IDENTIFYING POTENTIAL PACIFIC SAND LANCE BURYING HABITAT IN THE SCOTT ISLANDS MARINE NATIONAL WILDLIFE AREA

Context

The Scott Islands marine National Wildlife Area is the first protected marine area established under the Canada Wildlife Act. The conservation objective of the Scott Islands marine National Wildlife Area (SImNWA) is to conserve migratory seabirds and species at risk as well as their habitats, ecosystem linkages, and marine resources that support these species for the long term.

Fisheries and Oceans Canada (DFO) has committed to developing a new fisheries regulation under the *Fisheries Act* to restrict fisheries that pose a risk to the conservation objectives of the SImNWA. The proposed regulation will:

1. prohibit fishing of three key forage fish species that serve as a food source for seabirds (Pacific sand lance, Pacific saury and North Pacific krill);
2. prohibit groundfish bottom trawling within portions of the area consistent with the existing groundfish trawl footprint; and
3. prohibit salmon gill net and seine fishing in the SImNWA.

DFO has committed to develop this regulation for pre-publication in Canada Gazette I by 30 June 2020.

This Science Response (SR) will focus on the Pacific sand lance, an important seabird forage fish (Hedd et al 2006) that lacks a swim bladder and is highly dependent upon suitable sandy substrates for burying themselves in the sea floor (Robinson et al. 2013). The substrate dependence highlights the need for assessing possible spatial and temporal overlap with bottom contact fishing in the SImNWA. The SR will summarize the best available seabed and sand lance discarded catch data and identify (map) potentially suitable subtidal burying habitats. The substrate and discarded fish catch data will then be used to assess the potential spatial and temporal overlap between the bottom trawl footprint and Pacific sand lance habitat.

Advice used from this SR will be used to inform future fisheries restrictions where the fishery poses a risk to the conservation objectives of the SImNWA. Advice will also be used to inform the development of research and/or fisheries mitigation measures for the Scott Islands marine NWA Management Plan in collaboration with Environment and Climate Change Canada, Indigenous groups, other partners and stakeholders.

Objectives

1. To summarize the best available seabed and sand lance commercial discarded catch data for the preliminary identification and mapping of potential suitable subtidal burying habitats within the SImNWA.

2. To use information from the first objective to characterize, map, and evaluate the spatial and temporal overlap between potential sand lance burying habitat and the bottom trawling footprint within the SImNWA.

This Science Response results from the Science Response Process of February 26, 2020 on Identifying Potential Pacific Sand Lance Burying Habitat in the Scott Islands Marine National Wildlife Area.

Background

Scott Islands Marine National Wildlife Area

The SImNWA supports the highest concentration of breeding seabirds in the Canadian Pacific, sustaining 40% of British Columbia's seabirds, including 90% of Canada's Tufted Puffins, 95% of Pacific Canada's Common Murre, 50% of the world's Cassin's Auklets and 7% of the global population of Rhinoceros Auklet. The surrounding ocean waters provide key foraging habitat for the birds that nest on the islands, including important prey species such as Pacific saury, krill and Pacific sand lance (See references within Boutillier 2016).

The SImNWA encompasses about 11,546 km^2, of which about 2,319 km^2 (20%) overlaps with the commercial groundfish bottom trawl footprint (established in 2012). This SR focused attention to regions where the bottom trawl footprint overlaps the SImNWA water depths < 100 m; the 797 km^2 study region in Appendix Figure 1.

Seabird Diets

Pacific sand lance forms an important component of the diets of several species of seabirds breeding in the SImNWA, including the Common Murre (*Uria aalge*), Tufted Puffin (*Fratercula cirrhata*), and Rhinoceros Auklet (*Cerorhinca monocerata*). Studies have shown that in two of those species, the Tufted Puffin and Rhinoceros Auklet, breeding success is closely tied to the availability of Pacific sand lance in any given year – the more sand lance available, the more successfully these birds breed (e.g. Hedd et al. 2006). Rhinoceros Auklet nestling diet data collected by Environment Canada and Climate Change on Triangle Island within the SImNWA shows that sand lance made up more than 40% of the diet in 7 of the last 14 years (Appendix Figure 2).

It has been hypothesized that there is more sand lance in the diets of auklet nestlings in years in which the spring transition occurs in the first two weeks of April (Borstad et al. 2011). This transition moves a cold, highly productive water mass from the north across the area of the Scott Islands, and probably creates good feeding conditions for the new cohort of sand lance. This in turn may create greater availability of sand lance to Triangle Island seabirds several months later, when they are provisioning offspring.

Pacific Sand Lance Life History

The Pacific sand lance is a small short-lived species that lacks a swim bladder and has a relatively complex life cycle requiring a variety of habitats to sustain their populations. Sand lance are not fished commercially in British Columbia, in contrast to congeneric species which are fished in the North Sea for industrial purposes such as oil and meal (Lesser Sandeel, *A. marinus*) and in Japan for food (Japanese sandeel, *A. personatus*). Consequently, little is known about the distribution and/or quantity of habitats for spawning, burying, or foraging along the Pacific coast in general, or the SImNWA in particular.

This information is important to obtain, however, because activities such as bottom contact fishing (i.e., trawling) might impair sand lance populations and/or their habitats and will ultimately have direct consequences for seabirds and other marine vertebrate predators. Off the southeast coast of Scotland for example, commercial bottom trawl fisheries for sandeel (*A. marinus*) from 1990 to 1999 had a negative effect on seabird populations by removing their prey, and consequently areas off the northwest UK coast were closed in 2000 to trawl fishing (Daunt et al. 2008).

