Assessment of potential environmental effects of the proposed NZ King Salmon expansion on seabirds, with particular reference to the NZ King Shag

Prepared for New Zealand King Salmon

July 2011
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Assessment of potential environmental effects of the proposed NZ King Salmon expansion on seabirds

Reviewed by

Ken Grange...

Approved for release by

Graham Fenwick
Executive summary
New Zealand King Salmon proposes a Plan Change to allow finfish farming within areas currently closed to marine aquaculture. This assessment is one of several studies commissioned as part of an information gathering and consultation phase of the proposed Plan Change and associated Assessment of Environmental Effects. The primary objective of this desktop study is to:

Evaluate the potential impact of the proposed finfish farming on seabirds, with special reference to New Zealand King Shags.

Key findings are:

- The Marlborough Sounds supports a diverse and abundant seabird community.
- Three of the species (NZ King Shag, Black-billed Gull, Black-fronted Tern) are endemic and considered to be Nationally Endangered.
- Of these, the entire population (estimated at about 650 individuals) of the NZ King Shag is restricted to the Marlborough Sounds.
- Relatively few Black-billed Gulls and Black-fronted Terns occur in the Sounds after they have nested on braided rivers.
- All other seabird species are both more abundant and widely distributed.
- NZ King Shags nest at nine breeding colonies, usually March-December, and feed on bottom-dwelling fish which they obtain from 20-40 m depth.
- Potential effects of marine farming on seabirds usually concern entanglement, exclusion from feeding areas, changed prey abundance, provision of roosts, litter, and disturbance of breeding or feeding birds. With the exception of disturbance, none of these is likely to adversely affect seabirds. However, it is well known that breeding NZ King Shags are easily disturbed by approaching boats, but resting and feeding birds are more tolerant.
- Because of the sensitivity of roosting NZ King Shags to disturbance it is concluded that the proposed Plan Change Zones at Papatua and Waitata may adversely affect roosting birds. Therefore, it is recommended that a condition of any consent application at these sites includes a buffer zone of 100 m around each of these roosting areas, within which no activities associated with the salmon farms may occur.
- Despite the conservation status of NZ King Shag most of the information about the species comes from anecdotal observations or short-term studies. Therefore, there remain extensive and significant gaps in our knowledge of the biology of the species. Currently, information about such basic life history parameters as the timing of breeding are incompletely known. In particular, information is required about population parameters (such as adult mortality rates, clutch size, breeding success, age of first breeding, and nest site fidelity), feeding locations, and variations in diet both within seasons and between years and locations. Such gaps in the knowledge of the biology of the species may
reduce the confidence with which some environmental effects may be predicted. However, this is not the case with this application, where distance from roosting sites and breeding colonies and the extent of the salmon farms in relation to the overall extent of foraging habitat are likely to have insignificant environmental effects on seabirds, particularly NZ King Shags.
1 Brief description of plan change and Resource Consents

NZ King Salmon is seeking to develop eight new salmon farms in the Marlborough Sounds. The sites are proposed to be included in the Marlborough Sounds Resource Management Plan by way of a Plan Change. NZ King Salmon also intends to lodge resource consent applications for salmon farming at each of the new sites. It is intended that these consents will be heard together with the Plan Change application. Details of the activities provided for by the Plan Change, and of the resource consent proposals, are set out in the Assessment of Environmental Effects (AEE) lodged with the Plan Change and resource consent applications. Further information regarding the proposed design, layout and operation of the eight farms is contained in the report from NZ King Salmon attached to the AEE. This information has been relied on for the assessment contained in this report.
2 Methods

A comprehensive search of literature sources for seabird distribution and abundance information relevant to the Marlborough Sounds included:


Particular emphasis was given to searches for information sourced from the Ornithological Society of New Zealand. This included:

5. The two atlases of bird distribution in New Zealand, covering the periods 1969-1979 (Bull *et al.* 1985) and 1999-2004 (Robertson *et al.* 2007).
6. eBird New Zealand, an electronic database of bird observations ([http://ebird.org/content/newzealand](http://ebird.org/content/newzealand)).

I also checked field notebooks for my own bird observations made during the period 1990-2011 when I spent 1-2 weeks most summers in the Marlborough Sounds.

In addition, I contacted Rob Schuckard and David Melville to discuss NZ King Shag research that is in progress.

Finally, a site visit was made to the Port Gore area, plus existing salmon farms in Queen Charlotte Sound on 22 June 2011.
3 Description of existing seabird information

The occurrence and overall distribution of seabirds in Cook Strait and the Marlborough Sounds are well documented, particularly by Secker (1969), Bartle (1974, 1975), Bull et al. (1985) and Robertson et al. (2007). From these and other publications I have compiled a list (Table 3-1) of the more commonly occurring seabird species of conservation concern within this area. It is acknowledged that additional seabird species (e.g. Subantarctic Skua – Bartle 1974) occur in the area, but their occurrence is relatively rare and the area does not constitute a significant habitat for them. Much of the information about the distribution and occurrence of specific seabirds comes from Taylor (2000a, 2000b).

3.1 Seabirds of eastern Cook Strait and the Marlborough Sounds

3.1.1 Species occurrence and relative abundance

Eastern Cook Strait and the Marlborough Sounds support a large number of seabird species of conservation concern (Table 3-1). These include three endemic species that are Nationally Endangered, six that are Nationally Vulnerable and eight that are At Risk because of declining populations. Of the three endemic species that are Nationally Endangered, the New Zealand King Shag qualifies because of its small (small is generically defined as 250-1000 mature individuals by Miskelly et al. 2008) but stable population size. Although the Black-fronted Tern and Black-billed Gull have larger populations they qualify because their populations are considered to have declined 50-70% (Miskelly et al. 2008). The NZ King Shag is resident in the Marlborough Sounds. However, generally both the Black-fronted Tern and Black-billed Gull occur there in small numbers only during late summer to winter, after they have bred on braided river beds. The Marlborough Sounds are not considered to be a major habitat for these two species because after breeding they disperse to coastal areas in both the North and South Islands (Robertson et al. 2007).

