A SEAL / FISHERY INTERACTION MANAGEMENT STRATEGY
BACKGROUND REPORT

Marine and Marine Industries Council

June 2002

Published by: Department of Primary Industries, Water and Environment, Tasmania

Tasmania

Citation: Marine and Marine Industries Council 2002. *A Seal / Fishery Interaction Management Strategy: Background Report.*

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Acknowledgements

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PREFACE

In response to concerns raised by fishers regarding interactions between seals and the fishing and aquaculture industries, the Minister for Primary Industries, Water and Environment referred the matter to the Marine and Marine Industries Council by establishing the Seals Term of Reference.

The Seals Term of Reference is the second reference for the Marine and Marine Industries Council (MMIC), established by the Minister for Primary Industries, Water and Environment in August 1999.

The members of the MMIC represent a range of key stakeholders, and have individual expertise in areas such as marine conservation, management and utilisation. The Chairman of the Marine and Marine Industries Council is Mr Tony Harrison, a marine management consultant.

The Seals Terms of Reference[1] provided to MMIC required them to *investigate and report on:*

- The extent of the seal problem and its economic impact in Tasmania.
- Current trends in the seal population and the factors influencing population changes.
- Current practices both locally and elsewhere in successfully dealing with the problem.

The problem was described as:

> "The fishing and aquaculture industries believe that seals are having significant adverse economic impact on their commercial operations. However, seals are a protected species and the management options in dealing with seals need to reflect this status."

The outcomes sought were:

- A management strategy which identifies best practice for dealing with the problem.
- Identification of any legislative or policy changes addressing this issue.
- A communications strategy to support the management plan.

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[1] A copy of the Terms of Reference can be found at Attachment 1.

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ABBREVIATIONS

AHD'S	Acoustic Harassment Devices
ADD's	Acoustic Deterrent Devices
CalCOFI Rep	California Cooperative Oceanic Fisheries Investigation Reporter
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CSIR	Predecessor to CSIRO
DFO	Department of Fisheries & Oceans
DPIWE	Department of Primary Industries, Water and Environment
EAO	Environmental Assessment Office (British Columbia Government Agency)
MARMAM	Marine Mammals Research and Conservation Discussion (email list)
MMIC	Marine and Marine Industries Council
NCB	Nature Conservation Branch
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NWFAC	Northwest & Atlantic Fisheries Centre
NZDOC	New Zealand Department of Conservation
OH&S	Occupational Health and Safety
PIRSA	Primary Industries and Resources South Australia
SSGA	Scottish Salmon Growers Association
TAFI	Tasmanian Aquaculture & Fisheries Institute
TSGA	Tasmanian Salmonid Growers Association
UNEP	United Nations Environment Programme
USA	United States of America

Chapter 1 - Introduction

Report structure

This Background Report summarises the current knowledge of seal interactions with fisheries and aquaculture in Tasmania. It is based on previous studies conducted by the Tasmanian Government and other research institutions, information collected from questionnaires and follow-up interviews with fishers. It also provides a summary of current knowledge and experiences globally, in particular in South Africa, Canada, the United States of America, the United Kingdom, New Zealand and Japan.

A management strategy based on this information accompanies this report.

Scope

The scope of the investigation is limited to Tasmania[2], not including Macquarie Island as no interactions with fisheries under Tasmanian jurisdiction have occurred to date at Macquarie Island. Under Offshore Constitutional Settlements the Commonwealth Government is responsible for interactions with certain fisheries around Tasmania, notably trawling. It also conserves seals in waters adjacent to Tasmania, but beyond State jurisdiction.

This report focuses on Australian fur seals (*Arctocephalus pusillus*) and New Zealand fur seals (*Arctocephalus fosteri*), the two species primarily involved in interactions with commercial and recreational fishing and/or aquaculture operations in Tasmania (hereafter referred to as seal/fisheries interactions).

Seal/fisheries interactions are not unique to Tasmania as similar experiences are found both nationally and internationally. Despite this, the body of literature documenting seal/fisheries interactions (and in fact marine mammal/fisheries interactions in general) is limited. Descriptions of seal/fisheries interactions in Tasmania are summarised in relation to each activity and concentrate on previously published studies, the opinions of researchers and fishers obtained through discussion and questionnaire responses[3]. Where relevant, reference has been made to studies of marine mammal/fisheries interactions in other jurisdictions. The Report includes a brief summary of current and previously trialed mitigation measures.

[2] Tasmania is defined as Tasmanian waters to three nautical miles, plus fisheries under Tasmanian jurisdiction

[3] A copy of the 'Seal Interactions with Fisheries & Aquaculture Questionnaire – December 2000' is at Attachment 2

Definition

There are two common types of seal/fisheries interactions:

1. Direct (Operational) interactions typically involve seals taking fish from lines or nets, damage or loss of the catch and fishing operations being disturbed. They can have negative or positive effects on the marine mammal and/or the fishery (Pemberton *et al.* 1995; Pemberton and Shaughnessy 1993; Northridge and Hofman 1999). Direct interactions also include seal mortality due to entanglement in discarded fishing gear, drowning in nets and being shot or maimed by fishers (Wickens *et al.* 1992; Pemberton *et. al* 1994).

2. Indirect (Biological) interactions refer to the competition between seals and fishers for shared resources (Gulland 1986; Harwood 1984; 1987; Wickens *et al.* 1992).

In Tasmanian fisheries current concerns relate to direct interactions with seals. Fishers are primarily concerned with the taking and killing of fish by seals, damage to fishing gear, the effect of seal proximity on fish behaviour, risk to human safety and the loss of personal income resulting from these interactions.

On the other hand, the Tasmanian salmonid farming industry is concerned with the direct predation of farmed fish stocks by seals, the entanglement of seals and other marine mammals in fish farm predator nets, a reduction in feeding rates of fish through stress associated with seal presence, and injury to personnel.

Chapter 2 - Seal Ecology

There are three families of seals (pinnipeds): Phocidae (earless seals), Otariidae (fur seals and sea lions) and Odobenidae (walruses). Of these, only seals from the Otariidae are commonly found in Tasmanian waters. Southern elephant seals (Phocidae) breed occasionally on Maatsuyker Island (and very rarely on mainland Tasmania). Australian and New Zealand fur seals, of the family Otariida, are known to interact with fishing operations in Tasmanian waters, so further descriptions will be restricted to these species.

Physical characteristics

Distinguishing between New Zealand and Australian fur seals is problematic as the two species share many physical attributes, with differences in vocalisation, locomotion and thigmotactism (body contact) being the most useful distinguishing features (Goldsworthy *et al.* 1997).

New Zealand fur seals

The New Zealand fur seal, identified by a dog-like head with long whiskers and obvious external ears, has large fore and hind flippers which can bend forward enabling them to climb across boulders and rock shelves when on land. This seal has grey to dark-brown fur and the adult males (or bulls) develop massive necks and a thick mane. Adult males grow to about 200 cm long and can weigh up to 180 kg. Females are smaller, reaching 150 cm in length and 50 kg in weight.

Australian fur seals

The Australian fur seal also lives in Tasmanian waters but has light brown fur and lacks the high-pitched aggression call of the New Zealand fur seal. Australian fur seals grow to about 200 cm long with adult males weighing up to 280 kg and females 80 kg. Adult males develop a mane of coarse light hair on the neck and shoulders. Adult females are a ginger-brown to silver colour, and newborn pups are black.

Distribution, Habitat and Biology

New Zealand fur seals

The New Zealand fur seal occurs in Western Australian, South Australian, Tasmanian and New Zealand waters. In Tasmania the species only breeds off the south coast on Maatsuyker Island and two nearby islands, Walker and Little Witch (Table 1, Figure 1). Breeding colonies are located in small, boulder coves and around caves and crevices. Approximately 100 pups are born each year in Tasmanian waters. Females fertilised in summer suspend development of the embryo until April, so pups are born soon after the pregnant females arrive in the breeding area from early December until January. Pups, which weigh 4-6 kg at birth, are weaned at 8-10 months of age. Females start to breed at

about 6 years of age, while bulls are unlikely to hold a breeding harem and territory until 9 years of age.

While New Zealand fur seals were relatively abundant in Tasmanian waters prior to European sealing in the early 1800s, they now probably only number in the hundreds in the Victorian and Tasmanian region. Many sites previously occupied by fur seals have not been recolonised following their extirpation by sealers, and it is likely that many of these sites were New Zealand fur seal breeding colonies. Historical information presented by Warnecke (1982) indicates that the range of New Zealand fur seals extended through Bass Strait including islands in the Furneaux group where it was abundant.

New Zealand fur seals are however more abundant in South Australia and Western Australia, where these populations are currently expanding (Shaughnessy *et al*. 1995; Gales *et al*. 2000) and there is potential for their breeding populations to increase, thereby increasing the total seal abundance in the Victorian and Tasmanian region. There are insufficient data on non-breeding, dispersing animals upon which to make any meaningful assessment of population trends.

In Tasmania, New Zealand fur seals haul-out (come ashore to rest) at numerous islands and shores around the coast but mainly in the southwest region. Breeding and haul-out areas are occupied all year round although the number of seals present at breeding sites is highest from December to January and at haul-outs during autumn and winter. Occasionally individuals will come ashore on the mainland Tasmanian coastline. They may be resting, moulting or seeking new feeding sites and may stay in the area for days to weeks until they have grown a new coat or are rested. Important haul-out (non-breeding) sites are listed in Table 1.

Australian fur seals

Australian fur seals are distributed along the coastline from New South Wales to South Australia, and are the most commonly seen seal species in near-shore Tasmanian waters. Australian fur seals form dense territorial colonies during the breeding season, dominated by individual males defending harems of up to 30 females. Females produce one pup every one to two years, usually born during November to December. Pups, which weigh between 5 and 12 kg at birth, usually suckle for 10-11 months, although some cows may suckle a pup for up to four years. Females start to breed at about 5 years of age, while males will not typically hold a breeding territory until they are 8-13 years of age. When on land they prefer rocky islands and exposed reefs but forage widely in coastal seas extending over the continental shelf.

There are five breeding colonies of Australian fur seals in Tasmanian waters, all of which are located in Bass Strait. Estimated pup production in Tasmanian waters was 3200 pups in the 1999/2000 breeding season (Pemberton 2001). The Tasmanian pup production represents on average less than a quarter of the overall production for the species, with the most recent data from the Victorian colonies showing an annual pup production in the order of 13,800 pups. The pup production rate for the species is then in the order of

17,000 pups giving a total population estimate of approximately 60,000 - 77,000 Australian fur seals (Pemberton 2001).

Assessment of long-term population trends in Tasmanian colonies is rather speculative because of a paucity of historical data and inconsistency in survey methodology over time and between areas. Estimates of seal numbers during the early years of sealing have been attempted using records of seal pelt cargoes. Such estimates are of dubious value when one considers that multiple species and age classes were harvested and there appears to have been considerable intentional misreporting and secrecy over harvest amounts. The estimates however suggest total seal and sea lion populations in the region as being in the order of a few hundred thousand rather than millions of animals.

Surveys in the 1940's and 1970's yielded counts of about 11,000 individuals but it is difficult to extrapolate actual abundance from these counts. Comparisons of aerial photographs of breeding sites taken in the 1940's with more recent photographs of the same sites do not reveal differences in seal numbers or distribution of breeding animals at the sites. A survey of Pedra Blanca in May 1949 yielded an estimate of seal population on the island of 500 - 700 seals (A. M. Olsen, pers. comm.). Recent comparable surveys have yielded similar figures (R. Gales, DPIWE, pers. comm). Estimates of the seal population in the Victorian Bass Strait region by Dr Harold Thompson of CSIR in 1949 were between 20,000 and 60,000 seals. These data do not show any compelling evidence of population building or decline between the 1940s and more recent years when more systematic survey work commenced.

Pup production in Tasmania in the 1991 season was estimated at 4500, considerably more than the most recent estimate of 3200 in 1999 (both numbers were not corrected for early pup mortality). Numbers at Tasmanian breeding sites are however quite variable from year to year so these data cannot be used to infer a decline over the period. Numbers at Victorian sites appear to have increased between 1991 and 1999 although the rate of that increase is variable between colonies. Best estimates of total (both Victorian and Tasmanian) population in the region in 1991 were in the range of 47,000 to 60,000 (about 13,300 pups) compared to the 60,000 to 77,000 estimate for 1999/2000. Care should be taken when assessing the rate of change over this period, as the data are quite variable from year to year.

It is important to appreciate that total population trends are perhaps more relevant than local trends in Tasmania because there is clear evidence that seals breeding in Victoria also forage in Tasmanian waters. Overall, it appears that the total Australian fur seal population in the region is increasing and may continue to do so as more territory is occupied at the major Victorian breeding sites. A major increase would require the occupation of breeding areas that have not been occupied since the 1800s. It is also possible that the already increasing New Zealand fur seal populations in Western Australia and South Australia may expand into Bass Strait increasing the overall number of seals in the region. Predicting future population growth is heavily reliant upon assumptions about occupation of breeding sites and the impacts of weather on breeding success. This makes further determinations of population trends difficult to verify.

Table 1 Important Tasmanian Breeding and Haul-out (non-breeding) sites for Australian and New Zealand fur seals (Pemberton and Kirkwood 1994).

Breeding sites

New Zealand fur seal

- Maatsuyker Island
- Little Witch
- Walker Island

Australian fur seal

Bass Strait islands including:

- Reid Rocks (south of King Island)
- Tenth Island (near Low Head)
- Moriarty Rocks (south-east of Clarke Island)
- Judgement Rocks (near Deal Island)
- West Moncoeur (south of Wilson's Promontory)

Haul-out (non-breeding) sites - both species at some time

- Bull Rock near Stanley (Australian fur seal and New Zealand fur seal)
- Bass Pyramid, due west of Killiecrankie, Flinders Island (Australian fur seal)
- Ile de Phoques, north of Maria Island (Australian fur seal)
- Hippolyte Rock off Tasman Peninsula (Australian fur seal)
- Cape Pillar, end of Tasman Peninsula (Australian fur seal)
- Cape Raoul, end of Tasman Peninsula (Australian fur seal)
- Cape Queen Elizabeth and The Friars off Bruny Island (Australian fur seal)
- Pedra Branca Island and the Mewstone (Australian fur seal)
- Sugarloaf Rocks (East Pyramid) near Muttonbird Island, south of Port Davey (Australian fur seal)
- Maatsuyker Island, Needles, Walker Island, Little Witch (Australian fur seal and New Zealand fur seal)
- Albatross Island (north-west of Hunter Island) (Australian fur seal and New Zealand fur seal)
- Black Pyramid (south-west of Albatross Island) (Australian fur seal and New Zealand fur seal)
- Point Hibbs (south of Strahan) (Australian fur seal and New Zealand fur seal)
- Wright Rocks (south-east of Deal Island) (Australian fur seal)

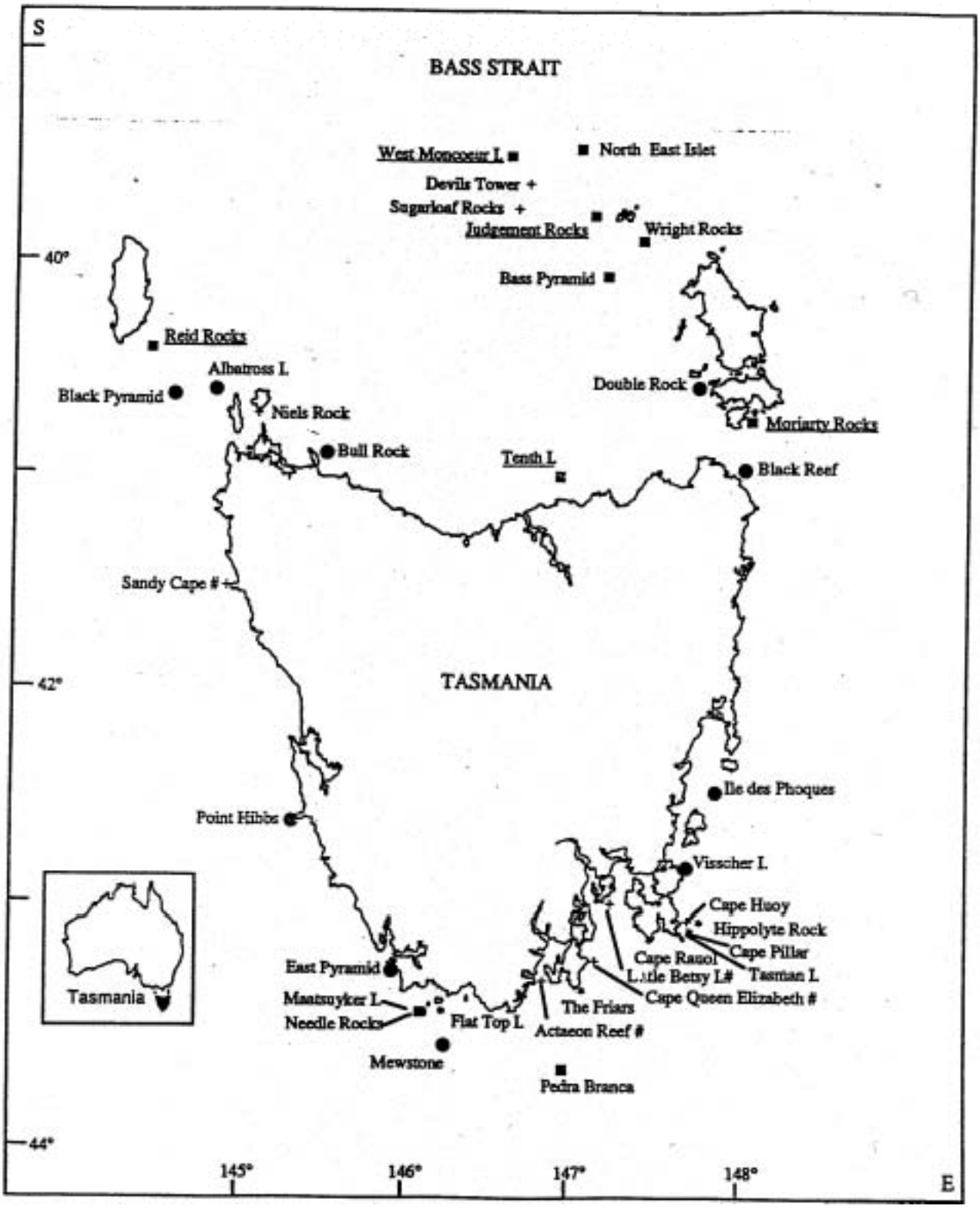
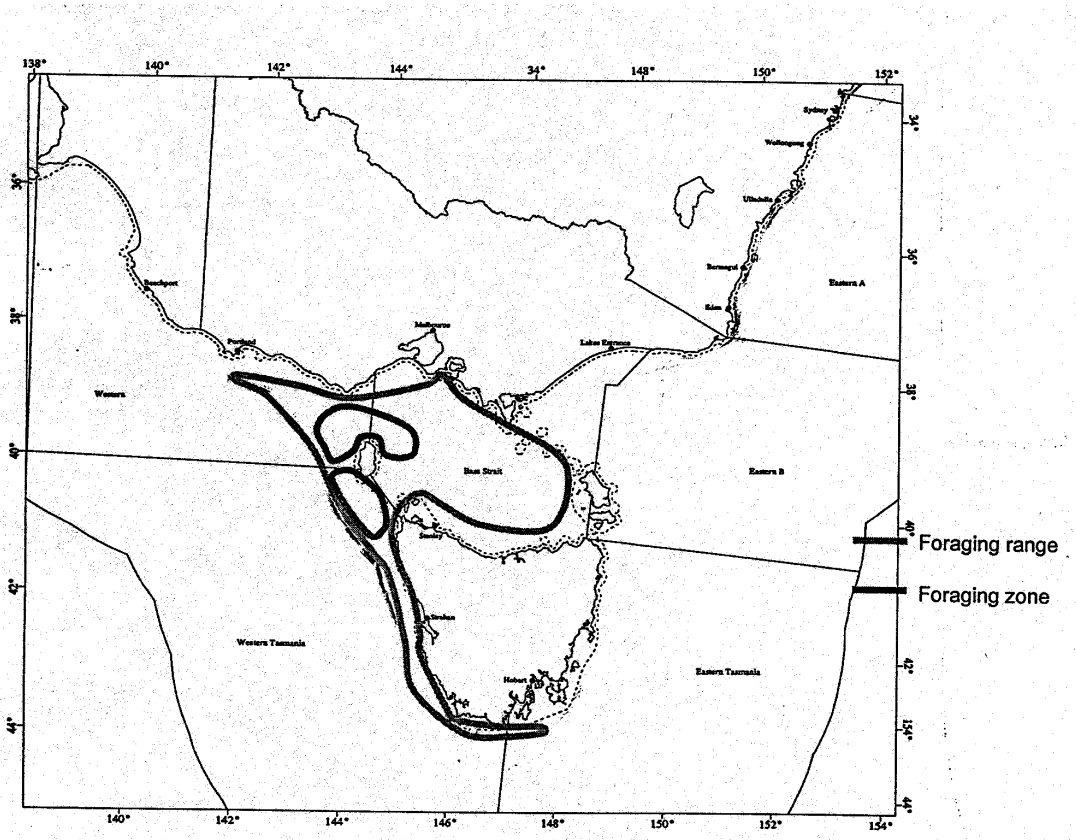


Figure 1 Location of important seal breeding colonies and haul-out sites of fur seals in Tasmanian waters (Pemberton and Kirkwood 1994).

