

Cruise Report for Pac2025-037: Rockfish Conservation Area Monitoring in Georgia and Johnstone Straits, November 2025

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V8L 4B2

2026

**Canadian Technical Report of
Fisheries and Aquatic Sciences 3778**



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Canadian Technical Report of Fisheries and Aquatic Sciences

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Johnstone Straits, November 2025

by

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Cat. No. Fs97-6/3778E-PDF ISBN 978-0-660-99828-2 ISSN 1488-5379

<https://doi.org/10.60825/pqzg-ce32>

Correct citation for this publication:

Nephin, J., Jeffery, S., Detering, J., Dunic, J. C., Shultis, T., Bluteau, C., Stacey, C. D., Haggarty, D. 2026. Cruise Report for Pac2025-037: Rockfish Conservation Area Monitoring in Georgia and Johnstone Straits, November 2025. Can. Tech. Rep. Fish. Aquat. Sci. 3778: ix + 35 p.
<https://doi.org/10.60825/pqzg-ce32>

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ABSTRACT

Nephin, J., Jeffery, S., Detering, J., Dunic, J. C., Shultis, T., Bluteau, C., Stacey, C. D., Haggarty, D. 2026. Cruise Report for Pac2025-037: Rockfish Conservation Area Monitoring in Georgia and Johnstone Straits, November 2025. Can. Tech. Rep. Fish. Aquat. Sci. 3778: ix + 35 p.
<https://doi.org/10.60825/pqzg-ce32>

This report summarizes the activities and preliminary results of research cruise Pac2025-037, conducted from November 8–28, 2025, aboard the CCGS Vector in the Strait of Georgia and Johnstone Strait. The primary objective was to collect data to evaluate the effectiveness of Rockfish Conservation Areas (RCAs) using an Early-Later-Control-Impact study design. Remotely operated vehicle (ROV) surveys were used to re-sample benthic transects originally surveyed in 2009–2010, enabling future comparisons of Inshore Rockfish and Lingcod abundance and size structure inside and outside RCAs approximately 15 years later. Benthic imagery was collected using the YellowEye ROV until mechanical failure halted further data collection. Despite these challenges, multiple transects were successfully completed across several RCAs. Secondary objectives included the collection of water property, multibeam echo sounder and sub-bottom profile data to support oceanographic monitoring programs and glass sponge reef research and mapping. This research cruise contributes to ongoing efforts to evaluate spatial management measures for inshore rockfish conservation in British Columbia.

RÉSUMÉ

Nephin, J., Jeffery, S., Detering, J., Dunic, J. C., Shultis, T., Bluteau, C., Stacey, C. D., Haggarty, D. 2026. Cruise Report for Pac2025-037: Rockfish Conservation Area Monitoring in Georgia and Johnstone Straits, November 2025. Can. Tech. Rep. Fish. Aquat. Sci. 3778: ix + 35 p.
<https://doi.org/10.60825/pqzg-ce32>

Ce rapport résume les activités et les résultats préliminaires de la mission océanographique Pac2025-037, menée du 8 au 28 novembre 2025 à bord du NGCC Vector dans le détroit de Georgia et le détroit de Johnstone. L'objectif principal était de recueillir des données pour évaluer l'efficacité des aires de conservation des sébastes (ACS) à l'aide d'un plan d'étude précoce-ulérieur-contrôle-impact. Des transects benthiques, initialement exécutés en 2009-2010, ont été rééchantillonnés avec un véhicule télécommandé afin de permettre des comparaisons futures de l'abondance et de la structure de taille des sébastes côtiers et de la morue-lingue à l'intérieur et à l'extérieur des ACS, environ 15 ans plus tard. Des images benthiques ont été collectées à l'aide du véhicule YellowEye jusqu'à ce qu'une défaillance mécanique interrompre la poursuite de la collecte de données. Malgré ces défis, plusieurs transects ont été réalisés avec succès dans plusieurs ACS. Les objectifs secondaires comprenaient la collecte de données sur les propriétés de l'eau, les sondes multifaisceaux et les profils de sous-fond pour soutenir les programmes de surveillance océanographique et la recherche et la cartographie des récifs d'éponges siliceuses. Cette étude contribue aux efforts continus visant à évaluer les mesures de gestion spatiale pour la conservation des sébastes côtiers en Colombie-Britannique.

1 Introduction

In response to conservation concerns for inshore fish populations of rockfishes and lingcod in British Columbia (B.C), Fisheries and Oceans Canada (DFO) implemented a conservation strategy, which included setting aside Rockfish Conservation Areas (RCAs) (Yamanaka and Logan 2010). Other components of the strategy included substantial reductions in commercial Total Allowable Catch (TAC), improved monitoring and stock assessment, and improvements in accounting for rockfish catch. One-hundred and sixty-four RCAs were established between 2003-2006.

Between 2009-2011 Haggarty et al. (2017) conducted remotely operated vehicle (ROV) surveys inside and outside of some RCAs in order to assess their effectiveness. They found no significant difference in fish density or sizes, and hypothesized that not enough time had elapsed between the creation of the spatial protections and sampling (Haggarty et al. 2016). Rockfish species are long-lived, slow to mature and have sporadic reproductive success (Love et al. 2002). As such, it has been found that it can take 15 to 20 years of protection before significant reserve effects can be detected (Starr et al. 2016). When these early surveys were completed, the methods and locations sampled were well-documented so that data collected on future surveys could be comparable to assess changes (Haggarty et al. 2017).

In 2025, DFO developed monitoring advice to assess the effectiveness of RCAs (DFO 2026). In that paper, existing data for rockfish abundance in and near RCAs were summarised and it was concluded that no coastwide dataset existed that could serve as baseline information. Advice was provided for how to collect baseline data and assess coastwide RCA effectiveness moving forward. Another part of the advice was to use data from the 2009-2011 ROV surveys completed by DFO as baseline data for the part of the coast previously surveyed, and repeat those transects to assess the recovery of rockfish and lingcod populations in RCAs within that limited geographic area.

Twenty-one days of CCGS Vector ship time were obtained from November 8 to 28, 2025. This cruise was divided into two legs: Leg 1 took place on Nov 8-17, Leg 2 was Nov 17-28. On this cruise we re-surveyed transects inside and outside of RCAs from these previous surveys in the inside waters between Vancouver Island and the mainland. These transects were previously surveyed in February 2009 and November 2010 (Strait of Georgia), and August 2010 (Johnstone Strait) from the Canadian Coast Guard Ship (CCGS) Vector with DFO's Deep Ocean Engineering Phantom ROV. Data from PAC2025-037 will serve as a comparison of rockfish abundance roughly 15 years later in an Early-Later-Control-Impact analysis.

1.1 Objectives

The primary objective of PAC2025-037 was to collect later data for an Early-Later-Control-Impact study by collecting benthic imagery along transects previously surveyed in 2009-2010. The main research question being asked was, "Is the abundance and abundance of larger size classes of Inshore Rockfish and Lingcod in RCAs currently greater than it was in 2009-2010, and is the amount of change more than in similar unprotected areas?". Work for this objective was conducted during daylight hours using the YellowEye ROV. After unforeseen events caused the

YellowEye to be damaged, the new objective for daylight hour operations was to configure, repair, and trial a smaller ROV (Seamor Chinook) that was available for use, to test its capabilities for collecting video data on transects. Secondary objectives were pursued during non-daylight hours. On Leg 1, the secondary objective was to collect CTD water property data at stations throughout the Strait of Georgia (temperature, conductivity, pressure, dissolved oxygen and fluorescence). On Leg 2, the secondary objective was to collect multibeam echo sounder (MBES) and sub-bottom profile data at sponge reef sites in the Strait of Georgia.

1.2 Crew and partners

This was a collaborative research cruise between three sections in DFO Science: Non-destructive survey tools (NDST), Groundfish section, and Marine spatial ecology and analysis section (MSEA), as well as Ecosystems and Ocean Science Division (OSD), Canadian Hydrographic Service (CHS) and Natural Resources Canada (NRCan). Cruise participants and roles are shown in Table 1. Leg 1 participants working the day shift are shown with the YellowEye ROV in Figure 1. Staff and/or members of three First Nations were also scheduled to participate as daytime visitors; however, only one First Nation was actually able to participate due to ROV issues that curtailed operations on the days when two other Nations were scheduled to visit. Three guardians from Xwémalkwu (Homalco) First Nation joined the CCGS Vector on November 14 to observe ROV operations and learn more about species identification. On-shore support for video streaming operations were facilitated by Ocean Networks Canada (ONC).