In general, sand lance forage on small zooplankton in the water column during daylight hours from spring until late autumn (March to October). They enter subtidal sediments for a few hours during complete darkness when they can't see to feed. Sometime in late autumn-early winter (November-January), most sand lance stop feeding and older fish enter and remain in suitable subtidal seabed sediments to develop gonads; the fish eventually briefly emerge from sediments during this period to lay eggs in coarse sand areas in the subtidal or intertidal (Robards et al. 1999; C. Robinson, DFO, Pacific Biological Station, Nanaimo, BC, unpublished).

The sediment properties of sand lance burying habitats are well described in the primary literature. For example, in coastal BC, sand lance were found to use sediments consisting of medium-coarse sands with low silt content (Haynes et al, 2008; Robinson et al. 2013). In Alaska, *A. hexapterus* has a strong preference for sediments with medium coarse sands (Ostrand et al. 2005). Similar sediment properties in subtidal burying habitats of *A. personatus* have been identified in the San Juan Islands (Greene et al. 2017).

Identifying Suitable Burying Habitat in SImNWA

Geological setting

Cook Bank, in the SImNWA, is a shallow bank that extends northwest from northern Vancouver Island and is part of the Queen Charlotte Basin. The Skonan Formation is a Tertiary marine sedimentary rock unit that is present across much of Queen Charlotte Sound (Shouldice, 1973; Young, 1981). On Cook Bank the Skonan Formation outcrops at the surface or is covered with shallow marine sediment that was deposited since the last glacial maximum; the local sea level was at least 95 m lower exposing much of Cook Bank to subaerial conditions (Lutenauer et al., 1989). Modern depositional conditions are characterized by strong tidal currents and reworking by storm activity. Sand and gravel are the dominant surficial sediment in water depths shallower than 100 m and mud is generally absent. Zones of sand waves are mobile and are reworked by wave and current activity, while gravel deposits are immobile. Calcarious sediments are common on Cook Bank reaching 100% concentration in places near the Scott Islands (Bornhold and Barrie, 1991). These calcareous deposits are likely to extend further east in lower concentrations.

The methodologies of Endris et al. (2011) were followed for seabed classification. In their seabed analysis of the Southern Gulf Islands and San Juan Archipelago, 34 classes are presented. The Cook Bank classification has been simplified due to lack of sediment grain size data and for effective application to a fish habitat model. Seabed features were classified based on morphology and acoustic backscatter intensity. Previously existing sediment grainsize data were used to constrain the grain size of morphological classification. Here we present three classes on Cook Bank; 'Bed Forms', 'rock outcrop and gravel deposits', and 'flat featureless seafloor'. For the 'bed form' class two subgroups have been merged. These subgroups include sand ribbons and sand waves, which are both indicative of elevated bed shear stress produced by strong bottom currents. The 'bed form' class is presented in Endris et al. (2011), but there are no occurrences of sand ribbons in the Southern Gulf Islands and San Juan Archipelago. The Cook Bank 'rock outcrop and gravel' class includes the following classes from Endris et al.

(2011): ‘mound or linear ridge’, ‘unconsolidated sediments’ under the sand/gravel group, ‘pinnacle or boulder’ and ‘fractured bedrock’. The Cook Bank ‘flat and featureless’ class is not represented in the Endris et al. (2011) classification. The ‘Unconsolidated sediments’ under the sand/gravel group is similar but on Cook Bank there is no gravel in the flat and featureless class.

Groundfish Bottom Trawl Fishery in the SImNWA

Commercial groundfish bottom trawl data from DFO’s groundfish view of the Fisheries Operations System (GFFOS) was examined for any catch (landed or discarded at-sea) of sand lance within the SImNWA. This data is from a merge of at-sea observer logbooks, which provide set-by-set enumeration of location details and the amounts of each species caught, and dockside monitoring program data which provides the actual weight of each species landed. Trawl fishing events (tows) are logged in the database with a start or end point, or a combination of the two points. Not all fishing events have a reported set of coordinates, and not all events have a reported end point. Mid points are available for some of the logs but these were not used as they have not been validated.

Groundfish trawl nets are restricted to a minimum mesh size of 76 mm in most areas, with the exception of Queen Charlotte Sound where a minimum of 140 mm in the last 50 m of the net is required, including the cod-end, and minimum of 76 mm for all other parts of the trawl net (2019/20 Groundfish IFMP). Escape panels are also required in the intermediate portion of all trawl nets to permit the release of unwanted fish. Any sand lance caught in trawls is discarded at sea (according to logbook data) and reported by observers, and is referred to in this SR as discarded catch. Catch of sand lance is not prohibited and there was no sand lance reported as being landed by dockside observers from 2005-2018 (see below for year selection).

In April 2012, an agreement was reached between the commercial groundfish bottom trawl sector and conservation organizations to address habitat impacts from bottom trawling. A fishing footprint was established to protect sensitive benthic habitats, such as corals and sponges, to restrict the fishery to areas previously trawled from 1996-2011, and to minimize trawling in areas deeper than 800m. In the SImNWA, approximately 80% of the area is closed to groundfish bottom trawl due to this footprint.

For the SR analysis, we considered the amount of bottom trawl activity occurring within the SImNWA before and after the bottom trawl footprint was established: 2005-2011 and 2012-2018.