Studies of the movements and diving of Australian fur seals have shown that they may travel great distances to feed (Arnould and Hindell 2001; Littnan and Arnould 2000). Male seals fitted with satellite transmitters at Seal Rocks in Victoria have been tracked through the waters of western Bass Strait, one animal travelling as far south as Pedra Branca (R. Kirkwood, Phillip Island Nature Park, pers. comm.) (see Figure 2). Three female fur seals tracked from Kanowna Island, also in Victorian waters, utilised a considerable area of Bass Strait (Littnan and Arnould 2000, Figure 3). Dives made by breeding females are usually less than 100m, and are often associated with bottom feeding in shallow waters of the continental shelf (Arnould and Hindell 2001; Hindell and Pemberton 1997; Littnan and Arnould 2000). Australian fur seals travel and dive during both night and day.

Figure 2 Foraging zones and ranges of 7 adult male Australian fur seals tracked from Seal Rocks in winter and spring (Data supplied by Dr R. Kirkwood, Phillip Island Nature Park, Victoria).



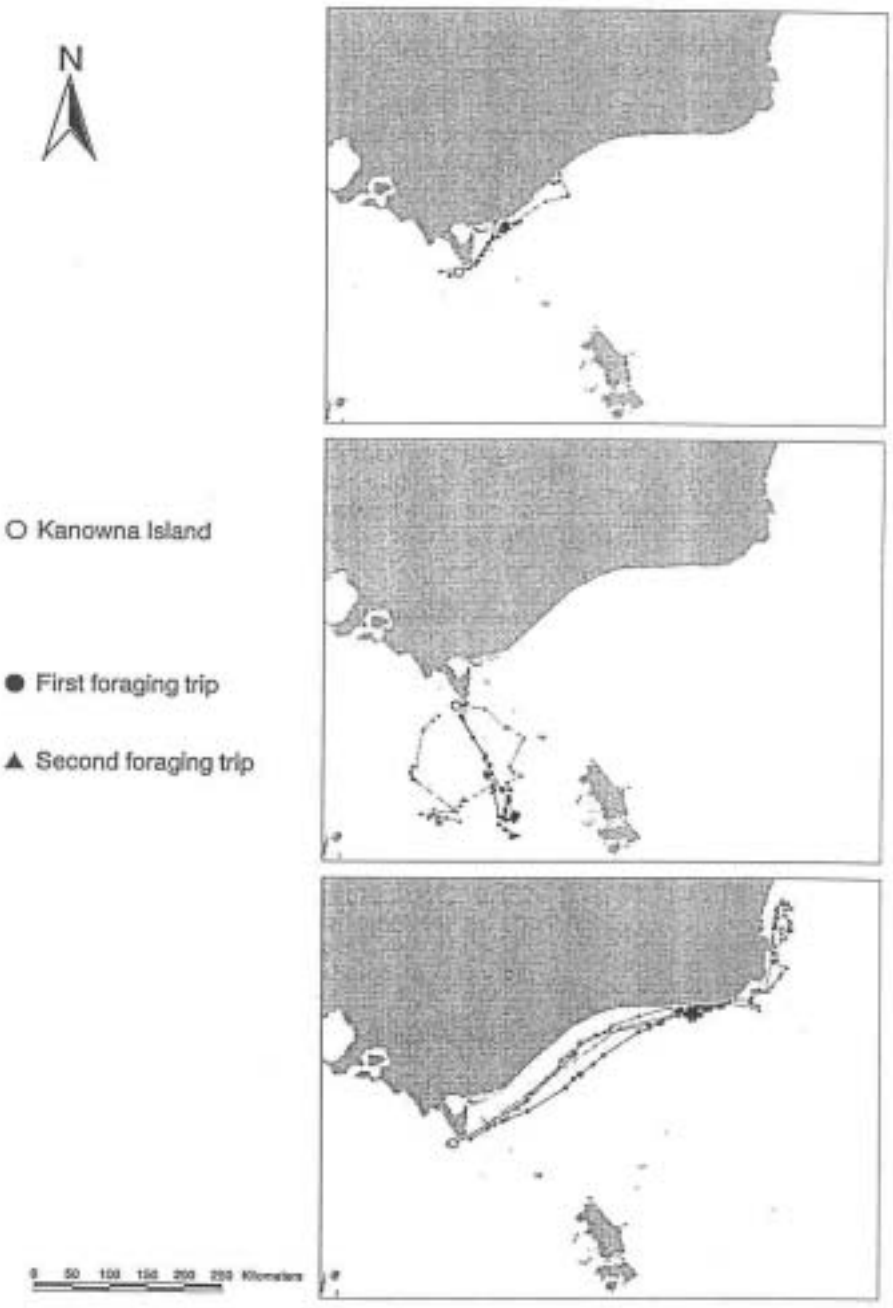


Figure 3 Examples of the records obtained by satellite telemetry of the at-sea movements of three female Australian fur seals from Kanowna Island (from Littnan and Arnould 2000).

Chapter 3 - The Extent of Interactions.

Seal interactions with wild fisheries and aquaculture are not unique to Tasmania, and many other countries have similar problems. It is clear that there is no easy solution or foolproof management strategy that could be adopted in Tasmania. Once it is acknowledged that some level of interaction will occur in the presence of fishing and aquaculture, the focus shifts from trying to eliminate the problem to the more effective management of the interactions.

In Tasmania, the nature of the interactions (and mitigation measures) has been the subject of investigation by biologists over the last ten years (Pemberton and Shaughnessy 1993; Pemberton, Gales and Skira 1995; Schotte and Pemberton 2000).

3.1 Fishing

3.1.1 Historical

A brief scan of Tasmanian history reveals that seal/fisheries interactions occurred throughout the 1900s. Seal/fisheries interactions are not a new phenomenon, nor are Government's attempts to balance the conservation of seals with protecting the interests of fishers.

There are well documented instances of fishers seeking Government help to control seals interfering with nets in the Tamar in 1916, around Flinders Island in the 1920s and in the Tasmanian southeast in 1940 and 1949 (see Attachment 3).

3.1.2 Present

Cuthbertson (2000a) sets out in detail the interaction between seals and scale fishing in south-east Tasmania[4]. He records the types of seals involved, typical behaviour patterns, and fishing related activities likely to attract seals.

To evaluate the current situation the MMIC conducted a survey of all commercial and recreational fishers in Tasmania. A total of 153 questionnaire forms were returned. Commercial scale fishers accounted for 47% of surveys returned, 79% of fishers using grab-all netting. Fifty percent of those respondents experiencing seal interactions reported daily interactions with seals. Of these the most common type of interaction (77%) was the taking of fish from nets followed by net damage (24%). These two types of interaction were attributed equal economic importance by many fishers[5].

[4] Cuthbertson M, *Jaws of Debt*, Mark Cuthbertson, Saltwater River Tas.24p.
[5] Summary of questionnaire responses at Attachment 4.

Interactions with seals varied greatly in relation to season, location and fishing method. Further, within a fishery, some fishers record sporadic levels of interaction while others had daily interactions when fishing. Many fishers were of the opinion that seal numbers had increased in the last decade and that for some fisheries, eg. commercial gill netting, rates of interaction had increased steadily over time. It is important to note that, regardless of any perceived increase in seal numbers, several cray-fishers suggested that the level of interaction at present is similar to that 15-20 years ago. Very few fishers called directly for a cull of seals, while about 10% of commercial scalefishers admitted to shooting seals interacting with their fishing gear.

It was evident from this survey that the impact on the commercial and recreational gill net fishery far exceeded that on other fisheries.

3.1.3 Scalefish Fishery

Access to this fishery is restricted to those fishers who hold a fishing licence (scalefish) and fishing licence (vessel). The scalefish fishery, up until 1994, operated with minimal management controls or limits on total catch and total effort. Other controls in the fishery include minimum size limits for key species and associated mesh size regulations. Areas closed to fishing apply principally in shark or fish nursery areas, and areas vulnerable to netting such as river mouths and estuaries. Limits on fishing gear also apply in some regions.

When the scalefish fishery management plan was introduced in 1998, controls and restrictions on the amount of fishing gear that could be used in State waters were imposed on all scalefish fishers. Unlike the abalone and rock lobster fisheries, the scalefish fishery is predominantly managed by input (gear) controls, rather than output (catch) controls.

The principal fishing methods used for taking scalefish in Tasmanian waters are gillnets, multiple hooks deployed on longlines and various seine nets. Other methods such as droplining, trolling, trapping, spearing and dipnetting are also used to take scalefish and cephalopods.

Key target species landed in the commercial fishery include blue and spotted warehou (*Seriolella brama* & *S. punctata*), silver trevally (*Pseudocaranx dentex*), various species of flathead (*Platycephalus* spp.) and flounder (mainly *Pleuronectidae*), jackass morwong (*Nemadactylus macropterus*), bastard and striped trumpeter (*Latridopsis forsteri* & *Latris lineata*), arrow squid (*Nototodarus gouldi*), Australian salmon (*Arripis trutta*) and garfish (*Hyporhamphus melanochir*). All are destined for the table fish market. Developments in markets and fish handling have recently seen significant increases in effort targeted at species such as banded morwong (*Cheilodactylus spectablis*) and wrasses (of the genus *Notolabris*). These rocky reef species are sold on the premium 'live fish' market.

The Tasmanian jack mackerel fishery has also operated under separate management arrangements except for small scale operators (operators with boats less than 20m) who are subject to the general scalefish management regime.

Other species taken as a significant bycatch or as a limited seasonal target species include school whiting (*Sillago bassensis*) and southern calamari (*Sepioteuthis australis*). While not true 'scalefish', shark (particularly school shark (G*aleorhinus galeus*) and gummy shark (*Mustelus antarcticus*)) are an important part of the catch in State fishing waters in terms of both volume and value.

In summary, the fleet is highly diverse and target species and configuration change both seasonally and by area. The fleet is highly dynamic and responsive to changes in markets and demand.

3.2 Interactions with seals in relation to fishing method

The lack of available published data has made assessing the level of interaction and its impact on Tasmanian fishers difficult. For a comprehensive understanding of interactions with seals it would be necessary to institute a formal and regular process of data gathering.

3.2.1 Gill Netting

Tasmanian gill net fishers report varying levels of interaction with seals. Seals may be present during fishing operations or follow boats to fishing areas. Interactions range from no interaction through to the taking of fish from nets and/or the damage of fish, gear and nets. The incidental catch of seals in commercial gillnets has also been recorded by some fishers.

Seal interactions with the live fish gill net fishery were reported as a ‘serious problem’ by Pemberton *et al.* (1998) after numerous fishers contacted Parks and Wildlife. Observers spent 22 days at sea on 38 commercial gill-netting trips May-July 1997 to investigate rates of interaction and prospects of solutions. Seals were observed on 15 occasions. Three seals damaged six nets on one day and seals were also observed throwing fish on two occasions (Pemberton *et al.* 1998).

Gill nets for live species are usually bottom set[6]. Underwater predation of fish is difficult to detect at depth, although seals are sighted taking fish while nets are hauled. Variable losses of catch are attributed to seals. At least one fisher reported leaving the fishery, citing seals as the ‘last straw’. Many fishers report extreme frustration and personal stress at witnessing the taking of fish by seals. The negative economic impact of seals on gill net fishing is widely experienced within the industry.

All scalefish fisheries are subject to natural variability within the marine environment affecting productivity, stock availability and recruitment. Some fisheries are weather dependent (eg. drop-lining and gill-netting) while others can be subject to increased fishing effort in some years. Other impacts affecting various methods of fishing for scalefish species are summarised in Table 2.

[6] A weighted net is set vertically above a reef at depths of up to 20m

Table 2 Consequences of the interaction between seals and the scalefish fisheries in Tasmania and Victoria.

Fishing method	**Interaction**	**Consequence**
General (common to all methods)	• damage to fishing gear	• cost of repairs • lost fishing time
Gill-netting	• seals damage gear • take fish from nets • seals damage fish • seal presence • seal by-catch	• cost of repairs • lost catch • mortality or reduced sale price • perceived affect on fish behaviour
Trawling	• seals drowned in nets • live seals aboard	• lost fishing time • lowered catch • safety of personnel compromised
Long-lining/ drop-lining	• fish taken directly from lines or 'floaters' eaten	• reduced or damaged catch
Squid jigging	• in Victoria squid are sometimes pulled off jigging machine	• reduced catch

3.2.2 Other fisheries

The extent of seal interaction with **rock lobster** fishing gear is difficult to assess but is likely to be small. Many operators report having either no interactions with seals or low and sporadic levels of interaction. The most frequently reported types of interactions include pulling bait out of savers, predation or damage to undersize rock lobsters whilst being released, or the eating of 'softshellers' during the non-fishing season. One rock lobster fisher on the West Coast of Tasmania reported catching 2-3 juvenile fur seals per year drowned in rock lobster pots. Inadequate information precludes an accurate assessment of interactions, as rock lobster pots are often set overnight and at considerable depth. Therefore, while some bait loss may be attributable to seal predation, other predators (e.g. octopus) and the loosening of bait skewers during the setting of pots or rough weather may be equally responsible.

Rock lobster catches may also be affected by octopus predation. Octopus will enter rock lobster pots and may kill all rock lobsters in a pot. Many fishers acknowledge that as octopus are a prey item of Australian fur seals, seal predation may help regulate octopus numbers and therefore rock lobster mortality.

No interactions between **giant crab** fishing operations and seals have been reported.

Very few **abalone** divers have reported negative interactions with seals. In a recent survey of fishers, however, one out of five abalone divers reported aggressive behaviour encounters with seals. The majority of interactions include playful pulling of fins while diving, although in some cases divers have been frightened by large seals darting around at high speed.

3.3 Marine farming

3.3.1 Salmonid farming

Salmonid farming occurs in many temperate regions of the world, with the majority of production occurring in Norway, Chile, the United Kingdom (Scotland) and Canada (British Columbia) (Table 3). In many regions salmonid aquaculture overlaps with the breeding and/or foraging ranges of pinniped species. However, only in British Columbia, Washington State (USA), Chile, New Zealand and Australia, do interactions occur with otariids (fur seals and sea lions).

Table 3 World Production of Farmed Salmon in 1988, 1995 and 1997

	1988 Production		1995 Production		1997 Production	
	'000 Tonnes	% Share	'000 Tonnes	% Share	'000 Tonnes	% Share
Norway	80.3	57.5	251.0	45.5	316.0	52.0
Chile	3.1	2.2	126.3	22.9	96.0	16.0
United Kingdom	17.6	12.6	65.0	11.8	86.0	14.0
British Columbia	6.6	4.7	23.8	4.3	40.0	7.0
Ireland	4.2	3.0	16.0	2.9	15.0	2.0
Eastern Canada	3.3	2.4	14.7	2.7	*	*
United States	2.0	1.4	14.7	2.7	22.0	4.0
Japan	14.1	10.1	14.1	2.5	?	?
Faroe Islands	3.4	2.4	12.4	2.2	20.0	3.0
Other Countries	5.1	3.7	13.9	2.5	11.0	1.5

* British Columbia and Eastern Canada included as one figure for Canadian production under Eastern Canada (Anon 1997)

The farming of salmonids has grown into one of Tasmania's major primary industries in little more than a decade. Growth has continued to be rapid in recent years. In 1998/99 production was 9,195 tonnes with a farm gate value of $71.1m (Figure 4; ABARE Fisheries Statistics, 2000). Projections are for the industry to double by 2005 (Anon 1999). Industry surveys by the Tasmanian Salmonid Growers Association Board to December 2001 showed that sales had expanded to 12,118 tonnes for the calendar year 2001. The industry will continue to grow in 2002. Due to a high degree of value adding, the value of the Tasmanian industry at first point of sale is estimated at $160,000,000 in 2002 (O. Carington Smith, TSGA, Pers. comm.).

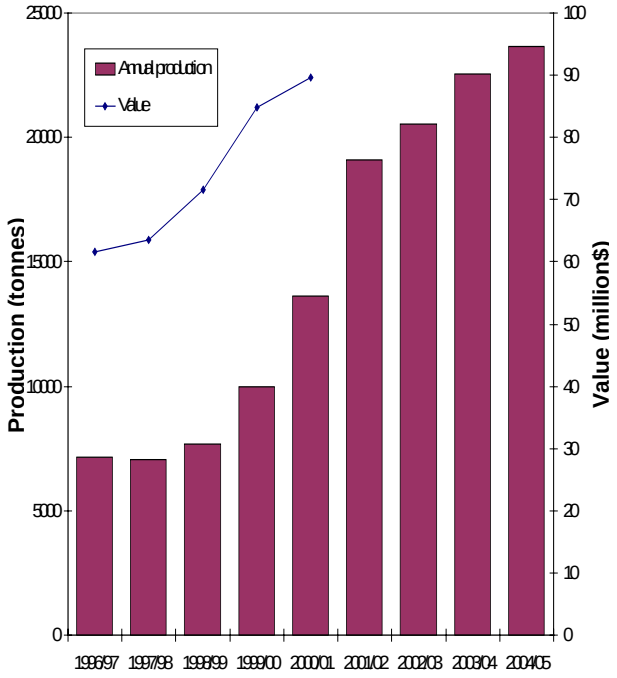
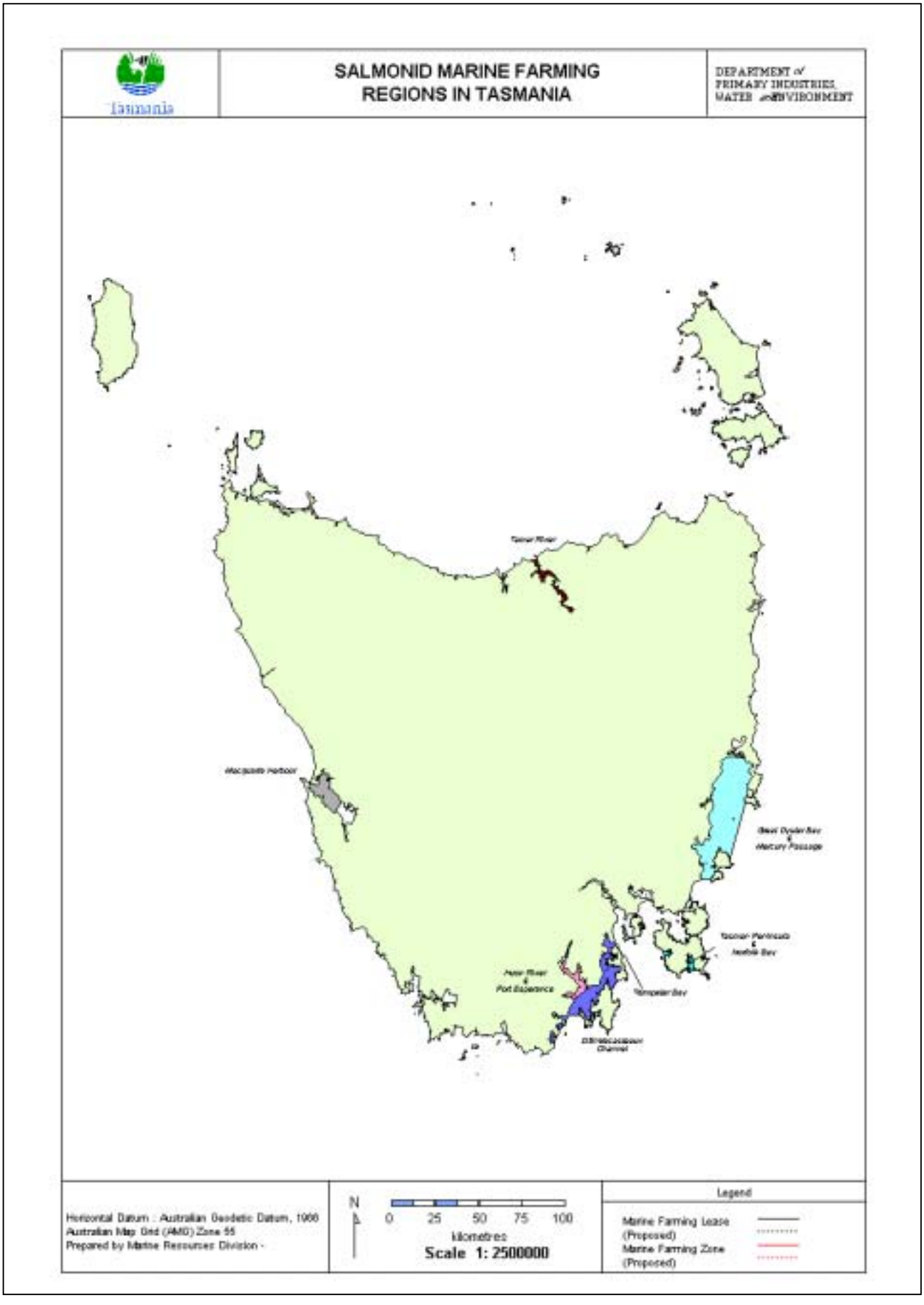


Figure 4. Current and predicted salmon production (t) and its value in Tasmania (1995-2005).