Table 1. Cruise participants and their roles. All participants were affiliated with Fisheries and Oceans Canada. NDST = Non-destructive survey tools; MSEA = Marine spatial ecology and analysis section; OSD = Ocean Science Division; CHS = Canadian Hydrographic Service.

Crew Member	Program	Leg	Role
Jessica Nephin	MSEA	1	Chief Scientist
Sharon Jeffery	MSEA	2	Chief Scientist
Dana Haggarty	Groundfish	1	Dive logger/Annotator
Edith Kraus	Groundfish	1	Dive logger/Annotator
Matthew Siegle	Groundfish	2	Dive logger/Annotator
Jillian Dunic	Groundfish	2	Dive logger/Annotator
Ben Snow	NDST	1, 2	ROV team
Jackie Detering	NDST	1, 2	ROV team
Dustin Schornagel	NDST	1, 2	ROV team
Andrew Vanier	NDST	1, 2	ROV team
Cynthia Bluteau	OSD	1	Oceanography
Tammy Shultis	CHS	2	Multibeam /sub-bottom profiling

1.3 Events summary

Major events undertaken during PAC2025-037 are outlined in Table 2. Details of each dive event can be found in the results section (Table 3).



Figure 1. Daytime science crew from leg 1 on the CCGS Vector.

Table 2. Daily summary of events. IOS – Institute of Ocean Sciences, Sidney; PBS – Pacific Biological Station, Nanaimo.

Local date	Shift	Location	Event
07-Nov	Day	IOS	Loading starts
08-Nov	Day	IOS	Finish loading and lab set up
08-Nov	Night	Transit	Transit to Dinner Rock RCA
09-Nov	Day	Dinner Rock RCA	Attempting transects in RCA, but had issues with ship steering, ROV lasers, poor weather making positioning difficult, and heading hold issues with the ROV. Completed a test dive.
09-Nov	Night	Desolation Sound	CTD casts
10-Nov	Day	Desolation Sound RCA	ROV operations inside and outside RCA. Still working through some issues with ROV, but completed 5 transects.
10-Nov	Night	Bute Inlet	CTD casts

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Local date	Shift	Location	Event
11-Nov	Day	Desolation Sound RCA	ROV operations inside and outside RCA. Added more weight to the clump to reduce the tether angle from the vessel. Extended the free end of the tether to 70 meters to allow the ROV to get closer to shore to complete the shallow end of the transects. Completed 5 transects on 3 dives.
11-Nov	Night	Johnstone Strait	CTD casts
12-Nov	Day	Thurston Bay RCA	ROV operations inside and outside RCA. ROV handling better after the thrusters mount which had become loose was fixed. Windy conditions made vessel position difficult. Completed 3 transects.
12-Nov	Night	Loughborough Inlet	CTD casts
13-Nov	Day	Chancellor West RCA	ROV operations inside and outside RCA. Delays caused by wind and a sensor malfunction in the ROV. Completed 3 transects.
13-Nov	Night	Transit	Transit to Read-Cortes RCA
14-Nov	Day	Read-Cortes RCA	ROV operations inside and outside RCA. Participants from Homalco First Nation came aboard and observed for half the day. Completed 4 transects on 5 dives.
14-Nov	Night	Toba Inlet	CTD casts
15-Nov	Day	Dinner Rock RCA	ROV operations inside and outside RCA. Completed 5 transects.
15-Nov	Night	Northern Strait of Georgia	CTD casts
16-Nov	Day	Sabine Channel-Jervis/Jedediah RCA	ROV operations inside and outside RCA. Had to abort last dive because of wind. Completed 4 transects.
16-Nov	Night	Northern Strait of Georgia	CTD casts
17-Nov	Day	Northumberland Channel RCA	Science crew change and ROV operations inside and outside RCA. Completed 4 transects.
17-Nov	Night	Gabriola Island Sponge Reef	Multibeam and sub-bottom profile data collection
18-Nov	Day	Ballenas Island and Sabine Channel-Jervis/Jedediah RCAs	ROV operations inside and outside RCA. Excellent conditions, completed 6 transects on 5 dives.
18-Nov	Night	Halibut Bank and Sechart Sponge Reefs	Multibeam and sub-bottom profile data collection

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Local date	Shift	Location	Event
19-Nov	Day	Northumberland Channel RCA	ROV operations inside and outside RCA. Completed 4 transects. Had to abort last dive because a ratfish got stuck in an ROV thruster.
19-Nov	Night	Halibut Bank and Sechelt Sponge Reefs	Multibeam and sub-bottom profile data collection
20-Nov	Day	Trincomali channel	Attempting to fix malfunctioning thruster for the day. Sourced new fuses to help with repair and ship RHIB ran to Brentwood bay and Nanaimo harbour to pick them up. Concluded by end of evening that the thrusters were not reparable and switched to plan B, which was to pick up a backup ROV at PBS.
20-Nov	Night	Halibut Bank and Sechelt Sponge Reefs	Multibeam and sub-bottom profile data collection
21-Nov	Day	PBS	Bench testing backup ROV in shop with help from Seamor ROV technician, tested winch system on ship, loading backup ROV and alternate winch onto Vector.
21-Nov	Night	Halibut Bank and Sechelt Sponge Reefs	Multibeam and sub-bottom profile data collection
22-Nov	Day	Trincomali Channel RCA	Testing and configuring backup ROV on ship. Completed a test dive.
22-Nov	Night	Galiano Ridge and Active Pass Sponge Reefs	Multibeam and sub-bottom profile data collection
23-Nov	Day	Prevost Island North RCA	Another test dive of backup ROV. Issues with heading and depth sensors.
23-Nov	Night	Galiano Ridge and Active Pass Sponge Reefs	Multibeam and sub-bottom profile data collection
24-Nov	Day	PBS dock	Seamore ROV technician onboard Vector to assist with troubleshooting. Backup ROV is operational by the end of the day.
24-Nov	Night	Galiano Ridge and Active Pass Sponge Reefs	Multibeam and sub-bottom profile data collection
25-Nov	Day	Prevost Island North RCA	Attempted to complete a transect using backup ROV. Sonar and tracking not functioning. Dive was aborted. Second test dive was also unsuccessful.
25-Nov	Night	Galiano Ridge and Active Pass Sponge Reefs	Multibeam and sub-bottom profile data collection

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Local date	Shift	Location	Event
26-Nov	Day	Galiano Ridge and Active Pass Sponge Reefs	Completed sub-bottom profile transects
26-Nov	Night	Galiano Ridge and Active Pass Sponge Reefs	Multibeam and sub-bottom profile data collection
27-Nov	Day	PBS	Offload all ROV equipment
28-Nov	Day	IOS	Offload remaining equipment

2 Vessel and sampling equipment

2.1 CCGS Vector

The CCGS Vector is a 39.7m Canadian Coast Guard science vessel (Figure 2). The following ship components were utilized on this cruise:

- Starboard A-frame
- Port side pedestal mount for hydrophone pole
- Hydrophone pole
- Hydrowinch for CTD
- Multibeam echo sounder
- 3.5 kHz transducer
- Aft deck crane

2.2 YellowEye ROV system

The YellowEye ROV is a large ROV rated to dive to 2000 m (Figure 3). Its primary camera is an Insite Pacific Mini Zeus high definition camera; an upgrade from the previous camera used on the Phantom ROV that completed the previous surveys, which was a standard definition Sony EVI 300 Zoom video camera. The ROV is also equipped with several standard definition cameras to provide views of the following to assist with piloting: tether view, skid view, forward facing driving angle, and a rear facing view. Green scaling lasers were mounted on the same tilt mechanism as the main Mini Zeus camera. The lasers had a spacing of 10 cm. The YellowEye was not equipped with a still camera for this survey.



Figure 2. CCGS Vector tied up at the dock; Pacific Biological Station.

The YellowEye ROV was also equipped with calibrated stereo video cameras (GoPro13, 1080p, 60fps, in Anglerfish Creative Lighting custom housings) for estimating fish sizes more precisely than can be done with the lasers. Additionally, the GoPro footage appeared to resolve more detail and have increased clarity and brightness compared to the main Mini Zeus camera. This difference in video quality may have been a result of the relative locations of where the cameras were mounted on the ROV frame. The GoPros were mounted just above the skid on the bottom of the frame while the Mini Zeus was mounted near the top of the ROV frame in between the yellow flotation pieces.

