Department of Conservation
*Te Papa Atawhai*

# Hoiho (Yellow-eyed penguin) foraging and indirect effects: Expert workshop - Research and management priorities for fisheries impacts

## Workshop Report for the Conservation Services Programme

*Hoiho/Yellow-eyed penguins (F.Hjorvarsdottir)*

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Conservation Services Programme POP2016-05

# 1. Introduction

## 1.1 Context/Rationale

Hoiho/yellow-eyed penguins are currently classified as Nationally Endangered (facing a high risk of extinction in the short term) and Endangered internationally by the IUCN Red List of Threatened Species. These threat classifications are based on the species confinement to a small area when breeding and a declining population. While traditionally conservation efforts have focused on terrestrial threats (including habitat loss and introduced predators), there is growing concern around threats (both direct and indirect) that hoiho encounter at sea.

The Department of Conservation (DOC) and Te Rūnanga o Ngāi Tahu as Treaty Partners are responsible for managing the conservation of hoiho while other agencies such as Fisheries New Zealand are the lead agency for managing at-sea threats.

On May 28, 2018, DOC hosted a full-day workshop that brought together research providers (scientists with experience relevant to hoiho, local benthic habitat, fish stocks etc), Fisheries New Zealand fisheries managers and fishing industry representative with knowledge of fishing activities within hoiho habitat. The objectives for the workshop were as follows:

## 1.2 Workshop Objectives

- To identify mechanisms through which commercial fishing may be indirectly impacting hoiho mainland populations. These indirect effects may include, but are not limited to, benthic habitat modification, food web changes influencing prey availability and competition for prey.
- To identify particular fisheries, fishing methods and areas that, based on current information, have a high likelihood of posing adverse indirect effects on hoiho.
- To provide recommendations for management options for fisheries identified as having a high likelihood of posing adverse indirect effects, appropriate to eliminating or mitigating the effects.
- Where current information limits our understanding of how particular fisheries are indirectly affecting mainland hoiho, provide recommendations for future priority research to allow the assessment of need for management responses, and the development of appropriate management options.

## 1.3 Workshop structure and participation

Participants in the workshop included Ursula Ellenberg, Thomas Mattern (Eudyptes EcoConsulting) Yolanda van Heezik, Phil Seddon, Anna Wood (Otago University), Mel Young (PhD student, Otago University), Bruce McKinley, Greig Funnel, Kris Ramm, Freya Hjorvarsdottir (DOC), Trudi Webster (Yellow-eyed penguin trust), Damon Cooper (Harbour Fish), Mark Geytenbeek (Fisheries New Zealand) and Ryan Hughes (Marico Marine). Jody Weir was contracted by DOC as an independent note-taker, she was also

responsible for collating the minutes and for preparing this report. The workshop was structured into the following three areas:

1. Presentations on relevant data compiled for the purposes of the workshop
2. Discussion on presented material and any potential patterns identified
3. Further discussion around identified potential mechanisms, potential management options and research recommendations

# 2. Summary of Material Presented

## 2.1 Yellow-eyed penguin diet and indirect effects affecting prey composition (Thomas Mattern)

Even though the mainland population of Yellow-eyed penguins represents the most studied group of penguins in New Zealand, information about their prey composition is scarce. The bulk of the work to date has been conducted in the mid-1980s and early 1990s with more recent dietary information being very limited. However, data at hand suggest that a significant shift in the major prey species has occurred in the past 30 years where red cod, a dominant prey species in terms of frequency of occurrence and diet biomass at many sites in the 1980s, has been largely replaced by blue cod since the 1990s.

There is a considerable difference in size between red cod, that were predominantly caught during the larval and early juvenile stage (50 – 80 mm), and blue cod, which was consumed at significantly larger sizes (160 – 220 mm). This may affect the survival of penguin chicks which appear unable to ingest such large prey. The shift from red cod to blue cod coincided with a substantial reduction in landings in the red cod fishery, with some indications that fishing pressure may have contributed to a depression of red cod stocks. It appears that fisheries-related disturbance of the Yellow-eyed penguins' benthic foraging habitat may have favoured blue cod, due to this species' relative tolerance to fishing disturbance leading to an apparent increased availability in fished areas.

There are regional differences in Yellow-eyed penguin diet composition. In regions where seafloor habitats are defined by coarse sand and gravel penguin diet is dominated by opalfish, while in regions with structured benthos (e.g. biogenic reefs, horse mussel fields) but also seafloors exposed to bottom fisheries, blue cod is a more important prey species.