We also considered two major seasons within each of the before and after bottom trawl footprint establishment periods: the November to February spawning period where sand lance will primarily be in the sandy sediment, and the March-October foraging period when sand lance will only be intermittently in sandy sediments when not feeding in the water column.

Analysis and Response

The SR analysis focused on two important questions:

1) Does bottom trawling directly remove sand lance?

In British Columbia there are no directed fisheries for sand lance, and from 2005-2018, there was no sand lance reported as being landed by dockside observers. The commercial bottom trawl data were examined for fishing events from all trips that caught and discarded sand lance. If a fishing event (tow) had a null or 0 value for the sand lance catch record then there was no sand lance catch reported for that fishing event. Of the 358 records found coast-wide during 2005-2018, only 34 records were located within the SImNWA; none of these tows reported landed catch of sand lance. Overall, the data examined within the SImNWA for the spawning and foraging periods showed that there was no reported landed catch of sand lance and only minimal discards of sand lance at sea during the foraging period (Table 1; ~ 26 kg or yearly average of < 2 kg (~ 6.6% of coast-wide sand lance discards) within the SImNWA during 2005-2018). There were even fewer reports of sand lance discards within the study area with only 27 records found during foraging period representing about 5% (~21 kg or yearly average of < 2 kg) of coast-wide sand lance discards. Discarded catch of sand lance in the commercial trawl fishery was very low because the trawl mesh size is 76 mm and too coarse to retain small-bodied fish like sand lance. Furthermore, underwater video observations show sand lance able to escape or avoid capture by commercial bottom trawls (G. Workman, DFO, unpublished).

In a recent study, the bycatch of forage fish in large-meshed bottom trawls was incidental, as most fish pass through the larger mesh. Piatt et al. (2018) compared the spatial catch of small forage fish in bottom trawl nets with other methods of sampling (fish and bird diet composition, seine nets). For pelagic fish like capelin there was a good spatial correlation between bottom trawl bycatch and groundfish diets (spearmen r=0.76) or puffin diets (r=0.64). These relationships however, were much weaker for sand lance (r= 0.08 and 0.00, respectively), perhaps because the catch of below-substrate sand lance depends more on time of day, season or degree to which the sea floor is “plowed up”. In addition, it is possible that fishery observers might unintentionally have underreported sand lance by-catch because these small fish get caught up in mesh corners or smushed in the middle of the groundfish catch. Hence, there is no need to pick them out of nets or deliberately discard them; if they don’t’ fall out of net when it is aboard and being emptied, they will fall out when the net is being set and first dragged through the water.

Table 1. A year-by-year summary of the commercial trawl landed catch (multiple species), discarded catch of sand lance, and the number of vessels and bottom tows in the SImNWA during the November-February spawning period and the March-October foraging period. Note that April 2012 marks the beginning of the commercial groundfish bottom trawl fishery boundary.

Year	**November to February**			**March to October**		
	# Vessels (tows)	Landed catch (kg)	Discarded sand lance catch (kg)	# Vessels (tows)	Landed catch (kg)	Discarded sand lance catch (kg)
2005	26 (358)	840,703	0	29 (1,047)	2,833,970	13.55
2006	19 (256)	643,874	0	27 (800)	1,836,742	0.9
2007	6 (103)	266,027	0	27 (701)	1,196,200	0
2008	13 (84)	178,165	0	23 (487)	915,128	0
2009	17 (323)	706,050	0	24 (537)	1,189,376	0.9
2010	15 (279)	694,047	0	23 (703)	1,379,707	0.45
2011	9 (136)	491,410	0	22 (442)	845,511	0
2012	8 (147)	560,212	0	20 (356)	705,406	7.71
2013	8 (68)	149,751	0	17 (345)	833,061	2.27
2014	10 (82)	239,696	0	15 (263)	621,064	0.45
2015	8 (73)	328,410	0	18 (382)	854,466	0
2016	8 (88)	461,653	0	17 (743)	1,947,645	0
2017	5 (48)	324,099	0	17 (574)	1,385,694	0
2018	4 (31)	195,131	0	14 (516)	1,315,777	0

Source: Data from GFFOS, extracted November 11, 2019 (2012-2018 records) and January 8, 2020 (2005-2011 records).

2) Does bottom trawling within the SImNWA commercial footprint spatially and temporally overlap with potential sand lance habitat identified from acoustic backscatter?

Potential sand lance habitat identified from seabed morphology and acoustic backscatter: Three major seabed sediment types were interpreted by marine geologists from Natural Resources Canada from the available multibeam bathymetric data and acoustic backscatter collected by the Canadian Hydrographic Service in the SImNWA (2010-2019). The distribution of the three sediment types is described below.

1) Bed Forms – Seabed that has been reworked by high bottom currents resulting in concentrations of well-sorted, fine to coarse sand and gravel.

Two primary bed form morphologies are observed on Cook Bank and their distribution is related to elevated bed shear stress from high current velocity and sediment availability. They generally indicate an effective sorting process where finer grains are removed by high bottom currents. Sand ribbons occur in zones of long and narrow alternating bands of sand and gravel that extend along the predominant current flow direction. These features alternate between high surface roughness with high backscatter intensity and smooth surfaces with low backscatter intensity. Zones of alternating sand ribbons are as large as 8 km long and 6 km wide.

