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in the southern squid trawl fisheries, 2001**

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EXECUTIVE SUMMARY

Doonan, I.J. (2001). Estimation of Hooker's sea lion, *Phocarctos hookeri*, captures in the southern squid trawl fisheries, 2001.

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This report summarises the methods used and results given to the Ministry of Fisheries (MFish) as part of Objective 2 of Project ENV2000/01: *To provide weekly within season estimates of total captures, releases, and deaths — by sex and area — for Hooker's sea lions taken in the southern squid fishery. Estimates to begin two weeks after the start of the 2000/2001 fishery and continue until 30 May 2001. Estimates of the confidence intervals and coefficient of variation of the point estimates must also be provided.*

The squid season in SQU 6T started in February and the last data were collected on 24 April 2001. All tows in SQU 6T were observed and they all used a sea lion exclusion device (SLED) through which animals can potentially be ejected from the trawl net. SLEDs have a cover net at the exit site, which can be left open for animals to escape through, or closed so that no animals can escape. In-season estimates of total kills were estimated using the fraction of observed tows on SLEDs with closed cover nets that caught Hooker's sea lions. No discount factor was applied to the encounter rate, i.e., the kill rate was taken to be the same as the encounter rate. The data were collected on a weekly basis by companies and collated by the Seafood Industry Council (SeaFIC). The final in-season estimate of total kills of Hooker's sea lions in the squid management area SQU 6T was 66 with a c.v. of 16% and 95% confidence limits of 53–83. Three sea lions were captured and released alive. For SQU 1T, the last data were collected on 31 May and the estimate of the number of kills was 6 (c.v. = 43%).

A retrospective check of the in-season method in the last three squid seasons, 1997 to 2000, showed that the in-season method provides an adequate estimate. The check used the tow-by-tow records from TCEPR and observer logbooks from the squid season in SQU 6T.

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

The squid season in the southern waters of New Zealand operates on the shelf around the Snares Islands and the Auckland Islands (Figure 1). The fishery runs from either January or February to April or May. The depth distribution of trawls has a major peak at 170 m and a minor one at 420 m. A 12 nautical mile exclusion zone around the Auckland Islands (in SQU 6T) prevents fishing close to the primary breeding rookeries.

Breeding, which concentrates the adult sea lion population at the rookeries, begins in late November when adult males establish territories. Males leave in February, but females stay on to suckle their pups. During suckling, about 50% of the females are foraging at sea.

The sea lion foraging area overlaps with squid fishing on the Auckland Islands Shelf and results in incidental captures of sea lions (see Figure 1). To restrict the impact of squid fishing on the population size of sea lions, the squid fishery is closed when the total number of sea lion deaths from incidental capture in squid trawls exceeds a level set before each squid season (currently 64). To monitor the total number of deaths, an estimate is made weekly during the season from observer data and company reports of total trawls all of which are collated by SeaFIC (Seafood Industry Council).

Following the trials of SLEDs (sea lion exclusion device) in the 2000 season, all vessels in SQU 6T used SLEDs and all of these were observed. SLEDs allow the potential ejection of animals from the trawl net. There is a cover net at the exit site and when this is left open, animals can escape. The cover net can be closed so that no animals can escape, which is needed to gather data for an estimate of the encounter rate, as distinct from the kill rate (or strike rate). To convert the encounter rate into a kill rate for nets using a SLED with an open cover net, the encounter rate was to be adjusted by the expected rate that an animal would escape the SLED alive, called the discount rate. The discount rate was estimated elsewhere using data from video cameras filming in closed cover nets and it was to be used if it met two conditions: two or more animals observed in the cover net, and that the discount rate was estimated to be 25% or more. At the time the data were collected, no formal discount rate was available.

This report summarises the method and results of the in-season estimation of the total number of deaths of Hooker's sea lions from squid trawling. Validation of the in-season method was carried out using the 1997 to 2000 tow-by-tow records collected for MFish. The tow-by-tow data for the 2001 season were not available at the time of writing, so data for previous years were used instead.

