Seabirds - Potential Salmon Farm Relocations in the Marlborough Sounds

Update of Existing Report

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Executive summary

This report provides an update to an earlier report (Sagar 2011) that assessed the potential environmental impacts of salmon farms on seabirds (particularly New Zealand king shag) in the Marlborough Sounds. Key findings from three recent publications on king shags not available at the time of the Sagar (2011) report are summarised, and the potential effects on king shags of relocating up to six existing salmon farms to nine potential new locations within the Marlborough Sounds are assessed.

Based on existing information, the potential effects of disturbance, noise, exclusion from foraging habitat and changes to water characteristics were assessed. The locations of proposed new farms are at similar, or further, distances to king shag colonies as existing farms. Operational noise reaching king shag colonies from proposed new sites is likely to be at or below ambient levels. Modelled changes to water column characteristics resulting from operations at the proposed new sites suggest increases in turbidity will be modest and often relatively far from farm sites. These three potential effects are unlikely to affect king shags. It is possible that some parts of the proposed new farm sites in the Pelorus Sound area could exclude king shag since they will occupy water of a suitable depth for king shag foraging. Any exclusion at the proposed new sites could, in time, be offset by access to currently unavailable, occupied habitat following farm removal.

1 Background and scope of the report

The Ministry for Primary Industries (MPI) engaged the National Institute of Water and Atmospheric Research (NIWA) to provide an update to an existing report (Sagar 2011) in light of recent publications on New Zealand king shag *Leucocarbo carunculatus* (hereafter king shag), and to provide comment on the proposal to relocate up to six existing salmon farms to nine potential relocation sites, all within the Marlborough Sounds.

2 Recent Publications

Since the previous seabird report (Sagar 2011) was produced there have been three publications of direct relevance to king shag (Fisher & Boren 2012, Kennedy & Spencer 2014, Schuckard et al. 2015). The work reported in the most recent of these publications (Schuckard et al. 2015) was additionally referred to in the 'King Shag Management Plan' document (Schuckard 2015). The key findings of each of these three publications are summarised here, taking each in chronological order of publication.

2.1 Fisher & Boren (2012)

This study employed boat-based line transects, boat-based, within-farm observations, time lapse photography and land-based observations to quantify the foraging distribution and use of mussel farms by king shags within Admiralty Bay. A total of 38 boat-based line transects were carried out over the course of a year (February 2006 to March 2007), with three transects run per month for all but one month when five transects were run. Transects extended from Current Basin in the south-west, included inner Admiralty Bay in the south-east, and ran to outer Admiralty Bay near to Half Way Point on D'Urville Island, west of the Trio Islands. A total of 13 boat-based within-farm transects were run through 44 mussel farms in inner Admiralty Bay, from Clayface Point to Whangapoto Point. Finally, time-lapse photography from six cameras produced 3779 images over 41 days of four mussel farms immediately to the south-west of Clayface Point, and land-based observations of king shags on mussel farm floats were carried out on five occasions also overlooking the farms to the south-west of Clayface Point.

Key results from these observations were that king shags were recorded on all boat-based line transects except the two furthest south-west transects in Current Basin and inner Admiralty Bay, with most sightings in outer Admiralty Bay. Highest densities of king shags were recorded between Clay Point and Reef Point (north of Whangapoto Point), between Stewart Island and the Trio Islands, and off Stewart Island. However, the authors noted that king shag distributions shifted over varying temporal scales. Generally, high-density areas were in water of 30-45 m depth. A total of 34 king shags was recorded from the 13 boat-based surveys within farms: all birds bar one were observed resting on floats, the remaining bird was observed swimming on the surface. No birds were observed feeding within farms. A similar pattern emerged from time-lapse photography and land-based observations: both of these approaches revealed king shags on mussel farm buoys, with a single bird observed swimming between lines. Based on these results it would seem reasonable to conclude that king shags make use of farms structures for resting, but that feeding within mussel farms is very unlikely to occur.

