ISSN 1175-1584

MINISTRY OF FISHERIES
Te Tautiaki i nga tini a Tangaroa

Phocarctos hookeri (New Zealand sea lions): incidental captures in New Zealand commercial fisheries during 2000–01 and in-season estimates of captures during squid trawling in SQU 6T in 2002

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New Zealand Fisheries Assessment Report 2005/17
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Published by Ministry of Fisheries
Wellington
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ISSN 1175-1584

Citation:
Baird, S.J.; Doonan, I.J. (2005).
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and in-season estimates of captures during squid trawling in SQU 6T in 2002.
New Zealand Fisheries Assessment Report 2005/17. 18 p.

This series continues the informal
New Zealand Fisheries Assessment Research Document series
which ceased at the end of 1999.

EXECUTIVE SUMMARY

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This report addresses the two specific objectives of ENV2001/02:

- Specific Objective 1 "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 2000/01 fishing year, including confidence limits and an investigation of any statistical bias in the estimate", and
- Specific Objective 2 "to provide weekly within-season estimates (with confidence intervals) of total captures, releases, deaths by sex and area for *Phocarctos hookeri* taken in the southern squid fishery (area SQU 6T) beginning two weeks after the start of the 2001/02 fishery until 30 May 2002".

Estimation of New Zealand sea lion incidental captures for 2000–01 (Objective 1)

The 2001 southern squid fishery had 100% observer coverage of the 23 vessels in SQU 6T between 15 January and 30 April. Vessels completed 580 tows, of which 576 were observed, and Sea Lion Exclusion Devices (SLEDs) were used on all but two of the observed tows. Most of the 39 New Zealand sea lions were caught singly, other than in three tows in which two animals were caught. Males accounted for 17 of the 39 New Zealand sea lions observed caught. Data from observed tows with cover nets tied down were used to estimate the total capture of New Zealand sea lions. The 33 captures from these tows gave a bycatch rate of 0.11 sea lions per tow, and an estimated total of 64 New Zealand sea lion captures (95% confidence intervals of 54–75, c.v. = 12%). Six New Zealand sea lions were observed caught in nets with the cover nets open, and three of these were released alive from the net.

Three male New Zealand sea lions were also observed caught (and landed dead) during three squid tows off the Stewart-Snares shelf in February and March. Four females were observed caught (two were released alive) during scampi tows in SQU 6T in May and June. No estimates are given for these captures because of the low number of animals seen and (for the scampi fishery) the small number of observed tows.

Within-season estimation for SQU 6T squid trawl fishery in 2002 (Objective 2)

The squid season in SQU 6T started in February and the last data were collected on 14 April 2002. Data were collected on a weekly basis by companies and collated by the Seafood Industry Council (SeaFIC). Within-season estimates of total kills were calculated using the fraction of observed tows that caught New Zealand sea lions. Observed tows were defined as those tows that were observed by a Ministry of Fisheries observer and that either used a SLED with a closed cover net or did not use a SLED. The final within-season estimate of total kills of New Zealand sea lions in the squid management area SQU 6T was 84 with a c.v. of 26% and 95% confidence limits of 59–119.

Sex of the observed captures of dead animals was not reported, so no within-season estimates of female sea lions are provided here.

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 Scientific Observer Programme collects data on the incidental catch of New Zealand (Hooker's) sea lions (*Phocarctos hookeri*) as part of its monitoring programme.

New Zealand sea lion captures are reported predominantly from the squid trawl fishery (Baird 2001). The southern squid trawl fishery is based off the Stewart-Snares shelf and around the Auckland Islands in SQU 6T in depths of about 150–300 m during January to May. The Total Allowable Commercial Catch for SQU 6T has been about 30 000 t since 1990–91. Annual reported catches peaked in 1993–94 and 1994–95 when at least 30 000 t were reported. Since then reported catches have declined and reached a low of 950 t in 1998–99, which resulted from reduced squid abundance and the early closure of the fishery as a management measure for New Zealand sea lions (Annala et al. 2001). Landings from this area totalled 3254 t in 2000–01.

Breeding populations of New Zealand sea lions are located primarily in the Auckland Islands group. Breeding begins in late November when adult males establish territories. Males leave in February, but females stay on to suckle their pups, during which time about 50% are foraging at sea at any one time. Pup production estimates in 2001 showed a 0.1% increase over the previous season and the mean population estimate (and 95% confidence intervals) for 2000–01 was 14 108 (12 305–16 163) (Anon. 2002). Proximity of the southern squid trawl fishery to the foraging grounds of the 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 the cover net is left open, the SLED provides a potential escape route for the animals.

New Zealand sea lions are nearly always caught singly and are usually landed dead. A maximum allowable level of fishing related mortality (MALFiRM) (Anon. 2000) 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 estimation of the bycatch of New Zealand sea lions nears the MALFiRM determined for that year, as happened in all seasons since 1996, except for the 1999 season.

2. ESTIMATION OF NEW ZEALAND SEA LION CAPTURES, 2000–01 (Objective 1)

2.1 Methods

2.1.1 Data sources and treatment for 200001

Data used 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. These data were extracted from the MFish databases *obs*, *obs_lfs*, and *warehou*.

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) 2000–01 in the southern squid (*Nototodarus sloanii*) trawl fishery in SQU 6T and

on the Stewart-Snares shelf. and in scampi (*Metanephrops challengeri*) trawl fishery in SQU 6T.

The following observer data were extracted by target species for each fishing operation: gear type, latitude and longitude, date and time, 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. The results from the Conservation Services Levy autopsy programme (overseen by the Department of Conservation) verified the identification and sex data for those sea lions landed dead (Gibbs et al. 2003). The following total fishing effort data for each fishing operation were extracted: target species, gear type, latitude and longitude, date and time.