Sand waves are flow transverse when there is a preferred flow direction and tend to occur in smaller areas or fields. When multiple currents interact, they may form more irregular, honeycomb-like structures. Acoustic backscatter is typically low to medium, but fields of sand waves are visible in relief maps. Sand wave fields are relatively small and disjointed. The largest field is 1.5 km long and more than 5 km wide. Sand wave fields on Cook Bank are the most comparable environment to known Pacific sand lance habitat (sand dunes) in Haro Strait, San Juan Islands. The Bed Form class is underrepresented by grain size samples but ranges from fine to coarse sand and tends to be well-sorted to moderately well-sorted. Sand ribbon bands with high acoustic backscatter are more likely to have a higher gravel content.

2) Rock outcrop/gravel deposit – Poorly-sorted gravel and sand.

Surface is generally rough with very high acoustic backscatter and may have mound-shaped relief of up to 20 m. Outcrops are likely from the clastic Skonan formation. This formation is variable from southern to northern Queen Charlotte Sound, but is likely soft enough on Cook Bank to be readily eroded by bottom currents and storm wave activity. Erosion of these mounds has produced coarse and poorly-sorted sedimentary deposits adjacent to and on top of mounds. Sediment fill between mounds may have a high surface roughness where gravel from mound erosion has been deposited, or a relatively smooth surface where active bed forms are present. Some flat-topped, laterally extensive mounds are overprinted by active bed forms that may be well-sorted, medium to coarse sand. There is a low number of grain size samples from this unit that range from fine sand to coarse gravel and tend to be poorly-sorted.

3) Flat and featureless seafloor **-** Shelf break and slope characterized by very fine to fine sand.

This class starts at roughly 80 m of water depth and covers the slope. At greater depth this unit likely transitions to mud. Deepening water and lack of high relief features results in lower bottom current velocity and deposition of finer sands that have been mobilized from the shallow bank. Grain size samples are very fine to fine sand.

Based on the interpretation of available multibeam bathymetry and acoustic backscatter data for the SImNWA, it is estimated that for the three sediment types described above the highest potential for sand lance burying habitat is within the bed form class, comprising 368 km^2 or 46% of the seabed assessed. The rock outcrop and gravel sediment and featureless seafloor makes up about 226 km^2 of the study area. Three areas (~203 km^2) of the seafloor within the study region remain to be mapped acoustically and assessed for potential sand lance burying habitat.

Spatial and temporal overlap between bottom trawl fishing and suitable burying sediments

To examine the spatial and temporal overlap of commercial groundfish bottom trawl fishery with Pacific sand lance spawning and foraging periods, all logbook records from 2005-2011 and 2012-2018 for the months of November to February and March to October, respectively, were extracted from the GFFOS and plotted as points representing fishing events (bottom trawl tows). Each point represents the start position of a tow, or an end position if no start position was available. The locations of the commercial bottom trawls within/nearby the SImNWA were aggregated over 3 km^2 blocks to protect harvester privacy.

During the 2012-2018 November-February spawning period, ~1% (6 out of 537) of tows in SImNWA overlapped with potential sand lance burying habitat and similarly ~1% (14 out of 1,539 SImNWA tows) during 2005-2011 (Table 3). This is not shown on Appendix Figure 3 because of privacy concerns. Note that because DFO does not know exactly where vessels traverse between the start and end point of the tows, there may be potentially more or less trawl activity occurring over sand lance burying habitat; at present there is no way of quantifying this spatial overlap in greater detail.

During the March to October foraging period, commercial bottom trawl activity overlapping with potential sand lance habitat was minimal with ~2.5% of SImNWA activity (80 out of 3,179 tows) occurring within the study area in 2012-2018 and ~5.6% (263 out of 4,717 tows) in 2005-2011(Table 3, Appendix Figure 4); there were fewer tows in the SImNWA and PSL habitat area after the establishment of the trawl footprint.

Table 3: Estimated number of commercial groundfish bottom trawl tows in SImNWA and potential sand lance (PSL) habitat during spawning and foraging periods from 2005-2018.

	Time Period	Tows in SImNWA	Tows in PSL habitat	Tows in PSL habitat (as % of SImNWA)
Nov-Feb	2005-2011	1,539	14	0.9
	2012-2018	537	6	1.1
	Total	2,076	20	1.0
Mar-Oct	2005-2011	4,717	263	5.6
	2012-2018	3,179	80	2.5
	Total	7,896	343	4.3

Source: Data from GFFOS, extracted November 11, 2019 (2012-2018) and January 8, 2020 (2005-2011 records).

The best available information for the study area indicates that there appears to be only a few areas where commercial bottom trawling may spatially overlap and interact with potential sand lance burying habitat. However, it is not presently known what abundance of sand lance occupies these habitats or the actual retention rates by the commercial trawling. Furthermore, DFO (2018) reported on some potential impacts of bottom trawling on the seabed, but there is little information about whether trawling would remove or retain sand suitable for sand lance burying; it was noted that coarse-meshed trawls result in low remobilization of sediment at depths of 100-200m and any sediment plume is likely to remain ~10m from the seabed and not influence shallower habitats. It is important to note that at this time, that conclusions concerning the potential impact of bottom contact trawling on sand lance or sand lance habitat in the limited regions of overlap identified in the study area is based on limited qualitative data and observations.

Depth overlap between commercial bottom trawl and potential sand lance habitat:

In Alaska, studies conducted in deeper (>200m) waters have found some sand lance in groundfish diets. We are unaware of any quantitative and systematic surveys for sand lance in the SImNWA that include intensive search efforts at depths > 100 m. Furthermore, there are no known groundfish diet data for the SImNWA study area to support the occurrence of sand lance in deeper waters. It is important to note that the occurrence of prey in groundfish diets will be challenging to link directly to prey habitat use because of the foraging behaviours of the groundfish, movements of the groundfish and sand lance, state of digestion of sand lance in stomachs, etc.