Pool-based photogrammetric calibration of the Go Pro stereo camera system was carried out on October 23, 2025 using a SeaGIS a 1000mm x 1000m x 500m calibration cube and its paired scale bar. The SeaGIS CAL software was used to process the stereo camera videos. The left (portside of ROV) and right (starboard side of ROV) cameras were assigned 'Hero 9-13 Black 1920 x 1080 Wide Water' CamCAL files as per survey settings. The calibration process resulted in relative precision values exceeding high definition camera conventional threshold of 1:10000 with calculated relative precision values between 1:13700 and 1:15100.

The YellowEye ROV was equipped with a Waterlinked A125 Doppler Velocity Logger (DVL). The DVL provided live altimeter data, reporting distance between the seafloor and the bottom edge of the ROV skid frame. However, altimeter data quality was poor during ROV operations when over soft sediments. The ROV was fitted with a pair of Teledyne Bowtech K lights (one above the

MiniZeus Camera and the other illuminating the tether camera view), a pair of Ocean Tools L7-Flood lights (generally forward facing) and a pair of Deep Sea Power and Light Sphere SeaLites (LSL-2000) placed in line with the stereo cameras. The lights produced up to 5000, 12,000 and 10,000 lumens, respectively. The ROV was equipped with a scanning sonar (Imagenex 881A) to support piloting situational awareness. An Applied Acoustics Pyxis Ultra Short Baseline (USBL) positioning system and Applied Acoustic Transponders (Models 1019, 1113HD, 1329D and/or 1119D) provided real-time positions of the clump weight (subsea anchor) and ROV during operations.

The ROV was deployed and recovered using an Imenco Mini latch mechanism and the ship's crane. The ROV tether ran through a Rugged Controls custom instrumented sheave block on the starboard A-frame on the aft deck. The tether was stored and managed by a Hydramec electric winch (Model HH293). The winch was bolted to the port-forward winch pad on deck. A total clump weight of 120-230 lbs composed of two closely spaced groupings of kettle bell weights were secured to the tether between 50 and 70 meters from the ROV. The tether distance between the ROV and the clump is the amount of free leash the ROV has to operate within. We tested multiple leash lengths and found that a longer leash length allowed the ROV to operate further from the ship and closer inshore. However, the longer leash increased the entanglement risk between the tether and the ship's hull-mounted instruments and propeller, requiring more active management of the tether angle between the ship and the depth of the clump weight relative to the seafloor.

2.3 Seamore Chinook ROV

ROV transects were completed with the YellowEye ROV from November 8 to 19, 2025. On the last transect on November 19, a ratfish was sucked through one of the thrusters of the YellowEye ROV, disabling the thruster and forcing the crew to abort the dive because the ROV could not be navigated safely. After a day of attempting to repair the ROV, it was determined that a control panel had been damaged and a replacement panel was not available. The decision was made to return to PBS to onboard the Seamor Chinook ROV as a replacement and attempt to complete the survey with it.

On November 21, 2025, a Seamore Chinook ROV (Figure 3) was brought on-board as a replacement ROV. No video data for the RCA assessment was collected with the Chinook ROV, as it was determined after testing that: its scaling lasers were too dim to be visible on the seafloor, the field of view was not adequately lit to identify rockfish species, and its heading and depth sensors were not consistently functioning. However, in attempting to operate the Chinook ROV from the Vector the team was able to determine the best deck set up for deployment, learned how to troubleshoot problems with this ROV, and what its capabilities are to collect benthic imagery on future surveys. DFO Science and Coast Guard crew worked together to test the Chinook ROV on the Vector and the lessons learned will be valuable for subsequent surveys with this, and similar sized, ROVs.



Figure 3. Side view of the YellowEye ROV on deck of the CCGS Vector (left), Front view of YellowEye beside Seamor Chinook ROV (right)

2.4 Other equipment

For water properties sampling, we used a pumped SBE25 conductivity-temperature-depth (CTD) profiler, manufactured by Seabird Ltd, deployed from the hydrowinch on the forward starboard side of the CCGS Vector. The CTD was also fitted with an ECO fluorometer (Weltlabs), and a SBE43 dissolved oxygen sensor (Seabird Ltd).

For seabed mapping, we used two pieces of equipment mounted to a gondola on the hull of the CCGS Vector. A EM710MkII multibeam sonar system and Applanix POSMV V5 OceanMaster IMU, and the Knudsen Chirp 3260 3.5kHz sub-bottom profiler.

3 Methods

3.1 Benthic imagery collection

3.1.1 Survey design

Initial imagery surveys of RCAs (2009-2011) conducted shortly after RCAs were implemented were designed as Control-Impact studies as no comparable visual data existed at the time from before RCAs were implemented. On these early surveys, data from inside RCAs were compared to nearby sites that were open to fishing, in order to infer reserve effects. Paired transects 300 m to 900 m in length were placed in similar rocky, higher complexity habitat inside and outside of RCAs using the geographic information system (GIS) software package ArcView (version 3.0 ESRI). Rocky, complex habitat was identified from the best bathymetry data available in the area, which ranged from multibeam bathymetry to nautical charts. Most transect lines were planned perpendicular to the slope of the seafloor and were conducted from deep to shallow, although transects in areas with very steep terrain in the Johnstone Strait region were run parallel to the

slope. Transect metadata was published in (Haggarty et al. 2017), including location, date, time, latitude, longitude, and duration of each transect. The data was stored in an internal database which contains information on biota, fish lengths, habitat and positions of the ROV along the transects.

On the PAC2025-037 cruise, we followed the survey design of these early RCA surveys so that the data would be comparable. The early transects were collected over multiple cruises and so there were many more transects than we could complete on a single 3 week cruise. When choosing which transects to re-sample we prioritized transects completed in the winter months to reduce the potential impact of seasonal differences between the early and later data. Then, we completed several filtering steps to reduce the number of total transects and focus our sampling effort on the RCAs that had transects that were well-matched between the RCA and reference sites. To accomplish this we:

1. Removed transects that were found to have no rockfish habitat;
2. Removed transects within RCAs that did not have an unprotected reference site with similar habitat;
3. Removed transects that intersected an RCA boundary; and
4. Removed transects that were not well matched based on depth, proportion of rock, current speed, complexity, pre-RCA fishing effort, and sponge reefs (see example in Figure 4).

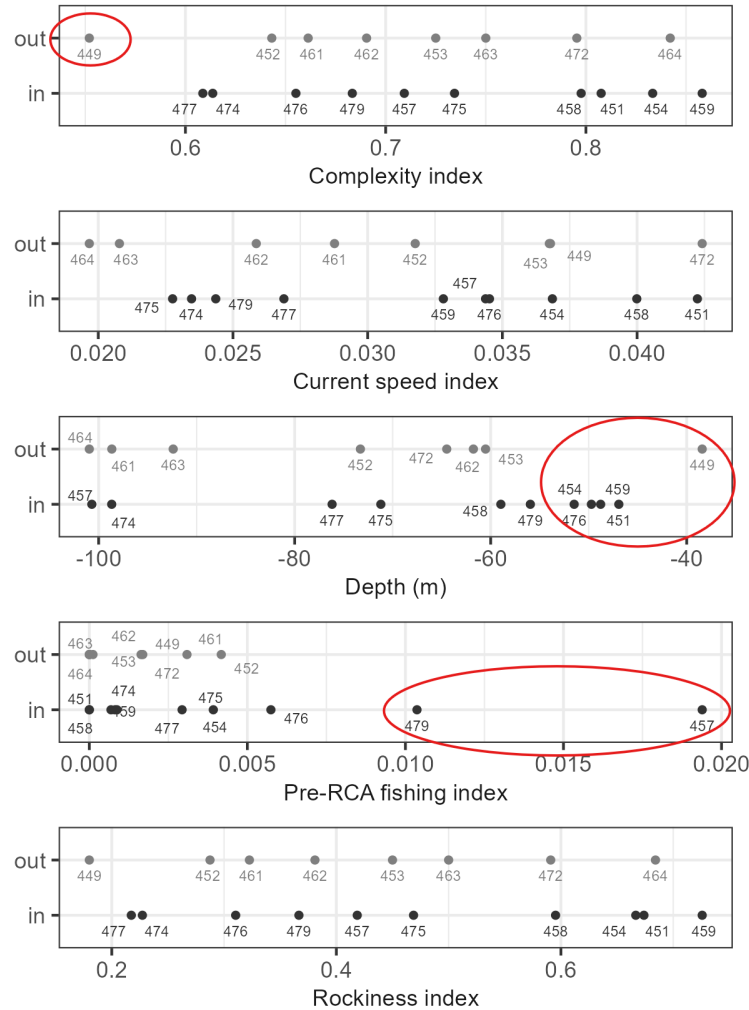


Figure 4. Example figure showing how transect mis-matches were identified. Points represent mean values at the location of potential transects to re-survey inside and outside of Desolation Sound RCA. Red ovals highlight mis-matched sites.