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. Where the numbers of tows recorded in the TCEPR database were less than that in the observer database, as occurred in data for several vessels, the data for those observed tows that were missing from the TCEPR records were incorporated into the commercial data.

The extracted data were stratified by target fishery, gear type (where appropriate), area, and month for each target fishery area. In previous years, some estimators used for this work (for example, Baird 2004) 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. If the number of observed fishing operations is low, the variance estimation (by a bootstrap method) may be unreliable.

Furthermore, if vessels show different marine mammal bycatch rates (and in some fisheries, some vessels have higher bycatch rates than others) 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.

For the 2001 SQU 6T squid fishery where the fishing effort was 100% (or near to) covered by observers, the actual numbers of the New Zealand sea lion incidental captures are collated and reported by appropriate strata. About 52% of observed tows were on vessels that used SLEDs with the cover nets tied down. Industry data used for the within-season work were collated and compared with those from the observer records, but there were some discrepancies in the reporting of the use of cover nets between the two data sets, and the industry dataset was smaller than the observed set (Table 1 in Appendix 1). The observed data used for the calculation of the bycatch rate are those tows with cover nets tied down and it was assumed that all these tows were observed.

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

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

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

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

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: $$c.v. = \frac{\sqrt{Var(\hat{T})}}{\hat{T}}$$

Given the two distinct areas of fishing activity in SQU 6T, one to the north of the Auckland Islands and one to the southeast, the data are divided at 50° 20' S to determine if there is any difference in catch rates between the two areas. Observer coverage and sea lion catch rates by gear type and nationality are also investigated.

2.2 Results

New Zealand sea lions were reported from observed fishing operations in three target fisheries:

- 39 were observed caught in squid trawls in the Auckland Islands part of SQU 6T, and 33 of these were observed caught in tows with the cover nets tied down,
- 3 were observed caught in squid trawls off the Stewart-Snares shelf, and
- 4 were observed caught during scampi trawls off the Auckland Islands Shelf.

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

A limit of 75 sea lions was set as the MALFiRM for the 2001 season (Anon. 2002). During this season, all vessels were instructed to use SLEDs, and at least one MFish observer was placed on each vessel in the SQU 6T fishery (Anon. 2002). To measure the effectiveness of the SLED to eject New Zealand sea lions and to monitor the MALFiRM, cover nets were tied down over the escape hatches (to retain any sea lions) of at least 20% of all tows, and cameras were used on some vessels to record underwater footage of the SLED use.

Twenty-three vessels participated in southern squid trawl fishery in SQU 6T, with 580 tows reported from this area between 15 January and 30 April 2001. Most vessels targeting squid shifted from the fishery at the Stewart-Snares shelf in the first week of February to the Auckland Islands Shelf (Figures 1 and 2 in Appendix 1). Fishing here was mainly off the southeastern edge until mid February when most vessels shifted to the fishing grounds just north of the Auckland Islands. For the period when MFish observers were placed on vessels (15 January to 24 April), 576 of the 580 tows were observed (99%).

MFish observers reported 39 New Zealand sea lion captures, 3 of which were released alive (all from one vessel). The distribution of the start positions of observed tows, including those that captured New Zealand sea lions, is shown in Figure 1. Vessels from five nations fished in the 2001 season, with Ukrainian and Polish vessels using midwater nets. These 11 vessels represented the largest in the fishery, ranging in size from 82 to 105 m overall length. They

accounted for 70% of all tows in SQU 6T and 80% of those tows with cover nets tied down. About 60% of this midwater effort was in waters off the southeastern edge (see Figure 1). Twelve vessels (50–93 m overall length) from Japan, Korea, and New Zealand used bottom trawls, with about 67% of their effort conducted off the northern edge of the Auckland Islands Shelf.

About 60% of the midwater tows were made with the cover net tied down (Table 1). Five midwater trawl vessels caught 29 New Zealand sea lions, and 28 of these were caught in nets with the cover nets tied down on vessels that expended the most effort in this area. About 34% of bottom trawls were made with the cover net tied down (four vessels) and five bottom trawl vessels caught 10 sea lions. Five of these were landed dead from trawls with the cover net tied down, two of the remaining five were landed dead from the pre-SLED area of the net, and three were landed then released alive. Of the 33 captures in nets with the cover nets tied down, 30 had been ejected through the SLED into the cover net and 3 were in the pre-SLED area of the net.

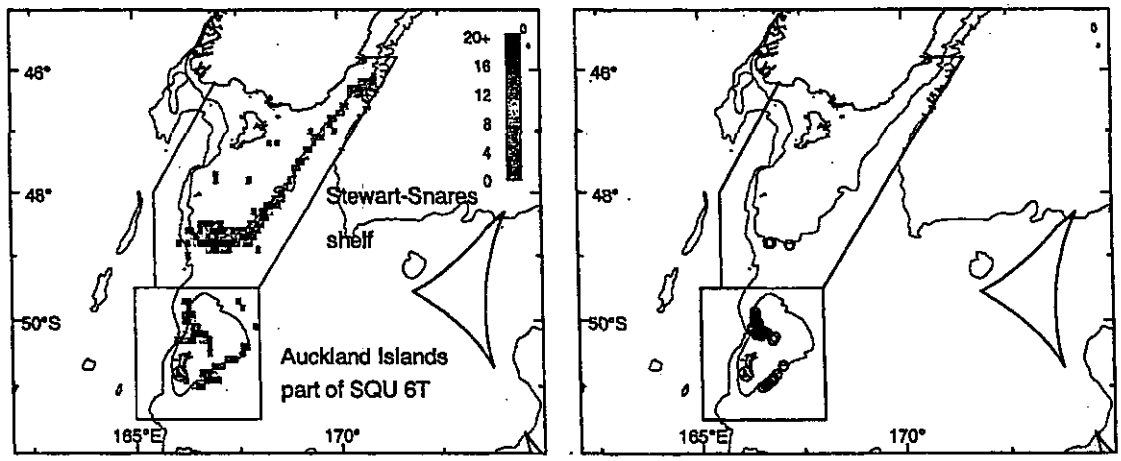

Figure 1: Distribution and density of squid trawling effort (number of tows in 0.1 degree cells), based on start of tow positions (left), including tows with New Zealand sea lion bycatch (o) (right), for defined fishery areas of Stewart-Snares shelf and Auckland Islands part of SQU 6T, 2000–01.