Many of the species listed in Table 1 are open-ocean species that may occur around the entrance to the Sounds, but do not usually occur within the Sounds. Thus, all the albatrosses, mollymawks, and most of the petrels and shearwaters tend to occur outside of the Sounds. Exceptions may occur during bad weather or when birds such as, albatrosses, mollymawks and petrels feeding on offal follow a fishing vessel a short way into the outer Sounds. Previously, large numbers of Snares Cape Petrels and Giant Petrels scavenged offal from the Tory Channel whaling station (Dawbin 1948).

Within the Marlborough Sounds the marine bird fauna is dominated numerically by (in no particular order): Northern Giant Petrel, Fluttering Shearwater, Blue Penguin, Australasian Gannet, NZ King Shag, Pied Shag, Black Shag, Little Shag, Black-backed Gull, Red-billed Gull, Black-billed Gull, Caspian Tern, Black-fronted Tern, White-fronted Tern, and Arctic Skua. In addition, intertidal and shallow water areas are used by Variable Oystercatcher, NZ Pied Oystercatcher, Reef Heron and White-faced Heron.
Table 3-1: The status of seabirds of conservation concern commonly reported from eastern Cook Strait and the Marlborough Sounds. *, after Miskelly et al. 2008. Species considered by Miskelly et al (2008) to be Not Threatened are omitted from this Table.

<table>
<thead>
<tr>
<th>Species</th>
<th>Scientific name</th>
<th>Conservation status*</th>
<th>Breeding in Marlborough Sounds?</th>
</tr>
</thead>
<tbody>
<tr>
<td>NZ King Shag</td>
<td>Leucocarbo carunculatus</td>
<td>Nationally Endangered</td>
<td>Yes</td>
</tr>
<tr>
<td>Black-billed Gull</td>
<td>Larus bulleri</td>
<td>Nationally Endangered</td>
<td>No</td>
</tr>
<tr>
<td>Black-fronted Tern</td>
<td>Chlidonias albostriatus</td>
<td>Nationally Endangered</td>
<td>No</td>
</tr>
<tr>
<td>Gibson’s Albatross</td>
<td>Diomedeaa antipodensis gibsoni</td>
<td>Nationally Vulnerable</td>
<td>No</td>
</tr>
<tr>
<td>Salvin’s Mollymawk</td>
<td>Thalassarche salvini</td>
<td>Nationally Vulnerable</td>
<td>No</td>
</tr>
<tr>
<td>Pied Shag</td>
<td>Phalacrocorax varius</td>
<td>Nationally Vulnerable</td>
<td>Yes</td>
</tr>
<tr>
<td>Reef Heron</td>
<td>Egretta sacra</td>
<td>Nationally Vulnerable</td>
<td>Yes</td>
</tr>
<tr>
<td>Red-billed Gull</td>
<td>Larus novaehollandiae scopulus</td>
<td>Nationally Vulnerable</td>
<td>Yes</td>
</tr>
<tr>
<td>Caspian Tern</td>
<td>Hydroprogne caspia</td>
<td>Nationally Vulnerable</td>
<td>No</td>
</tr>
<tr>
<td>Blue Penguin</td>
<td>Eudyptula minor</td>
<td>At Risk - Declining</td>
<td>Yes</td>
</tr>
<tr>
<td>White-capped Mollymawk</td>
<td>Thalassarche cauta steadi</td>
<td>At Risk - Declining</td>
<td>No</td>
</tr>
<tr>
<td>White-chinned Petrel</td>
<td>Procellaria aequinocitialis</td>
<td>At Risk - Declining</td>
<td>No</td>
</tr>
<tr>
<td>Sooty Shearwater</td>
<td>Puffinus griseus</td>
<td>At Risk - Declining</td>
<td>No</td>
</tr>
<tr>
<td>Flesh-footed Shearwater</td>
<td>Puffinus carneipes</td>
<td>At Risk - Declining</td>
<td>No</td>
</tr>
<tr>
<td>Hutton’s Shearwater</td>
<td>Puffinus huttoni</td>
<td>At Risk - Declining</td>
<td>No</td>
</tr>
<tr>
<td>NZ Pied Oystercatcher</td>
<td>Haematopus finschi</td>
<td>At Risk - Declining</td>
<td>No</td>
</tr>
<tr>
<td>White-fronted Tern</td>
<td>Sterna striata</td>
<td>At Risk - Declining</td>
<td>?</td>
</tr>
<tr>
<td>Fluttering shearwater</td>
<td>Puffinus gavia</td>
<td>Relict</td>
<td>Yes</td>
</tr>
<tr>
<td>Diving Petrel</td>
<td>Pelecanoides urinatrix</td>
<td>Relict</td>
<td>No</td>
</tr>
<tr>
<td>Fairy Prion</td>
<td>Pachyptila turtur</td>
<td>Relict</td>
<td>Yes</td>
</tr>
<tr>
<td>Cook’s Petrel</td>
<td>Pterodroma cookii</td>
<td>Relict</td>
<td>No</td>
</tr>
<tr>
<td>Campbell Mollymawk</td>
<td>Thalassarche impavida</td>
<td>Naturally Uncommon</td>
<td>No</td>
</tr>
<tr>
<td>Northern Royal Albatross</td>
<td>Diomedeaa e. epomophora</td>
<td>Naturally Uncommon</td>
<td>No</td>
</tr>
<tr>
<td>Southern Royal Albatross</td>
<td>Diomedeaa e. epomophora</td>
<td>Naturally Uncommon</td>
<td>No</td>
</tr>
<tr>
<td>Northern Buller’s Mollymawk</td>
<td>Thalassarche bulleri platei</td>
<td>Naturally Uncommon</td>
<td>No</td>
</tr>
<tr>
<td>Southern Buller’s Mollymawk</td>
<td>Thalassarche b. bulleri</td>
<td>Naturally Uncommon</td>
<td>No</td>
</tr>
<tr>
<td>Westland Petrel</td>
<td>Procellaria westlandica</td>
<td>Naturally Uncommon</td>
<td>No</td>
</tr>
<tr>
<td>Northern Giant Petrel</td>
<td>Macronectes halli</td>
<td>Naturally Uncommon</td>
<td>No</td>
</tr>
<tr>
<td>Snares Cape Petrel</td>
<td>Daption capense australis</td>
<td>Naturally Uncommon</td>
<td>No</td>
</tr>
<tr>
<td>Buller’s Shearwater</td>
<td>Puffinus bulleri</td>
<td>Naturally Uncommon</td>
<td>No</td>
</tr>
<tr>
<td>Antarctic Prion</td>
<td>Pachyptila desolata</td>
<td>Naturally Uncommon</td>
<td>No</td>
</tr>
<tr>
<td>Black Shag</td>
<td>Phalacrocorax carbo</td>
<td>Naturally Uncommon</td>
<td>Yes?</td>
</tr>
<tr>
<td>Little Shag</td>
<td>Phalacrocorax melanoleucos brevirostris</td>
<td>Naturally Uncommon</td>
<td>Yes?</td>
</tr>
</tbody>
</table>
The occurrence of some of these species varies seasonally. For example, Black-fronted Terns breed on braided, gravel riverbeds of the South Island, but tend to occupy coastal habitats of both the North and South Islands during autumn and winter. Also, Arctic Skuas breed in higher latitudes of the Northern Hemisphere, but after breeding migrate to New Zealand coastal waters where they are most often reported during December-April.