After filtering, we were left with 130 potential transects to survey within 22 RCAs (Figure 5). We prioritized the transects based on feasibility, location, the number of transects within the RCA, and how well the transects were matched between the RCA and its reference site. The transects were grouped into high and low priority. Our intention was to focus on high priority transects, but we retained the lower priority ones in case we needed to adjust our survey plan due to weather or other field constraints.

3.1.2 Pre-survey power analysis

We used a simulation-based power analysis, following the method in Gemmell et al. (in press), to test how much power we would have to detect an RCA effect if we re-surveyed all 130 of the planned transects, or only a sub-sample of them. We fit a Generalized Linear Mixed Model

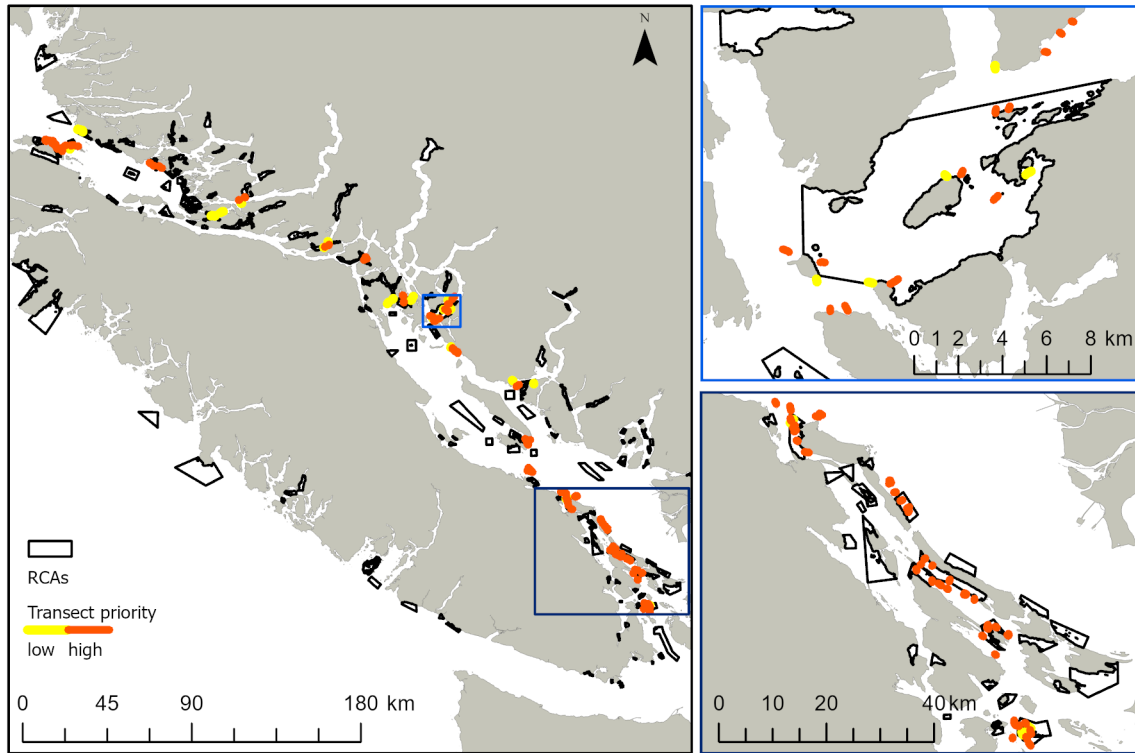


Figure 5. Map of the 130 potential transects within 22 RCAs (67 inside and 63 outside of RCAs).

(GLMM) using the sdmTMB R package (Anderson et al. 2025) to model Inshore Rockfish and Lingcod density. The R code to run the power analysis can be found in this [gitlab project](#).

We fit the model with the early DFO inshore rockfish and lingcod density data as the response variable. The model included depth, current speed, temperature, rocky substrate, seafloor complexity, and pre-RCA fishing as fixed effects, and transect as a random effect. The model also included a spatial random field. Using the sdmTMB simulate function and the parameter estimates from the fish density model, we simulated fish densities along the planned transect lines; once for the early period with no RCA effect and once for a later period with varying effect sizes applied. We tested effect sizes from 1.1 to 1.4, which represent a 10% to 40% increase in fish density. Those effect sizes are within the range of what would be expected over the time period (Perkins et al. 2021). We ran 300 simulations for each effect size (1.1 to 1.4), each sample size (70, 90, 110, and 130 transects), and each time period (early or later).

To estimate our ability to detect the simulated RCA effects, we fit another GLMM model using the simulated fish densities along the transects. This model was similar to the initial fish density model, but also included a fixed effect for time period (early/late), RCA (in/out), and an interaction between them, and the spatial random field was excluded. A positive and statistically significant interaction between time period and RCA indicated an RCA effect. We used all the replicate simulations ($n=300$) to calculate statistical power, which was defined as the proportion of simulations where the interaction between RCA and time period was significant and positive.

The minimum desired statistical power is generally thought to be 80%, meaning a study has an 80% probability of detecting an effect if one exists (Cohen 2013; Gelman and Carlin 2014).

Figure 6 shows the number of early transects that would need to be re-surveyed to reach the 80% threshold at various effect sizes, based on the simulation-based power analysis. The results suggest we would only be able to detect an RCA effect with the proposed sampling effort if the RCA effect has been at least 1.4 (i.e., there has been a 40% increase in fish density inside RCAs compared to outside). If the effect has indeed been large (e.g., 1.4), we would need to re-survey at least 90 transects to achieve adequate power. Our results also suggest that at very low effect sizes (e.g., 1.1), we would have a very low probability, roughly a 10% chance, of detecting an RCA effect.

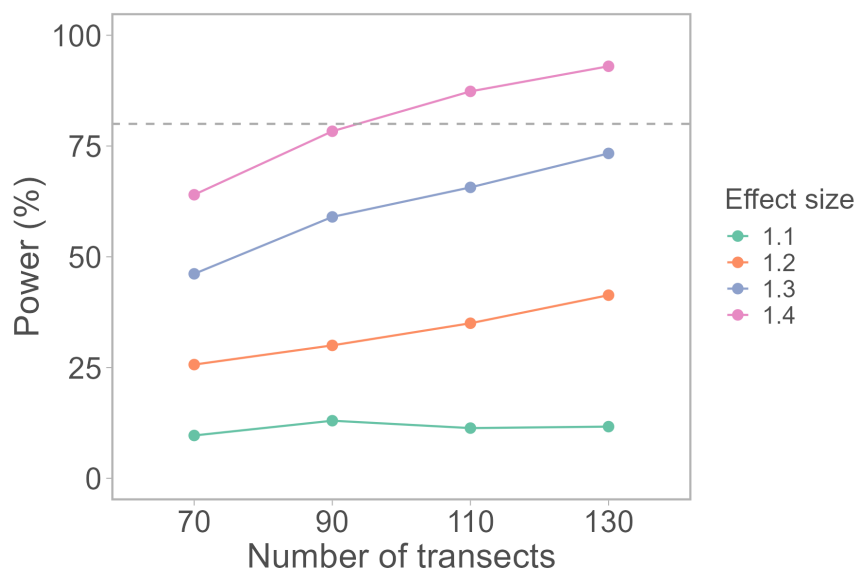


Figure 6. Variation in statistical power across sampling effort (number of completed transects) at various effect sizes.