Table 1: Use of mitigation measures on vessels in SQU 6T, based on observer data[1], 2001

	Total no.	% SLED	% pound grid	% camera	% cover net closed
Bottom trawl*					
Vessels	12	100	83	25	33
Tows	171	99	73	23	34
Sea lions	10	100	80	40	50
Midwater trawl					
Vessels	11	100	100	45	64
Tows	405	100	99	46	59
Sea lions	29	100	97	83	100
All vessels	23	100	91	35	48
All tows	578	99	91	39	53
All sea lions	39	100	92	72	87

* Data for use of pound grid and camera for five bottom trawls were not available.

[1] Further observer comments on the use of SLEDs included problems with the SLED being upside down on retrieval (thought to be caused by the weight of the cover net chain on an open cover net); cover nets were sometimes chained at the top of SLED; some grid bars were removed to increase the spacing from 180 cm to 360 cm; modifications were made to SLEDs and deflector panels on some tows, though reasons for these were not reported. The capture of one New Zealand sea lion in the pre-SLED area of the net was thought to be related to a problem in the net construction in the net area between the SLED grid and deflector panel. A grid was placed over the pound opening on most trawls.

Most sea lions were caught singly, but there were three tows in which two sea lions were caught. Two of these tows were from one vessel. Two vessels accounted for 50% of observed sea lion captures and 29% of all effort (and 54% of tows with cover nets tied down).

2.2.1.1 Estimates of incidental capture

For the 298 tows with the cover net tied down, 33 New Zealand sea lions were observed caught, which gives a bycatch rate for this part of the fleet of 0.11 New Zealand sea lions per tow. This gives a total estimate of 64 New Zealand sea lions (53–74, 95% confidence intervals, c.v. = 12%) (Table 2) and is similar to that estimated in the within-season work, which was based on 33 captures from 279 tows (Doonan 2001). There were no differences in the bycatch rates between months or areas (north and south of 50° 20' S).

Of the 33 captures used in the estimation of total captures, 14 were males and 19 were females. Of the six New Zealand sea lions that were observed caught during tows with the cover net open, 3 males were released alive and 3 females were landed dead.

The number of observed tows used for the estimation of total captures was divided unevenly amongst the vessels, with the number of tows observed per vessel ranging from 1 to 102 tows. There were no real differences between the observed mean catch rates for these vessels (Figure 2). The uneven distribution of effort between gear type and vessel nationality also resulted in large errors about the means, and thus no obvious differences between catch rates (Figure 3).

Table 2: 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 include only those with the cover net tied down, 2000–01.

Month	Total no. tows	No. observed tows	% tows observed	No. sea lions observed caught	Mean bycatch rate	Standard error	Estimated number caught	c.v. (%)
January	21	21	100	2	0.095	–	–	–
February	389	135	35	14	0.104	0.030	40	24
March	143	119	83	14	0.118	0.030	17	10
April	27	23	85	3	0.131	0.093	4	24
Total	580	298	51	33	0.111	0.019	64	12
North of 50° 20' S*	277	159	57	20	0.125	0.027	35	14
South of 50° 20' S	299	139	46	13	0.093	0.029	28	23

* Total effort data are observer data, because there were mismatches between observed and reported position data.

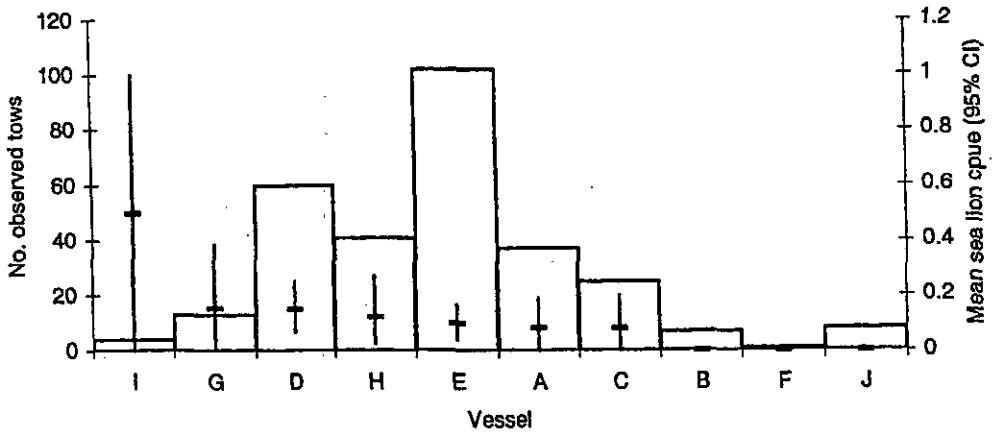

Figure 2: Number of observed tows and mean sea lion catch rates (and 95% confidence intervals) for observed squid vessels used in the total capture estimation for SQU 6T, 2001.