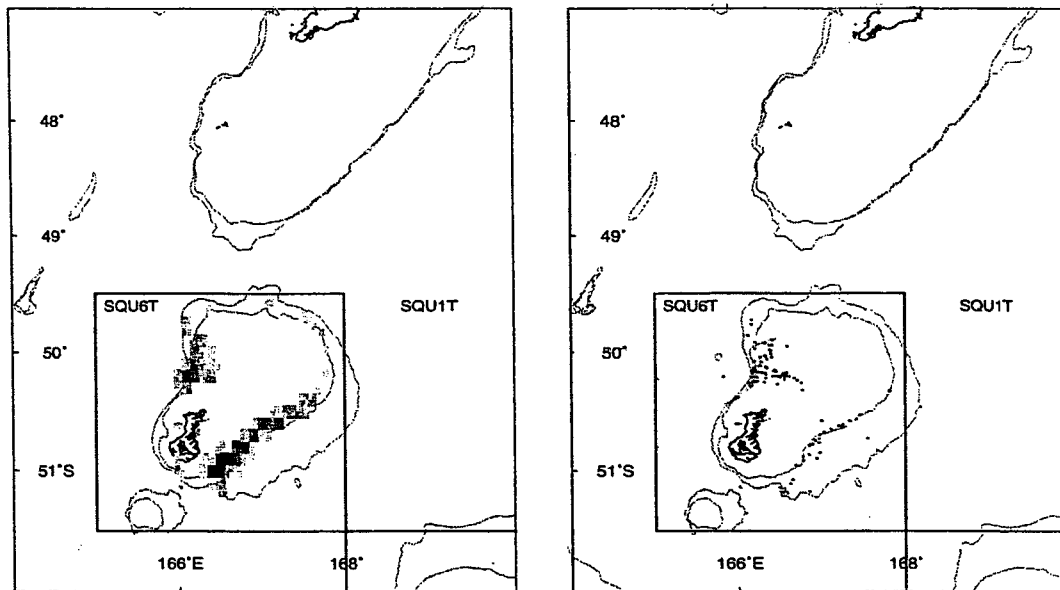


Figure 1: The relative density of trawl effort in the 2000 southern squid trawl fishery, SQU 6T, (left graph, density coded as a grey scale in 0.05 degree squares with black being the maximum) and the positions that MFish observers have observed Hooker's sea lions caught in squid trawls since 1993 (dots in right graph). The depth contours (faded lines) are at 250 m and 500 m.

2. METHODS

2.1 Data

All vessels in the southern squid trawl fishery report daily captures of Hooker's 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
- number of female sea lions captured and released alive
- number of female sea lions captured and dead

The Ministry of Fisheries receives the following information on the numbers of Hooker's 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.

Data for previous years were extracted from the following sources:

1. observed Hooker's sea lion capture data:
EMPRESS database *obs_lfs* developed and administered by NIWA
2. observed fishing effort data:
MFish Observer EMPRESS database *obs*
3. total fishing effort data
MFish Trawl Catch and Effort database
EMPRESS database *squid* developed and maintained by NIWA from Trawl Catch Effort Processing Return (TCEPR) records in the MFish Catch and Effort database

2.2 In-season calculations

At the end of each week t , total number of Hooker's sea lions killed (T_k) was estimated using MFish observer data. When no discount rate was to be applied, T_k was estimated by:

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

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 Hooker's sea lions were killed (encounter rate or the strike rate if the discount rate is zero), 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 Hooker's 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. For SQU 1T, m_t and $a_{k,t}$ refer to observed tows that did not use a SLED because only 6 tows used a closed cover net on the SLEDs so no estimate of encounter rate was available.

With a discount rate, T_k is given by

$$T_k = (N_t - m_t) p_{k,t} (1 - \text{discount rate}) + a_{k,t}$$

assuming that there was 100% observer coverage and all tows used SLEDs with closed cover nets (the case for SQU 6T where the discount rate was to be used). The first part of the above equation applies to the tows where a SLED was used with an open cover net.

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 Hooker's 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. This equation makes no allowance for the error in the estimation of the discount rate, if used. 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 and 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 Hooker's sea lion capture data from the SeaFIC.