3.1.3 Survey protocol

We attempted to replicate the sampling protocols used in the early surveys. We mapped the planned transect lines using Hypack software (2009) for navigation purposes. The position of the ROV was determined using TrackPoint 3 ultra-short baseline (USBL) acoustic tracking system (Ore International). The position and heading of the ship and ROV were also displayed in Hypack. When completing a transect, the ship's captain aimed to keep the vessel adjacent to, or behind, the ROV on the transect line. The ROV pilot aimed to follow the transect line as closely as possible, but deviations of 5 meters or less were considered acceptable as long as the ROV heading was aligned with the direction of the transect. The typical speed of the ROV was about 0.4 - 0.8 knots, or 1/4 to 1/2 meter per second. The ROV pilot aimed for an ROV speed of 0.6 knots and an altitude of 1 to 2 meters. The ship's captain aimed to match the speed of the ROV to maintain a consistent distance between the vessel and the ROV, in order to ensure the ROV had enough scope on its tether to move freely. When the transect was orientated perpendicular to depth contours, it was completed from deep to shallow.

Speed, heading, lighting and field of view were held as constant as possible, although

adjustments to the camera tilt angle were performed by the chief scientist or ROV pilot as needed based on variations in seafloor topography in order to get the best view of the seafloor and the best possible angle for viewing fish.

3.1.4 Dive logging and at-sea annotation

While dives were in progress, videos were live-streamed via Ocean Network Canada's live streaming platform, Seatube ([Expedition Management: Ocean Networks Canada](#)), allowing interested members of First Nations and the general public to view the dives. Two annotators recorded transect and dive start and end times, adding observations of seafloor characteristics and biota, with a focus on the target species of inshore rockfish, lingcod, glass sponges, and corals. The videos and the at-sea annotations have been archived on Seatube. These annotations were completed for descriptive and documentation purposes; all transects will also be annotated post-hoc to extract fish abundance metrics described in DFO (2026).

Dive metadata including start and end times of dives and transects, types of equipment and their configurations, and notes and summaries of each dive were also recorded using a shiny application developed in R. Code to run the dive logging application can be found in this [gitlab project](#).

3.2 Accessory data collection

3.2.1 CTD casts

CTD casts were completed during non-daylight hours on the first science leg. Locations of casts were selected from a list of regular sampling stations used by DFO's Ocean Science Division programs. The specific stations were selected daily based on that day's ROV's end location, and the next day's anticipated start location.

For each cast, the instrument was turned on with its magnetic switch while on the deck. Once the instrument was in the water and registered seawater conductivity, the internal pump was automatically triggered to start. The CTD was left near the surface to flush all the sensors for about 1 minute. The CTD was lowered at about 1m/s down to about 5-10 m off the bottom based on the wire-counter readings. Every few casts, when time allowed, the binary data files were downloaded from the instrument using Seabird's Seaterm software. The header information (ship, coordinates, and station name) was provided during download to embed it into the binary file. CTD cast were processed and quality-controlled upon return by the data products team at the Institute of Ocean Sciences. Casts were binned to 1-m depth bins, stored in individual files, and then made accessible via the searchable engine on <https://www.waterproperties.ca/data/>. The cruise number is used as an identifier for file metadata in the Water Properties searchable database. Hence all CTD files for this survey will begin with 2025-037 when they are published and will have "ctd" as their file suffix.

3.2.2 Seabed mapping

MBES and sub-bottom profile data were collected during non-daylight hours on the second science leg from November 17 to 26, 2025. A digital splitter was installed in the computer lab on the CCGS Vector to allow navigation data to feed into both bathymetric and sub-bottom data. Sound velocity profiles were taken throughout the survey using an AML Minos deployed via the aft port winch; these data were then loaded into the bathymetric acquisition software SIS 4. Bathymetric data was processed and quality checked using CARIS HIPS 12.0.15. The sub-bottom data was collected with a Knudsen Chirp 3260 3.5 kHz echo sounder using EchoControlServer.

We planned to collect MBES and sub-bottom profile data within five areas of interest with confirmed or prospective glass sponge reefs (Figure 7). Areas A and B were the highest priority for data collection since visual ground-truthing had identified live reef areas beyond the known sponge reef footprint (Dunham et al. 2018). We hoped to clarify reef boundaries in these areas using high quality multibeam bathymetry and sub-bottom data. If time allowed, lower priority areas C, D, and E were to be surveyed also. In these areas, seabed mapping would improve predictions of sponge reef footprints, although visual ground-truthing would still be required to confirm the presence of any live reefs.

The MBES and sub-bottom profile were initially run concurrently until the MBES had acquired a complete map of the bathymetry within the areas of interest. Additional sub-bottom profile data was then collected along transects placed perpendicular to the completed paired MBES and sub-bottom profile lines to assist with correlation between lines and confirm spatial extent of glass sponge reef.

4 Results

4.1 Benthic imagery

Benthic imagery inside and outside of RCAs was collected from November 10 to 19, 2025. On these days a total of 42 ROV transects were completed inside and outside of eight RCAs (Figure 8). The number of transects completed at each RCA site ranged from 1 to 5 inside RCAs, and 2 to 5 outside RCAs. Desolation Sound had the most balanced and highest sampling effort (5 in / 5 out). Chancellor Inlet west and Thurston Bay RCAs had the lowest coverage, with only a single transect completed inside the RCAs. The outside RCA transects were generally more evenly distributed, with no RCA having fewer than 2 reference area transects. See Appendix A for detailed transect maps by RCA.

We completed 42 out of the 130 planned transects. As this was the first scientific survey using the YellowEye on the CCGS Vector, the protocols for deployment, recovery, and underwater operations were still being tested and adjusted. In addition, we were restricted in the areas we were able to survey because of weather. The limits for operating conditions of the YellowEye off the CCGS Vector were not known prior to the survey. During the survey it was determined that using the current configuration, operations should be limited to less than 20 knots of wind and less than roughly 2 meter waves. Although the limits could be lower depending on the

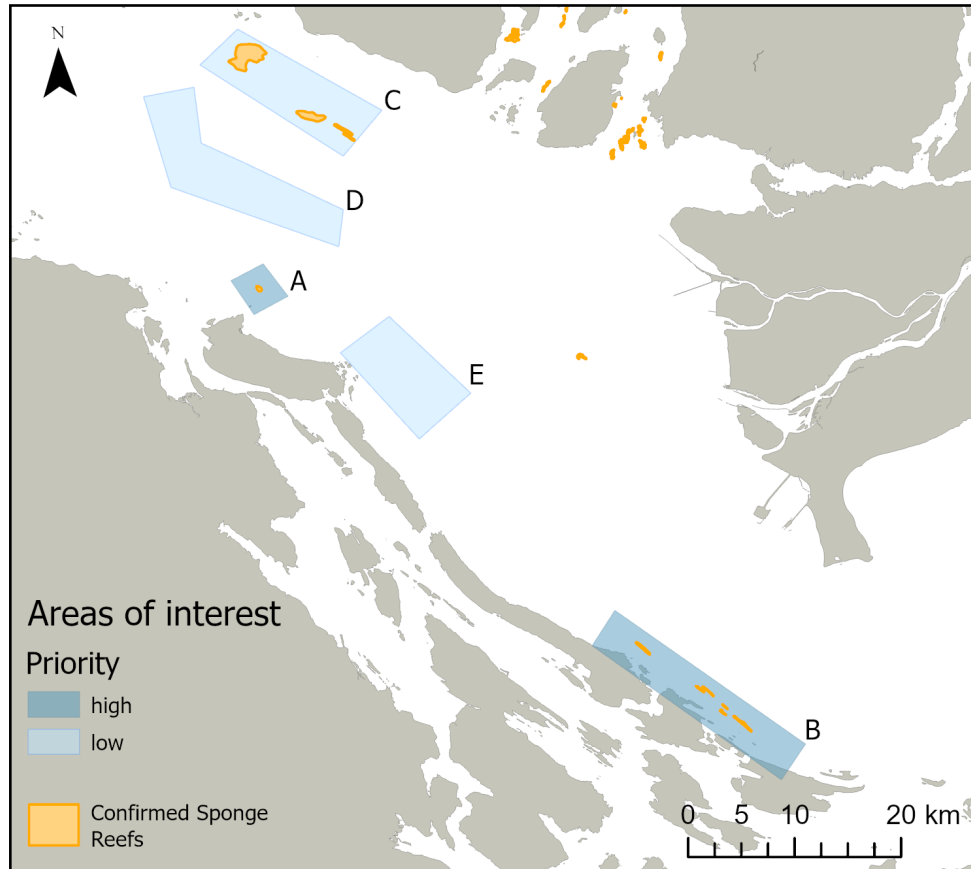


Figure 7. Area of interest for seabed mapping of confirmed and prospective sponge reefs. Prospective reefs not shown.

location and orientation of the transect relative to hazards (i.e., shoreline, rocks), and relative to the wind direction. Once the ROV was tested in favourable conditions around Desolation Sound and Johnstone Strait, we decided we would not be able to complete the planned transects within Queen Charlotte Strait due to predicted stronger winds and larger wave heights in that area. While we were partially limited by winter weather, the flexibility of the captain and crew of the CCGS Vector allowed us to maximize our data collection in the areas that we were able to survey.