The current knowledge of the Yellow-eyed penguins' diet composition and marine ecology in general is limited, which makes it difficult to assess the extent to which these effects contribute to the mainland population's current decline.

Reports and presentation:

Mattern, T & Ellenberg, U. 2018. Yellow-eyed penguin diet and indirect effects affecting prey composition. Report prepared by Eudyptes EcoConsulting for the Conservation Services Programme, Department of Conservation. 39p. https://www.doc.govt.nz/Documents/conservation/marine-and-coastal/marine-conservation-services/reports/pop-2016-05-indirect-effects-on-yellow-eyed-penguin.pdf

Presentation of report to the Conservation Services Programme Technical Working Group can be found at: https://www.doc.govt.nz/Documents/conservation/marine-and-coastal/marine-conservation-services/reports/yellow-eyed-penguin-indirect-effects-presentation.pdf

Ellenberg, U. & Mattern, T. 2012. Yellow-eyed penguin -review of population information. Report prepared by Eudyptes EcoConsulting Ltd. For the Conservation Services Programme, DOC. 144p. https://www.doc.govt.nz/Documents/conservation/marine-and-coastal/marine-conservation-services/pop-2011-08-yellow-eyed-penguin-population-information-review.pdf

### 2.2.1 Pre-moult adult and post-fledging dispersal of juvenile yellow-eyed penguins/hoiho (*Megadyptes antipodes*), over the 2016/17 and 2017/18 field seasons on Mainland New Zealand (Mel Young)

Fieldwork was conducted across eight breeding sites, ranging from Irahuka/Long Point to Bobby's Head in February- March 2017 and 2018. Adults that were known to be resident at the breeding site (defined as three re-sightings and/or breeding in the past season) were targeted for deployment of GPS-TDR archival tags (AxyTrek-3D, Technosmart, Italy).

Thirty-two deployments were undertaken at pre-moult on 15 breeding males, 13 breeding females, and four non-breeding adults over two seasons. Data for 59 trips were obtained, of which 44 trips were single-day return trips, eight overnight trips, and seven multi-day trips of three to five days duration. Several devices were lost or removed by the penguins after prolonged absence from the breeding area, which indicates that some birds stay at sea between 14 and 21 days at pre-moult. Maximum distance from the colony ranged between 10.5km and 69.4km, with maximum diving depths between 25.9m and 156.2m. 95% minimum convex polygons (MCP) indicate that foraging ranges increased by an order of magnitude from north to south, with Catlins hoiho being the widest-ranging, deepest-diving and covering areas up to 1480km$^2$.

Twenty-five fledgling hoiho of known age and of above-average mass (5.5kg) were deployed with satellite tags at seven breeding sites from Whenua Hou/Codfish Island to Aramoana from February-March 2017 (5) and 2018 (20). 23 tags transmitted from 5 to 67 days, with one juvenile reaching Cook Strait (distance travelled: 1012km), with the

remaining birds foraging predominantly to the north of Otago Peninsula to the mouth of the Rangitata River in the Canterbury Bight.

Presentation:

> POP2016-05: Yellow-eyed penguin foraging and indirect effects -Mel Young, University of Otago. Presentation to the CSP Technical Working group on the 27 July 2017: https://www.doc.govt.nz/Documents/conservation/marine-and-coastal/marine-conservation-services/meetings/pop2016-15-yellow-eyed-penguin-presentation.pdf

### 2.2.2 Overview of geospatial information relevant to the indirect effects of commercial fishing induced benthic habitat modification on the mainland population of hoiho (MPI and Marico Marine)

Collation of geospatial data was focused on the east coast South Island, and included information believed to have potential effects on hoiho. This included a presentation of hoiho tracking data, AIS data, VMS data, fishing restrictions, river discharge points, bathymetric data, benthic composition, fishing effort data and commercial catch data. Data layers were overlaid and discussed by participants.