### 3.1.2 Food and feeding

The distribution and numbers of birds in the Marlborough Sounds are a function of both the manner in which each species obtains its food and its breeding cycle. The feeding habits of birds recorded in the Marlborough Sounds may be divided into groups, based on the way that they obtain their food and the prey species that they consume.

Species such as oystercatchers will wade into the water up to their bellies to feed, but they also tend to feed over sand and mud exposed as the tide drops. The majority of these wading birds feed on intertidal invertebrates (including molluscs, polychaete worms and crustaceans), which they detect by sight. White-faced herons also feed by wading in water up to belly deep, where they feed primarily on fish and crabs.

Gulls feed primarily on offal or small fish and crustaceans, which they catch from the surface or within a few cms of it. Caspian Terns and White-fronted Terns feed primarily on small fish and crustaceans, which they catch by plunging into the water; Black-fronted Terns also feed in a similar manner, but they also take very small invertebrates pecked from the surface of the sea. Australasian Gannets also feed on fish, which they obtain by spectacular diving from a height into the sea.

Shearwaters feed on small fish and invertebrates which they usually capture by shallow diving, although some species e.g., sooty shearwater have been recorded at depths of 70 m (Shaffer et al. 2009). Shags and penguins also capture their food by swimming underwater. No specific feeding studies of Black, Spotted and Little Shags have been made in the Marlborough Sounds, but their likely types of prey and foraging areas can be deduced from the study of Lalas (1983) in Otago coastal waters. He reported that Black and Little Shags generally forage close to shore in shallow water feeding on small fish (mostly yellow-eyed mullet, thornfish, and red cod for Black Shag and cockabullies, flounder and sole for Little Shags). Spotted Shags feed up to 15 km offshore, mainly on small fish, such as, deepwater ahuru, and sprats, gudgeon and red cod. Little Shags are considered to be demersal (bottom) feeders, Spotted Shags pelagic (water column) and Black Shags both demersal and pelagic. The diet of NZ King Shags has been studied by Lalas & Brown (1998) and the results of this study are outlined below (section 3.2.4).

Tracking of Blue Penguins in Western Australia revealed that during the breeding season the birds foraged almost exclusively within 15-20 km of the colony, where waters were a maximum of 17 m deep (Klomp & Wooller 1988). Here they fed on a variety of surface schooling fish, squid and crustaceans (Klomp & Wooller 1988; Wienecke et al. 1995). Consequently, although Klomp & Wooller (1988) did not determine whether foraging range or depth was more important in determining where the penguins foraged, the fact that they fed on schooling fish, squid and crustaceans, which tend to swim in mid- or near-surface waters, indicates that foraging range was more important. In other words, the penguins are limited primarily by how far they can swim in a day and still return to their breeding colony at night, and only secondarily by how deep they are able to dive for food.
3.2 New Zealand King Shag

The conservation status of the endemic New Zealand King Shag is Nationally Endangered, based on its small (250-1000), stable total population of about 650 mature individuals (Miskelly et al. 2008). Because the entire population of the New Zealand King Shag occurs solely within the Marlborough Sounds, this species warrants particular attention.

3.2.1 Specific status and distribution

The New Zealand King Shag *Leucocarbo carunculatus* (Gmelin) was described from a specimen collected in Queen Charlotte Sound by J.R. Forster during Captain Cook’s visit to the area in 1773; Forster is known to have collected only two specimens: the first on 20 May 1773 between Ship Cove and Hippa Island (or on Hippa Island itself) and the second on 6 November 1774 between Ship Cove and Long Island (Medway 1987).

The generic placement and relationships of cormorants and shags is much debated, so the 2010 Checklist Committee of the Ornithological Society of New Zealand retained the arrangement followed by Holdaway et al. (2001) pending resolution of these issues (Gill 2010). Consequently, both these authorities recognised the New Zealand King Shag as a full species.