It is perhaps not surprising that fewer king shags were observed with increasing distance from breeding and roosting sites in the Admiralty Bay area, given the morphological constraints shags in general experience with respect to flight (e.g. Watanabe et al. 2011). Nevertheless, this extensive study provides a valuable framework with which to explore king shag at-sea distributions and abundances, and how these shift over time through an annual cycle elsewhere in the species' range.

2.2 Kennedy & Spencer (2014)

This work describes a comprehensive global classification of shags and cormorants, family Phalacrocoracidae) based on a phylogenetic analysis of over 8000 base pairs of mitochondrial and nuclear DNA sequences. The taxonomic status of king shag had been the subject of debate (for example van Eerden & Munsterman 2012). The work of Kennedy & Spencer (2014) confirms king shag as a distinct species.

2.3 Schuckard et al. (2015)

As noted above, the results of this king shag census have been referred to in the King Shag Management Plan (Schuckard 2015).

This study reports on a complete census of king shag populations at all nine breeding locations in the Marlborough Sounds. Counts were carried out using photographic approaches, from a fixed wing aircraft, on two separate occasions: firstly in February 2015 when all observed birds were counted (one colony, Squadron Rocks, omitted) and secondly in June 2015 when breeding pairs/nests were counted. In both cases, counts were completed in a relatively short period of time. For the February count, all sites were photographed over a 44-minute period, while for the census of breeding birds in June, all nine colonies were photographed over a timeframe of 87 minutes. The short time to complete the photographic record, combined with timing of the survey to occur before many birds were likely to have departed to sea was particularly important for the population estimate. The authors concluded that few, if any, would have departed before the aerial survey.

The total population estimate from the February 2015 survey was 839 individuals at eight locations. Duffers Reef held most birds (297, or 35% of the total), with 173 (21%) birds at North Trio, 103 (12%) at White Rocks and 75 (9%) at Rahuinui Island. Additionally, two sites in Queen Charlotte Sound (The Twins, towards the entrance to the Sound, and the southern tip of Blumine Island, some 10 km into the Sound from The Twins) were assessed by boat on 1 June 2015. No birds were recorded at The Twins, but nine birds were present at Blumine Island, although there was no evidence of breeding.

The June 2015 census of breeding pairs revealed a total of 187 nests, with North Trio supporting 63 breeding pairs (34% of the total), Duffers Reef 35 pairs (19%) and Rahuinui Island 22 pairs (12%). Unlike previous surveys (for example Bell 2010), no breeding birds were recorded from Squadron Rocks in 2015.

These count data represent the highest total for king shag to date. As noted by the authors, however, it is unclear whether this represents a genuine population increase or whether the larger estimates reflected enhanced efficiency and improvements of the counting protocols. In any event, these data will not affect the conservation status of king shag (currently 'threatened – nationally endangered': Robertson et al. 2013), and it seems reasonable to conclude that the population remains stable.

2.4 Summary of recent publications

Overall, the addition of information from the three recent publications summarised here does not substantially affect the conclusions drawn by Sagar (2011). Arguably the most relevant additional information relates to the comprehensive census carried out in 2015 (Schuckard et al. 2015), which found the highest population total for king shag to date. However, it would be inappropriate to interpret the results as evidence for a population increase. More likely the improvements in census methodology resulted in more birds and nests being recorded. Nevertheless, the 2015 census confirms a relatively small overall population (less than 1,000 mature individuals), which has been widely described as stable.

3 Relocation of salmon farms

3.1 Effects on seabirds other than king shag

As noted by Sagar (2011), the Marlborough Sounds supports a diverse and abundant seabird community, and although several species that occur in the Sounds have a 'threatened' conservation status (for example, black-billed gull *Larus bulleri*, black-fronted tern *Childonias albostriatus*: see Robertson et al. 2013), all have relatively large distributions and are relatively abundant. For these reasons, the proposal to relocate up to six salmon farms within the Sounds is very unlikely to have anything other than a negligible and unmeasurable effect on seabirds generally.

