in the southern squid trawl fishery and in the sub-Antarctic hoki (*Macruronus novaezelandiae*) trawl fishery in the Auckland Islands part of SQU 6T.

The following observer data were extracted by target species for each fishing operation: trip, tow, gear type, latitude and longitude, date and time, vessel identifier and nationality, number of New Zealand sea lions, life status (alive or dead), handling code (released, discarded, or retained), and sex, as recorded by MFish scientific observers. Insufficient data relating to the use of a SLED were collected by the MFish observer and catch effort logbooks, and fishing

industry data collected for the within-season estimation were used to determine which tow used a SLED.

Reconciliation of these two datasets was not as straightforward as in other years. Two vessels appeared to have changed names and there may be more than one vessel identification key for at least two vessels. Industry data were originally collated for the 2003 squid fishery within-season estimation work (as used by Doonan (2003)), and did not contain the same detail as that in the MFish dataset. Position data (latitude and longitude) were not available; rather the data were allocated to one of two areas (SQU 6T and SQU 1T). The industry data included more tows in SQU 6T than the MFish commercial and observer data: 1409 (all effort) and 349 (MFish observer present) tows in the industry data compared with 1386 and 338 tows in MFish data, and the difference between numbers of tows ranged from 0 to 17, with no differences for 7 vessels of the 28 vessels.

The industry data for SQU 6T is from 10 January 2003 to 28 April 2003, and the dates for which this effort was observed are 1 February to 25 April. The commercial and observed data from MFish also included the fishing activity of one vessel outside the main season, in May and June. These tows were not included in the analysis because all the vessel's effort was observed and there were no other vessels targeting squid in the areas at the time. Thus, the analysis for SQU 6T is limited to February to April.

Under the Conservation Services Programme administered by the Department of Conservation, dead New Zealand sea lions from the squid SQU 6T fishery are returned for autopsy (for example, Duignan et al. (2003)). Data received from the Department of Conservation for the 2002–03 fishing year provided verification of species identification and sex of all the captures reported by observers.

The following total fishing effort data for each fishing operation were extracted: trip, event, target species, gear type, gear parameters, latitude and longitude, date, time, and vessel identifier and nationality.

All data were error checked and erroneous data were amended where possible; for example, where position data of some fishing operations were identified as obvious outliers, the latitudes and longitudes were amended with reference to fishing operations before and after the incorrect data. Data will be investigated for any differences in sea lion catch rates by month, nation, vessel, sub-areas of SQU 6T (north and south of 50° 30' S), gear type, and use of a SLED.

2.2 Data analysis

The extracted data were stratified by target fishery, gear type (where appropriate), area, and month for the SQU 6T target fishery area. In previous years, some estimators used for this work (for example, Baird 2001) have been used with caution due to the relative observer coverage. For example, where the sampling fraction (of observed effort over total effort) is low (for example, under 10%), then extrapolation from the observed effort to that of the whole fleet in that stratum may be unwise, in that errors in the sample estimators will have a high leverage on the final total estimate for that stratum. Furthermore, if vessels show substantially different marine mammal bycatch rates then, where there are many vessels operating, the observer coverage needs to include several vessels — ideally in a representative way. Therefore, it was necessary to investigate the spread of observer and total effort data, by area, number of fishing operations, and number of vessels. Estimates of incidental capture rates, total estimates, and associated variance can be calculated only where there is confidence in the use of the bootstrap method.

The mean bycatch rate of New Zealand sea lions per observed tow ($\bar{y}$) is estimated by the ratio-of-means estimator:

$$\bar{y} = \frac{\sum c_i}{\sum n_i}$$

where n_i is the number of observed tows, and c_i is the number of observed incidental captures of sea lions. Then the total catch of sea lions, $\hat{T}$, is estimated by

$$\hat{T} = N\bar{y} \qquad \text{with estimated variance} \qquad Var(\hat{T}) = N^2 s_b^2 (1 - n/N)$$

where N is the total number of tows and s_b^2 is the sample variance of the bycatch rate. These are standard results from finite sampling theory (Cochran 1977, Manly 1992). The variance of the observed bycatch rate was estimated by bootstrapping (randomly resampling the observed data 1000 times, after Efron & Tibshirani (1993)), and thus this estimate of variance takes into account the sample size.