Although we did not expect to complete all 130 of the planned transects, we completed less transects than anticipated due to additional time needed for trialing the YellowEye system and the breakdown of the YellowEye mid-cruise. After November 19, no further benthic imagery was collected. Subsequent daytime hours were used to configure, repair and trial the smaller Chinook ROV.

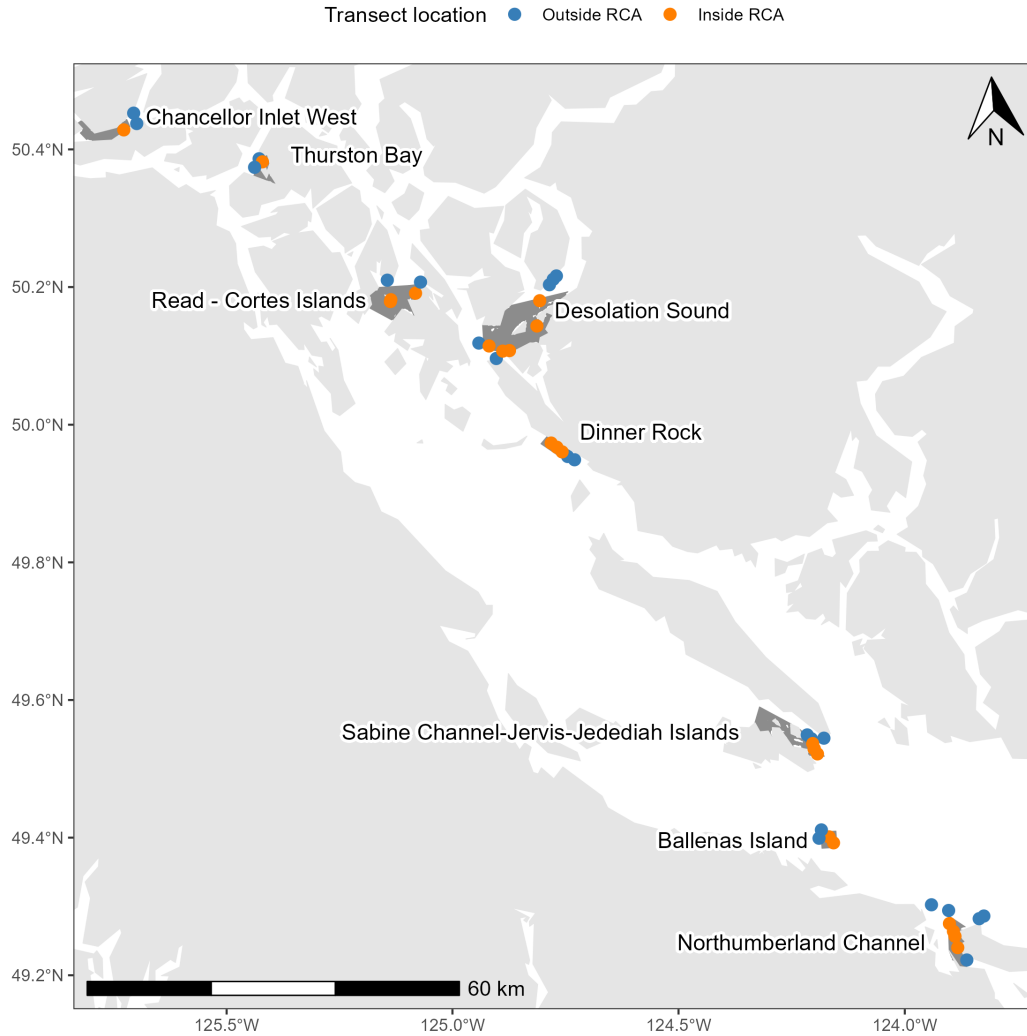


Figure 8. Locations of completed ROV transects inside and outside RCAs.

Summaries of each dive are shown in Table 3. We observed Inshore rockfish on almost all dives, but the number and size of rockfish varied greatly by dive, as did habitat. On many dives we observed rocky, steep, and complex terrain — ideal rockfish habitat. We also observed dense glass sponge aggregations. In five RCAs, we observed aggregations of reef-building glass sponges (e.g., *Aphrocallistes vastus*), these may be sponge gardens or reefs (where new sponges grow atop previous generations of sponge). In four RCAs, we observed dense aggregations of boot sponges (*Rhabdocalyptus dawsoni*). In Dinner Rock RCA, where we observed particularly dense boot sponge aggregations, we also observed aggregations of seaweeds (*Balticina willemoesi*), and many juvenile Quillback Rockfish and Lingcod. We also observed some juvenile Quillback Rockfish in Sabine Channel-Jervis/Jedediah RCA. Within Read-Cortes, Sabine Channel-Jervis/Jedediah, Northumberland Channel, and Ballenas Islands RCA we observed a high density of Inshore Rockfishes. See Figure 9 for example images of some of the species and habitats we observed.



Figure 9. Images of a selection of the species and habitats observed in the benthic imagery.

Table 3. Summary of dives completed inside and outside Rockfish Conservation Areas. QB=Quillback Rockfish; YE=Yelloweye Rockfish; LC=Lingcod; GS=Greenstriped Rockfish; KG=Kelp Greenling, CP=Copper Rockfish; RS=Redstripe Rockfish; YT=Yellowtail Rockfish

RCA	Dive	Transect	Location	Summary
Desolation Sound	Y00054	451	In	Dense glass sponge in middle; boot sponge aggregations throughout. Few fish, some QB, YE, GS, and KG.
	Y00055	449	Out	Mix of bedrock and mud, with rocky habitat near the start and near the end. QB, YE, and CP.
	Y00056	452	Out	GS, with some QB and YE.
	Y00057	479	In	Steep at the end. Some QB and GS.
	Y00058	454	In	QB, KG, Pile Perch.
	Y00059	457	In	Mud at start with several GS, wall at end w QB, YE and LC.

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RCA	Dive	Transect	Location	Summary
	Y00060	477	In	Few fish
	Y00061	462	Out	Wall dive. Few fish. Herring school at start.
	Y00061	463	Out	Wall with many glass sponges, QB, YE and LC. Ended transect a bit early, ROV was unable to make way.
	Y00061	464	Out	Vertical wall dive w several QB, YE, GS and a RS.
Thurston Bay	Y00062	585	Out	Mud bottom, then rock wall. QB, GS, KG. Visibility poor.
	Y00063	581	Out	Mud bottom, then rock wall with many glass sponges. Very low visibility.
	Y00064	583	In	Mostly mud with a few rocky areas with glass sponges. Many Walleye Pollock or Pacific Cod juveniles.
Chancellor Inlet west	Y00065	590	Out	Mostly muddy bottom but some steep bedrock on the shallow end. A few YE and QB.
	Y00066	587	Out	Started on muddy bottom and then changed to very complex bedrock substrate. YE, YT.
	Y00067	588	In	Rock wall with QB, YT, GS, Ratfish. Poor visibility.
Read-Cortes	Y00068	580A	In	Great rockfish habitat, lots of fish. Completed the first half of transect 580.
	Y00069	580B	In	Great rockfish habitat but muddy near the end. Glass sponges, YE and QB. Second half of transect 580.
	Y00070	574	Out	Many QB and some good habitat.
	Y00071	575	In	Lots of glass sponge garden habitat, some sponge rubble, many QB, YE and GS.
	Y00072	576	Out	Lots of glass sponges, several QB.
Dinner Rock	Y00073	465	Out	Sea whips, boot sponge aggregations, some boulders but mostly mud. Excellent juvenile LC habitat with several YOY, also adult LC, QB, YE, and KG.
	Y00074	466	Out	Mostly mud bottom with occasional boulder, sponge, sea whips, high fish diversity. QB, LC, sculpins, and perch.
	Y00075	467	In	Mud and sea whips at start, then boot sponge aggregations. Some adult QB, LC and YE, but mostly juvenile QB and LC.
	Y00076	468	In	Mud and sea whips at start, then boot sponge aggregations, then boulder habitat at end. QB, YE, LC where there were rocks.