The salmonid industry provided direct employment for 623 Full Time Equivalent (FTE) positions in 1999/2000 (Deloitte Touche Tohmatsu 2000). In 2001/2002 FTEs have grown to 925 due to industry growth, higher levels of value adding and more employment required on farms to manage difficult environmental conditions. Over 100 companies are now supplying goods and services to the industry (O. Carington Smith, TSGA, Pers. comm.).

Figure 5 Location of marine salmon farming lease sites in Tasmania



3.3.2 Seal interactions with Salmon Farms

National Parks and Wildlife Service became aware of seal attacks on marine fish farms in 1985 (Pemberton 1989). Since that time, numbers of reported interactions have increased, as has the annual production of farmed salmon.

Seals have learnt to target leases with the least anti-predation measures or those most affected by strong currents, which push anti-predator nets against fish holding nets. Salmon farming produces effluent such as uneaten salmon feed which falls through nets. Anecdotal evidence indicates that wild fish numbers may increase outside pens in response to high productivity and seals may feed on these wild fish. Oil slicks emanating from newly dispersed feed and escaped adult fish may attract seals to salmonid farms. The presence of seals around pens (whether eating wild or farmed stocks) reduces the feeding rates of farmed salmonids, resulting in a higher loss of feed falling through nets, thereby positively re-inforcing the problem.

The vast majority of interactions with Tasmanian marine farming operations currently involve the Australian fur seal (M. Greenwood, DPIWE, pers. comm.). Only two interactions with New Zealand fur seals have been recorded, and at least two interactions with Leopard seals have been reported (Pemberton and Shaughnessy 1993, M. Greenwood, DPIWE, pers. comm.). Sub-adult and adult male fur seals usually attack pens at night (T. Dix, TASSAL, pers. comm.). The types of interactions between fish farms and seals are summarised in Table 4. Interactions and responses differ markedly between sites and companies, and between sites within companies.

Table 4 Types of seal interactions encountered at salmonid farms

Interaction	**Consequence**
• Grab fish through predator and internal net or enter nets	• fish mortality • lost or reduced market value of damaged fish • increased effort of divers removing dead fish • increased susceptibility to disease
• Proximity of seals to pens	• stress and decreased feeding rates of fish
• Live seals trapped between nets	• decreased feeding rates • risk to workers in releasing seals • work time lost in dealing with seal
• Entanglement of seals in predator nets (by-catch)	• seal mortality (see Table 5.3)
• Net damage	• release of fish • cost of repair
• Boarding of boats or farming superstructure	• stress and risk to personnel safety • two reported instances of seal bite injury
• Seals attracted to farm by escaped salmon, oil slicks from feed or increased wild fish outside pens	• encourages further interaction

3.4. Tourism and Social Impacts

The educational and recreational benefits of seal watching to the local economy have spawned a new and growing industry. In Australia seal watching has grown rapidly with recent estimates of visitation to tourist sites amounting to nearly 400,000 tourists per year (R. Kirkwood, Phillip Island Nature Park pers. com.). Ticket sales alone are estimated at approximately $5 million per annum and, with multiplier effects, make this an important contributor to regional economies. Eight operators currently conduct seal watching tours in Tasmanian waters including the Friars (Bruny Island), Hippolyte Rock, Ile des Phoques, Tasman Island, Tenth Island, Bull Rock and occasionally Moriarty Rocks. Estimated visitation in Tasmania is 624 tourists per year valued at $US9,360 in total.

Interactions between tourist operators and seals may on the other hand also be negative. This depends on the level of interaction and the time of year, for example, close approaches by boat during the breeding season may be disruptive. Nature Conservation Branch Guidelines, DPIWE [7], are designed to minimise this effect.

[7] Includes no landing on colonies and prescribes boat approach distances

Chapter 4 - The Economic Impact of the Interactions.

4.1 Fishing

4.1.1 Tasmania

In 2001, survey forms were sent to all holders of a fishing licence (personal), so that information on seal interactions could be obtained from all current licence holders that fished for commercial purposes in the last 12 months. The results of this survey are summarised in Attachment 7.

Of the 615 survey forms sent out, 216 were returned. In terms of seal interactions, 147, or 68% of the respondents stated that their fishing operations had been interfered with by a seal, either directly or simply due to their presence, in the previous 12 months.

Fishing activities were categorised into the following sectors:

- Abalone diving
- Rock lobster fishing
- Rock lobster and scalefishing
- Scalefishing (live fishing, general scalefishing and Commonwealth fisheries)

Of the respondents who had conducted both scalefishing and rock lobster fishing activities over the last 12 months *and* had experienced some form of seal interference, 77% indicated that seals had interfered with both their scalefishing and lobster potting. Of the respondents who had been involved in the live fish (banded morwong and wrasse) fisheries, 100% had experienced seal interference with their fishing activities. Abalone divers who had experienced seal interference in the last 12 months had mainly been harassed by seals whilst diving. There are difficulties in attempting to attribute costs to this form of interference.

Graball netting accounts for most of the commercial fishing interactions that occur with seals. The types of interactions for this method are mainly damage to the gear (broken meshes), taking caught fish and damage to the fish. Gear damage doesn't appear to be a significant factor for the line fisheries, where the majority of interactions are due to seals actively taking/damaging fish on the line. These types of interactions are significant and can present difficulties in terms of attributing and estimating costs. Seal interactions with rock lobster potting tends to be directly due to the seals attempting to take bait from the pots, causing gear damage to the pots and bait savers. Fishers have remedied this situation by improving the way in which bait is secured in the pots.

As a very rough guide, and not taking into account latent effort or "inactive" fishers, the following table gives an approximation of the costs incurred to wild fishers as a result of seal interactions. The abalone sector was not included as only 1 respondent provided information on costs, and this was related to periodic scalefishing activities. Please note that seal interactions do not seem to be an issue with other types of wild fishing operations, such as scallop fishing, squid fishing, in Commonwealth waters, Danish seining or seaweed harvesting.

Fishing Sector	Cost to Industry ($)	% of Total Cost
Rock Lobster	50,708	6.1
Rock Lobster + Scalefish	104,976	12.4
Scalefish	462,329	54.8
Live Fish	225,279	26.7
Total	**843,292**	**100%**

These costs represent the "physical" costs attributed to interactions with seals (such as damage to nets, lost bait savers) and do not include the costs associated with seals taking fish from nets or lines, damage to fish or lost fishing days. Although difficult to determine, the survey results suggest that these costs are significant.

4.1.2 Elsewhere

4.1.2.1 Norway

Harp seals (*Phoca groenlandica*) were reported to eat the soft ventral parts of fish entangled in nets (Nilssen *et al.* 1992). Migrating seals have caused problems for Norwegian fisheries, particularly in coastal areas and fjords where substantial numbers have been captured and drowned in gill nets during winter (Haug *et al.* 1991). Fishers also claim that the presence of seals leads to changes in fish behaviour and that fish become less available on the traditional fishing grounds (Nilssen *et al.* 1992). A study investigating the incidence of seal damage to cod in gill nets in North Norway in January 1986 indicated that 2.2-26% of daily catches were possibly damaged by seals (Nilssen *et al.* 1992). Suggestions for minimising interactions were not discussed.

4.1.2.2 USA

In Alaska, conflicts between harbour seals (*Phoca vitulina*), Steller sea lions (*Eutomopias jubatus*) and salmon drift gill net fisheries led to a study of seal/fishery interactions in the Copper River Delta in 1988/89 (Wynne 1990). Field observations, dockside interviews and beached carcass surveys were conducted. Financial loss due to salmon depredation represented less than 1% of the ex-vessel value of salmon landed (Wynne 1990). The study recommended the development and demonstration of viable non-lethal deterrents for nuisance

animals. The systematic testing of acoustic deterrents, rubber bullets and cracker shells was also recommended (Wynne 1990).

In California, National Marine Fisheries Service (NMFS) observers monitored seal depredation in the halibut and angel shark set gill-net fishery during a four-year period (1990-1994), recording depredation in 19% of 60,967 sets (Beeson and Hanan 1996). Commercial fishermen reported that seals could damage 10-30% of daily catches, while individuals claimed losses of US$1000-$20,000 annually in terms of gear damage and catch loss (Beeson and Hanan 1996). Marine mammal mortality was also estimated for the same period from NMFS observer data, commercial fishers' logbooks and receipts of landed fish sales (Julian and Beeson 1998). An estimated 729 to 3438 sea lions per year were entangled in nets in these fisheries (Gearin *et al.* 1988a). This study also recommended killing habituated animals to decrease overall depredation, however interactions in this instance involved endangered fish stocks.

4.1.2.3 Japan

In 1993, 1725 gill nets in the Hokkaido region were reportedly damaged by Steller sea lions (*Eumetopias Jubatus*). Gear damage in total (2173 incidents) was estimated to be worth 500 million yen (US$5 million) (Akamatsu *et al.* 1996).

4.2 Marine farming in Tasmania

Some records of seal interactions and their impact have been collected by industry, however as the information is not collected in a consistent form across industry, comparisons are difficult. To assist in the quantification and qualification of seal interactions and their impact information must be collected in a consistent form.

In response to a request for information regarding interactions between seals and salmonid marine farms, marine farmers provided a variety of information. Where possible, this information has been summarised and included in this report.

Table 5 summarises data provided by two Tasmanian companies on seal attributed mortality of farmed salmon.

Table 5 Seal attributed mortality of farmed Atlantic salmon on two Tasmanian farms between 1997-2000. Mortality is expressed as a percentage of annual production. Cost to Industry based on an estimated $1000/tonne

Year	Mortality (%)		Average Mortality	Industry Production. (t)	Estimated cost to Industry
	Company A	Company B			
1997	0.84	0.17	0.51	7 068	$7 million
1998	1.45		1.45	9 195	$9.2 million
1999	1.03	0.76	0.90	10 906	$10.9 million
2000	2.1	1.93	2.02	11 500	$11.5 million

The cost of seal interactions to the salmon industry is estimated to be approximately $1000 per tonne of salmon produced. This is believed to be around 10% of the cost of production (T. Dix, Tassal Ltd. pers. comm), an estimated $11.5 million in 2000.

The information provided suggests a need for industry and DPIWE to develop a process for collecting relevant data to be used in the future monitoring and management of seal interactions. Further discussion is required as to what type of data need to be collected and in what form. This should include a record of seal interactions, when they occurred, what form they took, how many seals were involved and what damage, if any, occurred as a result.

Chapter 5 - The Conservation Impact of the Interactions.

Biological interactions (such as competition for resources) between species in marine ecosystems are very complex. Internationally, attention has focused on marine mammals being perceived as major predators of some fisheries. Seals are more visible than other marine predators and, because they can visibly interact and damage gear, are often seen as a 'nuisance' by fishers (Yodzis 2001). An understanding of ecosystem complexity and seal ecology (including diet and energy consumption) is necessary to determine the relationship between predators and the exploited fish stock. Only direct interactions between individual fishing methods and seals have been described.

5.1 Fishing operations

An unknown number of seals, and other marine mammals, in Tasmania are drowned in gill netting by both commercial and amateur fishers. Results of the Seal/Fishery Interaction Questionnaire 2000 show that a minimum of 9% of 126 commercial fishers recorded seal by-catch in their nets.

An unknown number of seals become entangled in fragments of discarded fishing net and set gill-nets each year. In 1992, Pemberton *et al.* estimated that 2% of Australian fur seals in Tasmania were entangled. The types of fishing debris involved in 196 entanglement cases are summarised in Table 6.

Table 6 Identification of marine debris involved in Australian fur seal entanglement (n=204)

Type of entanglement	Percentage	Fishing debris
Identified	65%	trawl net (54%) bait packing straps (20%) rope or line (15%) mono-filament gill net (7%) rubber o-rings (2%) shark net (5%)
Unidentified	11%	
Scarring	23%	

Data supplied by Nature Conservation Branch, DPIWE

At breeding colonies monitored for entanglement, 92% of entangled adult seals were lactating females (n=36). Of the sub-adult animals affected, 83% (n=15) were males. Southern non-breeding haul outs (Cape Pillar, The Friars, Pedra Branca and Maatsuyker Island) have also been monitored for seal entanglement. Of all seals observed to be entangled 46% were juvenile, 31% sub-adult and 23% were adults.

5.2 Fishing and food for seals

Together with other high-order predators (including whales, dolphins, seabirds, sharks and tuna), seals occupy a key place in the marine ecosystem. In Tasmanian waters Australian fur seals eat mainly schooling fish and cephalopod species. Whilst redbait (*Emmelichthys nitieus*), jack mackerel (*Trachurus declivis*), leatherjackets (*Monocanthus spp*.) and arrow squid (*Nototodarus gouldi*) constitute the main prey species, over 40 species of fish and over 10 cephalopod species have been identified as being eaten by seals (Gales *et al.* 1993; Gales and Pemberton 1994; Reid 1994). This diet information has been obtained from analyses of diagnostic hard parts in faeces and regurgitates collected on breeding and haul-out sites around Tasmania. There is the potential for some species which either lack diagnostic remains, or for which diagnostic remains are not consumed, to be under-represented, resulting in biases in our understanding of the diet profile of the species.

Table 7 Major Prey Species for Australian fur seals in Tasmania

Prey items	**1989-1990**	**1994-2000**
Number of Samples	357	1106
Prey remains	1496	4013
Fish		
No. species	25	34
Numerical abundance		
Redbait	43%	25%
Leatherjacket	12%	19%
Jack mackerel	1%	9%
Cephalopod		
Arrow squid	57%	41%
*Sepia (*unidentified 1)	4%	10%
Octopods	13%	40%

Source: Gales *et al.* (1993)
Gales and Pemberton 1994
Nature Conservation Branch, DPIWE, Unpublished Data

There is strong evidence to indicate that several of the major seal prey species, principally jack mackerel and arrow squid, exhibit marked inter-annual variability in their abundance in Tasmanian waters. Related to this variability, have been marked fluctuations in commercial catches of these species. For instance, the

commercial fishery for jack mackerel developed rapidly off the east coast of Tasmania in the mid-1980s, with catches peaking at over 35,000 tonnes in 1986/87 and 1987/88. In subsequent years, catches have only exceeded 20,000 tonnes twice (1990/91 and 1991/92) and more recent landings have generally remained between 5000 - 10,000 tonnes.

Significant commercial catches of Arrow squid were also reported by foreign vessels in 1978/79 and 1979/80 (over 3000 tonnes p.a.) and again in 1983/84 and 1984/85 (1500-2300 tonnes), largely from Bass Strait (Willcox *et al*. 2001). Apart from 1973/74, when just over 150 tonnes of arrow squid was taken from Tasmanian coastal waters, local catches remained below about 30 tonnes up until 1998/99. There has, however, been a recent expansion of the inshore squid fishery with an influx of automatic jig vessels. In 1998/99 about 95 tonnes was caught from coastal waters while in 1999/2000 the harvest reached 430 tonnes. Availability of arrow squid was poor in 2000/01, with less than 40 tonnes caught, despite extensive effort. It is noteworthy that arrow squid catch rates off Victoria were reported to be very high in 2000/01 (final catch figures are not yet available).

In terms of the broader commercial scalefish fishery, inshore production has remained relatively stable over the past three decades, ranging between 1000 – 2500 tonnes (Lyle and Jordan 1999, Lyle and Hodgson 2001).

Given the apparent magnitude of natural variability in abundance of the key prey species and the sporadic nature of the fisheries based on these species coupled with general stability in overall inshore scalefish fishery, a clear link between seal interactions on farms and reduced availability of prey (due to fishing) is not evident.

5.3 Marine farming

Shellfish farms are thought to have no impact on seals. Finfish farms may have a nett positive effect on individual seals by boosting food availability, however with the approval of DPIWE, seals posing serious problems around farms may be trapped for relocation and some mortality is associated with this trapping.

Figures for the entanglement of New Zealand and Australian fur seals at marine fish farms from 1998-2000 are summarised in Table 8. The large increase in seal entanglement mortality in 2000 was due in part to the changing of the mesh size of the corral net by one farm. No further deaths have been recorded by that farm since the introduction of a 100mm mesh size net for the corral area (Mike Greenwood, DPIWE, pers. comm.).

Table 8 Entanglement of Australian and New Zealand fur seals at fish farms, 1998-2000 (includes animals found floating on farm lease and not directly associated with fish nets)

YEAR	Australian fur seal	NZ fur seal
1998	2	0
1999	4	0
2000	27	0

Data supplied by Nature Conservation Branch, DPIWE

Chapter 6 - Current Trends in Seal Populations and Factors Affecting Them.

6.1 Seal Populations

New Zealand fur seals have not re-established substantial breeding populations in the Tasmanian region following sealing activities in the early 1800's. Although currently uncommon in Tasmanian waters, New Zealand fur seals are increasing in number in Western Australia and South Australia They are listed as rare and the Tasmanian Government's conservation objective is to protect the population, its habitat and breeding sites so as to allow the population to continue to rebuild.

Australian fur seals are presumed to be less abundant now than prior to European sealing activities, judging by the relatively restricted number of breeding sites presently occupied. There is evidence that, although the Tasmanian populations are relatively stable, the overall Bass Strait population of Australian fur seals is increasing, due to increases at several Victorian sites. The Tasmanian Government's conservation objective for this species is to protect the population, its habitat and breeding sites to allow current population levels to be maintained and potentially increase if additional breeding sites are colonised.

No active intervention measures are proposed to facilitate population rebuilding.

6.2 Conservation measures

States are responsible for seals in waters up to 3 nautical miles off-shore and on land where seals haul out, moult, rest and breed. The Commonwealth is responsible for seals in the waters of the Continental Shelf outside State Coastal waters and within the Australian Exclusive Economic Zone (EEZ) up to 200 nautical miles off shore (Shaughnessy 1999).

The management tools currently in use are a mix of management plans/action plans, legislation and protocols. There are two primary aims of seal management: conservation and protection of seal species, and the regulation of human/seal interactions.

6.2.1 National Measures

Seals in and around Tasmania form part of large populations that extend well beyond the jurisdiction of the State. The New Zealand and Australian fur seals are protected under the *Environment Protection and Biodiversity Conservation Act 1999* and an action plan. They are included in the list of marine species established by the Minister under the Act.

Section 254A provides for strict liability for killing or injuring a member of listed marine species. A person is guilty of an offence if:

(a) the person takes an action; and
(b) the action results in the death or injury of a member of a marine species; and
(c) the member is a member of a listed marine species; and
(d) the member is in or on a Commonwealth area.

All of the elements of the offence must be present before a person is found guilty of that offence.

6.2.1.1 The Action Plan for Australian Seals (1999)

In 1999 the Action Plan for Australian Seals ('the Action Plan') was released (Shaughnessy 1999). The Action Plan reviews the conservation status of the 10 seal species inhabiting Australian waters, including the waters of the Australian Antarctic Territory. It summarises the current knowledge on the biology, abundance and distribution of seals, identifies threats and recommends research and management actions required for their conservation.

All ten species of seal were assessed against the International Union for the Conservation of Nature and Natural Resources (IUCN), now The World Conservation Union Red List Categories[8]. New Zealand fur seals and Australian fur seals are considered to be at lower risk, but conservation dependant because the cessation of a 'habitat specific conservation programme' could lead to each of them qualifying for a threatened category if ready access by humans to breeding sites were permitted during the breeding season.

The Action Plan identifies conservation objectives, conservation actions already initiated, and conservation actions required. Each of these is broken down into research and management initiatives. Research priorities in relation to both the New Zealand fur seal and the Australian fur seal include:

- studies of genetic relatedness;
- population size, diet, behaviour, movements and feeding; and
- interaction between seals and fisheries.

This information is crucial to the proper management of these species. The management actions required are aimed at protecting the species whilst minimising seals' association with fishing vessels and set gear as a food source. It promotes the adoption of improved fishing practices, such as a protocol for dumping baits and discards (offal, unwanted catch and under-size catch), and an improvement in the use of exclusion nets on marine farms.

[8] The Categories are as follows: Extinct; Extinct in the Wild; Critically Endangered; Endangered; Vulnerable; and Lower Risk. The Lower Risk category is separated into three subcategories : Conservation Dependent; Never Threatened; and Least Concern.

6.2.2 Tasmanian Measures

Seals have been protected under Tasmanian legislation since 1891. At present Australian fur seals are protected under the *Wildlife Regulations 1999*, which provide that it is illegal to injure, kill, destroy, collect, damage, buy, sell or have possession of any such seal (or part thereof) without a permit. The New Zealand fur seal is similarly protected under the *Wildlife Regulations 1999*. In addition, the New Zealand fur seal is listed as rare under the *Threatened Species Protection Act 1995*. This listing prevents any person from knowingly, without a permit take, trade in or process New Zealand fur seals ("take" includes kill, injure, catch, damage, destroy and collect). For each listing under the *Threatened Species Protection Act 1995*, a listing statement must be prepared[9]. A listing statement for the New Zealand fur seal has not yet been prepared.