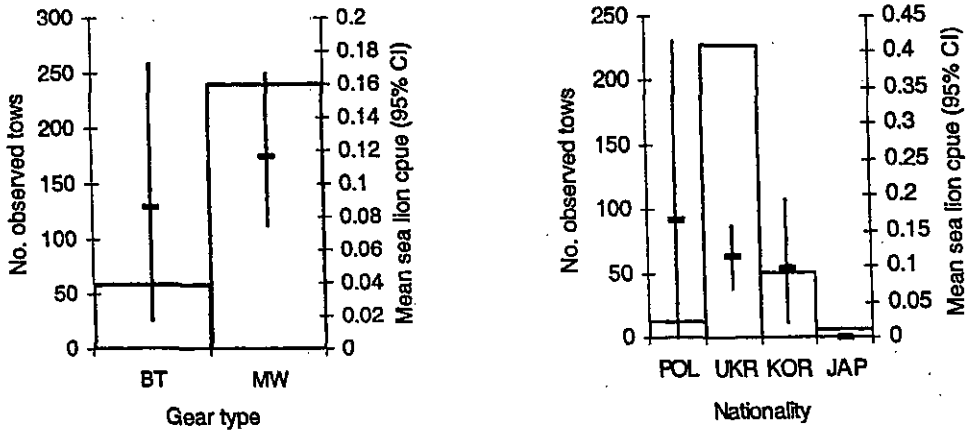

Figure 3: Number of observed tows and mean sea lion catch rates (and 95% confidence intervals) by gear type (left), where BT is bottom trawl and MW is midwater trawl, and by nationality, where POL is Poland, UKR is Ukraine, KOR is Korea, and JAP is Japan, 2001.

2.2.2 New Zealand sea lions and the southern squid trawl fishery off the Stewart-Snares shelf, 2000–01

Twenty-six vessels made at least 3334 tows targeting squid between December and June on the Stewart-Snares shelf, with a peak of 1100 tows in February. As in previous seasons, vessels alternated between this fishing area and SQU 6T (compare Figures 1 and 2 in Appendix 1). Twenty-five vessels were observed during January to April inclusive, with coverage ranging from 22% to 100%. Overall, 70% tows were observed. Observed effort peaked in February (Figure 2 in Appendix 1). About 68% of observed tows used midwater gear, though in February, when observer effort peaked at 1053 tows, there were equal numbers of bottom and midwater tows.

Three New Zealand sea lions were observed caught and landed dead off the southern edge of the Stewart-Snares shelf (see Figure 1), one in a bottom tow in February, and two in separate midwater tows in March. Sea lion exclusion devices were used by some squid vessels fishing in this area. No observer data are available to determine the use of SLEDs; however, industry

data collated for within-season estimation shows that 540 observed tows used SLEDs during operations on the Stewart-Snares shelf, and that 6 had closed cover nets. No SLEDs were used on the tows that caught three sea lions. There were too few captures to do any further analyses of these data.

2.2.3 New Zealand sea lions and the scampi trawl fishery off the Auckland Islands Shelf, 2000–01

Ten vessels targeted scampi in 1412 tows off the southeastern edge of the Auckland Islands Shelf during December to September in 2000–01. Daily effort by the fleet for the main months of the fishery is shown in Figure 3 in Appendix 1. About 98% of effort was during February-September inclusive, with the peak of 315 tows in May. Observers were placed on three vessels during May and June when eight vessels were operating here. For these months, 18% of the 450 tows were observed, and four female New Zealand sea lions were observed caught. All were single captures and two sea lions were released alive. Three were caught by one vessel that accounted for 18% of the observed tows.

2.3 Summary of 2000–01 incidental captures

Estimates are provided here only for the incidental captures of New Zealand sea lions in the SQU 6T squid fishery in 2000–01 because of the small numbers of catches in the Stewart-Snares shelf squid fishery and the scampi fishery around the Auckland Islands where the observer coverage was very limited, at fewer than 100 tows.

There has been an increase in the SQU 6T squid fishery annual bycatch rate for New Zealand sea lions in recent years, from 0.023 sea lions per tow in the 1996 squid season (see Doonan 2000) to 0.11 sea lions per tow reported for the 2001 season (Table 3), a high value which was expected after the within-season estimation work. The extra data acquired from SeaFIC for comparison with the observer and commercial data for this season indicated that some effort was missed from the within-season dataset; however, this amounted to a small number of tows, and the within-season and post-season estimates compare favourably. However, as indicated earlier, there were discrepancies in the data relating to the use of the SLED and associated gear.

Table 3: Fishing effort, observed effort, and mean bycatch rates (numbers of sea lions per tow) for the southern squid trawl fishery in SQU 6T, 1998–2001.

Year*	Total no. tows	% tows observed	No. observed caught	Mean bycatch rate	Standard error	Estimated no. caught	c.v. (%)
1998	1 413	24	15	0.045	0.01	63	22
1999	395	40	5	0.032	0.01	12	33
2000	1 206	36	25	0.058	0.01	70	17
2001†	580	51	33	0.111	0.02	64	12

* Data for 1998–2000 are from Baird (1999, 2001, 2004). Mean catch rates for 1993–97 were given by Doonan (2000).

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

Investigation of the observer coverage of those SQU 6T vessels chosen for use in the bycatch estimation (that is, those vessels with the cover nets tied down) showed that there was at least

30% coverage of vessels for each nation, except for the one New Zealand vessel which represented only 1% of the total effort. Of the other nations, the proportion of tows with the cover nets tied down ranged from 16% for Polish vessels (n = 67 total tows) to 68% for Ukrainian vessels (n = 338 total tows). The observer coverage was slightly more weighted to these vessels using midwater nets, with 81% of observed tows with cover nets tied down being midwater tows (compared with 70% of the total effort being midwater). This observed midwater effort may be biased in that there was more observed effort on vessels of one nation, with two vessels contributing nearly 70% of the observed midwater effort. Overall, these two vessels accounted for 54% of the observed effort (and 50% of the observed New Zealand sea lions) used in the estimation and represented 29% of all the effort in SQU 6T.