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RCA	Dive	Transect	Location	Summary
	Y00077	469	In	Lots of boot sponges, some small QB and LC.
Sabine Channel-Jervis/Jedediah	Y00078	486	Out	Rock wall with sponges, Splitnose Rockfish, YE, and juvenile QB.
	Y00079	487	Out	Rock wall with dense glass sponges and many QB and YE.
	Y00080	488	Out	Rock wall dive with lots of sponge, bubble gum coral at bottom. Many QB and LC.
	Y00081	489	In	Beautiful wall with sponges and many QB, YE and LC.
	Y00082	490A	In	Dive aborted due to weather. Repeated on dive Y00091.
Northumberland Channel	Y00083	570	In	Abundant fish. Many LC, QB, YE, GS, and CP.
	Y00084	562	In	Rocky ridges with mud between them. Many fish including LC, QB, YE, GS, CP and Tiger Rockfish.
	Y00085	569	Out	Boot sponges and some rock reef. Some QB and LC. School of squid carrying prawns at start.
	Y00086	567	Out	Mostly mud, some rock. QB and LC.
Ballenas Islands	Y00087	523	In	Nice glass sponge reef near start. Later soft bottom with boot sponge aggregations. Several QB, some GS, YE, LC, and Ratfish.
	Y00088	522	In	Soft substrate with boot sponge aggregations. QB, GS, YE, and LC.
	Y00089	525	Out	Muddy with boot sponge aggregations throughout. Some rocky reef. Big school of QBs, also some YE, KG, and LC.
	Y00090	524	Out	Muddy with some boot sponge aggregations. Large school of Shiner Perch close to end. Some QB and KG.
Sabine Channel-Jervis/Jedediah	Y00091	491	In	Mud and bedrock. Dogfish, YE, QB, GS, and Ratfish.
	Y00091	490B	In	Muddy substrate, some boot sponge aggregations. Rocky reef near end with YE, QB, Ratfish, and a skate.
Northumberland Channel	Y00092	517	Out	Muddy bottom and bedrock slope. QB, LC, GS and Canary Rockfish. School of herring early in transect. Ended dive early, ROV couldn't maintain position.

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RCA	Dive	Transect	Location	Summary
	Y00093	558	Out	Muddy bottom, with bedrock ridges near end with QB, YE, CP, KG, GS, and LC. Field of crinoids at end. Dive aborted before end of transect.
	Y00094	521	In	Muddy bottom with small section of rock walls. Few fish. Gadids, QB, Ratfish, and sea whips. Low visibility.
	Y00095	572	In	Muddy bottom with rock wall near end. Ratfish, QB, YE, Ratfish, and gadids. Very low visibility.
	Y00096	571	Out	Muddy bottom with many Ratfish. Very low visibility. Ended dive early, ROV had an issue with a thruster.

4.2 CTD casts

CTD casts were completed at 47 stations. See Figure 10 for a map of station locations. Most stations north of QU39 are part of the Coastal Inlets Program (field notes code OSDOEB-14), while QU39 and all stations to the south of it are part of the Salish Sea biophysical survey (OSDSOTO-19). The Coastal Inlets Program typically visits 1/3 of its target inlets each year. The sampling season changes from year to year, and so temporal resolution is quite sparse compared to other programs.

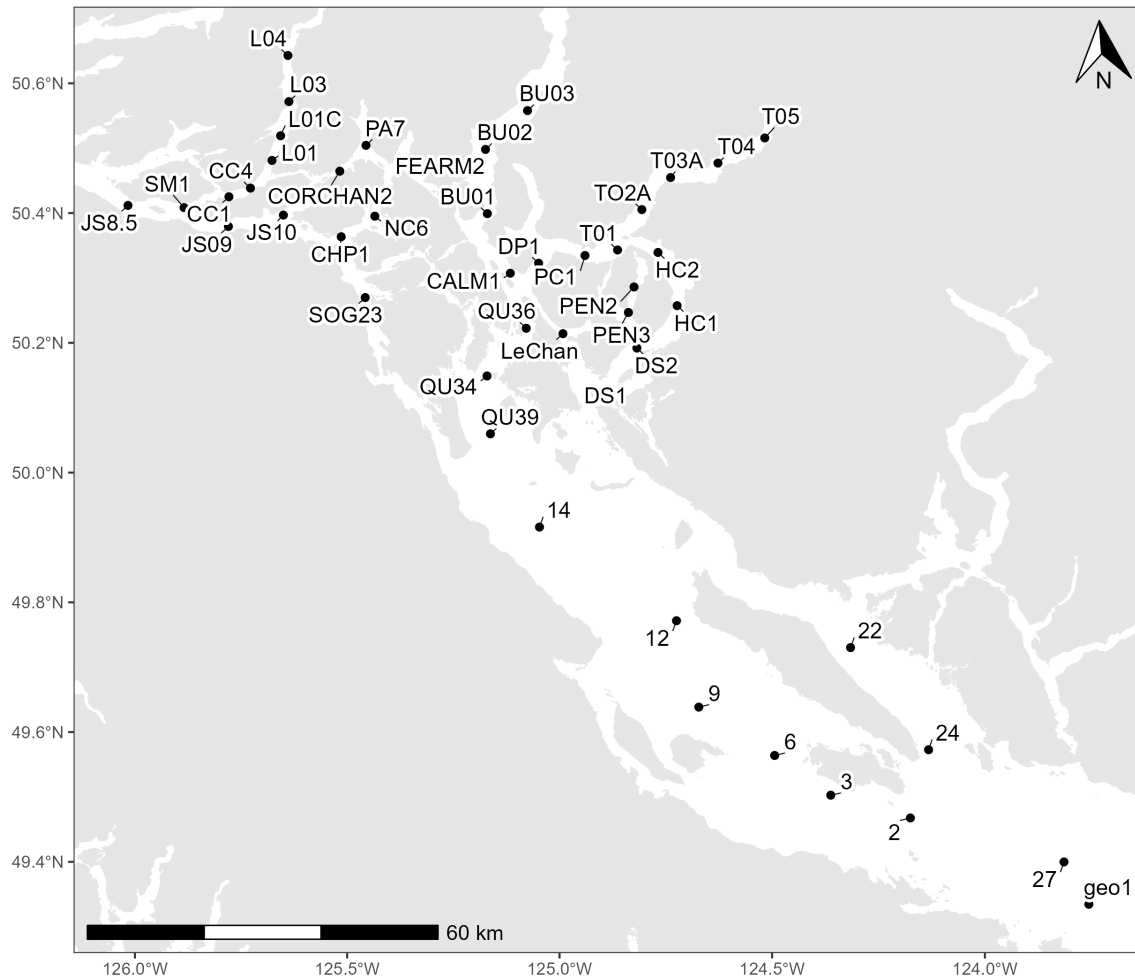
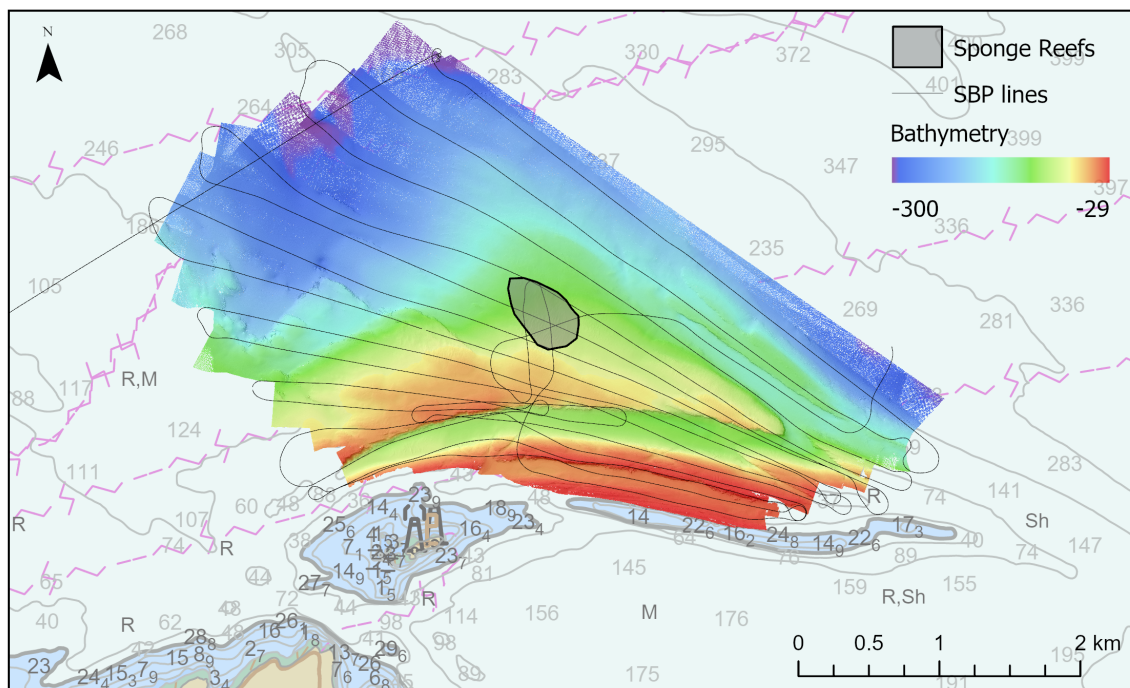
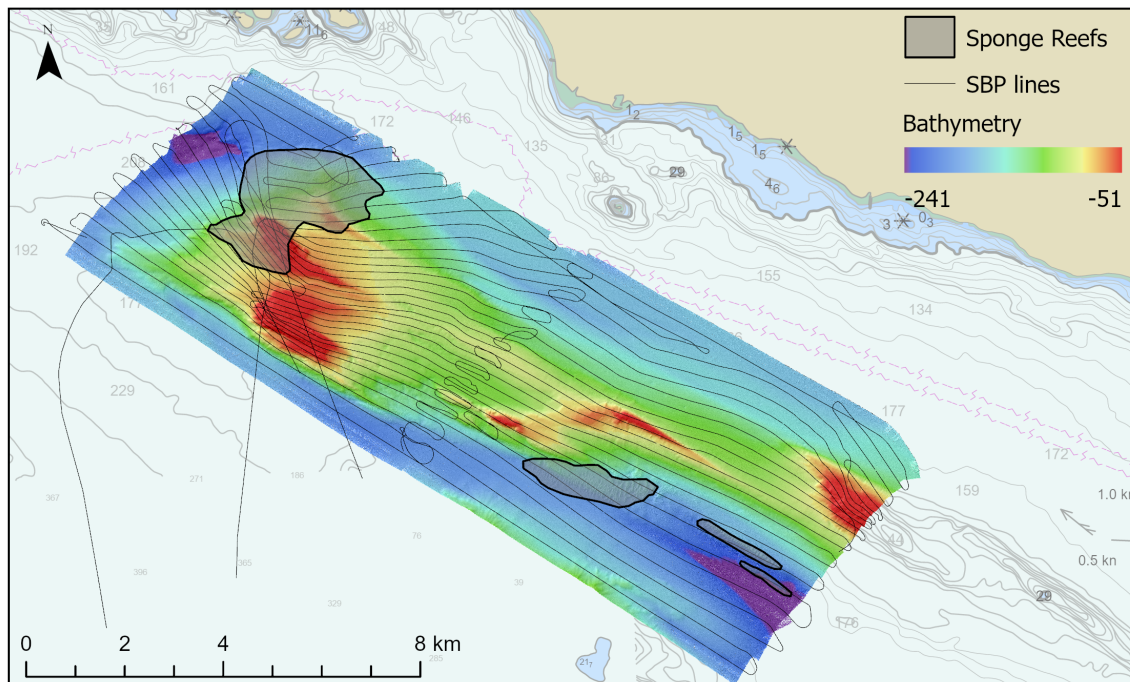