In this analysis and from a sand lance burying habitat perspective, we have relied on the observations that the amount of light reaching the seafloor diminishes with depth so as to not trigger emergence of sand lance from the sediments (Winslade 1974), and that conditions for build-up in silt on deep seabeds results from reduced physical forcing from tidal currents and winds (Bornhold et al. 1991). Hence, it is likely that unless unique physical conditions occur (eg deep currents) that remove silt from the seabed it is probable that most sand lance burying habitat occurs at depths < 100 m. The best available observations and catches of sand lance in BC and Washington support this assumption. For example, Robinson et al (2013) and C. Robinson (DFO, unpublished) have conducted grab sampling in the Salish Sea and have determined that depths between 10-50m contain the majority of sand lance caught in burying habitat. In the San Juan Islands, Green et al. (2017) caught sand lance in a sand wave field ranging in depth from 59-75m with an average of 69m depth. Underwater remotely operated vehicle video surveys on Cook Bank and Cape St. James (DFO, unpublished) recorded observations of sand lance at depths of 50-60m. Suitable sand lance burying habitats are most likely to occur at depths < 100m because silt content increases in deeper waters due to a lack of tidal and wind mixing (See references in Robinson et al 2013).

Table 4 shows that commercial ground fish trawling, during either the Pacific sand lance spawning or foraging periods, typically occurred at deeper depths than burying habitat would be expected.

Table 4. Average depths of commercial groundfish bottom trawl tows (in metres) within the SImNWA during 2005-2011 and 2012-2018 spawning and foraging periods including the start, middle (where available) and end depths of the tows. Abbreviation: n/a – no tow information or no tows.

	November-February			March-October		
Year	**Start**	**Middle**	**End**	**Start**	**Middle**	**End**
2005	201	178	200	168	157	169
2006	188	151	189	177	124	181
2007	181	185	187	95	97	96
2008	213	225	199	101	101	101
2009	196	208	199	100	99	100
2010	223	229	231	108	110	109
2011	236	237	246	112	113	113
2012	228	228	224	182	192	187
2013	209	211	208	190	206	197
2014	203	206	204	191	202	197
2015	205	195	213	184	n/a	187

	November-February			March-October		
Year	**Start**	**Middle**	**End**	**Start**	**Middle**	**End**
2016	203	n/a	207	181	n/a	182
2017	238	n/a	247	180	n/a	182
2018	208	n/a	210	179	n/a	182

Source: Data from GFFOS, extracted November 11, 2019 (2012-2018) and January 8, 2020 (2005-2011 records).

Conclusions

It is concluded that:

1. Pacific sand lance is well-known to be an important prey species of resident Rhinocerous Auklets, Tufted Puffins and other seabirds in the SImNWA.
2. Pacific sand lance lacks a swim bladder and relies on suitable low silt sand substrates for short-term (hours) burying when not feeding in the water column (spring and summer) and for longer-term burying (months) when developing gonads and spawning (late autumn and early winter). Burying habitat in coastal BC has been primarily found at depths <100 m, but trawl and groundfish diet studies in Alaska suggest that sand lance may be found in some abundance at greater depths (e.g., to 200 m).
3. A commercial groundfish bottom trawl area was established in the shallow waters of the SImNWA in 2012. Approximately, 797 km^2 of the trawl area overlaps SImNWA depths <100m (~20% of the total trawl footprint in the SImNWA) and constitutes the study area for this SR.
4. Expert interpretation of multibeam bathymetry and acoustic backscatter collected in the SImNWA at depths <100m identified that about 368km^2 of the study region (46%) might contain highly suitable sand lance burying habitat; 203km^2 (25%) of the study area requires additional multibeam bathymetry and acoustic backscatter survey data.
5. The best available information from the commercial trawl fishery from 2005 to 2018 in the SImNWA indicates that the discarded catch of Pacific sand lance is very low, with the discarded catch within the study area negligible (< 2 kg yearly average). Note that the discarded catch of sand lance occurred in the March to October period; no discarded sand lance catch was recorded during the November to February period. During 2005-2018, there were no reports of landed catch of sand lance. Some uncertainty remains regarding the reliability of the discarded catch observations as true estimates of sand lance bycatch.
6. Discarded catch of sand lance in the commercial trawl fishery was very low because the trawl mesh size is 76 mm and too coarse to retain small-bodied fish like sand lance. Furthermore, underwater video observations show sand lance able to escape or avoid capture by commercial bottom trawl.
7. The trawling depths of commercial groundfish bottom tows within the SImNWA 2005-2018 Nov-Feb spawning period averaged 209.0 m, and 150.8 m during the Mar-Oct foraging period.
8. It was estimated that ~4.3% of commercial trawl tows during the foraging period and ~1.0% of tows during the spawning period might have spatially overlapped with potential sand lance burying habitat; this is likely an underestimate because of the lack of detail regarding commercial bottom trawl tow track location, and deep water habitat information.