There has been no trade in Tasmanian seal products for more than 60 years.

The different protection status at a State and Commonwealth level, even though both use the IUCN criteria, is due to the scale on which they are assessed. At the Commonwealth level assessment is undertaken on a national basis, i.e. includes seal populations in all State and Commonwealth waters, whereas at a State level assessment is based upon the seal population in Tasmania's State waters.

6.3 Other Influences on Seal Populations

Various factors may affect the status of seal populations, such as climatic events, disease and human activities including various fishing operations and the illegal taking of seals. Sections 5.1 and 5.3 describe how fishing and marine farming operations generate seal mortality. This section summarises other factors that may negatively affect seal populations in Tasmanian waters, the scale and consequences of which are unknown.

6.3.1 Environmental Factors

Variability within the marine environment, such as climatic conditions, affects seal populations in several ways. Storm events in Bass Strait reduce pup production at certain breeding colonies by up to 90% in some years (Hume 2000), as large swells wash breeding colonies. Population growth at some sites can be significantly affected depending on the frequency of these storm events.

Oceanographic variability, for example changes in primary productivity and sea surface temperature, may lead to changes in prey availability. One study in North

[9] The listing statement specifies:
(a) a description, the distribution and the habitat of the taxon; and
(b) its conservation status with reasons; and
(c) management objectives; and
(d) management issues; and
(e) actions that need to be taken for the purposes of management and conservation of the taxon; and
(f) threats to the taxon; and
(g) any information relating to the taxon that is available in published references.

America (Hanan *et al.* 1989) found reduced seal interaction and depredation (predation of commercial species) rates following an El Niño event, possibly resulting from reduced prey availability and a reduction in seal numbers (Beeson and Hanan 1996). Reductions in prey availability may also lead to declines in body condition, longer search times for prey and lower foraging success (Castellini in Anon 1994).

The relationship between the diet of Australian fur seals and fluctuations in the oceanic environment is not clearly understood.

6.3.2 Disease

In common with seal populations around the world, Tasmanian populations of Australian fur seals are known to carry some viruses, including tuberculosis (Woods *et al.* 1995).

In 1988 approximately 17,000 seals were killed by the phocine distemper virus around the British Isles. In Lincolnshire and Norfolk, surveys conducted by the Sea Mammal Research Unit at the University of St Andrews show that animals in this area suffered high mortality in the 1988 phocine distemper virus epizootic, and that numbers are steadily increasing but have not yet reached their pre-epizootic level (web site for the Sea Mammal Research Unit, http://www.smru.st-and.ac.uk).

6.3.3 Illegal taking of seals

Human-related impacts on pinnipeds (apart from prey depletion) occur as a result of entanglement in net or lines, internal and external embedding of hooks, shooting or other trauma (Angliss and DeMaster 1998). It is extremely difficult to determine cause of death as projectiles are hard to find without whole body x-rays. Seals are usually quite decomposed upon discovery, and if intentionally drowned (in a trap), it is impossible to determine cause of death (R. Gales, DPIWE, pers. comm.).

The number of seals shot in Tasmanian waters each year is unknown, however DPIWE has numerous reports of seal shooting. A recent survey on seal/fisheries interactions in Tasmania (Attachment 4) has revealed that approximately 10% of fishers that responded admitted to shooting seals. However, there have been only five successful prosecutions in the last ten years. Those prosecuted have been within the aquaculture and commercial fisheries industries.

Chapter 7 - Minimising the Impact of Interactions.

Mitigation of seal/fisheries interactions has been the subject of research by government agencies worldwide for more than 20 years. Interactions vary depending on the type of fisheries operations, species involved, season, environmental variability and many other factors. Mitigation measures can be described as modification to fishing practices and/or equipment (Brothers *et al.* 1999) in order to reduce interactions between pinnipeds and fisheries operations. Mitigation measures need to be tailored to suit the behaviour of seals, particularly if they learn to circumvent measures.

Possible solutions include modifications to fishing equipment, methods and location; the use of devices that repel marine mammals from fishing areas or condition them to avoid these areas; and the removal of individual seals by capture and translocation or killing (Mate and Harvey 1987, Reeves *et al.* 1996). Mitigation measures can be divided into two groups – lethal and non-lethal.

7.1 Non Lethal Methods

7.1.1 Acoustic deterrents

7.1.1.1 Seal crackers[10]

Seal crackers or underwater firecrackers are explosive devices, which are thrown into the water where they explode under the surface. They have been used in Tasmania in an attempt to deter seals and whales from interacting with fishing operations. Reports from Canada indicate that while seal crackers may initially be effective, with repeated use seals become accustomed to them relatively quickly (Fraker *et al.* 1998). Seal crackers have been effective on a short-term basis in other situations, (NMFS 1997) but in the long-term, and with continuous use, seals learn to ignore or avoid the noise (Fraker *et al.* 1998; Gearin *et al.* 1986; NMFS 1997). However, the flash from the crackers continues to be effective at night time if crackers are used skilfully by the operator (O. Carington Smith, TSGA, pers. comm.). One Tasmanian fisher reported that if used sparingly, seal crackers were effective for deterring the juvenile/sub-adult seals from interacting with grab-all nets set off the East Coast of Tasmania during winter (M. Cuthbertson, pers. comm.).

[10] Presently seal crackers cost $2.50 (plus GST) per unit. Delivery time from the USA is normally 3-6 months.

From a management perspective, there are a range of issues concerning the use of seal crackers, these include (but are not limited to) animal ethics, permits, occupational health and safety, regulation and enforcement.

7.1.1.2 Acoustic harassment devices (AHDs)

Acoustic devices have been developed with the two-fold aim of 1) alerting marine mammals to the presence of fishing gear to reduce by-catch and 2) acoustically harassing marine mammals to prevent depredation of fishing gear (Reeves *et al.* 1996). Devices are often accused of attracting seals ('dinner bell' effect (Mate and Harvey 1987)) to nets rather than deterring them. While AHDs might prove effective in the short term, acoustic habituation of seals to installed AHDs is common (Arnold 1992; Beeson and Hanan 1996; Morris 1996).

7.1.1.3 Acoustic deterrent devices (ADDs)

The ADDs are modified AHDs with omni-directional or uni-directional arrays producing periodic sound emissions centred at higher decibel levels than AHDs (Reeves *et al.* 1996). In the past 4-5 years an ADD barrier at the Ballard Locks, USA, has successfully reduced the number of Californian sea lions feeding on steelhead migrating up stream (Pat Gearin pers. comm.; NMFS 1997). The Ballard Locks are, however, a closed estuarine environment with predation by seals on a free-swimming endangered fish stock, a situation not directly applicable to Tasmanian seal/fisheries interactions.

A recent report to the Canadian Salmon Aquaculture Review recommended that ADDs be phased out of all intensive fish culture operations over 2 years as the long term impacts of high intensity signals on marine mammals are not known. Seals appear to be undeterred by ADDs but may experience hearing damage at close range (Iwama *et al.* 1997).

Improved acoustic deterrents currently being developed will decrease at a rate of 20dB every ten-fold increase from the source, thereby allowing seals to become annoyed well before injury could occur (New Zealand King Salmon Company, pers. comm.). Any acoustic system should be well designed and tested, as seals are able to locate acoustically silent tunnels (J. Temte on MARMAM).

An experiment was designed in Japan to quantify the escape behaviour of 10 captive Steller sea lions in response to underwater sounds (Akamatsu *et al.* 1996). Adult sea lions were repelled only by impulsive sounds transmitted at high source levels (210dB re 1µPa at 1m) or pure tone sounds (165dB source level). However, sea lions appeared to acclimatise to repeated sound projections and a sound pressure level below 165 dB did not appear to repel Steller sea lions from a fishing net (Akamatsu *et al.* 1996).

A report of a workshop on Physical Countermeasures against Predation by Seals and Sea Lions at Salmon farms held in 1997 in BC Canada, reported that there is evidence that high-amplitude ADD's disturb harbour porpoises under short-term experimental conditions (Fraker *et al.* 1998). Other non-target species of marine mammals may also be disturbed by high-amplitude ADDs (Fraker *et al.* 1998). The evidence of effects on non-target marine mammals is inadequate for Canada's Department of Fisheries and Oceans to consider revoking the licenses for salmon farmers to use high-amplitude ADDs. Notwithstanding, the Salmon Aquaculture review undertaken by the BC Environmental Assessment Office recommended that high-amplitude ADDs be phased out by 1999 (Fraker *et al*. 1998)

7.1.2. Capture and relocation

Trapping and relocation of fur seals that repeatedly attack fish farms was introduced in Tasmania in 1990 to assist fish farmers whilst improved predator net designs were being developed (Hume *et al.* unpublished data). This non-lethal method of mitigation involves removing the offending seal from an area. While 63% of seals are not recaptured, some seals have been trapped and transported on repeated occasions (Hume *et al.* unpublished data). This method is most effective when used in very specific circumstances when seals have entered pens (see Protocols – Attachment 5).

Relocated seals were previously tagged but this was discontinued due to high tag loss rates, and they are now marked with PIT transponders.

Routine biological samples are taken from the following seals:

(i) Any "new" seal that has not been trapped in the previous 12 months.
(ii) Seals where species identification (Australian fur seal or New Zealand fur seal) has not been confirmed.
(iii) Seals which look "unwell", or have signs of injury.
(iv) All New Zealand fur seals, leopard or elephant seals.
(v) Any "repeat offender" animals with dramatic weight loss since previous capture.

This practice yields sufficient sera for adequate disease surveillance (tuberculosis, leptospirosis, brucellosis and morbillivirus) and is also critical for animal welfare issues. Faecal samples (in traps) are collected for parasitological analysis.

In 2001, seal relocations were greater than at any time over the past five years. A total of 585 seal relocations took place in 2001, compared to 471 relocations in 2000, 58 in 1999 and approximately 160 in each of the previous two years (Table 9). This data is summarised by area in Table 10. Further analysis of the data shows that over the period January 1997 to December 2001, 1441 relocations occurred. Of these 1441, 667 individual seals were relocated, the balance being recaptures. The number of times individual seals were recaptured is provided in Table 11, and the percentage frequency of recaptures each year is shown in Table 12.

Table 9 The number of seal relocations to various release points per year

Release Point	1997	1998	1999	2000	2001
Badger Head	17	162	58	373	
Other	4	1		3	3
Gravelly Beach	124				
Kelso (Tamar)	1				
Low Head	18				
Marrawah				1	
Montagu				18	1
Pardo Beach				17	196
Pardoe Point				7	332
Peggs Beach				17	40
Robins Landing				25	
Rocky Cape				3	4
Sisters Beach				2	
Swansea				1	
Trial Harbour				4	
Cockle Creek					4
Dodges Ferry					1
Orford/East Coast					2
Release Farm					1
Roaches Beach					1
ANNUAL TOTAL	164	163	58	471	585

Data provided by Nature Conservation and Marine Farming Branches, DPIWE

Table 10 The number of seal relocations from various capture areas per year

Area	**1997**	**1998**	**1999**	**2000**	**2001**
Tasman	10	54	11	22	167
North D'Encrecast reaux Channel	48	52	8	251	138
Mid D'Encrecast reaux Channel	16	2	21	101	148
Southern D'Encrecast reaux Channel	90	55	18	95	161
Tamar				2	
TOTAL	**164**	**163**	**58**	**471**	**585**

Table 11 Frequency of seals captured or recaptured 1990 – June 2001

Number of times seals captured	% seals
1	63%
2	14%
3	6%
4	5%
5	4%
6	2%
7	2%
8	1%
9	<1%
10+	2%

Table 12 Percentage of all individuals recaptured each year

	Number of new individuals captured	Number of recaptured individuals	Percent recaptured
1990	1	0	0
1991	5	0	0
1992	9	0	0
1993	22	0	0
1994	16	6	27%
1995	3	4	57%
1996	10	4	29%
1997	62	6	9%
1998	56	24	30%
1999	36	17	32%
2000	151	42	22%
2001	148	92	38%

It is acknowledged that salmon companies have invested and continue to invest millions of dollars in seal defences. This investment has rapidly become redundant as seals learn how to exploit weaknesses in the systems (often caused by environmental conditions).

Trapping and relocation have been successfully used where:
(i) there has been failure of a predator protection system,
(ii) breach of a corral enclosure,
(iii) seals are within fish pens, and
(iv) seals are exhibiting aggressive behaviour.

In some of these cases farms have reported increased productivity by up to 50%.

In assessing the effectiveness/success of trapping and relocating seals, one factor that must be taken into account is the cost effectiveness of the program. Since 1994 DPIWE has continued to absorb some of the high costs involved with the program (approximately $670 per seal relocated, including staff costs but not including GST). Salmonid farming companies pay approximately $550 per relocation including GST. In 2000/2001 the Department introduced a sliding relocation cost based on the number of individuals collected from a farm in one collection: $550 for one seal, $715 for two seals, $1100 for three seals and $1210 for four seals.

For those seals that may attack farms most frequently, i.e. seals which cannot be trapped (Hume *et al.* unpublished data) or seals which have been

captured/removed previously (NMFS 1997), the effectiveness of this method is limited. Given the return rates of relocated individuals, the migratory behaviour of the seal population and the fact that capture and relocation is rarely used for farms with other measures in place, it is not appropriate to use capture and relocation as a broad scale management tool.

In summary, the merit of the trapping and relocation program of seals from marine fish farms is debatable, because whilst relocation benefits salmon farmers, this can be at the cost of others. It is clear that it is essential that all parties work together to find "smart" solutions to the seal/fisheries interaction problem and move away from the reliance on the trapping and relocation of seals from marine fish farms.

7.1.3 Exclusion Methods

7.1.3.1 Predator Netting

The use of anti-predator nets for the prevention of seal attacks on penned fin fish is widespread (Arnold 1992; Fraker *et al.* 1998; Morris 1996; Pemberton 1989; Pemberton and Shaughnessy 1993; Ross 1988; Schotte and Pemberton 2000). Predator nets are used in the salmon industry when fish attain a mass of 300 grams (Schotte and Pemberton 2000). Three types of predator nets are commonly used: curtain, box/envelope or bag nets (Arnold 1992).

The buffer distance (space between the internal and the predator net) is of critical importance, particularly in locations where tidal currents are strong (Figure 6). A buffer distance of one metre between nets is common on Tasmanian farms, particularly those using flexible circular polyethylene pipe pens (Polar circles or Flexible Ocean Pens). System farms have a larger buffer of 2m between nets. Until recently system farms were believed to reduce the likelihood of seal predation because of the distance between the predator net and the pens (Schotte and Pemberton 2000). However, recent attacks by seals have negated this view (O. Carington Smith, TSGA, pers. comm.).

The *tensioning* of primary and predator nets with weight/pulley systems may significantly increase the effectiveness of predator nets (Arnold 1992; Fraker *et al.* 1998; Pemberton 1997). If nets are too slack, strong currents may push the nets together exposing fish to attack (Morris 1996). Figure 7 shows an example of net-tensioning systems used in Scotland (Arnold 1992). Whilst Schotte and Pemberton (2000) concluded that flexible net pens could not easily be tensioned, methods have recently been developed to improve tensioning with such pens. Their study also concluded that net tensioning for system farms was not viable. Net tensioning is however used on Ocean Spar Cage systems on some farms overseas.

One recommendation of workshops on aquaculture/seal interactions has been to allow some *net fouling* in winter to reduce the visibility of fish to seals and to reduce the manipulation of nets by seals (Iwama *et al.* 1997; PIRSA 1998). In Canada there are some concerns over environmental impacts of biofoulants on marine organisms (P. Olesiuk, DFO, pers. comm.) and in Tasmania there are some concerns as to the relationship between Amoebic Gill Disease and biofoulant use (P. Bender, TSGA, pers. comm.). Whilst net fouling may reduce interactions, restriction of current flow into the pen can cause other problems for the fish.

Treating nets by dipping them in chemicals that causes *net stiffening* lessens their ability to be manipulated by seals. Resinated nets have also been used in Tasmania and have proven effective for some farms. The longevity of the rigid qualities of the net, and the cleaning and handling of the nets are issues that need to be considered.

Rigid steel mesh has also been used. Onesteel (previously BHP Wire) manufacture galvanised feed wire for Japanese steel net makers. One advantage of the Onesteel Marinemesh is the reduction in marine growth. This mesh type has been trialled at several farms in Tasmania and results have been positive. Some environmental concerns exist regarding effects of zinc on fish stock and on the seabed (Schotte and Pemberton 2000). The cost and practicality of using steel mesh on large flexible pens is a further consideration.

Some Tasmanian marine fish farms have implemented *electric fences* in the last 18 months to exclude seals from climbing over collars and into the water between the primary and predator nets. The fences may be effective in some instances in conjunction with other measures.

7.1.3.2 Bag Enclosures

Bag enclosures are a system of predator netting, which include weighted exclusion nets hung from the outer flotation rings of the cages. Although these bag enclosures can be effective against seals, they have disadvantages in fish management. Fish can only be kept in this type of system until they reach a certain size, then they must be moved to a different system of enclosure (R. Gales, DPIWE, pers. comm.). There are also reports that bag enclosures can pose problems of the inner and outer nets swinging against each other in rough weather, despite the weighted outer net (Arnold, 1992).

7.1.3.3 Surface Barriers

Seals may also access farmed fish via open-topped cages. Such cages may also be used as seal haulouts, greatly increasing the risk of unwanted interactions between seals and farm workers.

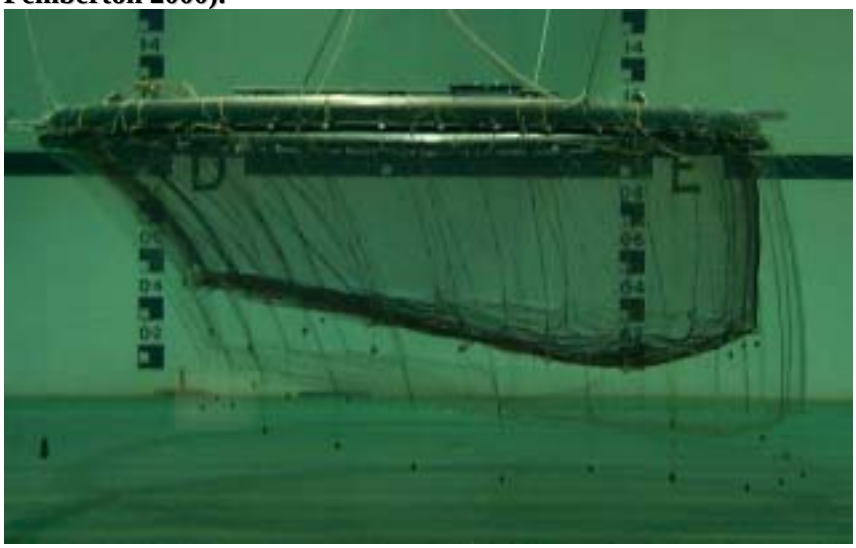
Experience in Washington State, USA, demonstrates that some seals (for example harbour seals and Stellers sea lions) can be effectively excluded from fish farms using properly tensioned predator nets to prevent underwater attacks. The cages in Washington State are generally located in areas where the tidal range and tidal currents are much greater than those experienced by Tasmanian fish farms.

Above-water access to cage structures is also effectively prevented by light nylon netting supported by a light frame structure combined with a single strand electric fence. The top of this net extends to approximately 3.5 m above the water, while the wire for the electric fence is located about 40 cm below the top of the mesh.

These exclusion methods have been successful in mitigating seal problems in some farms in Washington State (J. Bryan, Tasmanian Conservation Trust, pers. comm.).

Some Tasmanian fish farms have trialed surface barriers, including electric fences, with limited success (O. Carington Smith, TSGA, pers. comm.).

Figure 6 An illustration of the effect of strong current flow on buffer distance in anti-predator and inner nets for a Flexible Ocean Pen (taken from Schotte and Pemberton 2000).



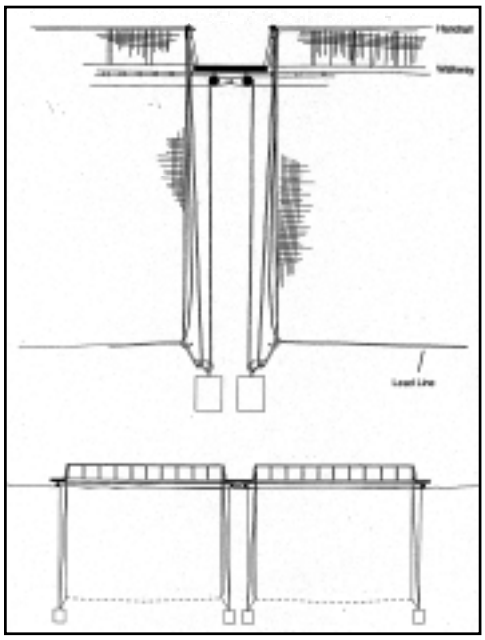


Figure 7 Example of net tensioning using individual pulley weights (from Arnold 1992)

7.1.4 Tactile Harassment

7.1.4.1 Rubber bullets

The firing of rubber bullets at California sea lions feeding on spring Chinook in Oregon, USA, has had mixed results as a deterrent. Field trials concluded that rubber buckshot could probably be used safely and effectively if fired at distances of 5-15m at an angle of 25º or greater (Gearin *et al.* 1988b).