2.3 Performance of the in-season estimate (SQU 6T)

In another objective of this project, Baird (2001) estimated the total sea lion kills for the 2000 squid season in SQU 6T from TCEPR and observer logbook data. These estimates are compared with the in-season estimates. Because of time delays in the loading of TCEPR and observer data into the databases, checking of the 2001 season was not possible at the time of writing this report. The logbook data are considered more accurate because logbooks are filled out at the time of each tow and give the position of the tow. Comparison of the total kills for the two data sources, logbook against company reports (which are verbal and are related to a day's activity), shows the accuracy of the in-season method. In theory, checks on species identification can be done on carcasses (both sea lions and fur seals) brought back to New Zealand for auditing. However, time lags in this work means that results are not available for the 1999, 2000, and 2001 data. Therefore, the species identification and the sex reported here are from the MFish observer records.

Doonan (1998, 1999) estimated the total tows and kills for the 1997 and 1998 season using the TCEPR and observed logbook data and Baird (2000) estimated the total tows and kills for the 1999 season.

Another important aspect is the spatial coverage of the observed tows. This should be in the same proportions as that for the fleet in case there are spatial differences in strike rates in the area, e.g., the strike rate may be reduced when fishing takes place further away from the rookeries. This was investigated in a simple way by comparing the latitude profile of the positions of tows for the fleet in 2000 with that for MFish observed tow positions in 2000. The analysis used the same TCEPR and observer logbook data as used above. Similar plots for the 1997, 1998, and 2000 season were given by Doonan (1998, 1999, 2000).

3. RESULTS

3.1 In-season calculations

Eleven reports were made (Table 1); the first reported on data up to 11 February 2000 and the last on data up to 18 June. The last day that fishing occurred was 24 April, but extra time was allowed for late returns and data corrections. For SQU 6T, MFish observer coverage was 100% and the total estimated number of kills of Hooker's sea lions was 66 (c.v. = 16%). The 95% confidence limits were 53–83. The encounter rate of 12 per 100 tows (c.v. 16%). Of the 33 animals caught in tows with closed cover nets, 31 were in the cover net. Three sea lions were captured and released alive.

Table 1: In-season calculations of kills (no discount rate applied) of Hooker's sea lions over the 2001 squid season in SQU 6T from data collated by SeaFIC. "Observed" refers to MFish observers. The encounter rate was estimated using observed data on tows that used a closed cover net. Reported total kills is the number reported to SeaFIC which includes kills observed by MFish and industry observers and those observed by vessel captains.

Data to date	Closed cover net on SLED		Total tows	Estimated total kills	Reported total kills
	Observed kills	Observed tows			
11 February	5	38	102	13	5
18 February	13	161	291	33	14
25 February	13	127	374	38	15
4 March	15	144	405	42	17
11 March	21	200	483	51	24
18 March	28	233	516	62	31
25 March	29	242	525	63	32
8 April	33	271	554	67	36
15 April	33	275	558	67	36
22 April	33	276	559	67	36
18 June	33	279	562	66	36

Three dead sea lions were reported for the Snares Islands part of the squid fishery (SQU 1T), which scales up to an estimated total of 6 (c.v., 43%). The last data were collected on 31 May. In this fishery, there were 5221 tows of which 4317 used no SLED and 604 used a SLED (only 6 tows used a closed cover net). Of the tows that used no SLED, 53% were observed and they caught 3 sea lions, to give a strike rate of 0.13 animals per 100 tows. The latter rate was applied to all data, except the 6 tows that used a SLED with an closed cover net.

3.2 Performance of the in-season method

For the 1997 to 2000 squid seasons in SQU 6T, the in-season monitoring gave similar results to that using the TCEPR and observer logbook data (Table 2).

Table 2: The squid fishery in SQU 6T, 1997–2000: comparison of total tows and estimated total kills from two sources, in-season (i.e., SeaFIC) and logbook (i.e., TCEPR and observer logbook data). “Observer” refers to MFish observers.

	Year	In-season	Logbook	Difference (% of logbook)
Estimated kills	1997	125	124	-1
	1998	62	62	0
	1999	14	13	-8
	2000	71	70	1
Total number of tows	1997	3 585	3 326	-8
	1998	1 394	1 412	1
	1999	392	395	1
	2000	1 191	1 206	-1

The distribution of observed tows with latitude showed some differences from that for the fleet (Figure 2), but these are not major given the relatively low number of tows in the 2000 season. Thus, at this crude level, the observed data approximately covered the area in the same proportion as the fleet data so there should be no overt bias in the estimated strike rate.