Recommendations to address uncertainty

1. Seabed sediment classes have been defined based on depositional characteristics. Ground truthing data in the form of grain sizes analysis from sediment gabs is sparse for bed forms and rock outcrop/gravel deposits. It is recommended that additional grab data be collected from both the bed form and the rock outcrop and gravel classes to help constrain the classification and reduce uncertainty in seabed class designation.
2. Designation of 'potential habitat' is based on a study in Haro Strait. No sampling has been conducted on Cook Bank to determine if bed form substrates contain substantial populations of Pacific sand lance or that rock outcrop and gravel zones do not contain Pacific sand lance. It is recommended that biological sampling be conducted to reduce the uncertainty that Pacific sand lance use the sediment bedform class.
3. Acoustic sampling for sand lance burying habitat and sampling for sand lance should be undertaken at deeper depths (to 200m) to establish with certainty as to whether Sand lance are present and using any available deeper habitat.
4. As demonstrated by the multibeam bathymetry data, seabed morphology on Cook Bank is extremely variable. Analysis of multibeam bathymetry data is a more effective method of seabed characterization than coarse gridded spatial modelling for sediment distribution. It is recommended that the area of multibeam bathymetry coverage at depths of <100m should be extended to the three regions comprising about 203km^2 of unknown seabed substrates.
5. The exact location of commercial trawl tracks is unknown because only starting and ending tow locations and depths are available for our analysis. While detailed track line data are captured by an Electronic Monitoring (EM) System, this data is generally not retained and reported to DFO unless it is required for an investigation. Detailed GPS tracks of the bottom trawl tracks would remove the uncertainty in spatial overlap between sand lance burying habitat and commercial trawling.
6. It is uncertain if commercial bottom trawling overlaps with potential sand lance burying habitat in the acoustically un-surveyed areas (203km^2) of the study region. Completion of an acoustic survey in these areas would reduce this uncertainty.
7. In Alaska, there is some correspondence between the spatial location of groundfish stomach content samples and sand lance occurrence. It is recommended that stomach contents of groundfish be assessed in and around the study area to address the uncertainty in sand lance presence and abundance in the bycatch observations.