7.1.4.2 Beanbag loads

Trials in the use of beanbag loads are currently under way in conjunction with the Ballistics section of the Tasmanian Police Department. They can be loaded in an ordinary shotgun and targeted at seals to scare them away from fishing operations. There are environmental concerns associated with the projectiles used as they consist of a nylon bag filled with lead shot.

7.1.4.3 Cattle prods

Cattle prods which discharge a low-wattage shock have been used at some Tasmanian marine salmonid farms with little success as seals tend to ignore the shock (M. Greenwood, DPIWE, pers. comm.).

7.1.5 Other non lethal methods

7.1.5.1 SharkPOD (protective oceanic device)

The SharkPOD creates an electrical field around divers and is marketed as a shark repellent (POD Holdings Ltd, Rochdale Park, South Africa). These devices have been trialed by divers at Tenth Island as a possible method of protection for divers at salmonid farms (Parks and Wildlife Service). Results were encouraging with seals appearing to flee from the SharkPOD. The possibility of using a similar technology around salmon pens has been assessed by a CSIRO electrical engineer and is considered worth pursuing. TASSAL's experience is that these are ineffective (T. Dix, TASSAL, pers. comm.).

7.1.5.2 Taste aversion

Taste aversion is a form of negative conditioning, which involves the application of an unpleasant or painful stimulus to train animals to avoid a specific behaviour (NMFS 1997). For seals, one method is to inject baits, such as salmon, with an

emetic such as Lithium chloride, which induces nausea. The aim is that seals will then associate eating salmon with a negative reaction.

This technique has been tested on captive sea lions (Kuljis 1985) and on free-ranging Australian fur seals in Tasmania (Pemberton 1989). Taste aversion was also field tested on California sea lions at Ballard Locks, USA, using tethered salmon where it proved to be inconclusive (Gearin *et al.* 1988b).

This method was thought to be impractical for year-round use (Morris 1996) but may prove useful at particular times of the year (e.g. prior to net-changing). Pemberton (1989) suggested the use of a sacrificial cage of salmon or trout with emetics positioned on the farm such that seals would have a good chance of encountering it before other cages. The negative stimulus of the emetic may be most effectively coupled with a negative reinforcer (e.g. acoustic signal, Pemberton 1989).

7.1.5.3 Vessel chase

High-powered boats may be used to chase, scare and harass seals. One company in SE Tasmania chases seals during net changes. The use of boats was found to be more effective than shooting at seals (Pemberton 1989). Tribal gill net fishermen in Puget Sound (Washington, USA) also used 'boat hazing' and firecrackers while fishing for Steelhead and coho salmon, for very short-term effect (Gearin *et al.* 1988a). This measure may be most effective if used sporadically during activities where the likelihood of interactions is high (eg. summer net changes of fish farms).

7.2 Lethal Methods

7.2.1 Culling

Culls of seal populations (see Table 13) are usually proposed in instances where seals are perceived as competing with fishers for the same resource (Yodzis 2001).

Table 13 Instances of current or historical culls or bounty programs for seals and sea lions due to perceived ecological interactions with fisheries (from (UNEP 1999).

Country	Species	Type of cull
United Kingdom	grey seals	various control programs from 1934-1982
Ireland	grey seals	bounty until 1977
Ireland	harbour seals	bounty until 1977
Norway	grey seals	cull from 1980-1989
Norway	harbour seals	cull from 1980-1989
Baltic Sea states	seals	bounties for various periods from 1889-1976
Sweden	grey seals	cull (180 maximum) commenced 1 May 2001 - 31 December 2001
Finland	grey seals	experimental cull 1997
Iceland	grey seals	bounty from 1982-??
Iceland	harbour seals	bounty from 1982-1990
Eastern Canada	harbour seals	bounty from 1927-1976
Eastern Canada	grey seals	cull from 1967-1984, bounty from 1976-1990
Eastern Canada	harp seals	seal hunt
British Columbia	Steller sea lions	various control programs from 1912-1968
British Columbia	harbour seals	bounty from 1914-1964, recent localised culls
Alaska	harbour seals	bounty from 1920-1967
Western United States	harbour seals	various bounties from 1920s-1972
New Zealand	New Zealand fur seals	open season in 1946
Australia	Australian sea lions	open season in 1920
Australia	New Zealand fur seals	open season in 1920
Australia	Australian fur seals	open season in 1948/49
Japan	Steller sea lions	bounty
Namibia	Cape fur seals	fur seal culling

Culling is an emotive issue in the eyes of the general public, conservation and animal welfare organisations. The effectiveness of culling has also been questioned (Harwood 1984; Kellert *et al.* 1995; Richey 2000; Yodzis 2001). In South Africa the complex Benguela ecosystem has been modelled to predict the impact of culling seals on hake stocks and on the seal population (Punt and Butterworth 1995; Wickens *et al.* 1992). The benefits of future culls were found to be small or even detrimental for reasons related to the cannibalistic nature of the hake species (Punt and Butterworth 1995). It has also been stated that predatory and cannibalistic fishes consume vastly greater amounts of commercially valuable fish than do marine mammals (NOAA publication cited in Waves, 2000).

In the UK where grey seal (*Halichoerus grypus*) populations have been subject to various control programmes from 1934-1982, the last large scale cull in 1963 proved ineffective over the long-term with seal numbers more than doubling within 20 years (Harwood 1984).

Recently, the Scientific Advisory Committee of the United Nations Environment Programme - Marine Mammals Action Plan developed the "Protocol for the scientific evaluation of proposals to cull marine mammals" (UNEP 1999). The protocol summarises requirements for data and analysis necessary for the analysis of culling questions related to the management of multi-species fishery situations.

In the case of direct interactions between seals and fisheries, where only a few individuals are likely to be involved, it has been suggested that indiscriminate culling will not be successful at controlling predation unless virtually all the local population is killed (Fraker and Mate 1999). Targetted culling may, however, provide a localised, short term solution, especially in dealing with problem animals.

7.2.2 Shooting seals interfering with nets

In 1916 the Royal Commissioner Prof. T. T. Flynn found that fisheries in the Tamar were 'becoming exhausted'. Fishermen complained that seals were partly to blame. Although he conceded that the population of seals at Barranjoey Island had increased and there were now 'several hundreds' of them, Prof Flynn could not agree with the fishers. He entertained the idea of 'thinning' the population, but not until after 'an investigation of at least a year' to discover the quantity and type of fish the seals were eating.[11] In 1920 the Fisheries Commission investigated the increase of seals around Flinders Island and issued licences for a limited harvest of young males. In 1926 the new Sea Fisheries Board investigated the export market for seal skins but there was no significant harvest.

In 1949 when commercial fishermen complained about the impact of increased seal numbers, the Minister for Fisheries asked Dr. Harold Thompson of CSIR

[11] Report of Fisheries Commissioners for 1916-7 P&P Parl. Tas. No.76.

(Fisheries Division) to investigate the issue. CSIR reported that lucrative fisheries coexisted in other places with seal populations far bigger than then existed around Tasmania. They estimated that in the Victorian Bass Strait region there were 20,000 to 60,000 seals and doubted that culling would assist fishermen. CSIR's Tasmanian based biologist, A. M. Olsen, visited Pedra Blanca in May 1949 and estimated the seal population to be between 500 and 700. However, he thought that permitting fishermen to kill individual seals damaging their nets or disturbing schools of fish was justified. Thereafter, on rare occasions, the Minister for Fisheries did give such permission.[12] After 1960 such permits were limited to the operators of marine aquaria.

After seals became the responsibility for the National Parks and Wildlife Service, permits to scare or kill offending seals at marine fish farms in Tasmania were granted to fish farm operators from 1987 to 1995. This option was available as a last resort only if all other non-lethal measures had proven to be ineffective. This temporary policy was implemented while the improvement of structural barriers was undertaken (Hume *et al*. unpublished data). A total of 33 seals were shot using the permit system in 1987/88. The last permit was issued on 30 November 1990. The method was considered to be dangerous to personnel and ineffective, as many seals were not properly shot (Pemberton 1989).

Seals interfering with fishing operations in Great Britain may be shot providing methods approved under the *Seal Conservation Act 1970* are used. Seals and sea lions interacting with salmon farms in Canada may also be shot by permit holders. Permits are granted only when proof is shown that lethal removal was the last resort. Recent increases in the number of kills (38% increase per year) has led to a review of predator control measures currently in use on Canadian fish farms (P. Olesiuk pers. comm.).

Two species of seal are found in Britain's coastal waters: the grey seal and the common seal. Both are protected under the *Conservation of Seals Act 1970*, which provides closed seasons during which it is an offence to take or kill any seal except under licence in certain particular circumstances. The Act provides a general exception which makes it lawful to kill a seal to prevent it from causing damage to a fishing net or tackle or to any fish in the net, providing the seal is in the vicinity of the net or tackle at the time (SSGA 1990). The effect of the closed season can be extended by the Secretary of State where it appears necessary for the proper conservation of seals. From 1995-99 inclusive, under the *Conservation of Seals Act 1970* a total of 31 applications for licences to shoot seals during closed seasons were lodged. 24 of these applications were granted (Scottish Parliament web site - http://www.scottish.parliament.uk/official_report/wa-oo/wa0803.htm).

[12] Department of Agriculture File 18/28

The number of grey seals in British waters in 1999 was estimated to be 109,100, nearly three times the size of the 1984 population, indicating a population increase of approximately 6% per year (Northridge and Hofman 1999).

Shooting of seals carried with it a number of risks from both a practical and ethical perspective. In many circumstances seals present a difficult target and strict protocols are typically required to reduce risks of human injury and the risk of wounding seals rather than killing outright. Wounded seals present animal welfare concerns as well as potential public safety risks. Killing of wildlife is also regarded as a serious ethical issue by some sections of the community.

Chapter 8 - Current practice in managing seal interactions.

8.1 Wild fisheries

8.1.1 Scalefish Fisheries

Cuthbertson (2000a) has published a guide to fishing around seals that provides detailed advice to both recreational and commercial fishers on how to minimise interactions with seals. This advice is based on identifying the type of seal involved and the behaviour being exhibited.

8.1.1.1 Seal Crackers

Seal crackers are available from Parks and Wildlife to fishers, but their effectiveness is dependent on proper use.

8.1.1.2 By-catch Mitigation

By-catch mitigation includes the regulation of mesh sizes, net strengths, the tensioning of nets and attending gear are all factors which may effectively reduce marine mammal by-catch associated with marine fish farming and commercial wild fishing operations (Arnold 1992; Pemberton 1997; PIRSA 1998).

Trials using different buoy colourings and shapes to gauge their effect on rates of seal predation have been carried out by a commercial fisher (Cuthbertson 2000b). Preliminary results indicate that the size and shape of buoys may influence fishing success when seals are present, however further trials are required.

8.1.1.3 Attending Gear (gill nets)

One of the most important methods of reducing depredation is for fishers to stay near and tend their gear (Gearin *et al.* 1988a). A study of Californian sea lion depredation on gill netting in Puget Sound recommended that fishers consider pulling their nets during times they cannot be actively checked or at night, citing unattended nets as the main source of net losses (Gearin *et al.* 1988a).

8.1.1.4 Steaming away from Seals

Some commercial gill netters and trawlers motor away from groups of seals at high speed for periods up to 15-20 minutes before setting their gear in an effort to minimise interactions.

8.1.2 Rock Lobster Fisheries

Oblong-shaped, wooden slat pots are used in Western Australia, and if they are winched in quickly the rock lobster collect at one end. The rock lobster tails hang out of the pot and are easily taken by sea lions. In some years, rock lobster fishing may occur on the continental shelf not far from colonies while sea lion pups are learning to forage. By-catch fatalities while sporadic, may be significant to such small populations (Dr Nick Gales, Australian Antarctic Division, pers. comm.).

Bait saver devices were introduced primarily to reduce bait loss and increase the catching time of rock lobster pots. Bait savers have the added benefit of reducing the possibility of bait loss due to seal predation. Currently no regulations limit the distance rock lobster pots are set from seal haul outs or colonies.

There are few reported accounts of interactions between seals and lobster/crab fishing operations. In California, where mesh traps are used, sea lions damage and destroy lobster traps in attempts to remove baits (Beeson and Hanan 1996).

8.2 Salmon Farms

8.2.1 Tasmanian Practice

Practical and scientific research into methods of reducing seal interactions has been undertaken jointly by industry and government since 1985. (Pemberton 1989; Pemberton *et al.* 1991; Pemberton and Shaughnessy 1993). Table 14 lists chronologically the types of mitigation measures trialed in Tasmania since 1985 and their relative effectiveness.

Table 14 – Chronological table of mitigation measures previously trialed on Tasmanian salmonid farms

Year	Measure	Effectiveness	Comments	Source
1985-1995 primarily 1987/88	Shooting to scare or kill	Can be effective under special circumstances	• Dangerous to personnel • Targets often missed • Problem persists • Ceased by some sections of industry	Pemberton and Shaughnessy 1993
1987 – 2001	Predator nets	Dependent on site	• Can be improved with R&D • Problems with polar circles	Pemberton and Shaughnessy 1993
1986-2001	Seal crackers	Effective under certain circumstances and with proper use	• Seals may become habituated • Better management required	Mike Greenwood Pers. Comm.
1999-2001	Electric fences	Good with other measures and system farms	• O H &S concerns with electricity and water	Mike Greenwood Pers. Comm.
1990- 2001	Trapping and release at farm	Short term benefit	• Permit required	Mike Greenwood Pers. Comm.
1990-2001	Trapping and translocation	Effective for individual animals except in cases where the seal returns to the area	• Expensive and temporary • Removal of seal can result in increased production • Permit required • Problem seals not necessarily caught	Mike Greenwood, D. Pemberton Pers. Comm.
1990-2001	Boat pursuit	Limited effect	• Effective to some extent • May inadvertently harm seals	Pemberton and Shaughnessy 1993
1985-2001	Acoustic harassment devices	Limited effect	• Habituation • Unknown impacts on ecosystem • Future possibilities positive particularly with trigger mechanism	D. Pemberton Pers. Comm.
1995-2001	Treated nets (biofoulant or resin)	May be effective under some circumstances	• Environmental & Amoebic Gill Disease concerns	Mike Greenwood Pers. Comm.
1987/88	Aversive conditioning trials with Lithium Chloride	Limited effect	• Would need to be conducted by external party • Used at the commencement of seal interactions • Problematic as registered drug	Pemberton 1989

8.2.1.1 Engineering Solutions

A recent Fisheries Research and Development Corporation (FRDC) engineering study examining structural options for the reduction of seal interactions (Schotte and Pemberton 2000) concluded that low tension through the base of predator nets and insufficient buffer distance between stock and predator nets were the primary areas of weakness. This report contains detailed analyses on the advantages and disadvantages of particular net-based mitigation measures and should be referred to for technical information.

8.2.1.2 Trapping and relocation of seals

The Tasmanian Parks and Wildlife Service/Nature Conservation Branch introduced the trapping and relocation of seals from fish farms in 1990 at the request of the aquaculture industry. Relocation was intended to be a temporary method of controlling the problem.

There are currently two protocols in place relating to the farm trapping and relocation of fur seals. The protocols have been modified several times to reflect changes in management principles. In 1998 a system of accreditation was introduced and only farms meeting certain standards are permitted to trap seals.

8.2.1.2.1 Relocation Protocols

The objective of relocating seals from fish farms is to remove trapped seals in a safe and ethical manner in order to reduce the risk of potential damage to fish stocks.

The Protocols specify the manner in which seals are to be relocated, how they are processed, how they are dealt with if they are sick or injured, and where they are to be relocated (Attachment 5).

8.2.1.2.2 Trapping and Holding Protocols

The objective of trapping and holding seals on fish farms is to humanely reduce the risk of potential damage to fish stocks and facilitate their relocation by the Parks and Wildlife Service.

The Protocols specify the traps to be used, the bait to be used and how it is to be contained, the manner in which seals are trapped and held, including where the cage is to be located on land, and how the seal is to be looked after in the cage (Attachment 6).

8.2.2 Other Australian States

8.2.2.1 South Australia - Tuna farms

Interactions, including both the entanglement of seals in nets and the damaging of large tuna, have occurred with New Zealand fur seals and Australian sea lions at tuna farms in South Australia (Pemberton 1997).The Spencer Gulf Aquaculture Management Plan currently states

that 'all marine mammals are protected under the *National Parks and Wildlife Act 1972*. For this reason aquaculture has been sited away from known breeding, nursery and haul out areas'. The Plan requires that all fin-fish cages have an anti-predator net at least 1m away from cage netting. By-catch is also addressed, and fisheries operators must notify SA Fisheries of any animals enmeshed in predator nets.

A Marine Animal Interaction Working Group Workshop was held by the Fisheries and Aquaculture section of Primary Industries and Resources South Australia in May 1998 (PIRSA 1998). Marine biologists and government and industry representatives agreed on several outcomes:

- A protocol be drafted to address the actions and responsibilities of individuals in the event that a marine animal is accidentally trapped;
- Four members be appointed to deal specifically with the issue of seal interaction with at-sea fish farms; and
- The outcomes be applied to the code of practice of tuna farm operators in South Australia.

Preventative measures suggested for the reduction of seal predation on farmed tuna included:

- The hanging of exclusion nets outside fish holding nets (at least 1m);
- The use of heavy weight netting to hold fish;
- Weed growth on nets to reduce visibility of fish to seals;
- Aerial nets and extended barriers above water surface; and
- The siting of tuna farming pens away from seal colonies and haul-outs (PIRSA 1998).

8.2.3 Overseas Practice

[Note. While some measures employed to mitigate interactions with phocids in Scotland and Canada are relevant to the situation in Tasmania, phocid seals can have different behaviours to otariid species.]

8.2.3.1 Canada

Canada is the world's fourth largest producer of salmon (Table 3). Interactions between farms and harbour seals, California sea lions, or Steller sea lions are common. Workshops held between salmon farmers, biologists and government agencies have cited netcage systems (system farming method) as the most effective means of anti-predator control (Fraker *et al.* 1998)[13]. Salmon growers in British Columbia are currently able, as a last resort, to apply for permits to shoot seals feeding on captive salmon. However, several groups are concerned at the increase in numbers of seals shot in recent years, particularly at some sites (P. Olesiuk pers. comm.).

The findings of a report to the Canadian Environment Assessment Office on marine mammal/salmonid farming interactions (Iwama *et al.* 1997) included:

- The effectiveness of acoustic deterrent devices (ADDs) is variable among sites in BC and appears to diminish with time. Pinniped attacks still occur even with the use of ADDs;

[13] The workshop that was the basis of the report by Fraker *et al* was on Physical Countermeasures against Predation by Seals and Sea Lions at Salmon farms held in 1997 in BC Canada

- The long-term impacts of high intensity signals from ADDs on marine mammals are not known, however, pinnipeds that are not deterred by ADDs may experience hearing damage at close range;
- The population effect of the practice of killing mammal predators around salmon farms is not known, given current information limitations. The Department of Fisheries and Oceans records show large numbers of individuals killed over short time intervals; and
- Improvements to and the maintenance of physical barriers between farm fish and predators should provide a long-term effective means of predator control. It is important to install such systems from the beginning of farm operations, before aquatic mammals establish predatory behaviour.

Recommendations from the report were;

- All existing salmon farms should be required to develop and implement a "predation control plan" within two years, and incorporate approved predation control plans into the aquaculture operating licence;
- ADDs should be phased out of use in all intensive fish culture operations over two years;
- Killing of predators at farm sites should be strictly controlled; and
- Siting of fish farms should be at an appropriate distance from seal and sea lion haul-out sites.

Many of these recommendations are relevant to the situation in Tasmania, although the seals involved behave quite differently. The siting of farms is perhaps less of an issue in Tasmania given the mobility and migration patterns of fur seals.

8.2.3.2 Scotland

Scotland (UK) is the third largest producer of farmed salmon globally (Table 3). In 1998 salmon were farmed at 330 sites (Scottish Executive 1998), and production was estimated to be worth £0.5 billion, providing over 6000 jobs (Scottish Executive 1998 from http://www.scotland.gov.uk/consultations/agriculture/).

Interactions between grey or common seals and fish farm operators are common in Scotland. In 1990 estimated predation losses were $2 million. The most effective non-lethal method of reducing seal damage to fish pens has been the introduction of heavy weights to maximise tautness on all nets (Iwama *et al.* 1997). A net-tensioning system had been installed at 9 marine farms in Shetland by 1992, completely removing the need for operators to shoot seals on these farms (Arnold 1992).

A summary of recommendations listed by the Scottish Salmon Growers Association Code of Practice (1990) and Arnold (1992) include:

- The siting of new farms should not occur close to concentrations of predators (Arnold 1992; Ross 1988; SSGA 1990).
- Adequate preventative measures should be incorporated into all farms at the planning stage;
- Salmon farm management is responsible for proper procedures to reduce the impact of predators on farmed stock (SSGA 1990);
- the most effective measures available are underwater anti-predator nets, scaring devices (SSGA 1990) and net tensioning systems (Arnold 1992).