# 3. Discussion Topics

## 3.1 Dredging (including oyster fishery in Foveaux Strait)

In Foveaux Strait, there is an oyster fishery that has been operating for over 120 year and has/is modifying the benthic habitat. While the fishery has operated for a considerable time peak exploitation was likely around the 1950s to 1970s with more modern dredge technology. *Bonamia ostreae* is a parasite that can be fatal for flat oysters. In years when there have been outbreaks of *Bonamia*, the oyster fishery has been closed or had a decrease in activity. It was raised as a speculation that when there have been outbreaks in the past, and there has been a reduction in fishing effort in Foveaux Strait, that the hoiho have possibly benefitted and subsequently experienced a spike in their population. There currently is no empirical demonstration of this however. There is currently an introduced *Bonamia* from Australia which is restrained to Big Glory Bay on Stewart Island for the time being. However, should this disperse more widely it could close the fishery in Foveaux Strait and consequently could affect the hoiho indirectly.

It was also noted - as is the case for other tidal ports around the world, the channel and basin areas of Otago Harbour require ongoing dredging to maintain desired depths. Dredging has been carried out in Otago Harbour since the 1860s, with disposal of dredged material "out to sea" occurring since at least 1882. Prior to 1985, all dredged material was placed at the Heyward Point site, but in 1985 the Aramoana disposal site was first used, and then Shelly beach site was added as a further option in 1987. Potential

effects of turbidity from the dredging on hoiho in the area were discussed, as the foraging tracks from the post-moulting Aramoana birds travel through some of the exclusion zones. It was raised that Victory Beach and other northern birds use this area as well. The potential of the dredging affecting the presence/absence of hoiho prey species was also discussed, and it was noted that blue cod might be attracted to these kind of disturbances, as prey items that weren't available to them before are potentially brought up to the surface with dredging activities.

## 3.2 Benthic composition layers

Hoiho seem to show a preference for certain bottom composition types, however this is colony dependent. From where we have data so far, hoiho seem to prefer gravelly habitat and tend to avoid muddy and sandy bottoms. However, given the coarse nature of the habitat modelling, further ground truthing at key sites would be necessary to reduce uncertainty.

## 3.4 Trawling activity

There was a discussion around trawling activity and whether it has increased or decreased. While there has been a reduction in the number of vessels and effort, the vessels that remain tend to be more efficient catch-wise than historically. Fisheries New Zealand has data on the trawl prints around the country (records of where trawling activity has occurred) and so could effectively produce an intensity map of what has been trawled and when. It could be that there are less vessels but that the trawl footprint is very similar. There was also some discussion around the trawl gear and mesh sizes used. There is new technology being trialled in Hawke's Bay. This technique is essentially a bottom trawl, but the trawl doors are off the bottom. If effectively reduces benthic impacts and makes the net lighter to trawl.

*Table 1: Table of effort for all small vessels in trawl fisheries, in the East Coast South Island area by fishing year (Abraham E.R., Thompson F.N (2015))*

| Fishing Year | 2002-03 | 2003-04 | 2004-05 | 2005-06 | 2006-07 | 2007-08 | 2008-09 | 2009-10 | 2010-11 | 2011-12 | 2012-13 | 2013-14 | 2014-15 | 2015-16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fishing effort (tows) | 19 803 | 16 707 | 17 703 | 15 130 | 12 618 | 9061 | 10 405 | 11 533 | 10 547 | 10 441 | 11 627 | 11 689 | 9368 | 9080 |

## 3.5 Fishing effort -future

After the group had reviewed maps illustrating where fishing activity has been, there were questions as to whether we could expect the patterns and intensity of effort to remain consistent or if there were any indications that fishing activity would change in the future. Fisheries New Zealand explained that with the introduction of digital monitoring, there will be much higher levels of monitoring, including monitoring of non-target species that are caught and discarded. In recent years vessel numbers have declined, and there seems to have been a reduction in the intensity of fishing as well. The costs of compliance are significant, and the new systems are highly technical and costly to set up, especially for smaller boats.