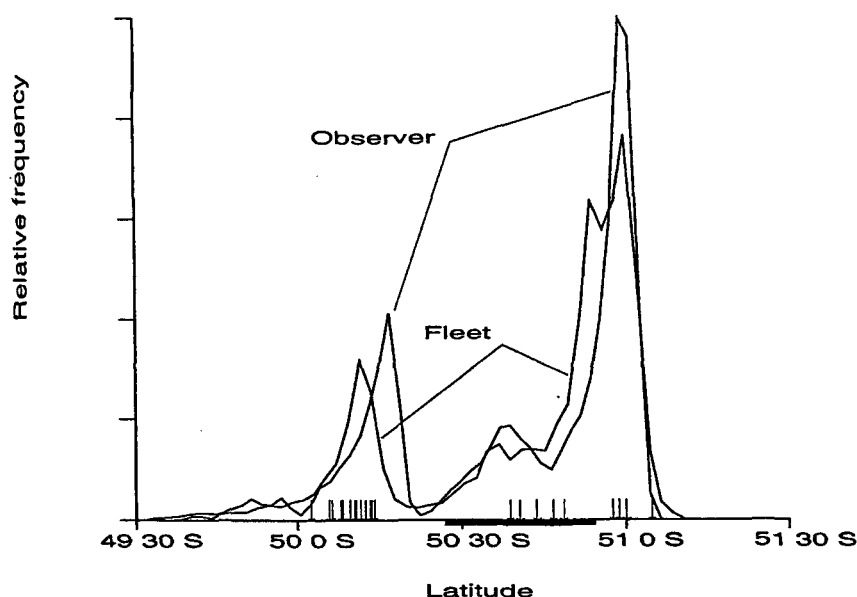


Figure 2: Check of observed tows over the fleet's tow distribution for SQU 6T in the 2000 squid season (January to March), the latitude profile of MFish observed tows, and the fleet's latitude profile. The profiles have been normalised so that the area under each is 1.0. Short arrows just above the x-axis show the latitude where sea lions (25) were observed by MFish observers to be caught. Solid bar shows the latitudinal extent of the Auckland Islands.

4. DISCUSSION

All indications are that the in-season method has worked well in the past and there is no apparent reason why this should not be so this year also. For the past four seasons, 1997–2000, the in-season estimate of total kills has been different from that using the logbook data

by, at most, one (Table 2). The total number of tows can be out by as much as 8%, but this is well within any c.v. for the kills estimate (Table 3). Although not shown, 8% errors have occurred twice for the number of observed tows: in 1997 (but cancelled out by an opposing 8% error in the total tows so that the estimate of total kills had a 1% error) and in 1999. At other times, the differences between data sources were within about 1%. The spatial distribution of SQU 6T observer coverage in the past three seasons has also been approximately the same as for the total fishery (Doonan, 1998, 1999, 2000). The latter is important because there are indications that strike rates decrease for increasing distances north of the Auckland Islands, so that uneven observer coverage may bias estimates of total kills.

The estimated total of sea lions killed here is not final and revisions to the total will occur over the next few years as new data are accumulated into the estimate of the discount factor. An example of the sort of reductions to expect initially can be made using an informal estimate of 35.6% (P. Cresswell, Ministry of Fisheries, Nelson, pers. comm.) which is based on three pieces of video evidence (i.e., three sea lions seen alive in the cover net). Applying this discount reduces the estimated numbers of sea lions killed from 66 to 55. The kill rate (animals per 100 tows) for using SLEDs with open cover nets would then be $12 \times (1 - 0.356) = 7.7$, which, incidentally, is in line with the trend in past strike rates. However, the estimated discount rate is taken from the lower 90% confidence level so if the true survival rate of sea lions exiting through a SLED is 100% (as implied by the 3 out of 3 survivals so far) then as more video evidence is acquired, the estimated discount rate is likely to increase next year, i.e., the estimate of the number of kills in 2001 is likely to decrease for the next couple of revisions.

5. ACKNOWLEDGMENTS

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