3.2 Current status of king shag in existing farm environment

As noted above, the king shag population has been described in a number of publications, reports and assessments as stable (e.g. Schuckard 2006a, Bell 2010, Robertson et al. 2013, MacKenzie 2014, Schuckard 2015). I concur with this interpretation of the king shag population and would add that a population trajectory can be described as 'stable' (i.e. neither increasing nor decreasing in size or numbers) when the demographic processes underlying this metric are unknown. This is the case for king shag, for which there is a paucity of information on demographic processes and rates (e.g. breeding productivity, adult survival, juvenile survival to recruitment, and so on). Nevertheless, provided population estimate data span a relatively long time period it is not necessary to fully understand the processes driving the observed population size in order to be able to identify a population's trajectory.

3.3 Potential effects of relocating up to six farms to six of nine new locations

Assuming the number of farms relocated remains the same, and the combined farm area of all relocated farms is approximately the same as that of current farms (no larger than current) then, all other factors being similar, it would be reasonable to assume that given a stable king shag population in the present environment then the population is likely to be stable in the new farm environment. However, this simple model is dependent to some extent on the farms occupying the new locations affecting king shags to no greater an extent than at the farms' current locations. There are a number of ways in which king shags could be affected by farm relocation to 'new' sites:

3.3.1 Disturbance of king shags at breeding or roosting sites

King shags could experience increased levels disturbance from relocated farms being closer to breeding or roosting sites compared to any disturbance experienced at current locations. This potential effect can be discounted for breeding and roosting sites towards the south-east Sounds since the proposed new salmon farm locations (farms 42, 47, 82 and 156) are at least ca. 11 km from the nearest king shag site (approximate distance between southern promontory of Blumine Island and proposed farm 47). Similarly, the nearest king shag breeding location, at White Rocks, is approximately 25 km from proposed farm 42, via the outer, east side of Arapawa Island. Indeed, the proposed sites are actually further away than current farm sites within Queen Charlotte Sound (e.g. the Ruakaka farm is ca. 8 km from the southern promontory of Blumine Island, and the Otanerau farm is ca. 13 km from White Rocks). Even in the Pelorus Sound area, proposed new farms 34 and 122 are still ca. 3 km from the king shag breeding colony at Duffers Reef, a similar distance from the current Forsyth farm, and sufficiently far from the colony to pose negligible disturbance. Similarly, proposed new farm 124 is ca. 4 km from king shag breeding colony at Tawhitinui, and highly unlikely to cause any disturbance.

3.3.2 Noise

Noise will be produced as part of salmon farm operations, will be greatest during hours of daylight but will occur throughout the night at reduced levels. Clearly, noise produced at a salmon farm will propagate away from the farm and could potentially disturb king shags at breeding and roosting sites. Halstead (2016) reported that the typical lowest ambient noise level at two sites, in Pelorus Sound at Katira and towards the eastern end of Tory Channel at Ruaomoko Point, was 35 dB. Halstead (2016) further provided noise prediction contours for proposed salmon farm locations, for both daytime and night-time, which showed that in all cases, the predicted 25 dB contour (i.e. below typical ambient noise levels) fell short of any king shag breeding colony. These findings would tend to suggest that noise propagating away from proposed salmon farm sites would be no more than ambient levels on reaching breeding sites. There remains the possibility that the type of noise potentially reaching king shag breeding sites may affect birds. For example, noise associated with feed dispensers during the day will likely sound different to a bird than ambient noise from wind and sea motion. It is not clear how king shags might respond to such farm-specific noise, if at all, nor is it clear whether and over what time frame birds may become acclimated to such noise.

Two of the relocation sites (proposed farms 124 and 106) are relatively close to the king shag roost site at Te Kaiangapipi, and noise prediction contours during the daytime from these two farm sites exceed ambient at Te Kaiangapipi (Halstead 2016). However, Schuckard et al. (2015) identified this roost site as ‘abandoned’ and on this basis noise from these proposed farm sites is unlikely to affect king shags.