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Sources of Information

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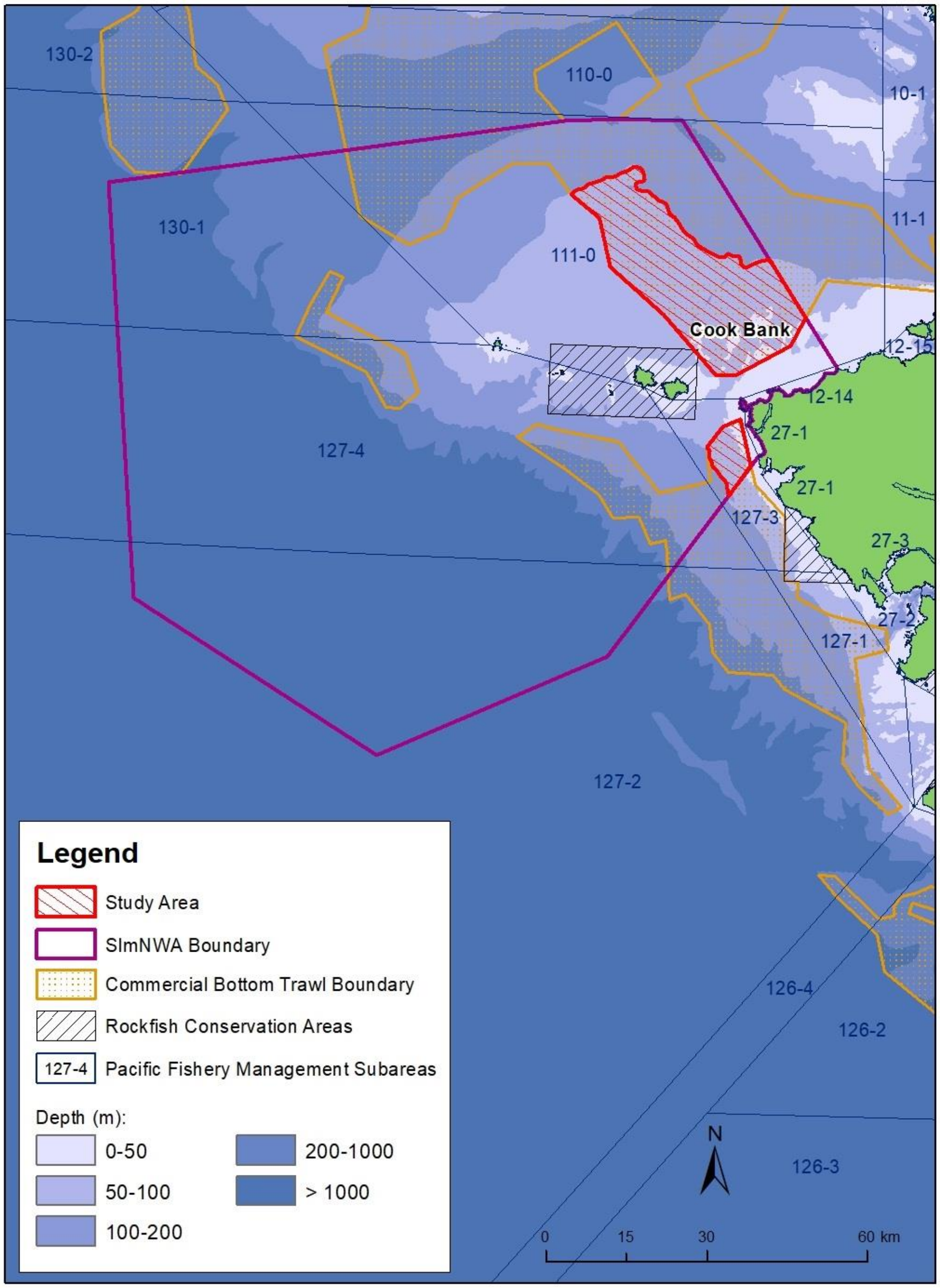
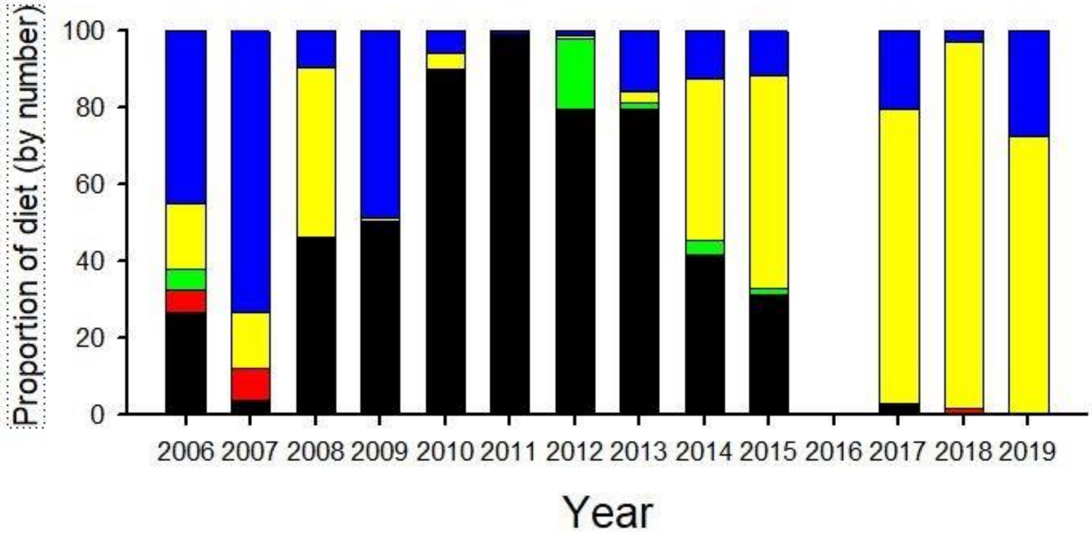
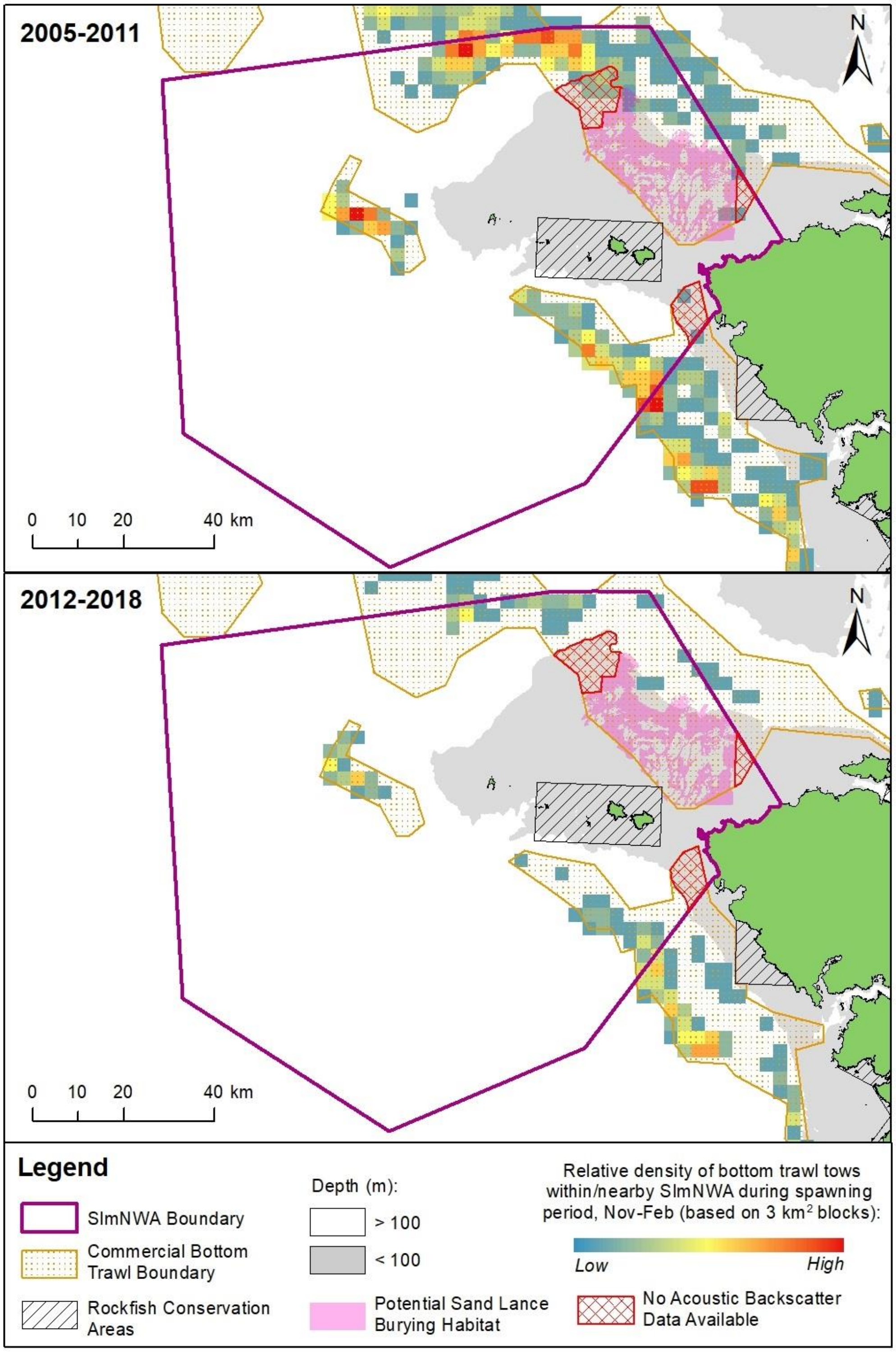
Appendix