## 4. Summary of Recommendations and Discussions on Priority Research

| Recommendation | Discussion |
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| Include Moeraki and South Catlins in juvenile tracking sampling | By adding these locations, and potentially others (Bench Island, Patterson Inlet and Port Pegasus were suggested as well) to the tracking programme, we would be able to better explain how hoiho using these areas may overlap with fishing activities. |
| Extend spatial and temporal tracking of 2nd year juveniles to identify interactions with commercial fisheries | There are more mature males than females among breeding hoiho. Many females are breeding for the first time at 2 years old and therefore there appears to be no 'pool' of young, non-breeding, females. By tracking experienced juveniles (i.e. young adults that haven't recruited to a particular area yet) we might be able to gather information on when the sex bias is starting to happen, and where the penguins are spending time when we start to lose female birds. Past methods for determining the sex of chicks (and thus being able to know when and where we are losing females in particular) have not worked well. Feather samples have been used to sex tawaki successfully and this method could be used for hoiho as well. There may also be an opportunity to collect the small amount of blood required (for sex-determination) from the needle that is used to insert the transponder tag into individual chicks. |
| Gather further information on ecological parameters of both commercially valuable and non-commercially valuable fish species of specific value to hoiho | The decline of mainland hoiho is a system-wide issue that includes multiple variables, including several environmental factors. We need a better understanding of what is happening in the wider marine ecosystem that hoiho are a part of. For example, we currently know very little about the ecology of most fish species that hoiho consume. There is some knowledge around commercially valuable species but even there, there are still gaps in our understanding (for example there may be information on adult fish but not the juvenile and larval stages). The ecological parameters (including what conditions they require to reproduce) of non-commercially valuable species are virtually unknown.<br><br>Both red and blue cod are both important for hoiho and are both commercially targeted species but there is presently a lack of information on where these species spawn and spend their time as juveniles. |

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| Fishing methods – investigate options to engage with fishers to develop options for gear switching in bottom fishing fisheries to reduce potential indirect and direct effects | Currently, set netting is the main method for targeting several species in the area. When fish species are more abundant, it is possible for fishers to trawl for them as well. Although this might work in some areas, it is not suspected to be as successful (as set netting). There have been some discussions amongst fishers of longlining, but bait is an issue (some species don't seem to take it). The cost of switching methods is also significant and funding must be considered if this approach is to be attempted. There is precedence however. On the west coast of North Island (where the bycatch is snapper), fishers are transitioning to trawl. |
| Investigate options to engage with fishers to develop options to reduce spatial and temporal overlaps to reduce potential indirect and direct effects | There are some spatial and temporal overlaps between hoiho and fishing activities that might be avoidable. For example, the hoiho research could advise fishers on what time of day is the best to fish (to avoid interactions with hoiho). Since hoiho forage during the day, limiting fishing to nighttime would presumably reduce overlap significantly. Fishers find that once the sun goes down, sea lice can destroy the catch, making this option unlikely. However, sea lice are more of a problem on gravel bottoms and aren't so prevalent on sandy bottoms, so there are areas where small scale spatial and temporal management could work. |
| Investigate options to determine whether there has been an increase in predation rates as a result of indirect effects of fishing on:<br><br>- population size of sharks<br>- population size of barracouta | Both barracouta and certain shark species are suspected to be predators of hoiho. Some of the penguins that are admitted to wildlife hospitals exhibit injuries consistent with barracouta or small shark bites. Even if the predator does not fully consume the hoiho, the injuries may be lethal. There seems to be an increase in barracouta bites in recent years, however it is possible these have been occurring for a long time, but that since it was not of interest in the past it was not recognized/recorded. There is currently a student at Massey University investigating this topic.<br><br>There are only occasional penguins admitted with shark bites. Presumably if hoiho are bitten by larger sharks, there would be no evidence left as it would be more likely to result in a fatality.<br>Shark populations are increasing on the North Island and it might be worthwhile to see if the shark populations are increasing in the hoiho range (for example, fishers have noticed more seven-gill sharks). |