3.3.3 Exclusion of king shags from potential foraging habitat

King shags could be affected by the proposed new farms if the new sites occupied preferred or important foraging habit relative to the habitat and foraging opportunities at the current farm locations, if the current locations were not occupied by farms (assuming here that king shags do not forage to any great extent beneath current farms). Clearly, it is not possible to quantify this potential effect: for the areas under consideration here (proposed new farms in Tory Channel and in Pelorus Sound) there is no information on which areas are of importance to king shags as foraging locations, and how the importance of these locations might change over time (for example, seasonally). Further, it is not possible to say to what extent king shags would use the space currently occupied by farms, if the farms were not occupying that space.

However, the proposed new farm sites in Tory Channel (farms 42, 47, 82 and 156) would be at or beyond the limit of what is thought to be the maximum foraging range for king shags, approximately 25 km (Schuckard 1994, 2006b), from the White Rocks breeding site. And while the southern promontory of Blumine Island, where nine birds (all non-breeding) were recorded in June 2015, is only ca. 11 km from the nearest of the proposed farm sites (farm 47), and therefore potentially within the foraging range of shags using Blumine Island, the relatively modest number of king shags at Blumine Island and the large area of available habitat much closer to the island would very likely render any effect on king shags minimal to negligible. Additionally, the proposal to relocate farms within the Queen Charlotte Sound-Tory Channel area would result in a general increase in distance from king shag breeding and roosting sites to new farm locations: current farm sites at Ruakaka and Otanerau are approximately 8 km and 14 km from Blumine Island and White Rocks, respectively. As noted above, minimum distances to new farm locations would increase to 11 km and 25 km with the removal of farms at Ruakaka and Otanerau. Notwithstanding the increases in distance to the proposed new farm locations, the four relocation sites in Tory Channel are all located in relatively shallow water. For example, the boundary of farm 42 encompasses water ranging in depth from 3 to 30 m, and the boundary of farm 47 encompasses water ranging in depth from 10 to 47 m (Brown et al. 2016). It is very likely that all four relocation sites in Tory Channel (farms 42, 47, 82 and 156) occupy water that falls within the foraging depth range of king shags (thought to be ca. 20-50 m, Schuckard 1994, 2006b, Fisher & Boren 2012, and see below). Overall, I would conclude that the proposed new farm locations in Tory Channel pose a negligible risk to king shags.

In the Pelorus Sound area there are five proposed new sites, four current sites that could be moved, although two of the latter are located to the south in Crail Bay, and two further current sites that will remain in their present locations. Proposed new farms 124 and 106 (Horseshoe Bay and Richmond Bay south, respectively), farm 125 (Waitata Reach mid-channel), and farms 122 and 34 (Blowhole Point north and south, respectively) are all within foraging range of king shags breeding at Duffers Reef. Proposed farms 122 and 34 would be ca. 3 km from Duffers Reef, proposed farm 125 would be ca. 4.5 km from Duffers Reef and proposed farms 124 and 106 would be ca. 12 km from Duffers Reef. Additionally, proposed farms 122, 34 and 125 would also be within the foraging range of king shags breeding at North Trio and Sentinel Rock, and proposed farms 124 and 106 would be ca. 4.5 km from Tawhitinui and within the foraging range of king shags breeding at this site. However, there are four current farms with the Pelorus Sound area that are within range for king shags at Duffers Reef (and also within foraging range for shags at the North Trio and Sentinel Rock colonies, albeit requiring greater travelling distances than for birds at Duffers Reef). Existing farms at Forsyth Bay, Waihinau, Waitata and Richmond are ca. 3.5, 7.5, 7.5 and 8 km from the Duffers Reef colony, respectively. Two further current farms in Crail Bay are within foraging range for king shags at Tawhitinui, being ca. 6 km to the south. Overall, and based on distances from breeding colonies, the proposal to relocate farms in the Pelorus Sound area appears to be neutral for king shags in that four current coastally-located farms (two in Crail Bay, plus the Forsyth and Waihinua farms) could be replaced by new farms also at coastal sites. A fifth potential new site, farm 125 (Waitata Reach mid-channel) differs from other potential new sites in that it would be away from the coast in open water between Burnt Point and Post Office Point in the Waiata Reach. While such open water sites are thought to be relatively important for foraging king shags (e.g. Fisher & Boren 2012), this location is over water of 60-65 m depth (Brown et al. 2016). Based on observations of foraging king shags, Schuckard (1994) noted that 74% of birds foraged in water 20-40 m deep, and further reported that 'almost no birds fed in the centre of Waitata Reach, where depths are far beyond 40 metres and up to 70 metres'. In a later study, Schuckard (2006b) noted that only 7% of foraging king shags were in water of greater than 50 m deep, and Fisher & Boren (2012) found the highest densities of foraging king shags in Admiralty Bay in water 30-45 m deep. Based on these findings, potential new site 125 (Waitata Reach mid-channel) may be located in water that would be less than ideal for king shag foraging.