The coefficient of variation (*c.v.*) is given by: $$c.v. = \frac{\sqrt{Var(\hat{T})}}{\hat{T}}$$

3. RESULTS

3.1 Incidental captures of New Zealand sea lions, 2002–03

MFish observers reported New Zealand sea lion captures from observed fishing operations in two trawl fisheries:

- 10 were observed caught and landed dead in squid trawls in the Auckland Islands part of SQU 6T (6 females and 4 males). One observer also reported one badly decomposed sea lion which is not included in the analysis.
- 1 female was observed caught (and landed dead) in a midwater hoki trawl net off the eastern edge of the Auckland Islands Shelf in mid October 2002.

3.1.1 New Zealand sea lions and the southern squid trawl fishery in SQU 6T

3.1.1.1 Description of the fishery

Twenty-eight vessels deployed 1467 tows in the southern squid trawl fishery in SQU 6T from January to June 2003, and 93% of tows were made during February-April (Table A1). Eleven Korean vessels and eight CIS (Commonwealth of Independent States) vessels accounted for 32% and 40%, respectively, of the total effort. The remainder of the effort was on vessels from New Zealand (15%), Poland (8%), and Japan (5%). Observers were present on vessels from all nations except Poland: thus, 40% of the observed effort was on three Korean vessels, 32% on five CIS vessels, 20% on three Japanese vessels, and 6% on one New Zealand vessel.

Observed tows with no SLED and those with a SLED with the cover net tied down were used to estimate the sea lion capture rates, given that any caught animals may have had the potential to escape from tows that used a SLED, but had the cover net left open. Overall, 11 of the 28 vessels and 23% of the tows were observed (Table A1). About 53% of all tows and 51% of observed tows used midwater nets. The distribution of the start positions of observed tows, including those that captured New Zealand sea lions, is shown in Figure A1 in Appendix B.

3.1.1.2 New Zealand sea lion incidental captures and estimates

MFish observers reported 10 New Zealand sea lion captures, all landed dead. All incidents were of single captures. Nine captures (six females, three males) were observed during the main fishery (February-April) and one male was observed outside this time (in June) when an observed Korean vessel fished at SQU 6T during May and June. All the effort by this vessel was observed. There is no information regarding the use or not of any mitigation device by this vessel.

During March and April, observed tows with no SLED caught four sea lions and tows with a SLED and the cover net tied down caught five sea lions (Tables A1 & A2). Four of the 11 vessels caught sea lions, 1 CIS vessel without a SLED caught 4, 1 Japanese vessel with a SLED caught 3, and 2 CIS vessels each caught 1. No captures were observed from the one New Zealand vessel or the three Korean vessels during the main season. Observed vessels from CIS used midwater tows exclusively, whereas all other vessels used bottom trawl nets, apart from one Japanese vessel that used midwater nets on 25% of the observed tows. Eight sea lions were reported from midwater nets.

No differences were seen in the mean catch rates by area (north or south of 50° 30' S), by month, or by SLED use (Figure A2). However, midwater nets resulted in a substantially larger mean catch rate than that for bottom nets. This is further reflected in the comparison of catch rates for vessels from different nations, given that all CIS tows used midwater nets and two of the three captures in Japanese tows were in midwater nets (Figure A3). Differences between catch rates for those vessels with New Zealand sea lion catches were not obvious (Figure B3).

For the February-April season, based on observed tows being those without a SLED and those with a SLED and the cover net tied down, an estimated 39 New Zealand sea lions were caught (c.v. = 30%) (Table A1). Another sea lion was reported from the fully observed effort in May and June. Comparison of mean catch rates suggests the rate for 2003 was more similar to that observed in 1999 than in other recent years (Table B3).

3.1.2 New Zealand sea lions and the sub-Antarctic hoki fishery, 2002–03

Vessels targeted hoki in the sub-Antarctic fishery in all months of 2002–03. One sea lion was landed dead during a midwater tow off the eastern edge of the Auckland Islands Shelf during October 2002 when 3% of the 448 tows made were observed, and few observed tows were close to the Auckland Islands Shelf (Baird 2004b).