The analysis of the bycatch of New Zealand sea lions assumes that the observed sets are representative of all the fishing operations during the season and stratum for which the total catch of sea lions is estimated. Thus, the sampling fraction of observed over non-observed trawls is used in the estimation of the variance. One year of data is not adequate to test for any statistical bias. A long time-series of data is now available for further analysis of the factors that may allow detection of any statistical bias in the estimation of New Zealand sea lion capture and this work may be incorporated into the second year of this three year study.

3. WITHIN-SEASON ESTIMATION OF NEW ZEALAND SEA LION INCIDENTAL CAPTURES IN THE 2001–02 SOUTHERN SQUID TRAWL FISHERY IN SQU 6T(Objective 2)

Estimates of New Zealand sea lion captures were made weekly during the 2002 season from observer data and company reports of total trawls, all of which are collated by SeaFIC (Seafood Industry Council). A MALFiRM of 79 New Zealand sea lions was set for the 2002 season. During this season, only vessels collecting data from video cameras filming in closed cover nets were to use SLEDs and these vessels were all observed. The animals caught by these vessels were to be applied to these vessels only and they were not to be used to estimate a strike rate for the rest of the fleet.

For the rest of the fleet, the operational plan called for a strike rate to be estimated from a set of observed vessels so that about 20% of the total tows could be observed (Anon. 2002). No tows were to be done with a SLED. In practice, non-video vessels used SLEDS and some observed non-video vessels used SLEDs with the cover net open. Because the observed coverage on tows that could be used to estimate the strike rate for the non-video fleet was below 20%, the data from the video vessels were combined with the data from the non-video vessels and one strike rate estimated for the whole fleet. Data to be used in the strike rate calculations were from observed vessels that did not use a SLED and also those that used a closed cover net on the SLED. No discount factor was applied to the strike rate for animals that may have escaped the SLED alive.

3.1 Methods

3.1.1 Data

All vessels in the southern squid trawl fishery report daily captures of New Zealand sea lions to SeaFIC weekly. The following attributes from the SeaFIC database were used to categorise the data:

- date
- area (SQU 1T or SQU 6T)

- used a SLED
- used a SLED with a closed cover net

For each category, the following data were collected:
- number of tows in a day
- number of tows that captured a sea lion
- number of sea lions captured and released alive
- number of sea lions captured and dead

The Ministry of Fisheries receives the following information on the numbers of New Zealand sea lions captured in the southern squid trawl fishery:
- daily reports of captures from MFish scientific observers on board squid vessels
- daily reports of captures from vessels carrying industry observers.

This information was received on a weekly basis and compared with the SeaFIC data, where possible. The data were checked and converted into a form suitable for the in-season analysis.

3.1.2 In-season calculations

At the end of each week t, total number of New Zealand sea lions killed (T_k) was estimated using MFish observer data:

$$T_k = N_t p_{k,t}$$

where N_t is the total number of tows up to week t, and $p_{k,t}$ is the fraction of the tows in which New Zealand sea lions were killed (the strike rate), that is,

$$p_{k,t} = \frac{a_{k,t}}{m_t}$$

where m_t is the number of observed tows by MFish observers up to week t and $a_{k,t}$ is the number of observed New Zealand sea lion deaths by MFish observers. For SQU 6T, m_t and $a_{k,t}$ refer to observed tows that used a SLED with a closed cover net or observed tows where a SLED was not used.

Random sampling in the observer data, if this occurred at all, was in the choice of vessel to observe and when to observe it, not with individual tows. Thus, tows were observed in clusters, i.e., all tows for a vessel over some time period. This would not matter if consecutive tows were independent, and although this cannot be assumed automatically, it is assumed here because data are not available by tow or by clusters of tows. Thus, the sampling distribution was approximated by the binomial model. This was considered appropriate because generally only one New Zealand sea lion is caught in a single tow, but if any large serial correlations are present for consecutive tows, then the variance estimate will be biased. For positive correlations, the estimate is biased low, but it is biased high if the correlation is negative.

Thus, the coefficient of variation of T_k is given by:

$$\text{c.v.} = \sqrt{\frac{1-p_k}{mp_k}\left(1-\frac{m}{N}\right)}$$

where the t suffix has been suppressed for clarity. Confidence limits were estimated using the method of Wendell & Schmee (2001), which is based on random sampling from a finite

population using a hypergeometric distribution. Under such conditions it gives the exact bounds with the shortest length. Because the actual sampling was by clusters, these estimated bounds may be too tight. Again, these bounds make no allowance for the error in the estimation of the discount rate, if used.

Weekly within-season estimates were submitted to the Manager of Science Policy, MFish, within two working days of receipt of the within-season New Zealand sea lion capture data from the SeaFIC.

3.2 Results

Ten weekly reports were made (Table 4); the first reported on data up to 16 February 2002 and the last on data up to 14 April. The last day that fishing occurred was around 12 April when the fishery was closed. For SQU 6T, MFish observer coverage was 26% and the total estimated number of kills of New Zealand sea lions was 84 (c.v. = 26%). The 95% confidence limits were 59–119. The strike rate was 5.1 per 100 tows (c.v. 26%). One sea lion death was observed in SQU 1T.