The water depths within the farm boundaries of the four coastal locations of proposed sites within the 'Pelorus' area (farms 124, 106, 122 and 34) also extend beyond the preferred foraging depth range of king shags. Towards the north, proposed farms 122 and 34 occupy water ranging in depth from 30-65 m and 28-80 m, respectively (Brown et al. 2016), and approximately half of the area of farm site 122 is in water of at least 50 m depth (Brown et al. 2016). Based on current knowledge of king shag foraging (Schuckard 1994, 2006b, Fisher & Boren 2012), it would seem reasonable to conclude that part of the proposed farm area at these two sites would be beyond the preferred foraging depth of king shags (20-50 m). Proposed farms 124 and 106 are over water of 18-50 m and 30-56 m depth, respectively (Brown et al. 2016). Based on depth, most of proposed farm 124 occupies water that could potentially be exploited by king shags, whereas approximately one third of proposed farm 106 is over water of at least 50 m depth and unlikely, therefore, to be of importance to king shags.

Relocation of farms to new sites could potentially affect king shags through changes in the benthic environment below and near to new farms leading to changes in abundance and availability of fish prey of king shags. Taylor (2016) concluded that the overall effect on prey of king shags of farm relocation to be insignificant, based on the widespread distributions of epi and infauna throughout the Sounds, including the proposed relocation sites, which are likely to underpin the fish prey of shags, and that the area of proposed farm sites is relatively small compared to the area of the Sounds overall. Further, Taylor (2016) noted that witch *Arnoglossus scapha*, likely a key prey species for king shags, is a visual forager and is able to exploit both benthic prey and also small pelagic fish, the latter being largely beyond the influence of salmon farms. Any reduction in prey availability to king shags that might arise from farm relocation would eventually be offset by habitat recovery below and near to vacated existing farm sites, perhaps over a timeframe of several years (Taylor 2016).

3.3.4 Changes to water characteristics

Salmon farms introduce nutrients in the form of fish food that enter the environment in both solid (e.g. fish faeces) and dissolved (e.g. ammonium based nitrogen) forms. One consequence of nutrient introduction to the system can be increased levels of primary productivity, as phytoplankton take advantage of nutrients, with flow-on effects of increased productivity at higher trophic levels and increased concentrations of seston (living and non-living, e.g. detritus, material in the water column), which in turn can increase water turbidity. Turbid water can potentially reduce the foraging efficiency in visual foragers such as shags.

Broekhuizen & Hadfield (2016a, 2016b) modelled water column effects of salmon farm relocations and found that, generally, seston concentrations could increase by a few percent above the current baseline levels, and that these modest increases were often relatively far from proposed farm relocation sites, due to current dynamics. Given the scale and locations of these modelled increases in seston concentrations in the water column, I think it unlikely the foraging of king shags will be affected. Further, although nutrient increases to the system can also result in enhanced levels of productivity, it would be fair to say that predicting how these changes might affect king shags, if at all, remains extremely difficult.