4. DISCUSSION

Estimates are provided here only for the incidental captures of New Zealand sea lions in the SQU 6T squid fishery in 2002–03 because catches in other fishery areas were too low. Observed data for the SQU 6T fishery were restricted to those tows which had no SLED or used a SLED with the cover net closed, such that a captured New Zealand sea lion could not escape other than by swimming back out of the net. Analysis of the 11 year dataset of New Zealand sea lion captures in the SQU 6T trawl fishery (under MFish project ENV2000/02) indicated that, apart from year (season), the major factor in explaining the variance in the estimates was the distance between the start position of the tow and the position of the nearest rookery (M. H. Smith, NIWA, pers. comm.). These data show that for 2003 the distribution of the observed tows relative to the distance from the nearest rookery was similar to that for the whole fleet.

There was no difference between the within-season and post-season estimates for the February-April SQU 6T fishery. The within-season estimate for 2003 was 39 sea lions with 32% confidence intervals of 22 and 68 (Doonan 2003); this estimate does not include the capture made in June 2003. The mean catch rate for SQU 6T in 2003 is the lowest since 1996 (Table A3) and the total estimate is the smallest for seasons when there has been at least 1000 tows in the fishery.

5. ACKNOWLEDGMENTS

The Ministry of Fisheries funded this work under Project ENV2001/02. Thanks to Paul Starr (SeaFIC) and the Squid Fishery Management Company for allowing release of the 2003 data to further characterise the use of mitigation measures. Thanks to the Department of Conservation for provision of the sea lion autopsy results.

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Appendix A: SQU 6T squid trawl fishery, 2003

Table A1: Fishing effort, observed effort, and mean bycatch rates (numbers of sea lions per tow) for the southern squid trawl fishery in SQU 6T where observed tows are those with no SLED or with a SLED and the cover net tied down, 2003*.

Month	Total no. tows	No. observed tows	% tows observed	No. sea lions observed caught	Mean bycatch rate	Standard error	Estimated number caught	c.v. (%)
February	439	42	10	0	0.0	–	–	–
March	614	111	18	2	0.018	0.012	11	63
April	312	161	51	7	0.043	0.016	14	25
Total	1 365	314	23	9	0.027	0.009	39	30

* Another 17 bottom tows were made (but unobserved) in early January and all of the 82 tows made in May and June on one vessel were observed and one sea lion was captured. Twenty-four tows with an observer present were not included in the February count because the SLED was used with the cover net open. Three tows in the total effort were not included because industry data suggest they did not use a SLED. All other commercial tows used SLEDs with the cover net open.

Table A2: Summary of SLED use on vessels in SQU 6T during February-April 2003, based on fishing industry data*.

	Total tows	Observed tow data			
		Total	No SLED	SLED	Cover net down
Bottom tows	640	175	33	142	123
Midwater tows	728	163	44	119	114
Total	1 368	338	77	261	237
No. sea lions	–	9	4	5	5

* Another sea lion was observed caught during June on a trip by one vessel in SQU 6T. See text for details. Industry data, though not directly comparable with the MFish commercial data, suggest that all but three unobserved tows during February-April used SLEDs.

Appendix A — *continued*

Table A3: Fishing effort, observed effort, and mean bycatch rates (numbers of sea lions per tow) for the southern squid trawl fishery in SQU 6T, 1993–2002. Note that slightly different estimation methods were used prior to the 1998 season.

Year*	Total no. tows	% tows observed	No. observed caught	Mean bycatch rate	Standard error	Estimated no. caught	c.v. (%)
1993	666	29	5	0.020	–	17 (7–36)	–
1994	4 660	9	3	0.007	–	32 (8–91)	–
1995	3 999	7	8	0.029	–	109 (41–191)	–
1996	4 450	12	13	0.023	–	101 (47–155)	–
1997	3 710	20	29	0.037	–	124	18
1998	1 413	24	15	0.045	0.010	63	22
1999	395	40	5	0.032	0.010	12	33
2000	1 206	36	25	0.058	0.010	70	17
2001†	580	51	33	0.111	0.020	64	12
2002	1 645	26	20	0.047	0.013	74	24
2003‡	1 365	23	9	0.027	0.009	39	30

- Mean bycatch rates and total estimates (with 95% confidence intervals) for 1993 are from Baird (1996); note that three sea lion captures in the scampi fishery around the Auckland Islands were added to the 1993 estimate. Mean bycatch rates and total estimates (with 95% confidence intervals) for 1994–96 are from Baird (1997). Data for 1997 are from Doonan (pers. comm.). Data for 1998–2001 are from Baird (1999, 2001, 2004a) and Baird & Doonan (2002).