Remains of New Zealand King Shags have been found as far north as Tokerau Beach, North Cape and other widespread sites between there and the relict South Island population, and so indicate a former New Zealand-wide population (Holdaway et al. 2001). Although breeding is confined to the Marlborough Sounds, a vagrant has been reported from Farewell Spit (Bull et al. 1985) and other vagrants may have reached Lake Horowhenua and Wellington Harbour (Gill 2010). Records of this species at Oamaru (Marchant & Higgins 1990) are erroneous and refer to the Stewart Island Shag *L. chalconotus* (Gill 2010).

3.2.2 Population size

Despite its rarity and endangered status it was only in 1992 that the first survey of the total population of New Zealand King Shag was completed. Buller (1891) mentions that there were about 50 birds at White Rock and subsequently, birds from this colony were killed for the feather trade and museum specimens (Nelson 1971). Falla (1933) listed White Rocks as the only known colony, with about 80 birds breeding. However, subsequently he listed two breeding colonies (White Rocks, Trio Islands) and one roosting site (Sentinel Rock) (Falla 1948). On 1 September 1951 about 150 adults and 29 nests were discovered on the penultimate rock in Duffers Reef (Dell et al. 1952). Nelson (1971) recorded that the penultimate rock and the one third from the end were in use since the discovery of this colony and the outmost rock has been in use by the shags since 1964. Oliver (1955) gave the first complete list of breeding colonies, including White Rocks, stacks off Forsyth Island (presumably Duffers Reef), Sentinel Rock (which he listed as a former breeding site), Trio Islands, and Chetwode Islands. A colony on D’Urville Island was present from 1951 to 1959 (Nelson 1971). Birds from this colony appeared to have moved to te Kuru Kuru, or Stewart Island, where breeding was recorded from 1960 to 1965 (Schuckard 2006b). This colony was washed out during a severe easterly gale in August 1967 and it was not used again until July 1981, when about 19 birds with “several” nests were recorded (Booth 1983). Subsequently, birds roosted there occasionally between 1988 and 1995, but no breeding attempts were recorded (Schuckard 2006b). However, a breeding colony has been present since 1995.
King Shags were first reported from Rahuinui Island in January 1988 when about 23 birds, including 18 newly fledged young, were observed (Schuckard 2006b).

The first count of the total population of New Zealand King Shags was made during June-July in the 1992 breeding season, when the total population was estimated at 524 birds in four breeding colonies (Schuckard 1994). A further nine surveys of these four breeding colonies were completed between 1994 and 2002, with additional information gathered at two smaller colonies (Schuckard 2006b). Over all 10 of these surveys 1992-2002, the average total population was estimated to be 645 birds, including 102-126 breeding pairs, with 92% at Duffers Reef, the Trio Islands, Sentinel Rock and White Rocks (Schuckard 2006b). Most recently, during the period September-December 2006 Bell (2010) estimated the total population at 687 birds in nine breeding colonies (Table 3-2, Figure 3-1).

Table 3-2: Numbers of New Zealand King Shag adults and nests estimated 1992-2002 and 2006 (after Schuckard 2006b and Bell 2010).

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Adults</td>
<td>Nests</td>
<td>Adults</td>
<td>Nests</td>
</tr>
<tr>
<td>Duffers Reef</td>
<td>201</td>
<td>30-37</td>
<td>183</td>
<td>28</td>
</tr>
<tr>
<td>North Trio</td>
<td>205</td>
<td>29</td>
<td>220</td>
<td>30</td>
</tr>
<tr>
<td>White Rocks</td>
<td>134</td>
<td>26-37</td>
<td>125</td>
<td>23</td>
</tr>
<tr>
<td>Sentinel Rock</td>
<td>51</td>
<td>11-17</td>
<td>35</td>
<td>8</td>
</tr>
<tr>
<td>Rahuinui Island</td>
<td>28</td>
<td>3</td>
<td>55</td>
<td>8</td>
</tr>
<tr>
<td>Stewart I</td>
<td>25</td>
<td>3</td>
<td>20</td>
<td>1</td>
</tr>
<tr>
<td>Squadron Rocks</td>
<td>Not counted</td>
<td>3</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>The Twins</td>
<td>Not used</td>
<td>Not used</td>
<td>13</td>
<td>4</td>
</tr>
<tr>
<td>Taratara</td>
<td>Not used</td>
<td>Not used</td>
<td>28</td>
<td>8</td>
</tr>
<tr>
<td>Total</td>
<td>645</td>
<td>102-126</td>
<td>687</td>
<td>112</td>
</tr>
</tbody>
</table>

The time of day that the counts were completed was different between the two observers. Schuckard completed his counts before many birds departed on their early morning feeding trips, whilst Bell completed his counts between 10:00 and 14:00 h i.e. after the departure of these birds. However, Schuckard (2006b) provided correction factors for the four main colonies for when counts were completed after the departure of feeding birds, and so Bell (2010) used these when estimating population size. The use of these corrections factors may lead to less accurate estimates of the number of adult bird, however, the number of nests counted in 2006 was within the range of the numbers of nests counted during 1992-2002, providing support for a stable population over the period 1992-2006.

Schuckard (2006b) also recorded breeding of NZ King Shags at the southern tip of Blumine Island, Queen Charlotte Sound. This was a new colony, established in 1999 and where 1 chick was raised in 2000 and 3 in 2001. The colony was not used in the summer of 2001/2002 and there are no reports of birds breeding there since 2001. The maximum number of birds seen on the island was 22 on 9 August 2001. No birds were present on 25 September 2002 and there was no sign that the roost had been used recently.
Figure 3-1: Location of New Zealand King Shag breeding colonies in 2006 (after Bell 2010).
Another breeding attempt outside the usual colonies occurred in April 2003, when 3 nests were observed on a small rock island to the south of Victory Island, Port Harvey, D’Urville Island (Schuckard 2006b). Similarly, the new breeding colony reported by Bell (2010) at Taratara was not in use and there was no sign that it had been used recently (e.g., old nests, guano on rocks) during my visit in June 2011. Consequently, sites such as Blumine Island and Taratara may be used for breeding very occasionally, supporting the comment by Nelson (1971) that sites of colonies can change over time.