3.4 Summary of potential effects of relocating salmon farms

Overall, the proposal to relocate up to six salmon farms to six of nine potential new sites is extremely unlikely to increase disturbance, including through noise propagation, to king shags. Potential new sites are either about the same distance from colonies or further away from colonies.

Noting that there is a paucity of quantitative data on the at-sea distribution, behaviour (particularly foraging) and abundance of king shags in Tory Channel and Pelorus Sound (the two areas where farms could potentially be relocated to), overall I think it unlikely the proposed new farm locations would affect king shags in anything other than a negligible way. Of the proposed new sites, only one is in open water, approximately in the middle of Waitata Reach, but here the water depth is generally in excess of 60 m and likely to be less favoured by the majority of foraging king shags.

In any event, the King Shag Management Plan (Schuckard 2015), coupled with proposed population monitoring (MacKenzie 2014), provide a framework for assessing any changes to the king shag population trajectory. In the general absence of detailed, quantitative data on many aspects of king shag biology and ecology, and recognising the difficulties associated with acquiring this information, monitoring the overall king shag population, and how individual colonies change over time, represents the most realistic and practical approach currently available for assessing potential impacts on this taxon.

4 Acknowledgements

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Appendix A Maps showing the locations of king shag breeding colonies mentioned in the report and salmon farm locations

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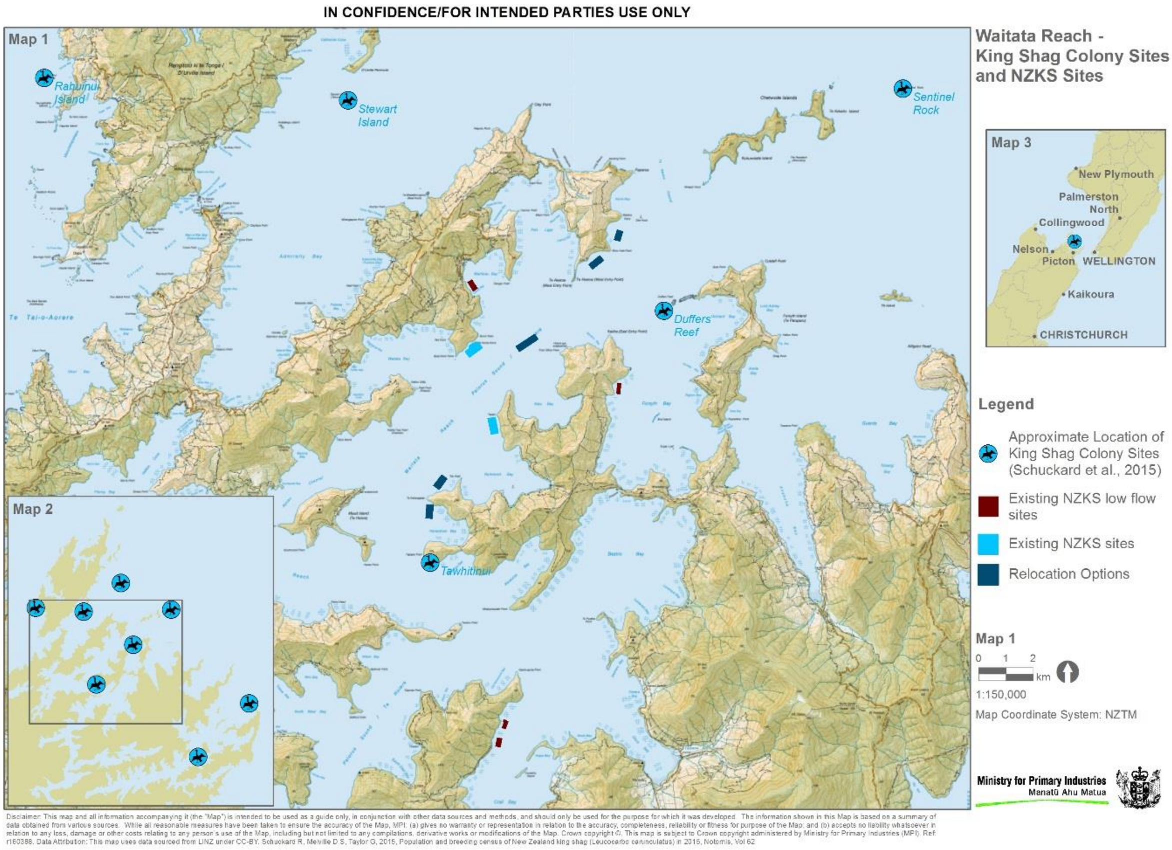