The strike rate reported by MFish observers in SQU 6T for 2001 is the third highest recorded (12 sea lions per 100 tows in 2001 and the previous highest of 6 in 2000), but it is in line with the trend of increasing strike rates from 1993 to 2000 (Figure 4). The increase in strike rate with year was estimated using strike rates from 1993 to 2000 to give 0.6 per 100 tows per year which is statistically significant (*t*-test at the 5% level). Why strike rates are increasing is unknown and investigating the cause needs further data (e.g., sightings of sea lions in the sea from fishing vessels), which is unlikely to be at hand for past years.

Table 4: In-season calculations of kills (no discount rate applied) of New Zealand sea lions over the 2002 squid season in SQU 6T from data collated by SeaFIC. "Observed" refers to MFish observers. The strike rate was estimated using observed data on tows that used a closed cover net or tows where no SLED was used. Reported total kills is the number reported to SeaFIC, which includes kills observed by MFish and industry observers and those observed by vessel captains.

	Closed cover net on SLED				
Data to date	Observed kills	Observed tows	Total tows	Estimated total kills	Reported total kills
16 February†[1]	3	74	365	15	3
23 February†[2]	4	100	463	19	4
2 March	5	118	542	23	5
9 March	5	132	658	25	5
17 March	6	180	837	28	6
23 March	8	263	1 112	34	8
31 March	8	317	1 294	33	8
7 April	14	357	1 463	57	14
10 April†[3]	22	370	1 541	91	22
14 April	22	434	1 653	84	22

†[1] Data from three vessels were missing, including one sea lion death.
†[2] Adjustments made to data to account for missing data from three vessels.
†[3] There were eight kills since 7 April which were reported by C. Blincoe, MFish. The extra tows done since 10 April were estimated from the trend in the last 3 weeks.

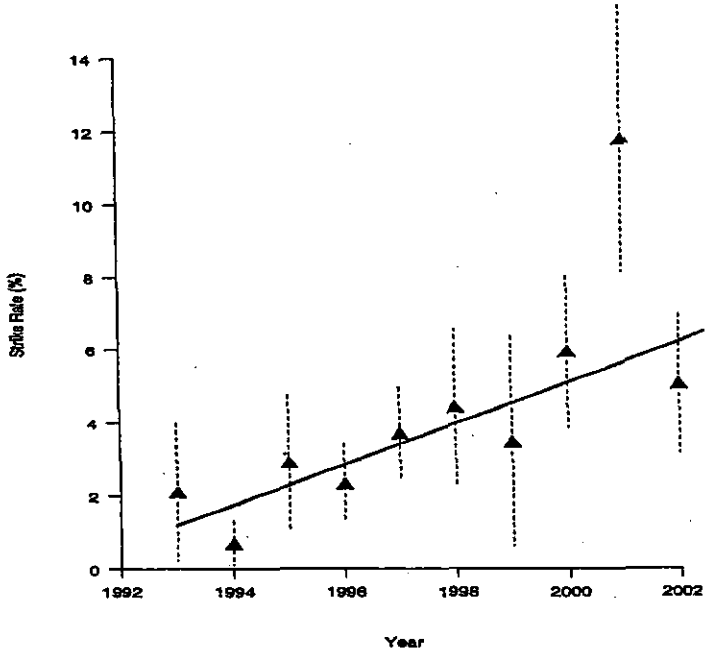

Figure 4: Strike rates (kills per 100 tows) against year for MFish observers (▲) with the regression line for 1993–2000 data. Vertical lines are ± 2 standard errors of the strike rates.

8. ACKNOWLEDGMENTS

Thanks are gratefully acknowledged to Brian Sanders and Colin Sutton (NIWA) for the database management and support, to the NIWA data entry staff, and to the observers of the Ministry of Fisheries Scientific Observer Programme for the collection of the data. Thanks also to Paul Starr (SeaFIC) for the timely provision of the weekly within-season data and to the Squid Fishery Management Company for allowing release of the 2001 data to further characterise the use of mitigation measures. This report was completed for Objectives 1 and 2 under the Ministry of Fisheries contract for project ENV2001/02.

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Appendix 1: Commercial and observed effort data, 2000–01