8.2.3.3 New Zealand

Salmon farming occurs on the South Island of New Zealand and Stewart Island either in sea cages or in freshwater race-ways. Annual production of salmon has remained stable over recent years at around 5000 tonnes green weight. The FOB (Free on Board) value of salmon exported from New Zealand was $35 million in 1999 (NZ Ministry of Fisheries).

New Zealand fur seal interactions with salmon farming operations have been experienced in Marlborough Sound. The New Zealand approach has been to promote exclusion methods. Predator proof netting developed by the King Salmon Co. Ltd appears to be effective in excluding seals. Giga nets that envelop groups of four salmon cages are currently being tested by the New Zealand King Salmon Company and are proving effective (Andrew Baxter, NZ Dept. of Conservation, pers. comm.).

Electronic scarers have been tested but were not very successful. A 6-month trial of seal translocation also took place during which time 11 seals were translocated, however more than 50% of seals returned. The government, NZ salmon farming companies, local Maori and tourist operators are not prepared to list shooting of seals as a viable management option. (Andrew Baxter, NZ Dept. of Conservation, pers. comm.).

8.2.3.4 Norway

Whilst being the largest producer of marine farmed salmon, Norway has relatively few problems with grey and harbour seal interactions. Little documentation exists regarding the interactions between seals and the salmonid farming industry (Kjell-Tormod Nilssen pers. comm). Although salmon farming concession holders may shoot five (5) seals each per year (V. Wadley, TSGA, pers. comm.), few cases have been reported (Iwama *et al.* 1997).

8.2.3.5 Washington State

In Washington State system cages are provided with suitably tensioned predator nets to prevent underwater attacks. Seals are excluded from above water access to cage structures by light nylon netting supported by a light framed structure combined with a single strand electric fence. The top of this net extends to approximately 3.5 metres above the water while the wire for electric fence is located about 40 cm below the top of the mesh. The cages in Washington State are generally located in areas where the tidal range and tidal currents are much greater than those experienced by Tasmanian fish farms.

Chapter 9 - Summary

The main points summarised in this report are:

1. Seal interactions with wild fisheries and aquaculture are not unique to Tasmania or of recent origin. Interactions with fishing have been recorded for over 75 years and many other countries have similar problems.
2. The nature of the interactions and mitigation measures with the scalefish fishery has been well documented by Cuthbertson (2000a).
3. Biological studies over the last ten years have helped to better understand the problem.
4. Surveys commissioned by the MMIC have allowed the economic impact of the interactions to be reliably estimated for both the Fishing and Aquaculture Industries.
5. The annual approximate cost of the interactions to the fishing industry is $843 292, and the cost to salmon farmers was estimated at $12.1 million for 2001.
6. Neither fishing nor fishing interactions appear to inhibit the rebuilding of seal populations.
7. Seal/fisheries interactions will occur as seal numbers continue to increase, fishers fish, and the aquaculture industry continues to grow.
8. There is no easy solution or fool-proof management strategy that could be adopted in Tasmania.

NOTE THAT THE FOLLOWING POINTS ARE NOT FOUND IN THE BACKGROUND REPORT BUT ARE RATHER THE CONCLUSIONS OF THE MMIC DELIBERATIONS ON THIS REFERENCE

9. Future focus must shift from trying to 'solve' the problem to more effectively manage the interactions.
10. There has been an increasing use of relocation as a management tool to deal with seal interactions in Tasmania. Relocation was introduced as a temporary measure and is a short-term management tool. Continued relocation will not address the underlying problems faced by the aquaculture industry.
11. Better training of operatives, the adoption of proven practices and investment in innovative methods of protecting nets and fish pens, and the use of non-lethal deterrents has the potential to produce better outcomes.
12. Investigations by both industry and Government, in Tasmania and elsewhere, will continue to produce new tools to tackle the problem. These should be authorised for conditional use as soon as possible.
13. A cooperative approach between industry and Government is essential in order to fully utilise the benefits of any new developments.

Chapter 10 - Reference

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ATTACHMENT 1

TERMS OF REFERENCE
SEALS, FISHERIES AND AQUACULTURE

Problem: The fishing and aquaculture industries believe that seals are having significant adverse economic impact on their commercial operations.

However, seals are a protected species and the management options in dealing with seals need to reflect this status.

Investigate & Report

- Extent of problem and its economic impact.
- Current trends in the seal population and the factors influencing population changes.
- Identify current practices both locally and elsewhere in successfully dealing with the problem.

Outcomes Sought

- A management strategy which identifies best practice for dealing with the problem.
- Identification of any legislative or policy changes required to address this issue.
- A communications strategy to support the management plan.

ATTACHMENT 3

Seals and the Fishing Industry to 1970

Tony Harrison

A brief scan of Tasmanian history reveals that seal/fisheries interactions have been a common theme. Since the late 1880s and throughout the 1900s governments have been asked to solve this perennial problem. The following provides a snap shot of the issues raised and how they have been dealt with in the past.

In 1890 the Government appointed a new Board of 23 Commissioners to hold "the general superintendence, management, and protection of the Fisheries in the Colony, including Shellfish, Crustaceans, Seals, and other Fish." These honorary part time officials retained the role until 1926.

Sealing as an industry was dying by 1825. Gov Arthur reported in 1827 that 'many of the rocks and islands which once afforded a rich harvest are now entirely deserted.'[14] A small cargo from Bass Strait was exported in 1832. Despite the end of the industry families that had been sealers continued to live on some Bass Strait islands and kill seals.

Regulations were gazetted in 1891 to ban the killing of all seals in Tasmanian waters including Macquarie Island[15]. Although the initial ban was for three years it continued in force until 1908 when it was incorporated into the first set of consolidated Fisheries Regulation. Regulation 9 (of 305 of 1905) protected all fur seals and seals of all kinds on or within three miles of Tenth or Barranjoey Island off the Tamar. The regulation described the Fur seal as *Arctocephalus cinerus* but clearly applied to both the Australian and New Zealand fur seals. Seals were now protected by law and stocks began to recover.

When Prof. T. T. Flynn conducted a Royal Commission into Tasmanian fisheries in 1916 he recorded that fisheries in the Tamar where 'becoming exhausted'. Fishermen complained that seals from Barranjoey Island were partly to blame. Although Flynn was not impressed by the attitude of these fishermen he conceded that the population of seals had increased and there were now 'several hundreds' of them. He entertained the idea of 'thinning' the population but not until after 'an investigation of at least a year' to discovered the quantity and type of fish the seals were eating[16].

In 1920 police in Launceston seized a quantity of seal skins. The owners claimed they were from the hair seal and thus not illegal. Following this action 'residents of the islands in Bass Strait' sought permission to again legally take seals. The Commissioners investigated and concluded that 'seals were now becoming numerous in Bass Strait' and properly managed may in future 'form the basis of a profitable industry'. But to allow them to be 'indiscriminately slaughtered would be a mistake' and refused the request[17].

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[14] HRA S 3 vol 5 p 700
[15] Regulation (357 of 1891) and March 11 1891
[16] Report of Fisheries Commissioners for 1916-7 P&P Parl. Tas. No.76
[17] Report of Fisheries Commissioners for 1920-1 P&P Parl. Tas. No.46

The Commissioners continued their investigations and in their report for 1921-2 confirmed that numbers had increased but there was 'no substantiation of the statements that seals were responsible for any depletion of edible fishing grounds'. This advice had come from the police officer on Flinders Island 'who had an intimate knowledge of the habits of seals' in that area. He recommended that and a fishing season in May and June for young male seals ('wigs') be introduced but all other seals be fully protected. All skins produced must be inspected by police and a fee of £2 per boat be charged. The Commissioners implemented the recommendation[18].

In its report for the following year the Commissioners reprinted a report by the Canadian Commissioner for Fisheries, Prof. Prince, for the New Zealand Government, and drew attention to the similarity between the state of seals there and around Tasmania. Prince recommended a continuing ban on sealing and then a strictly controlled harvest. 'There is no force in the argument that fur seals are reducing the supplies of fish in the neighborhood of rookeries..(it) is well known that in the Behring Sea the presence of enormous herds of seals has no effect on the great abundance of valuable fish.'

The Commissioners used Prince's report to reject the petition of 16 Tamar fishermen for 'a continuous open season' in order to reduce 'the destruction done to their nets by seals and the large quantities of edible fish consumed by them.' The commissioners sought further justification by claiming that the 'seal rookery on the island known as White rock, to the north of Maria island, has in no way interfered with the supplies of edible fish that abound in that locality[19].

The fishermen then sought intervention from the Attorney General A.G. Ogilvie who took a keen interest in the management of fisheries. Ogilvie got 'numerous petitions and representations' on the subject and proposed to the Commissioners that they change the season from May June to December - January. Several members took umbrage at the 'Attorney-Generals interference', but he had the power to amend the Regulations without their consent[20]. The more cogent response came from Clive Lord, the Curator of the Museum, who believed that killing seals in the breeding season would 'exterminate' the population. Lord then read a letter he had received from a resident of Cape Barren island describing and deplorable behaviour of other residents on the island in ignoring conservation rules and killing seals and geese. With the Commissioners resolutely opposed to any change, they resolved to send the Chairman to meet with the Attorney-General.

In 1925 Ogilvie introduced new legislation placing sea fisheries under the control of a four member Sea Fisheries Board chaired by the Commissioner of Police. Another member was T.T. Flynn, the Professor of Biology at the University of Tasmania.

It is likely that some seals were taken under licences issued by the Sea Fisheries Board in 1926. The Board referred to the fur seal as *Arctocephalus tasmanicus* and it sent three pelts to England for evaluation. It soon found that there was no viable export market. The subsequent harvests were so small they never appeared in statistics and there was no further references to seals in subsequent reports of the Sea Fisheries Board.

[18] Report of Fisheries Commissioners for 1921-2 P&P Parl. Tas No.51
[19] Report of Fisheries Commissioners for 1922-3 P&P Parl. Tas No.46
[20] Mercury 21 Nov 1923

Intermittently through the years after the seal fishery ended fishermen complained of the impact of seals on their fishing. Following the episode in the 1920s another occurred in 1949. The President of the southern branch of the licensed Fishermen's Association, B.T. Cuthbertson claimed 'they should all be exterminated.' He favoured the Navy using depth charges[21]. The claim demanded a response from the Minister and Challenger[22] provided a briefing. While he admitted that seals were a nuisance to fishermen he did not think they harmed the fishery overall. In his experience squid were a far bigger predator and he was not in favour 'of disturbing the balance of nature'. He estimated only 'a few thousand seals remain'. Nevertheless he recommended that 'a fair amount of revenue' would accrue from taking 3000 seals from the southwest, 2000 from the east coast and 1000 from the northeast, without depleting the population. No one spent more time observing the operation of fishermen in Tasmanian waters between 1918 and 1950 than T J Challenger. In 1950 he described the question of seals and fishermen in a radio broadcast; the *Tasmanian Journal of Agriculture* published the text in February 1951.

Challenger's opinion was referred to CSIRO. Harold Thompson[23] replied that lucrative fisheries coexisted with seal populations far bigger than then existed. He estimated that in the Victorian Bass Strait region there were 20,000 to 60,000 seals he doubted that culling would assist fishermen. A.M. Olsen[24] visited Pedra Branca in May 1949 and estimated the seal population to be between 500 and 700. However he thought that permitting fishermen to kill individual seals damaging their nets or disturbing schools of fish was justified. Thereafter, on rare occasions, the Minister did give such permission.[25]

In the 1960s and 1970s a very small number of licenses were issued to marine aquaria to take three or four live seals.

[21] Examiner 17 Mar 1949
[22] T J Challenger was the Fisheries Inspector in the 1920s and 1930s. He was the only person employed regarding fisheries.
[23] Founding chief of what is known as the CSIRO's Division of Fisheries
[24] CSIRO fisheries officer based in Hobart
[25] Department of Agriculture File 18/28

ATTACHMENT 4

A REPORT TO THE MARINE AND MARINE INDUSTRIES COUNCIL ON THE SEAL INTERACTIONS WITH FISHERIES & AQUACULTURE QUESTIONNAIRE – DECEMBER 2000

Summary of findings

Questionnaires were distributed by mail in *Fishing Today* magazine to fishers in Tasmania, inter-state fishers working Tasmanian waters and to recreational fishers via Fishcare volunteers and the Marine Recreational Fishery Council. 153 questionnaire forms had been returned by the specified return date to the Department or were completed during dockside interviews.

The results of this questionnaire should be interpreted with care as several similar surveys conducted overseas have recorded discrepancies between questionnaire responses and fisheries observer data of interactions (Wickens 1994, Wynne 1990). Although much of the information is qualitative in nature, several trends have emerged. Marine fish farmers were the only sector of the marine farming industry affected by seals. Commercial scale fishers accounted for 47% of surveys returned, 79% of which fish using grab-all netting. Fifty percent of those respondents experiencing seal interaction, reported daily interactions with seals. The most common type of interaction (77%) for those fishers encountering daily interactions with seals was the taking of fish from nets, followed by net damage (24%). These two types of interaction were attributed equal importance by many fishers.

In talking to fishers around the State it was apparent that interactions with seals varied greatly in relation to season, location, and fishing method. Responses varied greatly within a fishery with some fishers recording sporadic levels of interaction while others encountered interactions daily when fishing. Many fishers were of the opinion that seal numbers have increased in the last decade, and that for some fisheries, eg. commercial gill netting, rates of interaction increased steadily. It is important to note also that several Cray fishers having fished for 15-20 years recorded similar levels of interaction today, regardless of any perceived increase in seal numbers. Very few fishers called directly for a cull of seals, while a reasonable proportion (9.5% of commercial scalefishers) admitted to shooting seals interacting with their fishing gear.

It is evident from this survey that there are particular types of fishing method that are more commonly affected by seals than others eg. marine fish farming and commercial gill-netting. Fisheries of future concern include the squid-jigging industry, which was identified as having interactions with seals in Victorian waters. Of equal concern are the numbers of seals which are drowned in gill-nets each year as by-catch.

The results of this questionnaire have provided an insight into the types, frequency and location of interactions with seals experienced by different fisheries in Tasmanian waters, and have identified areas which warrant further objective data collection, future monitoring and research, and trialing of mitigation measures.

Questionnaire circulation and response rate

The questionnaire was circulated to 1500 subscribers of the Tasmanian Fishing Industry Council (TFIC) *Fishing Today* Magazine on 18 December 2000. Of the 1500 subscribers 735 were either commercial fishers or marine farmers. A further 250 questionnaires were distributed to recreational fisherman by Fishcare volunteers and a further 30 to commercial fishers during dockside interviews. 153 questionnaires were received by the return date of 17 January, 2001. Eighteen questionnaires were returned between the return date and the finalisation of this report.

Type of fishing practised and the method most affected by interactions (Q1 and 5)

Commercial fishers (including marine farmers, abalone divers and rock lobster fishers) accounted for 126 responses, i.e. a return rate of 17%. Commercial scalefish fishers returned the highest number of questionnaires (Figure 1). If commercial fishers' responses are analysed in terms of fishing method most affected by seals, gill-netters were the most numerous to respond to the questionnaire, accounting for 79% of commercial scalefishers (Figure 2). Four of the 12 responses received from marine farmers came from salmonid farmers. Recreational fishers accounted for 17% (n=26) of responses. One questionnaire was received from a charter boat operator. Figure 3 summarises the responses of all respondents to the type of fishing method most affected by seals.

How often do seals interact with your fishing operation? (Q2)

Fifty percent of respondents to this question reported having interactions on a daily basis (Figure 4). The frequency of interactions with seals varied considerably in relation to the type of fishing practiced (Table 1). Rock lobster and commercial scalefish fishers indicated a higher level of interaction than other groups (Figure 5). The level of interaction for marine fish farmers (n=4) was underestimated as many shellfish farmers (n=8) responded to the questionnaire.

Table 1. The frequency of interactions reported by fishers and marine farmers

	Daily	Weekly	Monthly	Rarely	Never	No response	Total
Com./Abalone diver	1	1	3	2	-	-	7
Commercial Scalefish	54	12	2	4	-	1	73
Marine Farm	1	1	2	-	8	-	12
Rock Lobster	12	9	4	4	1	-	30
Rock Lobster/com. Scalefish	1	-	1	-	-	-	2
Recreational scalefish	6	6	7	5	1	1	26
Other	-	1	-	1	1	-	3
Total	75	30	19	16	11	2	153

Types of interactions (Q3)

On average, the taking of fish by seals was seen as the most common type of interaction (Figure 6). Of those respondents experiencing daily interactions, the majority rated the taking of fish as the most frequent form of interaction, followed by net damage (Table 2). Some respondents rated more than one interaction type as occurring with equal frequency.

Table 2. Most frequent type of interaction recorded by fishers encountering seals daily

	Taking fish	Feeding on discards	Net Damage	Stress Fish	Board Boat	Playful	Debait skewers
Daily interaction	58	7	18	6	0	7	3

Seal By-catch

Nine respondents (7% of commercial fishers) reported seal by-catch as an interaction. Seven of the nine were commercial gill-net fishers. One rock lobster fisher reported catching an average of 2-3 juvenile seals per year with their heads stuck in Cray pots on the West coast, and a recreational game fisher reported the occasional hook up of lines on seals. Seal by-catch is known to occur at marine fish farms but was not listed in questionnaire responses.

Numbers of seals present per interaction (Q6)

The majority of respondents indicated that on average, 1-2 seals were involved in seal/fisheries interactions. Groups of more than 5 seals appeared to be rarely involved in interactions with fishing operations (Figure 7).

The timing and location interactions (Q8-11)

The timing of seal interactions as recorded by respondents tends to indicate a greater occurrence of seal interactions in summer months in the north and north west of the state (Figure 8), while fishers in the south and east reported a greater frequency of interactions in winter and spring (Jun-Nov). The trend was less apparent for respondents fishing in the southeast. These reports are consistent with the migratory behaviour of male Australian fur seals. The lack of a trend in the southeast may be due to a constant number of seal interactions in this region or a greater number and diversity of fishing practices. Figure 9 illustrates the classification of the Statewide regions.

The timing of interactions (Q12)

Table 3. summarises the timing of seal/fisheries interactions in relation to the fishing method used. The majority of fishers indicated that interactions with seals could occur at anytime or during the day. This question is complicated both by the fact that the answer is dependent upon the timing of fishing and the fact that seals are more difficult to see at night (their usual foraging time).

Table 3. The timing of seal interactions in relation to fishing method.

Fishing method	Night-time	Dawn	Daytime	Dusk	Any-time	Dusk & dawn	No Response	Total
Abalone/ Com.diving			3		1			4
Drop lining	1		4		5			10
Fish farming	1				2		1	4
Fish trapping			1					1
Gill-netting	2	3	15	1	48	2	2	73
Gill-net/ Long-line			1					1
Handline	2		1	1	5			9
Inshore trawling					1			1
Long lining					1			1
Oyster farm			1					1
Purse seine		1						1
Rock Lobster	1	1	3		15		1	21
Rock Lobster/GN					3			3
Shark hooking					1			1
Squid jigging	1							1
Shark netting					2			2
Spearing		1						1
Trawling					1			1
Trolling			1					1
Other			2					2
No response			2		1		11	14
Total	8	6	34	2	86	2	15	153

Injuries caused by seals (Q14)

This question referred to Occupational Health and Safety issues regarding incidents with seals. However, many respondents were confused by the question, as indicated by the low response rate and the types of responses recorded. Seven respondents cited stress as an injury, one commercial gill net fisher recorded bruised hands and skin loss while pulling nets as a result of seals pulling the nets, while another stated that a seal tried to grab his arm. One marine farmer recorded an instance of a seal bite.

Feeding of seals (Q15)

This question was answered by 88% of respondents. Most of the respondents (n=128) never feed seals. Several fishers admitted to feeding seals occasionally either for pleasure or to see if the seals were hungry. One rock lobster fisher fed seals unused bait on a daily basis.

Dealing with seal interactions (Q16)

The most common method of dealing with interactions was a change in fishing practice (eg. moving, n=83), followed by ignoring the seals (n=38) or a combination of changing fishing practice or ceasing to fish (n=31). Shooting was listed as one method of dealing with seal interactions by 12 respondents (9.5% of commercial fishers).