† Observed data given here are for the section of the fleet that used SLEDs with the cover net tied down, during January-April.

‡ These data are for the February-April season. Another sea lion was caught in June (see text of report).

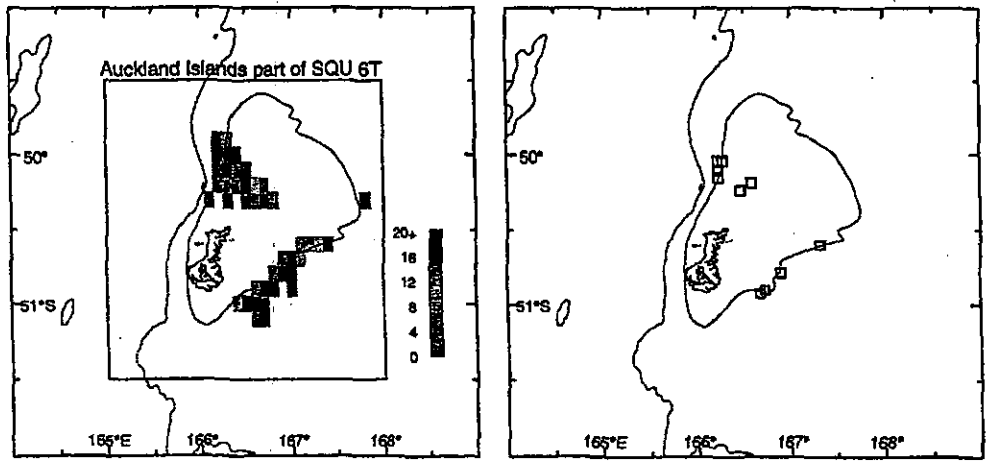

Figure A1: Distribution and density of squid trawling effort (number of tows in 0.1 degree cells), based on start of tow positions (left), and start positions of tows New Zealand sea lion captures (□)(right), for the Auckland Islands part of SQU 6T, 2003.