Figure A-1: King shag colonies and salmon farm locations: Waitata Reach – Pelorus Sound, Marlborough Sounds.

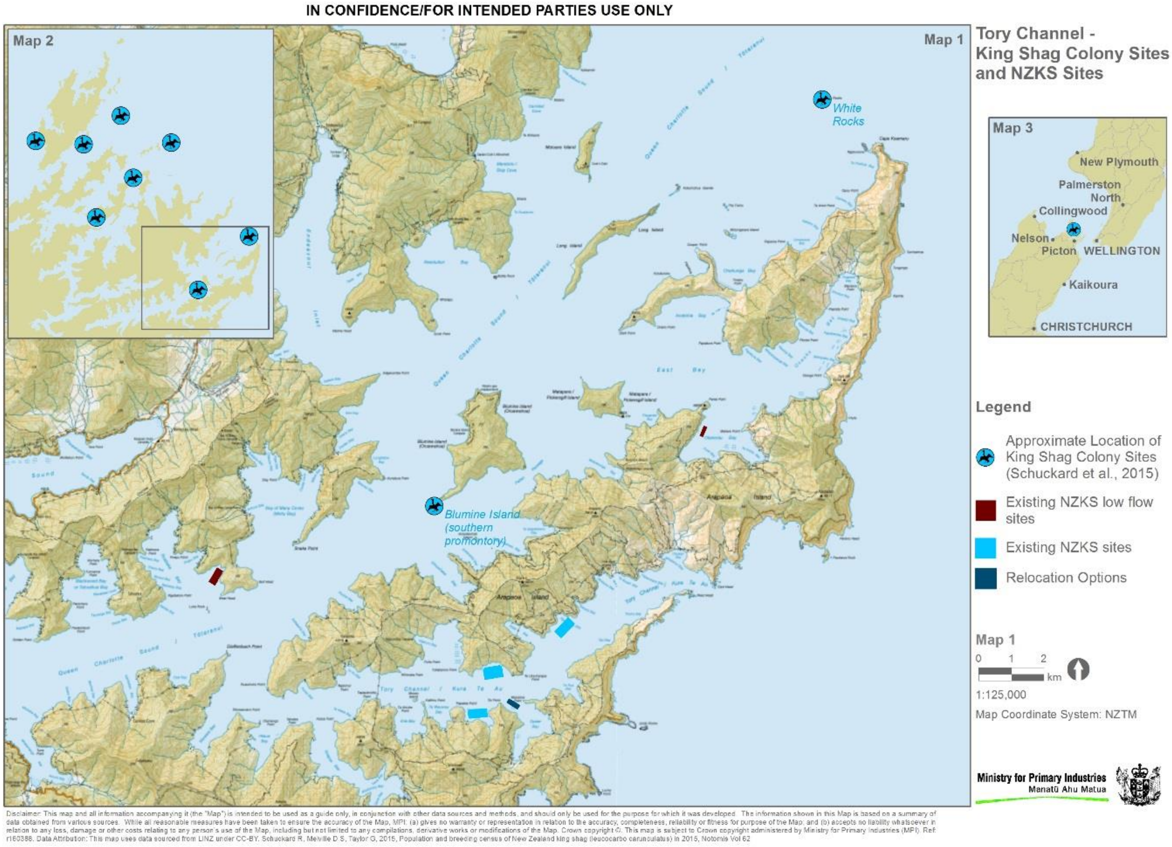

Figure A-2: King shag colonies and salmon farm locations: Tory Channel, Marlborough Sounds.