FIGURES

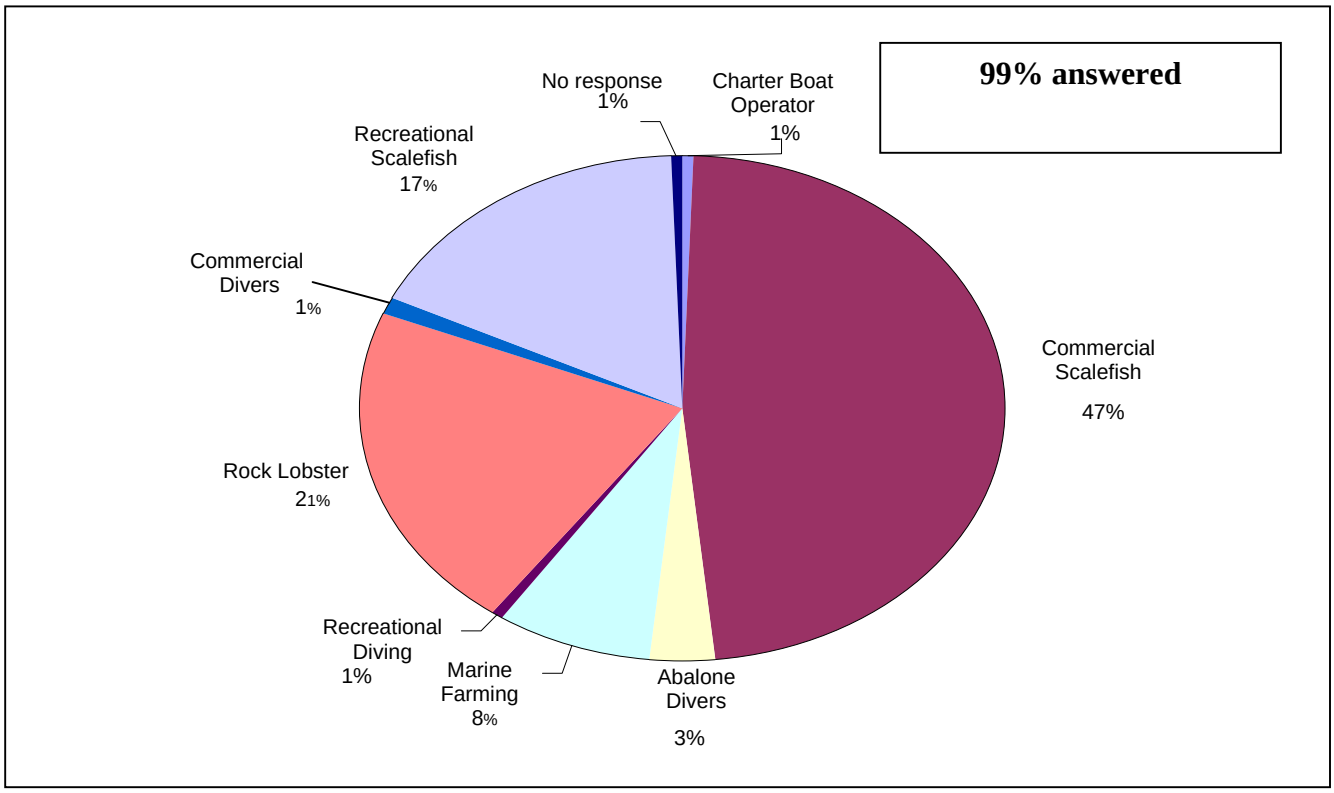

Figure 1. Categorisation of responses by principal type of fishing practiced.

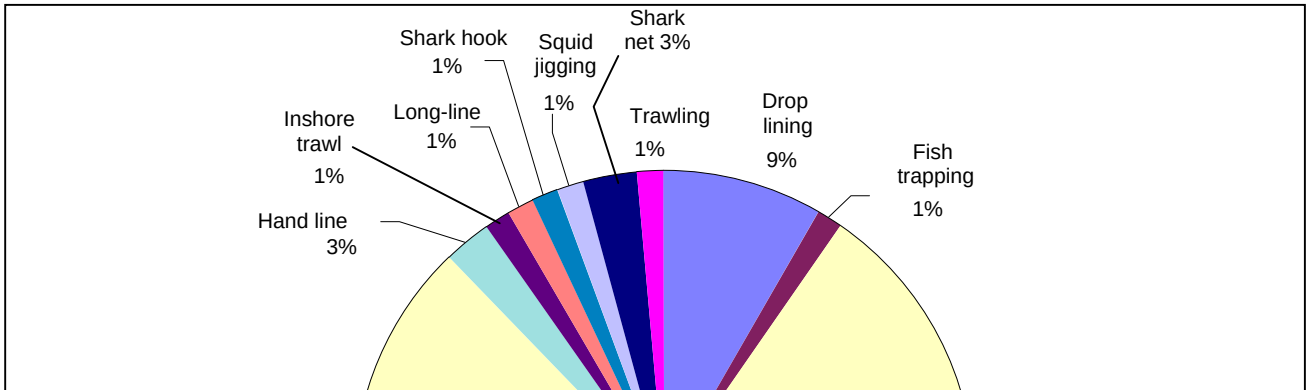

Figure 2. Breakdown of commercial scale fish respondents by fishing method.

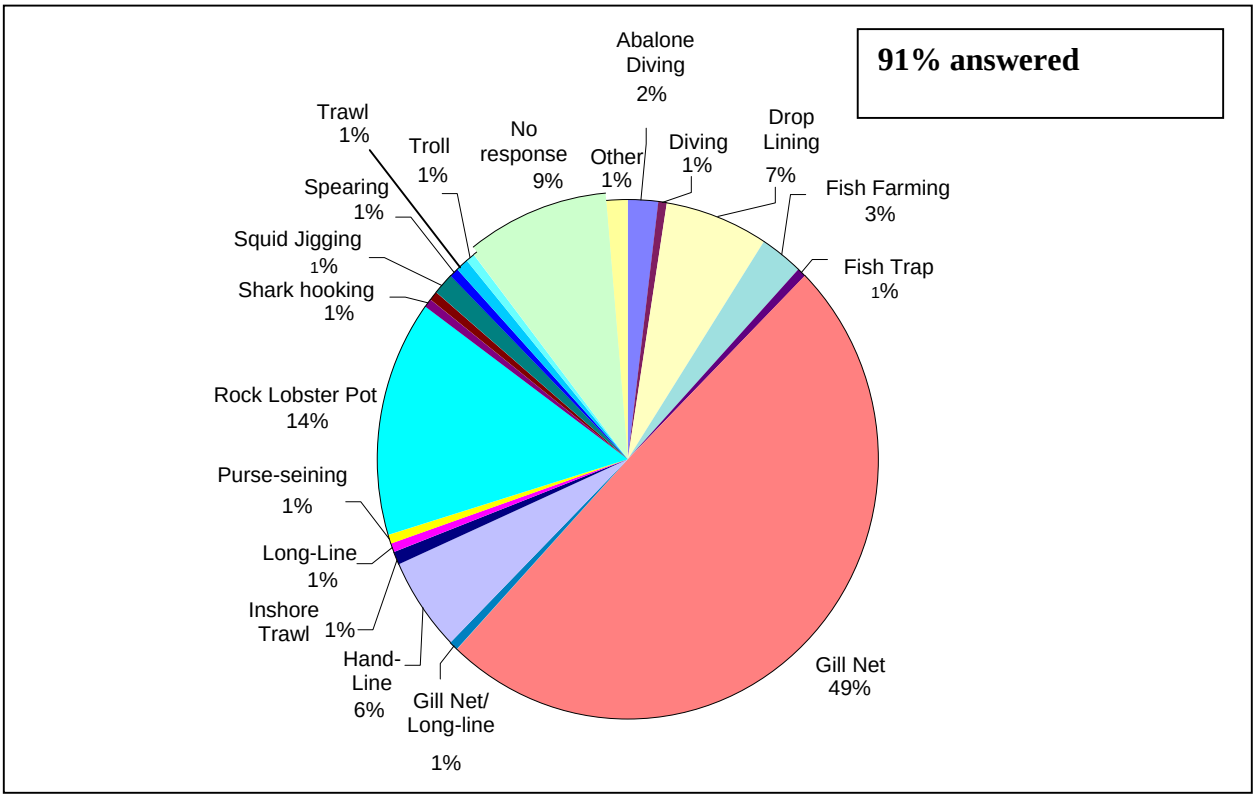

Figure 3. Types of fishing method listed as most affected by seal interaction

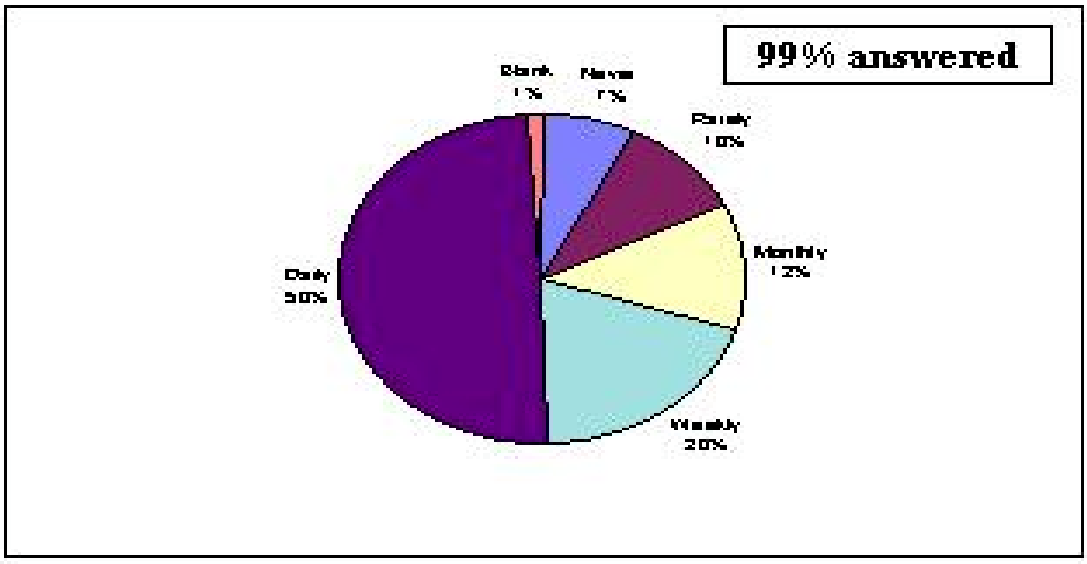

Figure 4. Frequency of seal interactions

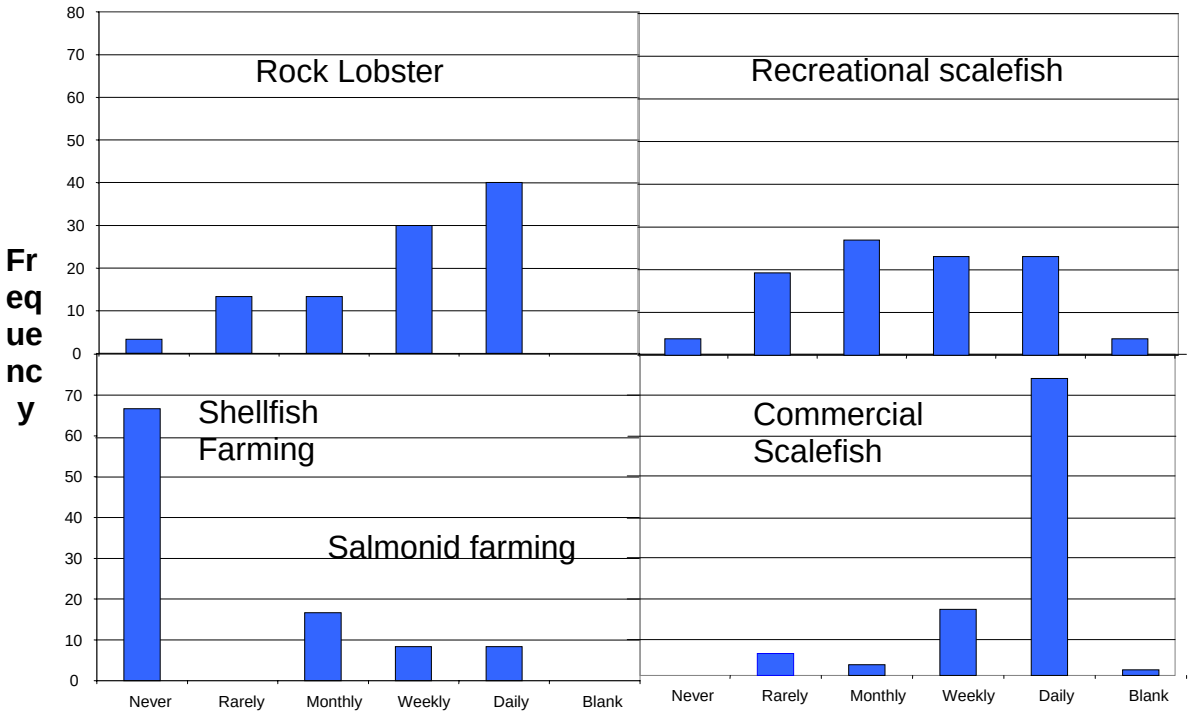

Figure 5. Frequency of seal interactions in relation to principal type of fishing practiced.