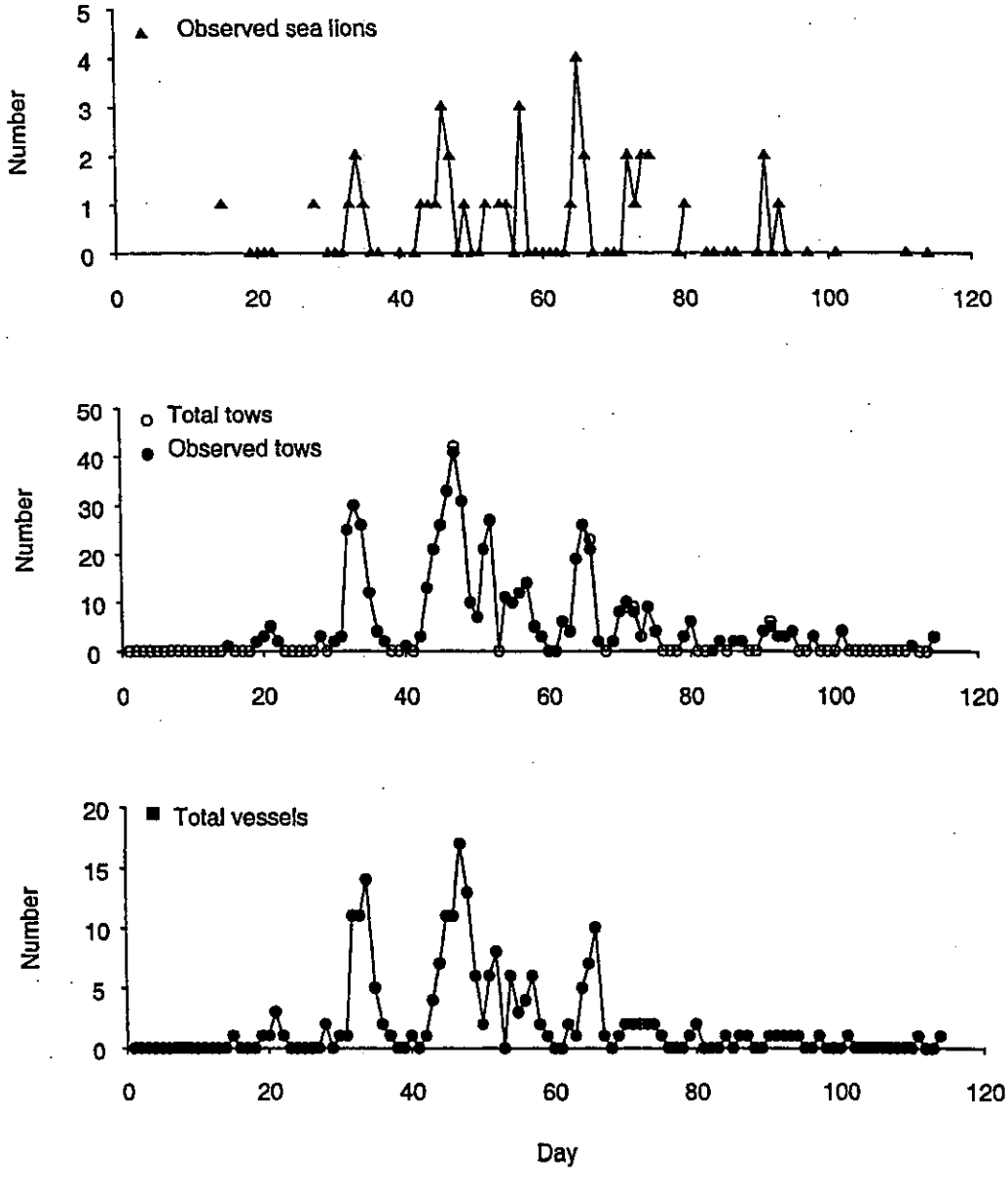

Figure 1: Daily number of vessels, total tows, observed tows, and observed New Zealand sea lion captures in the 2001 SQU 6T squid fishery, where fishing began on 15 January 2001 (Day 15) and finished on 24 April 2001 (Day 114).

Appendix 1: continued

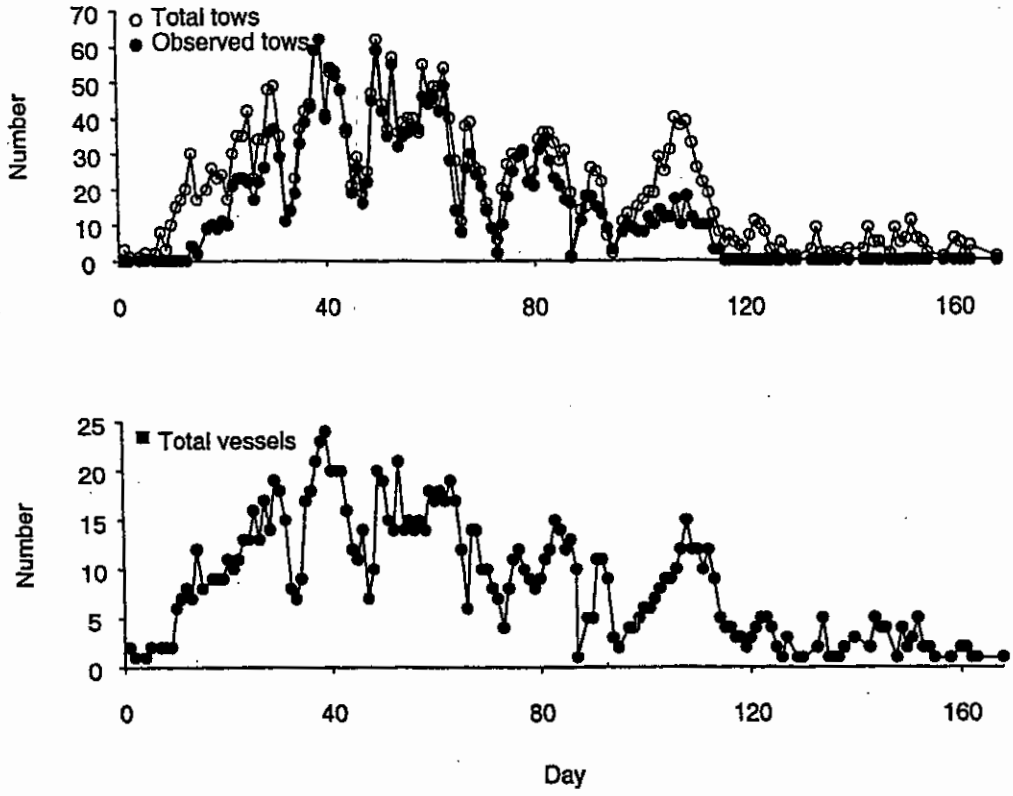

Figure 2: Daily number of total tows, observed tows, and observed New Zealand sea lion captures in the 2001 squid fishery on the Stewart-Snares shelf, where 1 January 2001 is Day 1 and 17 June 2001 is Day 168, when fishing ceased. Three New Zealand sea lions were caught in three tows, on Days 49 (18 February), 70 (11 March), and 89 (23 March).