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| | Fisheries New Zealand will check the commercial catch data and the observer data to see if there has been any change in catch levels of barracouta stock and if the age composition of the stock has changed. |
| Research to compile information on the calorific value of prey species and identify knowledge gaps for commercial fisheries | Not all prey species provide hoiho with the same number of calories. Certain fish may be consumed by hoiho because they are more abundant, not because they provide the best source of calories. Understanding the calorific value of certain prey species, including juvenile terakihi, sand fish and opalfish will help us to better identify the most critical species within hoiho diet (from a calorie viewpoint). Mel Young currently has a small grant to analyse fish samples but still needs whole fish samples. Fishers may be able to help supply samples for this work. |
| Investigate options to determine whether there has been a change in abundance of species that are low in the food chain and the impact commercial fishing has had upon this<br><br>- sprat<br><br>- *munida* | Sprat, part of hoiho diet, is not commercially targeted. Historically sprat would spawn around river mouths throughout New Zealand, but fishers are not seeing them there anymore. Other issues, including coastal runoff and development, are changing these environments (where freshwater meets the sea) and this is likely affecting sprat spawning and hence abundance. This, in turn, is likely to be influencing availability of this prey for hoiho.<br><br>Similarly, large numbers of young squat lobster (M*unida gregaria*), historically produced large red patches on the sea surface and on the beaches within hoiho habitat. Fishers don't see this important prey species in these large numbers anymore. Very little is currently known about environmental conditions that favour sprat or squat lobsters. |
| Continue to undertake habitat mapping with the particular objective to understand permanent bottom modification of commercial fisheries using multi-beam survey (PhD student)<br><br>Priority study sites:<br>- Boulder beach | There is a PhD student that aims to map hoiho habitat using multi-beam surveys. The student and her advisors are currently looking at technical issues to refine how well this technology can be used to verify habitat in hoiho foraging areas. Key sites to survey are foraging areas off Boulder Beach and Aramoana, as well as the overlapping area slightly south of Bobby's Head and Long Point. Mel Young could provide some tracking data for those locations. Another priority area is Foveaux Strait where all the oyster fisheries are found. While this area is outside the capacity for the student project, NIWA do pre-season survey of the habitat there, and could potentially provide this information. |

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| Continue to undertake habitat mapping with the particular objective to understand permanent bottom modification of commercial fisheries using cameras on hoiho | By affixing small waterproof cameras to the back of hoiho, researchers have been able to obtain video footage of the areas where these individuals are diving. This footage has been useful in identifying types of prey captured and methods for prey capture by hoiho. When the penguin is facing down towards the seafloor, or swimming along the bottom, the video footage also shows the bottom type. There have been instances where the cameras have documented what was later determined to be scouring marks from where a tow had left marks on the seafloor. Cameras on hoiho will therefore be helpful in mapping bottom types. Since these birds often repeat the same foraging trip more than once, we could potentially predict where the individual would go and hence where the video footage would be gathered. |
| Engage with fishers to gather information on different habitat types found along the coast of the South East and Southern South Island | Since some fishers have experience working in particular areas, they often know where certain bottom types are found. In particular, because of it's potential to damage gear, fishers have information on where horse mussel beds are (so that they can avoid them). This information could help improve our understanding of hoiho potential foraging habitat. |

## 5. Additional wider recommendations

| Recommendation | Discussion |
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| Explore the possibilities of Interference work | Research on lifetime reproductive success (LRS, Stein et al. 2017) suggests that delayed onset of first breeding is strongly associated not only with higher LRS, but also the quality and survival of the chicks that they produced. "Super breeders" start breeding later, produce more chicks and more recruits and are more likely to have a longer breeding lifespan than "ordinary birds", who start breeding much earlier and tend to die young. A long-term strategy might be to reduce or remove parental load from first-time breeding females at age 2 or 3, and to foster their fertile eggs into other nests. The young females could (a) settle on dummy eggs, but develop nest attendance synchrony with their mate, without bearing the cost of reproduction by having to raise 1-2 chicks, thereby increasing their foraging and predator aversion skills without being lumped with parental load or (b) raise only one fertile egg/chick, which might allow for greater breeding experience and mate synchrony, but at a reduced load.<br><br>Young females seem to be successful at raising one or two chicks, but the risk is that they compromise their survival to do so, because they underprepare for their moult. Therefore, it seems that the issue is not young females poorly provisioning chicks, but rather that the cost of breeding young is too high.<br><br>These conservation strategies are currently being used by Penguin Rescue and Penguin Place. Male-male pairs are being trained and monitored to act as foster parents and are successful when they are given eggs or chicks. Engaging otherwise lonely males in chick rearing duties will also reduce aggression at critical times. |
| Investigate options to see whether hoiho in Patterson Inlet are interacting with commercial aquaculture operations to the detriment of the birds | Aquaculture operations in Patterson Inlet overlap with hoiho foraging habitat. It is unknown whether this overlap is harming or benefitting the hoiho. There are some speculations that penguins may be benefitting from the salmon farms, but this remains to be determined. For example, a preliminary study found that stable isotope samples from hoiho close to salmon farms were completely different from those in other areas. A sample of the salmon would be needed to determine its isotopic signature. This signature could potentially be traced in the hoiho samples and thus allow for an estimate of if and how frequently these salmon are being consumed by hoiho.<br><br>Understanding how hoiho interact with aquaculture would provide information on how they adapt to new situations and how they cope with changes to their environment and food supply. |