In addition to breeding sites there are several roosts that are used regularly, particularly at White Horse Rocks, the northern and eastern coasts of Forsyth Island and Cape Lambert (adjacent to Taratara) (Schuckard 1994).

### 3.2.3 Breeding

From information available in the files of the Wildlife Service, Department of Internal Affairs, Nelson (1971) reported that King Shags usually nest once per year at each colony and, on average laid 1.8 eggs. However, on rare occasions they may nest twice in the same year; the bulk of the breeding activity occurred between March and December. The onset of breeding varied from colony to colony and from year to year so that in some years breeding activity would be seen throughout the year if all colonies were visited month by month (Nelson 1971). A similar breeding schedule was reported by Schuckard (1994) who reported that on the basis of observations of the collection of nest material and courtship circle flying he concluded that courtship-breeding occurred over the 6-month period March-August. During this period copulation, nest building, egg-laying, incubation, hatching and rearing of chicks occurred, and the first juveniles left the colony. From January all juveniles are able to fly (Schuckard 1994).

### 3.2.4 Food and feeding

King Shags obtain their food by swimming underwater and using their hooked beak to catch their prey. Anecdotal evidence from regurgitations made by birds disturbed at their nests in 1964 indicated that they fed on bottom-dwelling fish such as common sole (*Peltorhamphus novaezelandiae*) and sandfish (*Gonorhynchus gonorhynchus*) (Nelson 1971). The stomach contents of birds illegally shot because they were thought to be depleting blue cod (*Parapercis colias*) stocks also contained sole (Nelson 1971).

The diet of New Zealand King Shags in Pelorus Sound was deduced from diagnostic prey remains in 22 complete regurgitated pellets collected as two samples six months apart (Lalas & Brown 1998). There were about 683 prey items within the pellets with the left-eyed flatfish Witch (*Arnoglossus scapha*) accounting for about 90% of the prey items and 95% of the estimated wet weight of prey (Lalas & Brown 1998). Thus these results support the deduction of Nelson (1971) that King Shags prey primarily on bottom-dwelling fish.

In Pelorus Sound, King Shags dived in waters of depths up to 90 m, but tend to favour water depths of 20-40 m (Schuckard 1994), and rarely fed in water >50 m deep (Schuckard 2006a). When diving the birds stayed underwater for an average of 46.5 seconds (6 individuals, 22 dives) and as long as 95 seconds (Nelson 1971). In a separate study, Brown (2001) timed 53 dives of 22 different shags with dive time ranging from 65 to 190 seconds; the mean time underwater was 127 seconds. These dive durations were significantly longer than those recorded by Nelson (1971). However, it is known that dive time varies with water
depth for bottom-foraging shags (Stonehouse 1967, lalas 1983) and diving behaviour can also vary according to prey availability (Kato et al. 1992).

Schuckard (1994, 2006a) studied the distribution of King Shags foraging from the Duffers Reef, Trio Islands and Stewart Island colonies. Birds from Duffers Reef travelled, on average, 8.2 km and foraged in Forsyth and Beatrix Bays (Schuckard 1994). Whilst birds from colonies at the Trio Islands and Stewart Island, which together comprise about 36% of the total King Shag population, travelled, on average, 10.0 km and foraged in Admiralty Bay (Schuckard 2006a). From these studies Schuckard (2006a) concluded that the feeding areas of King Shags appeared to be constrained by distance from the colony and by water depth.

Overall, NZ King Shags forage primarily from the southern end of Arapawa Island to White Rocks within Queen Charlotte Sound and from the Tawhitinui Reach to the Sentinel Rocks and North Trio Islands in Pelorus Sound and Admiralty Bay (from Figure 1 in Butler 2003).
4 Assessment of environmental effects

In New Zealand, reviews of the potential effects of finfish farming on seabirds have focussed on Chinook Salmon (*Oncorhynchus tshawytscha*) in the Marlborough Sounds, Akaroa Harbour and Stewart Island. In addition, two reports produced by the Department of Conservation (Butler 2003; Lloyd 2003) examine the potential effects of the marine farming of mussels on marine mammals and seabirds; one of these reports, Butler 2003, specifically examines potential effects on NZ King Shags. A summary of potential effects, risks and likely consequences are listed in Table 4-1.

Table 4-1: Summary of potential detrimental impacts on finfish farming on seabirds.

<table>
<thead>
<tr>
<th>Effect</th>
<th>Impact</th>
<th>Potential consequences</th>
<th>Context of impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entanglement</td>
<td>None recorded</td>
<td>Insignificant</td>
<td>Entanglement risk minimised by current management practices</td>
</tr>
<tr>
<td>Exclusion</td>
<td>Surface feeders such as gulls, terns and shearwaters excluded</td>
<td>Insignificant</td>
<td>Unlikely to have an impact because of large foraging range of these species</td>
</tr>
<tr>
<td>Smothering of benthos beneath cages</td>
<td>Reduction in potential invertebrate and fish prey of shags and penguins</td>
<td>Insignificant – depending upon extent of sea cages</td>
<td>Unlikely to have an impact because of large foraging range of these species. Also, current management practices and locations of proposed farms are designed to minimise waste accumulating on sea bed beneath cages.</td>
</tr>
<tr>
<td>Changed abundance of small fish as prey</td>
<td>Aggregations of small fish attracted to sea cages may benefit shags, penguins and terns.</td>
<td>Unknown</td>
<td>In conjunction with on-site roosts could have beneficial effects for shags and terns</td>
</tr>
<tr>
<td>Provision of roosts</td>
<td>Floating structures recognised as providing safe roosting sites close to foraging areas</td>
<td>Unknown</td>
<td>In conjunction with access to aggregations of small fish could have beneficial effects for shags gulls and terns</td>
</tr>
<tr>
<td>Disturbance of bird feeding/breeding</td>
<td>Boat traffic and the presence of marine farm close to feeding/breeding sites results in disturbance of birds</td>
<td>Significant</td>
<td>Increased boat traffic and associated human presence could have detrimental effect on the breeding success and foraging success of birds</td>
</tr>
<tr>
<td>Impairment of digestive tract by foreign objects</td>
<td>Ingestion by seabirds of rubbish, flotsam and jetsam from farm operations.</td>
<td>Unknown</td>
<td>Current management practices minimise potential for rubbish from farms to end up in the sea</td>
</tr>
<tr>
<td>Attraction of flying birds to artificial lights</td>
<td>Injury or death following collision with farm structures</td>
<td>Insignificant</td>
<td></td>
</tr>
</tbody>
</table>
4.1 Potential effects of proposed finfish farming on seabirds other than NZ King Shags