Appendix 1: continued

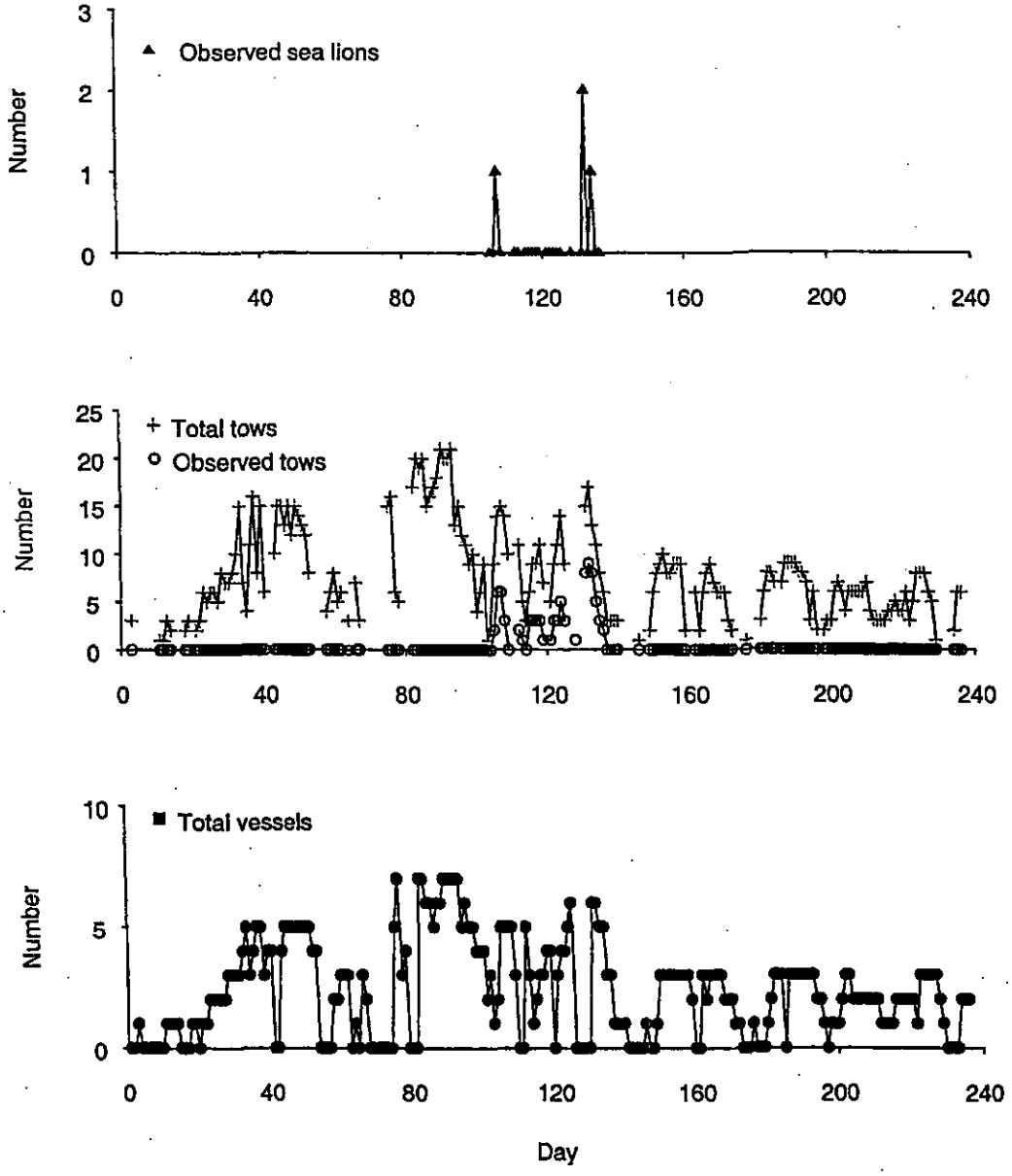

Figure 3: Daily number of vessels, total tows, observed tows, and observed New Zealand sea lion captures in the 2001 scampi trawl fishery on the south-eastern edge of the Auckland Islands Shelf, where Day 1 is 1 February 2001 and Day 236 is 24 September 2001. New Zealand sea lions were caught on 18 May, 13 June (2 sea lions), and 15 June.

Appendix 1: continued

Table 1: Comparison of within-season SQU 6T data with observer data on use of cover net, 2001

Vessel	No. tows*		Difference in reported number of tows†			No. New Zealand sea lions
	MFish	SeaFIC	Cover net open	Cover net tied	Total	
A	37	28	0	9	9	3
B	22	22	0	0	0	3
C	7	6	1	0	1	0
D	7	0	0	7	7	0
E	34	34	-1	1	0	2
F	60	60	0	0	0	9
G	35	35	0	0	0	1
H	105	101	3	1	4	11
I	23	26	-3	0	-3	0
J	22	22	0	0	0	0
K	7	6	1	0	1	0
L	1	1	0	0	0	0
M	6	7	-1	0	-1	0
N	17	16	-7	8	1	2
O	7	7	0	0	0	0
P	45	45	0	0	0	5
Q	9	9	0	0	0	0
R	6	6	0	0	0	0
S	17	19	-2	0	-2	1
T	28	28	0	0	0	2
U	26	28	-2	0	-2	0
V	38	39	7	-8	-1	0
W	17	17	0	0	0	0
Total	576	562	-5	19	14	39

* MFish tows are those extracted post-season from the Ministry of Fisheries *obs* database, and SeaFIC are those collated by SeaFIC for the 2001 within-season New Zealand sea lion estimation.

† This represents the number of observed tows from MFish observer database *minus* the number of observed tows reported to SeaFIC for the within-season work.