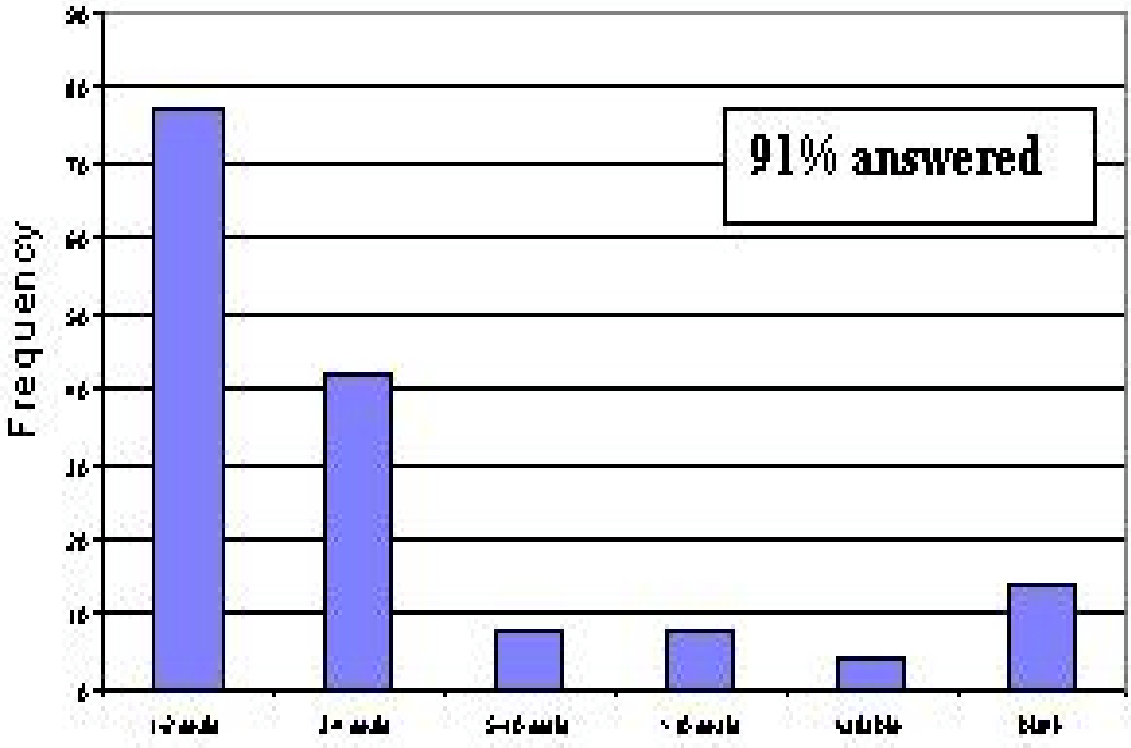

Figure 6. The types of seal interactions recorded by respondents

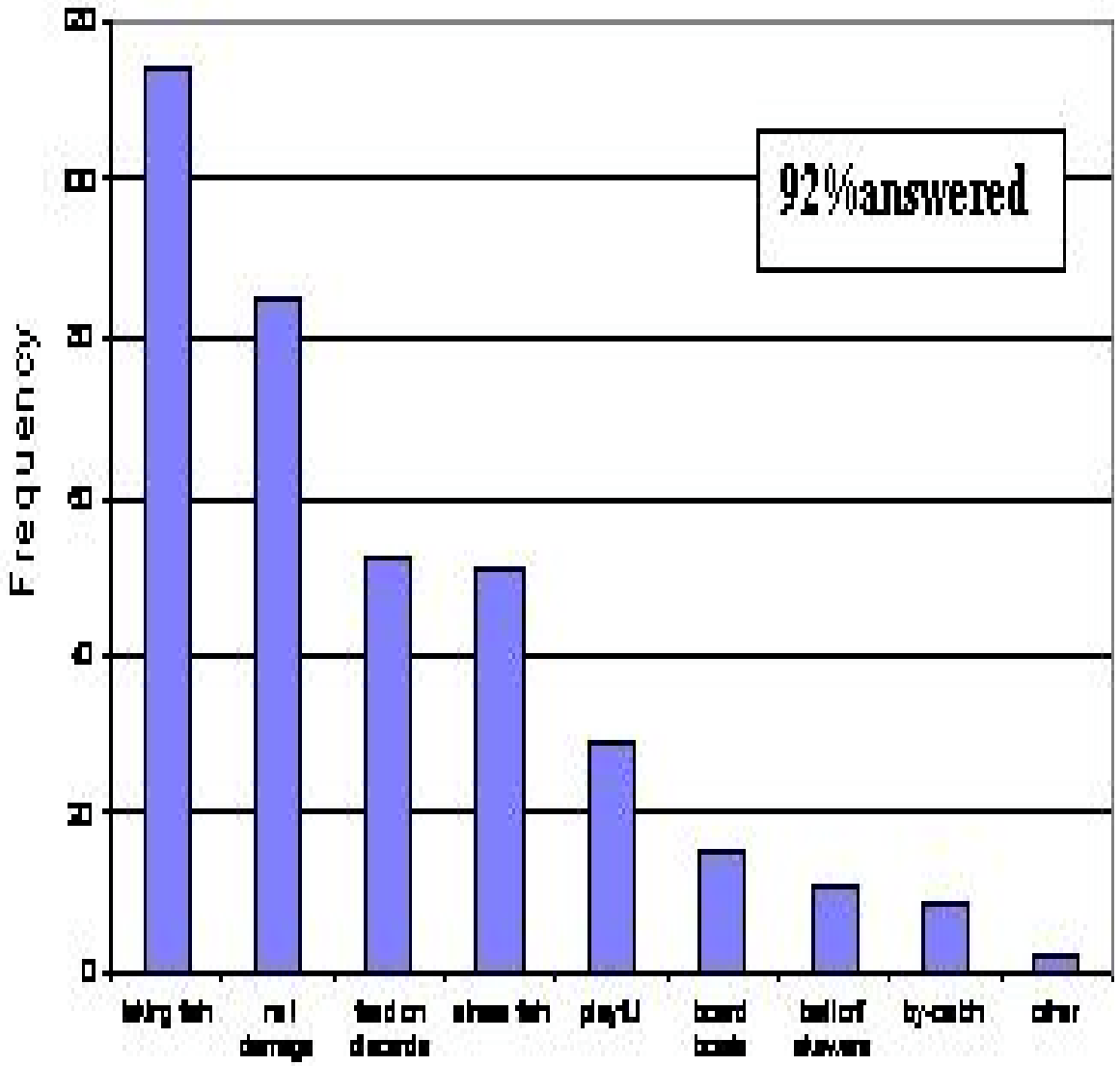

Figure 7. Number of seals present per interaction

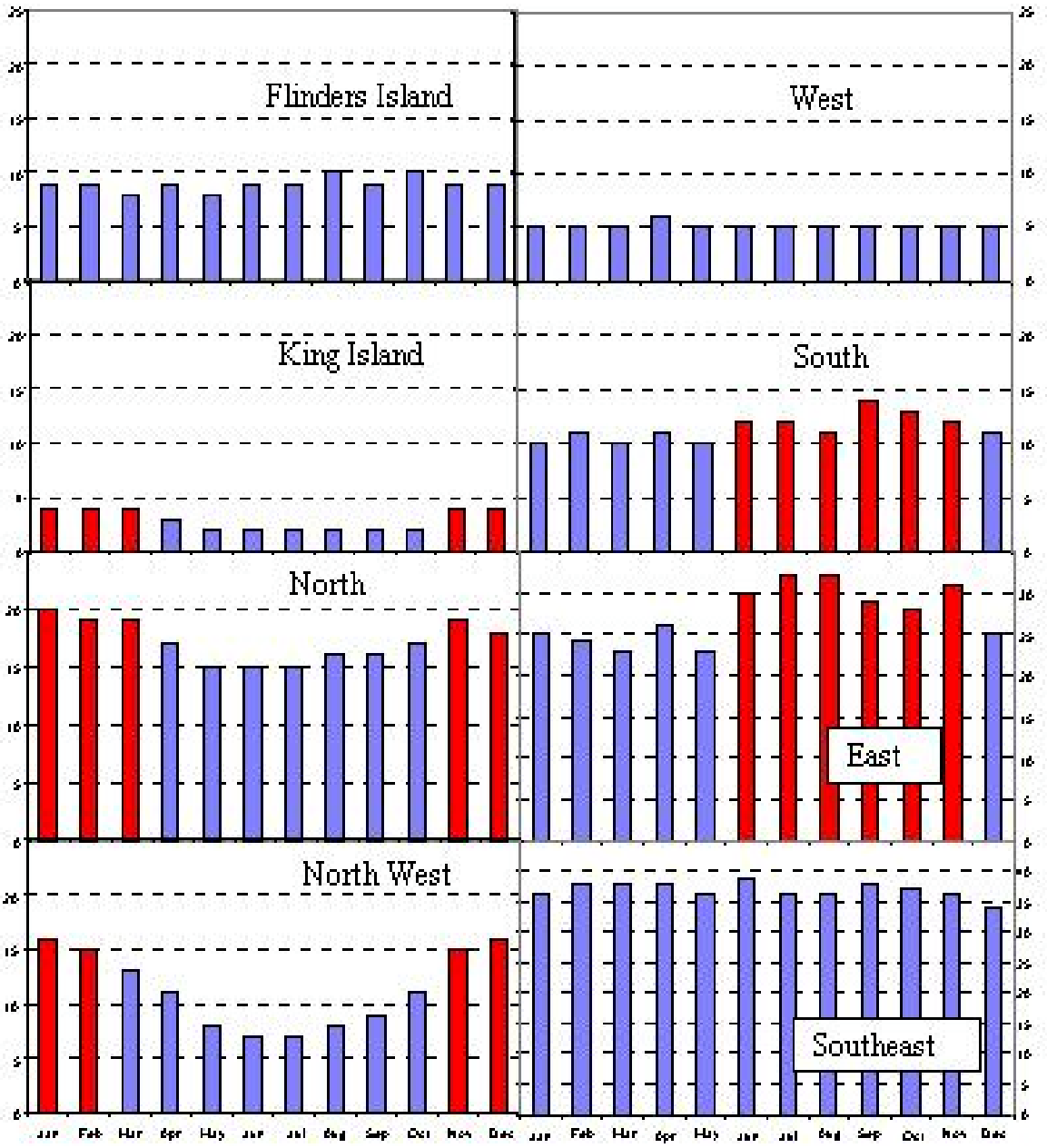

Figure 8. The timing of seal interactions around Tasmania

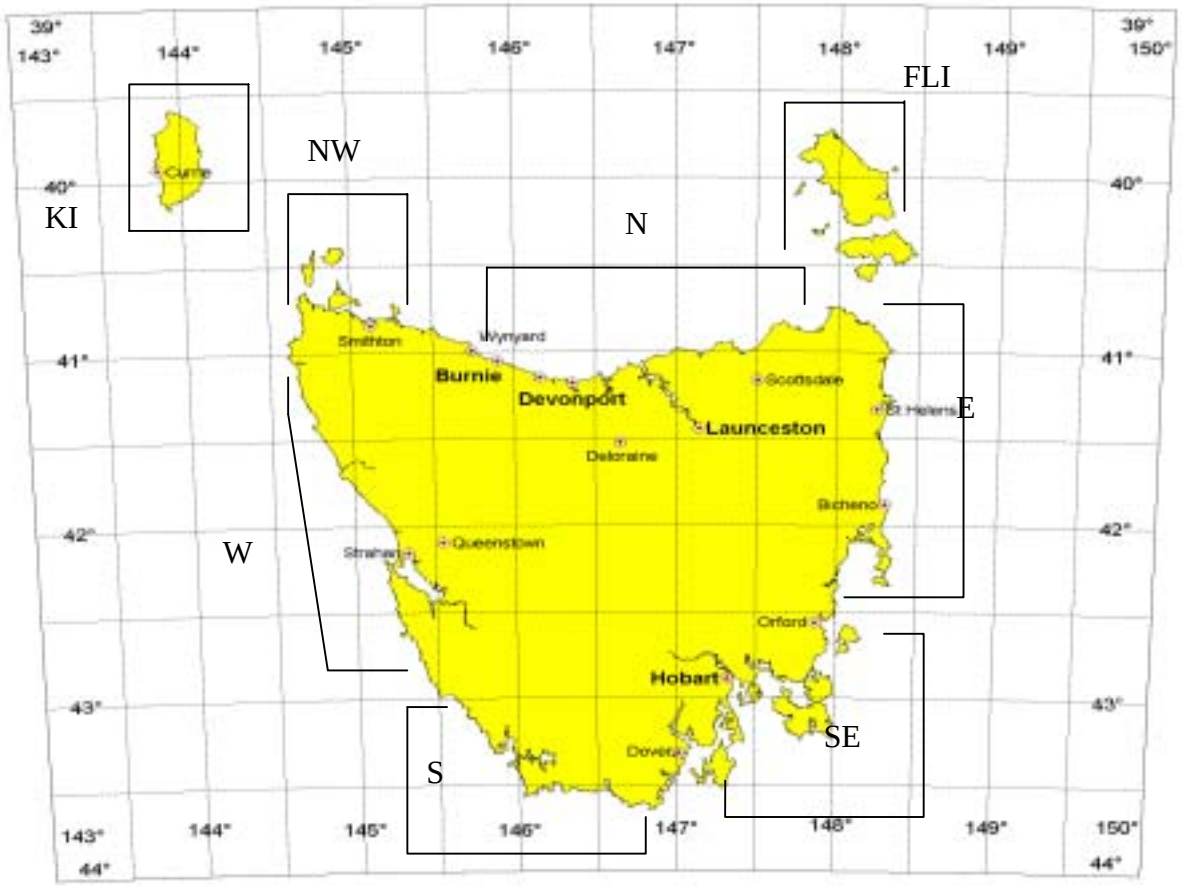

Figure 9. Diagrammatic representation of fishing sectors

ADDITIONAL COMMENTS RECEIVED FROM QUESTIONNAIRE RESPONDENTS

A small number of respondents to the questionnaire took the opportunity to provide additional comments. They ranged from: leaving the industry due to seals, supporting culling, shooting seals, supporting commercial hunting of the seal, through to enjoying diving with seals and reports of dead seals.

The following is a snapshot of the comments received.

Rock lobster fishers

1. "Seals forced me out of the inshore gill net fishery into cray fishing. Seals can pull bait out of cray pots, and have been known to eat under sized crays being returned, by nipping the tail and flipping the head off. They are not usually a problem, unless one follows you and pulls all your bait out.

Gill net, however, is a real problem. The seals play with fish caught in your net. I could not continue gill netting, had to move into crays …culling and relocation are not the answer. A small scale sealing industry may be the answer."

2. "Loves diving with seals. Doesn't have a problem with all seals, just 'rogues'. Shoots the ring leader seal (maybe 2-3 per month on average). Asked by other fisherman to shoot seals for them sometimes."

3. "Don't want to cull – waste of resources – shoot seals commercially."

Commercial scalefishers

1. "I have gone broke directly from the seal problem."

2. "Sold licence early 2000 – owing partly to seal interaction – 15 years gill net experience."

"I was 'A Class' scalefish operator. Could not afford all the net damage and costs. Sold out and will operate a 'C class' on a small scale."

3. "Cull particular problem animals, they seem to be related to salmon farming."

4. Population of seals is 5-10% above sustainable population. Problem population less than 5%. Supportive of culling. Sustainable environmental protection will only ever be

achieved by adopting good management practices. Over-protection creates imbalance in nature.

More seals on haul outs. It is individual 'problem seals' targeting gear. Large numbers moving North. But less than 1% interact.

Let nature take its course. Manage don't protect.

5. "Electronic mitigating device - a good FRDC research Project." (Commercial scalefisher)

6. Squid-jigger: "I have not encountered seals in Tasmanian waters, although there are many animals around Portland, Vic. If a seal tries to pull baits off the jigging machine I throw it a few squid and then there's no more problem".
" I don't think shooting seals will solve anything".

7. "I've seen juvenile seals with their heads in cray pots while diving and I've been underwater when a 'seal bomb' has exploded and had a head-ache for a month!"

8. "This is a complete waste of time as nothing ever gets done about fisherman being able to protect his own gear and living".

9. There should be a minimum level of training for all fishers. A code of practice is required for gill-netting fishers: long soak times, night setting of nets and laziness need to stop.

10. "Night shooting of gill nets without clearing gear attracts seals".

Several commercial gill-netting fishers expressed a keenness to be involved in future trials of newly developed seal deterrents and offered their time in testing them. Some of these same fishers expressed a reluctance to shoot seals while at the same time feeling extreme frustration during interactions. Variability in targeted fish stock availability was also listed as reason for decreased catch rates in some instances (eg. reduced levels of Blue Warehou and mackerel this year)..

Abalone/commercial divers

1. "Abalone diving for 7 years and 6 years as deckhand for a diver. I have noticed a dramatic increase in seal population in the last five years. I dive mainly in SE corner. I am concerned that the seals seem to be attracted by fish farms, thus creating more activity with sharks, particularly white pointers." He was forced to move from Nubeena because of seal and shark sightings." DPIWE should consider regular culling of seals, which in the past, net fisherman have done. DPIWE creates fish farms but does not look at the bigger picture when granting leases. Need a balance between farming and what it does to attract unwanted marine life.

1. " I enjoy the seals and they cause me no problems"

2. " I only have playful interactions with seals underwater and they cause me no problems"

Recreational scalefishers

1. "As a scuba diver seals have provided the most memorable encounters of my life. This has far outweighed any minor problem with seal holes found in nets on rare occasions. Several seals have been found dead on the beach-combing walks around the Bruny shoreline, Roberts Point, Woodcutter Point, Bligh Point."

2. On the subject of feeding seals: "We like to see the seals having a feed even if they have already helped themselves to the net".

Marine salmonid farmers

1. "Seals rarely take fish from nets since the introduction of a superior predator net.

ATTACHMENT 5

DEPARTMENT OF PRIMARY INDUSTRIES, WATER & ENVIRONMENT

JANUARY 2001

PROTOCOL FOR RELOCATION OF SEALS FROM FISH FARMS

OBJECTIVE To relocate seals trapped at fish farms in a safe and ethical manner in order to reduce the risk of potential damage to fish stocks**.**

TASK To maximise the effective relocation of trapped seals, specifically, the collection and releasing. Where appropriate the 48-hour interval may be exploited. This will enable all staff OHS obligations to be met and coincide with veterinary access if available.

Any circumstances arising that prevent adherence to the following must be discussed with contact officers prior to deviation from this procedure.

(a) During transfer from the approved fish farm holding cage to the DPIWE seal relocation cage, the seal must not be harassed by forceful striking or loud noise and the minimum number of people are to be involved to minimise stress on the animal. One person from DPIWE and up to two staff from the fish farm (one to hold up the door of the holding cage and the other being the fork lift driver) are usually all that are required.

(b) All seals relocated will be processed accordingly. Each newly captured animal must be taken to a veterinarian (where ever practical).

Seals which are trapped and relocated and which should be seen by a vet (and sampled where appropriate) include:

1. any “new” seal that has not been trapped and checked by a vet in the previous 12 months,
2. seals where species identification (AFS or NZFS) has not been confirmed by staff,
3. seals which look “unwell”, or have signs of injury,
4. all NZ fur seals, Leopard seal or Elephant seal ,
5. any “retrapped” animals with dramatic weight loss since previous capture should be checked – (greater than 15% loss in weight)

Following veterinary clearance (where appropriate) transport to the approved relocation site may occur. Each trapped animal will receive an identification microchip, photographed, sex determined and their species ID verified by staff (new seals). All seals will be painted with specific coded colour and weighed. Blood samples to be taken in accordance with specific sampling size, determined by NCB staff in consultation with DPIWE veterinary advice. Weighing to be done with the portable trailer scales which must be checked against commercial weighbridge reading at approximately 10 seal intervals. Alternative weighbridge sites if portable scales fail are K&D Mitre 10 Kingston and the Wood Barn, Brighton.

(c) Leopard and Elephant seals are weighed and only marked by paint on the back. All these seals must be examined by a vet and NCB staff. Handling time and procedures must be minimised. Each recapture animal where possible is weighed (and length measured) irrespective of when last caught. The relocation site for these species is Recherche Bay (Southern Tasmania), unless advised otherwise on professional (veterinary/ethics) advice. These animals must be transported singly.

If the species is identified as a New Zealand fur seal and after full processing, the contact officer will determine the relocation site on the East Coast for this species. It is a requirement that this species is transported individually from other species.

(d) An injured or sick seal in chronically poor condition must be inspected by a Veterinarian without delay. NCB marine biologist staff must also be contacted. After consultation a decision will be made and direction given to the Seal Relocation Officer.

(e) All Australian Fur seals will be relocated to Pardoe, APPM mill lane near Wrights Island, Rocky Cape and Pegg's Beach in Northern Tasmania on a rotation system. It is therefore necessary for the relocating officer to keep relevant staff informed of re-trap events routinely.

(f) At this stage Michael Greenwood or Chris Parker are to be advised and the option of selecting an alternative relocation

site will be considered if an animal has been trapped for the third time in a season. Alternative sites are to be Robins Landing, Marrawah, and Trail Harbour. This is subject to consideration of the current pressures of the relocation schedule.

All standard OHS procedures must be followed when handling seals.

ATTACHMENT 6

DEPARTMENT OF PRIMARY INDUSTRIES, WATER & ENVIRONMENT
JANUARY 2001

PROTOCOL FOR THE TRAPPING AND HOLDING OF SEALS ON FISH FARMS

OBJECTIVE To humanely trap and hold seals at fish farms in order to reduce the risk of potential damage to fish stocks. In facilitating their relocation by DPIWE staff the trapping process and protocol aims to minimise contact and familiarity of seals with humans and human-related activities.

RECOMMENDATIONS

1) No free feeding of seals should occur (including from within the marine fish farm lease).

2) Traps where ever practicable should not be baited with captive-bred aquaculture produce. All bait used must be contained within an agreed bait saver.

TASK

(a) The fish farm is required to notify DPIWE immediately (see contact procedure) once it knows that a seal has been trapped. If more than one seal has been trapped on the same day, the seal that has been the longest in captivity should be removed first.

(b) If the seal has been trapped between 6 p.m. (18:00 h) and 6 a.m. (06:00 h) then the fish farm must remove the trap with the seal from the water and take it to land within 6 hours, and notify the DPIWE contact officer of the capture by no later than 7 a.m. (07:00 h). The seal should then be transferred to an approved designed holding cage. If the seal is trapped during the day (06:00 h until 18:00 h) then the removal of the trap and seal from the water, and the notification of the contact officer must be immediate. The seal should then be transferred to an approved design holding cage.

(c) Once on land, the holding cage must be located to an approved quiet zone and covered with an approved black-out tarpaulin to

reduce stress and disturbance to the animal (and also to minimise with human activities). This will also reduce the possible risk of disease transmission from seal to humans. In warm weather a hose is to be left running on the tarpaulin to cool the seal.

(d) During the transfer from the approved holding cage to the DPIWE seal relocation cage, the seal must not be harassed in any way, eg by forceful striking or loud noise, and the minimum number of people are to be involved to minimise stress on the animal. One person from DPIWE and up to two staff from the fish farm (one to hold up the door of the holding cage and the other being a fork lift driver), are usually all that are required.

(e) The maximum time limit between trapping and notification (and containment in an agreed trap and holding cage) and release at relocation site is 48 hours. If this cannot be adhered to, the seal must be released locally (but only after consultation with DPIWE seal contact officer).

(f) If the trapped seal is not available from holding cage to relocation cage upon arrival by the DPIWE Seal Relocation Officer then a standby charge may apply at a rate of $100.00 per hour.

(g) Other conditions may be specified on a trapping permit. All conditions must be strictly adhered to.

All standard OHS procedures must be followed when handling seals.

ATTACHMENT 7

A SUMMARY OF RESULTS FROM THE WILD FISHING AND SEAL INTERACTION SURVEY

- Survey forms were sent to all holders of a fishing licence (personal), so that information on seal interactions could be obtained from all current licence holders that fished for commercial purposes in the last 12 months.

- The objective of this survey was to assess the economic impact that seals have on wild fishing activities. Information relating to seal interactions as well as the nature of fishing activities was requested to identify particular areas, fishing methods or fisheries that are particularly susceptible to seal interactions.

- Of the 615 survey forms sent out, 216 were returned. In terms of seal interactions, 147, or 68% of the respondents stated that their fishing operations had been interfered with by a seal, either directly or simply due to their presence, in the previous 12 months.

- Fishing activities were categorised into the following sectors:
  Abalone diving
  Rock lobster fishing
  Rock lobster and scalefishing
  Scalefishing (live fishing, general scalefishing and Commonwealth fisheries)

- The following table summarises responses for wild fishing activities where fishers had either experienced some or no seal interference in the previous 12 month period. Information from 5 respondents could not be analysed, or was not relevant to this study.

	Abalone Diving	Rock Lobster	Rock Lobster + Scalefish	Scalefish	Live Fishing
Seal Interference	13 (6%)	18 (8%)	44 (21%)	51 (24%)	21 (10%)
No interference	21 (10%)	27 (13%)	5 (2%)	11 (5%)	0

Points of interest include:

i. Of the respondents who had conducted both scalefishing and rock lobster fishing activities over the last 12 months ***and*** had experienced some form of seal interference, 77% indicated that seals had interfered with both their scalefishing and lobster potting.

ii. Of the respondents who had been involved in the live fish (banded morwong and wrasse) fisheries, 100% had experienced seal interference with their fishing activities.
iii. Abalone divers who had experienced seal interference in the last 12 months had mainly been harassed by seals whilst diving. There are difficulties in attempting to attribute costs to this form of interference.

- The following table summarises responses for the types of interaction that had occurred for each fishing method undertaken by fishers in the 12 months prior to the survey. The results give an indication of the extent of the interactions for each method

		Type of Gear Interaction			
Fishing Method	Reported Methods Used By Respondents	Gear Damage	Taking Caught Fish	Damage to Fish	Taking Bait
Graball netting	89	89	86	73	16
Hook and line	67	30	53	36	11
Lobster potting	60	34	13	12	45
Longlining/droplining	48	16	36	27	10
Fish trapping	39	13	7	9	2
Squid jigging	36	12	20	7	0
Beach seining	16	7	8	5	0
Shark mesh gillnetting	11	7	8	7	0
Small mesh gillnetting	10	8	8	8	2
Purse seining	6	2	1	0	0

Points of interest include:

i. Graball netting accounts for most of the commercial fishing interactions that occur with seals. The types of interactions for this method are mainly damage to the gear (broken meshes), taking caught fish and damage to the fish.
ii. Gear damage doesn't appear to be a significant factor for the line fisheries, where the majority of interactions are due to seals actively taking/damaging fish on the line. These types of interactions are significant and can present difficulties in terms of attributing and estimating costs.
iii. Seal interactions with rock lobster potting tends to be directly due to the seals attempting to take bait form the pots, causing gear damage to the pots and bait savers. Fishers have remedied this situation by improving the way in which bait is secured in the pots.

- The following table summarises fishing activity for all respondents in terms of approximate days fished in the previous 12 month period.

Fishing Days	<25	26-50	51-100	101-150	151-200	>201
No. of fishers	19	24	33	56	40	43

- Respondents were asked to give an estimate of the number of days in the past 12 months where they wanted to fish but were unable to because of direct seal interference with gear, catch or simply their presence. The following table summarises this information.

Lost fishing days to seal interference	No. of fishers
<2 days	45
3-10	28
11-20	16
21-30	11
31-40	10
41-50	7
51-100	13
>101 days	12

- As a means of obtaining some information on the economic impact of seal interactions on wild fishing activities, fishers who had experienced seal interference were asked to give some approximation of the costs incurred (in the previous 12 month period) for gear maintenance and replacement directly attributable to interactions with seals as opposed to normal wear and tear. Fishers were also asked to estimate the percentage of maintenance costs they would attribute to interactions with seals as opposed to normal wear and tear on fishing gear and maintenance of their vessels. These results are summarised in the following table.

	Avge costs due to seals ($)	Maximum ($)	Minimum ($)	% Costs due to seals (Average)
Live Fish	2589.40	7000	0	49.1
Rock Lobster	331.40	750	20	11.6
Rock Lobster + Scalefish	1296.00	5700	0	16.7
Scalefish	1546.20	11600	0	38.6

- This information on costs within the context of seal interactions, and the economic impact of these interactions, needs to be considered in terms of the number of active fishers, the relative numbers of fishers within each category and those fishers who experience seal interference as part of their fishing activities. The current number of fishing licences within each category is as follows:

  Rock lobster – 153
  Rock lobster and scalefish – 81
  Scalefish – 299
  Live fish – 87

- As a very rough guide, and not taking into account latent effort or "inactive" fishers, the following table gives an approximation of the costs incurred to wild fishers as a result of seal interactions. The abalone sector was not included as only 1 respondent provided information on costs, and this was related to periodic scalefishing activities. Please note that seal interactions don't seem to be an issue with other types of wild fishing operations, such as scallop fishing, squid fishing, in Commonwealth waters, Danish seining or seaweed harvesting.

Fishing Sector	Total Cost to Industry ($)	% of Total Cost
Rock Lobster	50,708	6.1
Rock Lobster + Scalefish	104,976	12.4
Scalefish	462,329	54.8
Live Fish	225,279	26.7
Total	**843,292**	**100%**

These costs represent the "physical" costs attributed to interactions with seals (such as damage to nets, lost bait savers) and do not include the costs associated with seals taking fish from nets or lines, damage to fish or lost fishing days. Although difficult to determine, the survey results suggest that these costs are significant.