All of the potential effects discussed below apply to all of the proposed new sites.

4.1.1 Entanglement and habitat exclusion

The generally perceived negative effects of both shellfish and finfish sea-cage aquaculture on seabirds have centred on entanglement (resulting in birds drowning), habitat exclusion, and displacement from feeding grounds. Lloyd (2003) reviewed the potential effects of mussel farming on New Zealand’s seabirds and marine mammals. He identified possible effects (detrimental or beneficial) as entanglement, ingestion of foreign objects, changed foraging success, exclusion spread of pathogens or pest species, and creation of roosting places. However, there are no reports of seabird death as a result of entanglement in fixed lines used in mussel farms and spat catching areas.

In the absence of reports of entanglement of seabirds in finfish farming gear elsewhere in New Zealand this is unlikely to occur in the Marlborough Sounds, and so the consequences are likely to be insignificant. Despite the absence of reported deaths due to entanglement in New Zealand finfish farming operations, drowning of birds (most commonly cormorants) after entering sea cages has occurred overseas (Iwama et al. 1997). However, the deployment of top nets over sea cages to exclude birds appears to be an effective management procedure.

The potential effects of habitat exclusion are considered to be insignificant given the small area that would be occupied by the proposed sea cages in relation to the large total area available for foraging seabirds.

4.1.2 Aggregation of shoaling fish, depletion of benthic prey and provision of roosting sites

In the Marlborough Sounds, species that forage closer to the coastline (such as shags, gulls and terns) are known to feed around structures, including mussel farms and salmon farms (P.M. Sagar, pers. obs). Of the possible detrimental effects, changes in foraging success of species that feed in open water on schooling fish (e.g. white-fronted tern) is most likely to be correlated to the area physically occupied by any marine farming operation. However, increases in the abundance and diversity of some prey species around mussel farms have been documented (Grange 2002), and shoals of small fish are likely to be attracted to finfish farm structures for shelter and to feed on food falling through the sea cages (Cawthron Marine Report 2011). Consequently, this may increase the abundance of prey species of penguins, shags, gulls and terns, and so be beneficial to these species, although the consequences are unknown.

However, it is acknowledged that a major aim of finfish farm management practices is to minimise the amount of fish food that evades consumption by fish in sea cages. Consequently, this would minimise not only the number of shoaling fish attracted to the outer perimeter of sea cages, but also the potential benefits to fish-eating birds. Minimising the amount of uneaten food and organic waste that accumulates on the seabed beneath sea cages may also reduce the impact on the benthic invertebrates that inhabit the area. The effects of marine salmon farming on benthic invertebrates and wild fish populations are discussed in the report by Taylor & Dempster (2011).
With respect to marine salmon farms the Bird Policy of NZ King Salmon concerns only Black-backed Gulls, which remain unprotected under the revised Wildlife Act. The purpose of this Bird Policy is to deter the birds from consuming fish food and small fish. The policy also requires that any shot birds are retrieved and disposed of appropriately.

In a review of the ecological effects of marine finfish aquaculture in New Zealand Forrest et al. (2007) concluded that none of these potential effects is well understood. In addition, they noted that if any adverse effects on habitat exclusion or modification do occur, then their significance will depend on the spatial scale of the finfish farming operation in relation to the distribution and abundance of prey species.

In summary, changes in the foraging success of some seabirds may be positive or negative, depending upon the species. Some species (e.g., Fluttering Shearwaters and Australasian Gannets) may not be prepared to forage close to farms and will avoid approaching salmon farms. Fortunately, individuals of all these species naturally forage over very large areas. Unless an area is of unusually high foraging value (in the Marlborough Sounds there is no evidence either way on this), exclusion from that small part of their natural range is unlikely to change their overall foraging success markedly. On the other hand, the foraging success of species that are prepared to forage close to farms (e.g., White-fronted Terns, pelagic-feeding shags) may actually rise.

Both shellfish and finfish marine aquaculture farms provide new roosting sites (usually on buoys supporting sea cages or ropes supporting predator exclusion netting) and increased fish activity (not only the fish inside the sea cages, but also those attracted to the detrital fish food). This increase in marine aquaculture farms in the immediate vicinity attracts, and possibly benefits, some bird species (Lalas 2001), with shags, gulls and terns the species most likely to benefit from additional roosting sites. Use of such new roosting sites may reduce the energy expenditure of the birds because they do not have to fly to and from their natural roosting sites which may be some distance from their foraging area. However, it is also acknowledged that large numbers of gulls to salmon farms poses problems, particularly with respect to consuming fish food and the potential predation of young salmon.

4.1.3 Disturbance of breeding/feeding birds

Increased human activity associated with marine farms can have detrimental effects on the feeding and breeding of seabirds. For example, small boat traffic or noise associated with marine farm activities may disturb birds that are feeding or breeding in the vicinity. However, given the range over which the seabirds forage within the Marlborough Sounds and the locations of the proposed new sites, any effects are likely to be negligible.