Appendix A — *continued*

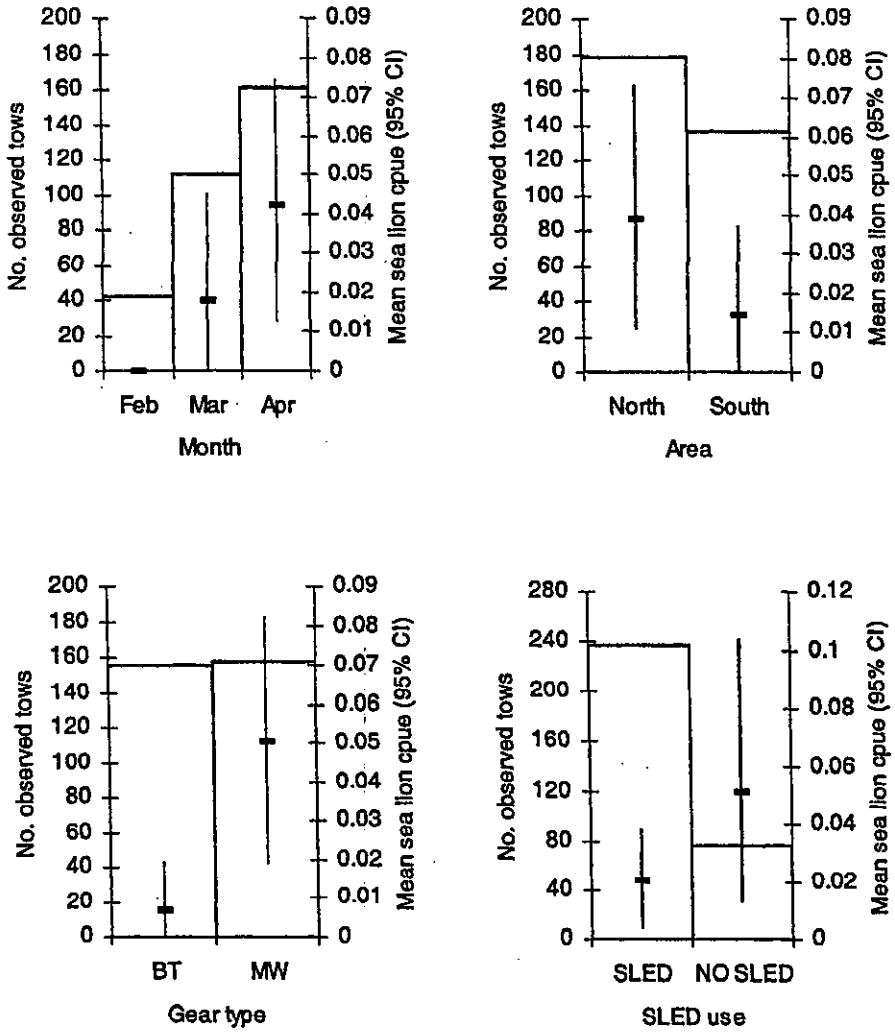

Figure A2: Observed effort (histogram) and mean catch rates (number of New Zealand sea lions per tow ± 95% confidence intervals) by month, area (north and south of 50° 30' S), gear type, and SLED use, in the SQU 6T squid trawl fishery, 2003.

Appendix A — *continued*

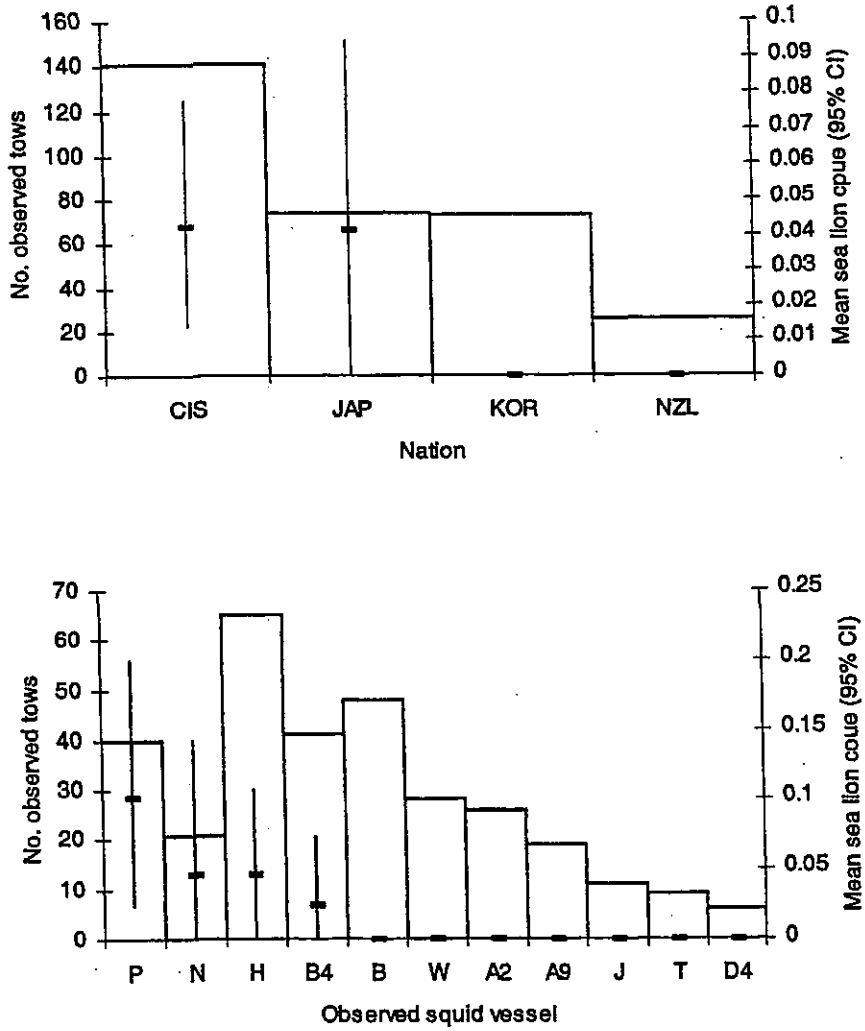

Figure A3: Observed effort and mean catch rates (number of New Zealand sea lions per tow ± 95% confidence intervals) by nation and by observed vessel in the SQU 6T squid trawl fishery, 2003. [Note: CIS is Commonwealth of Independent States, JAP is Japan, KOR is Korea, and NZL is New Zealand.]