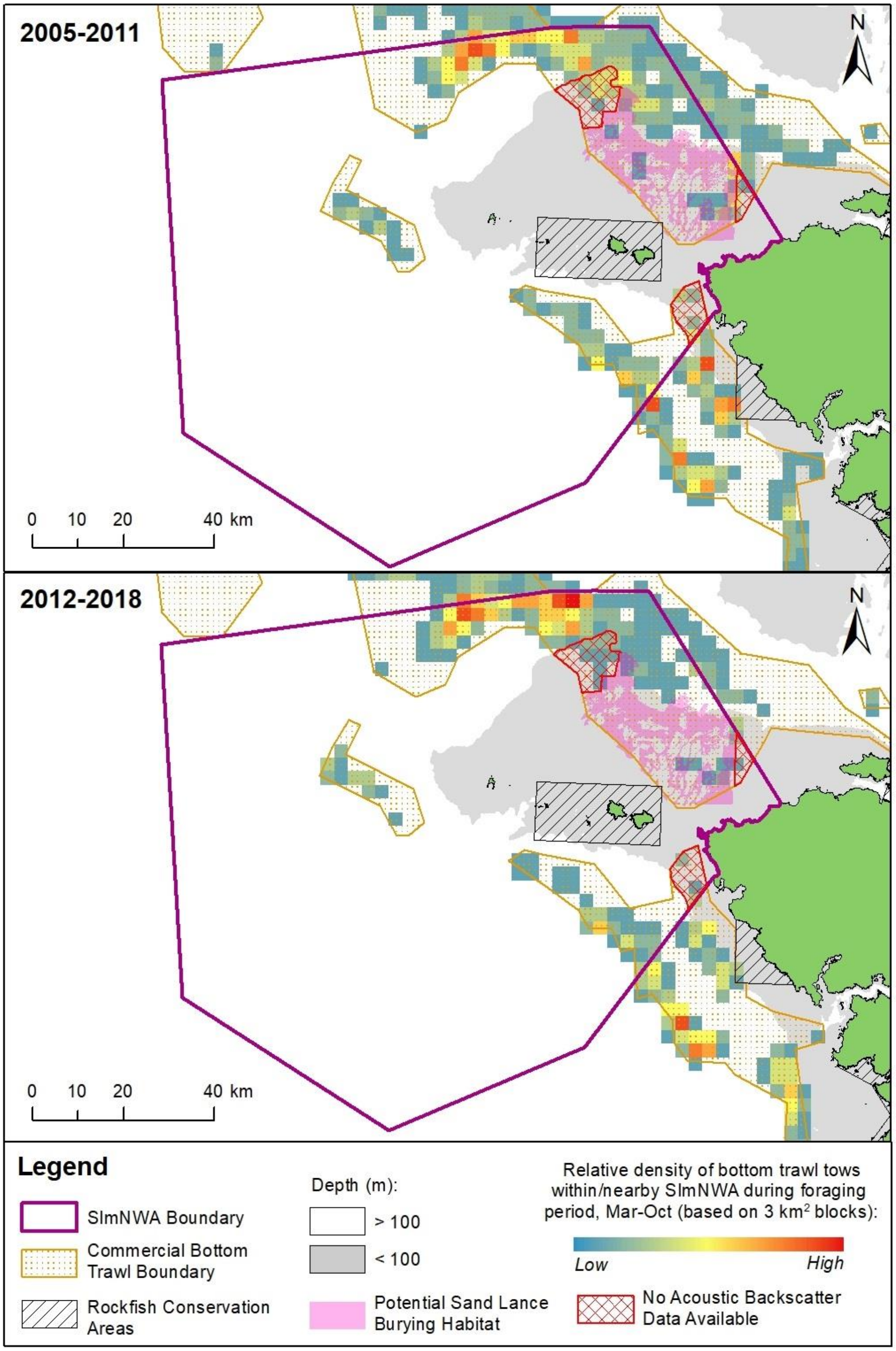
Appendix Figure 1. Scott Islands marine National Wildlife Area boundary (SImNWA; purple line) and the portion of the SImNWA open since 2012 to commercial bottom trawl (orange hatched region). The study area includes the two red hatched regions of the SImNWA <100m depth zone that overlaps with the commercial trawl boundary (~797 km²).



Appendix Figure 2. Interannual variation in the diets fed to nestling Rhinoceros Auklets on Triangle Island, within the SImNWA, by percentage number from 2006-2019. Pacific sand lance is in black, Pacific herring in red, juvenile salmon in green, juvenile rockfish in yellow, and others (largely Pacific saury, squid) in blue.



Appendix Figure 3. General location of commercial groundfish bottom trawls in the SlmNWA study area from 2005-2011 and 2012-2018 during the sand lance spawning period from November to February in comparison with the interpreted seabed sediments.



Appendix Figure 4. General location of commercial groundfish bottom trawls in the SImNWA study area from 2005-2011 and 2012-2018 during the sand lance foraging period from March to October in comparison with the interpreted seabed sediments.

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