4.1.4 Impairment of digestive tract by foreign objects

Ingestion of marine litter, particularly plastics, is common among seabirds and can cause death by dehydration, blockage of the digestive tract, or toxins released in the intestines. However, marine litter arising from marine farming operations can be mitigated by management practices such as those currently described in the standard operating procedures of NZ King Salmon.
4.1.5 Attraction of seabirds to artificial lights

The submerged artificial lighting associated with marine salmon farming and an assessment of its environmental effects is described by Cornelisen (2011). Seabirds flying at night do become attracted to artificial lights and have been recorded colliding with fishing vessels and lighthouse (references in Cornelisen 2011). The attraction of seabirds to artificial lighting appears to be particularly severe in conditions where mist prevails (P.M. Sagar personal observations).

In the Marlborough Sounds species such as gulls, prions and shearwaters feed at night, particularly when the moon is half to full. However, the diffuse underwater lighting associated with salmon farms is unlikely to attract these species in any great number, and so the potential effect is likely to be not to be significant.

4.2 Potential effects of proposed finfish farming on NZ King Shags

4.2.1 Entanglement and habitat exclusion

This potential effect applies to all of the proposed new sites, except Ngamahau which appears to be outside the normal foraging area of NZ King Shags.

The generally perceived negative effects of both shellfish and salmon sea-cage farming on New Zealand King Shags have centred on entanglement, habitat exclusion, and displacement from feeding grounds. For example, in a study of the possible effects of a large mussel farm on NZ King Shags Lalas (2001) concluded that the most commonly anticipated negative effects (entanglement and avoidance of feeding grounds due to increased boat traffic) were largely unfounded. Butler (2003) also was concerned about the potential loss of feeding habitat for NZ King Shags, where large marine farms were developed, particularly with respect to the loss of habitat for flatfish – the major prey of the shags. However, there was insufficient information to determine whether this was a significant risk. Likewise, Lloyd (2003), in a review of the potential effects of mussel farming on New Zealand’s seabirds and marine mammals, identified entanglement and exclusion among the possible detrimental effects. However, there are no reports of seabirds death as a result of entanglement in fixed lines used in marine farms. Additionally, there have been no reports of deaths of NZ King Shags in any commercial fishery (Richards et al. 2011).

King Shags have been observed feeding within the mooring area of mussel farms (Butler 2003), and so it is possible that they may also feed within finfish farms. However, the location of the proposed farms is probably the most critical factor with respect to possible habitat exclusion. The proposed Plan Change Zones are all in water greater than 15 m deep (Cawthron Marine Science Report 2011), and so fall within the depths usually used by King Shags for foraging. However, the extent of the proposed salmon farms is insignificant compared to the over area of such depths within the foraging range of NZ King Shags. Consequently, the potential effects of habitat exclusion are considered to be insignificant.

4.2.2 Aggregation of shoaling pelagic fish, depletion of benthic prey and provision of roosting sites

This potential effect applies to all of the proposed new sites, except Ngamahau which appears to be outside the normal foraging area of NZ King Shags.
Lalas (2001) concluded that NZ King Shags may benefit from a new and additional food source as the birds took advantage of small pelagic fish attracted to marine mussel farms. However, pelagic fish have not featured to any extent in the little information available about the diet of NZ King Shags, and so currently there is insufficient information to determine whether this in fact would be a mitigating factor.

The accumulation of detritus on the seabed below marine farms may result in the loss of habitat for bottom-dwelling fish, the main prey of NZ King Shags. Management of the feeding of farmed salmon can minimise the amount of detritus that accumulates on the benthos. In addition, sea cages can be sited in areas where marine currents help disperse the detritus, and so reduce the amount accumulating immediately below the sea cages. In this application, seven of the eight proposed sites have been selected because of their high water current velocities. Consequently, this has implications for the potential accumulation of detritus on the benthos and subsequent depletion of benthic prey favoured by flatfish.

King Shags use mussel floats for roosting and have been observed feeding within mussel farms (Butler 2003), although there are no reports of them using salmon farm structures. However, as with other seabirds, use of such new roosting sites may reduce the energy expenditure of the birds because they do not have to fly to and from their natural roosting sites which may be some distance from their foraging area.

Therefore, the combined effects of aggregations of shoaling fish pelagic fish, depletion of benthic prey, and provision of roosting sites are considered to be insignificant.

4.2.3 Disturbance of breeding/feeding birds

Butler (2003) reported that it is well established that NZ King Shags are vulnerable to disturbance by boats approaching too close to nesting birds, and this led the Department of Conservation to propose marine buffer zones of 1000 m around all breeding colonies (Davidson et al. 1995). Buffer zones of 300 m around roosting sites at Te Kaiaingapipi and White Horse Rock, Pelorus Sound, were also proposed (Davidson et al. 1995). However, these proposed distances contrast with that of Taylor (2000a), who recommended that small boats do not approach NZ King Shags colonies closer than 100 m. Neither Davidson et al (1995) nor Taylor (2000a) reported the basis of their recommendations, and so it is presumed that they were not based on scientific studies but anecdotal observations.

More recently, Lalas 2001, cited in Butler (2003) described investigations into the possible disruption of the feeding of King Shags through the approach of boats. He found that King Shags would cease foraging when approached to within 200-300 m and would escape, by diving, when the boat approached to distances of 50-100 m. By diving, rather than flying away, the birds could resume foraging around their original location within a much shorter time once the boat had passed. When resting ashore or on emergent objects King Shags flew off when approached to within about 30 m.

These results suggest that passing boats are unlikely to have a significant impact on their foraging and resting activities. The establishment and subsequent growth of the Stewart Island Shag (a close relative of King Shags) colony in Otago Harbour despite regular boat traffic was considered by Lalas (2001) to indicate that this was not a significant detrimental factor to shag populations. However, extending conclusions from research results on Stewart
Island Shags to NZ King Shags may not be appropriate without some scientific evidence that the species behave similarly.

The response of NZ King Shags is likely to vary according to the type of human activity being undertaken. For example, the birds are likely to respond differently with respect to the speed and noise of an approaching boat, or whether the boat is passing by or stopping to enable fishing to be undertaken, or whether the activity is transitory or more or less permanent (as in the case of salmon farming).

Therefore, in the absence of controlled experimental information a precautionary approach is suggested, with buffer zones of 100 m around roosting sites.

The issue of proximity to breeding colonies is not applicable to any of the proposed Plan Change Zones because all are more than 1000 m away.

**4.2.4 Impairment of digestive tract**

This potential effect applies to all of the proposed new sites, except Ngamahau which appears to be outside the normal foraging area of NZ King Shags.

This is discussed in section 4.1.4 above and is directly applicable to NZ King Shags. In particular, marine litter arising from marine farming operations can be mitigated by management practices such as those currently described in the standard operating procedures of NZ King Salmon.

**4.2.5 Attraction to artificial lights**

NZ King Shags are not known to feed at night, although this may be a result of the lack of observations at this time. Currently, it is assumed that they are diurnal feeders, spending the night at breeding colonies or roosts, which they depart before dawn to fly to their foraging areas (Schuckard 1994). However, although the great majority of feeding of shags and cormorants occur during the day, they have been recorded foraging at night White et al. 2008 and references therein). In the case of Rock Shags *Phalacrocorax magellanicus* and Imperial Shags *P. atriceps* (close relatives of NZ King Shags), 70% of night absences from colonies and roosts coincided with half-full or nearly full moon (Sapoznikow & Quintana 2002).

The preferred prey of NZ King Shags are bottom-dwelling fish (Lalas & Brown 2006) which are more likely to shun light than be attracted by it as appears to be the case with some pelagic fish (Cornelisén 2011). Therefore, if NZ King Shags fed at night to some extent they are highly unlikely to be affected by the use of artificial underwater lighting at the proposed marine farms.
5 **Recommended options**

5.1 **Recommendation 1**

Of the proposed Plan Change Zones, Papatua is in Pig Bay, Port Gore, where a breeding colony of NZ King Shag was located in 2006; the first time that breeding had been reported at this site (Bell 2010). However, no birds or evidence of breeding was found during a site visit to this area on 22 June 2011. Therefore, it is concluded that the site may have been used in just the one breeding season and is now only used for roosting, as recorded by Schuckard (1994, 2006b), who recorded the site as Cape Lambert.

In addition, the proposed Waitata Plan Change Zone is close to the White Horse Rocks roost of NZ King Shags. The shags are apparently not so easily disturbed when at rest (Davidson et al. 1995, Taylor 2000a).

Consequently, a precautionary approach would be to establish a buffer zone of 100 m around these roosting sites where no activities associated with the proposed salmon farms would occur; this could be included as a condition of consents should the Papatua and Waitata Plan Change Zones proceed.
6 Summary and conclusions

New Zealand King Salmon propose up to eight Plan Change Zones to enable expansion of their Chinook Salmon farming operation. This aim of this report is to assess the potential impacts of these Plan Change Zones on the seabirds of the Marlborough Sounds, with particular reference to the NZ King Shag.

The Marlborough Sounds support a diverse and abundant seabird community, including three endemic species (NZ King Shag, Black-billed Gull and Black-fronted Tern) that are classified as Nationally Endangered. However, while the King Shag is restricted to the Marlborough Sounds throughout its life, the Black-billed Gull and Black-fronted Tern breed on braided riverbeds and a relatively small proportion of their populations feeds in the Sounds during late summer to winter.

The NZ King Shag is unique in being restricted in range to the Marlborough Sounds. Its total population is about 650 individuals and information indicates that it has been at this level for several decades. Most of the population breeds at just five sites: Duffers Reef, North Trio Island, White Rocks, Sentinel, and Rahuinui Island; with smaller breeding colonies at Squadron Rocks, The Twins, and Taratara (latter two sites 2006 only). A small study of their diet over a short period showed that they feed mainly on bottom-dwelling fish which they obtain from depths of 20-40 m. Foraging mainly occurs in Admiralty Bay and the outer half of Pelorus and Queen Charlotte Sounds.

Potential effects of marine farming on seabirds usually concern entanglement, exclusion from feeding areas, changed prey abundance, provision of roosts, litter, and disturbance of breeding or feeding birds. With the exception of disturbance, none of these is likely to adversely affect seabirds presently inhabiting the Marlborough Sounds. However, it is well known that breeding NZ King Shags are easily disturbed by approaching boats, but resting and feeding birds are more tolerant.

Because of the sensitivity of NZ King Shags to disturbance it is concluded that the Plan Change Zones at Papatua and Waitata should include a buffer zone of at least 100 m at these roosting colonies, with no activities associated with these proposed salmon farms occurring within the buffer zones.

Despite the conservation status of NZ King Shag most of the information about it comes from anecdotal observations or short-term studies. Therefore, there remain extensive and significant gaps in our knowledge of the biology of the species. Currently, information about such basic life history parameters as the timing of breeding are incompletely known. In particular, information is required about population parameters (such as adult mortality rates, breeding success, age of first breeding, and nest site fidelity) and variations in foraging areas and diet both within seasons and between years. In addition, there should be controlled observational experiments to determine the disturbance of NZ King Shags by a range of human activities.

Such gaps in the knowledge of the biology of species may reduce the confidence with which some environmental effects may be predicted. However, this is not the case with this application, where the proposed salmon farms and associated activities do not enter critical distances from roosting sites and breeding colonies and the extent of the area under salmon farms is so small in relation to the overall foraging habitat area. Thus, these proposed Plan
Changes are likely to have insignificant environmental effects on NZ King Shags and other seabirds.

7 Acknowledgements

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8 References


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