Figure 10. Locations of completed CTD stations.

4.3 Seabed mapping

Survey operations were conducted across three areas of interest within the Strait of Georgia over a nine-day period. A total of 888 km of survey lines were completed, covering an area of 165.6 km². The three surveys collected 1-meter resolution multibeam bathymetry and sub-bottom profile data in areas with known glass sponge reefs (Figures 11, 12, and 13). Sixty two sub-bottom profile lines were completed: 1-4 on the Gabriola Island survey, 5-26 on the Halibut Bank survey and 27-62 on the Mayne and Galiano Islands survey. The sub-bottom profile data are available upon request from the Pacific Geological Station, NRCan.

Preliminary analysis of the new high-resolution multibeam bathymetry has revealed additional prospective glass sponge reefs (locations not shown). The higher resolution data resolves greater detail, making it more effective for delineating reef boundaries with increased confidence compared to previous datasets. In addition, several sub-bottom profiles show acoustic anomalies consistent with glass sponge reef structures (Figure 14). Together, these datasets can be used to refine and potentially expand existing sponge reef boundaries within the three survey areas.



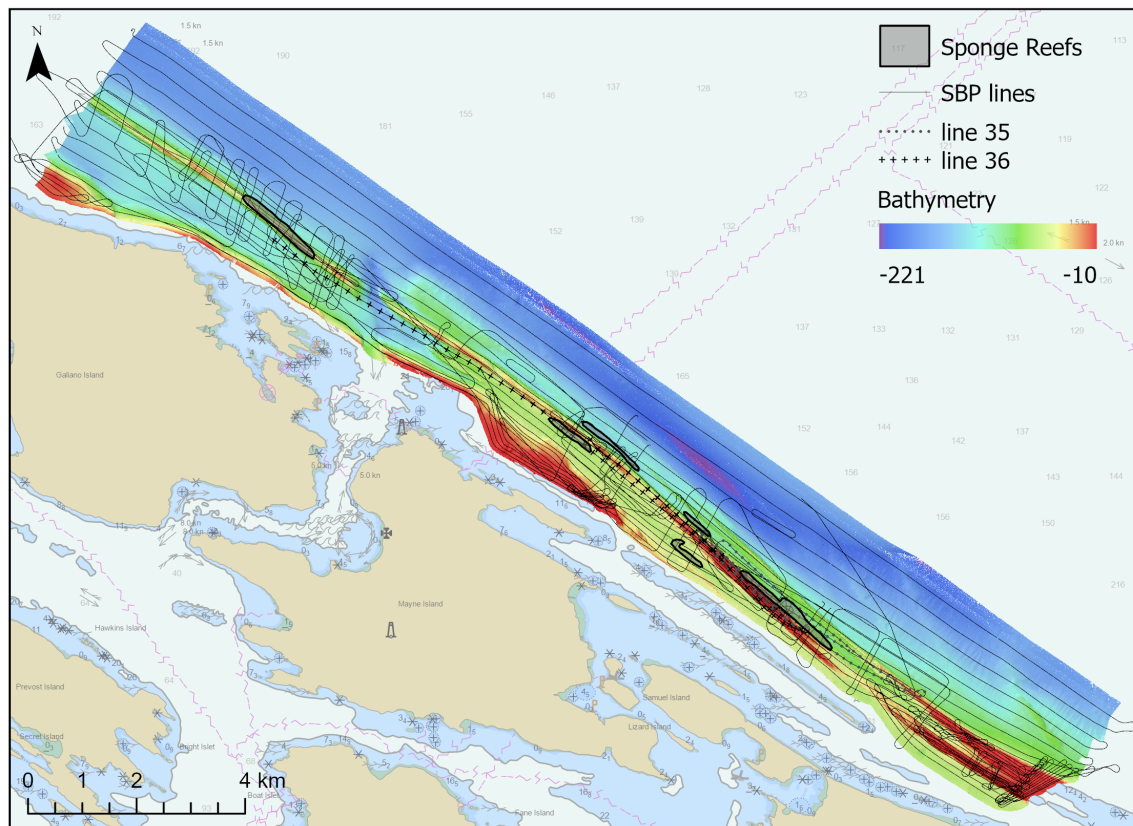


Figure 13. Multibeam bathymetry and sub-bottom profile (SBP) lines from the seabed mapping survey east of Galiano and Mayne Islands. Showing existing sponge reef boundaries that were delineated based on previous seabed mapping surveys. Locations of SBP lines 35 and 36 shown in Figure 14 are highlighted.

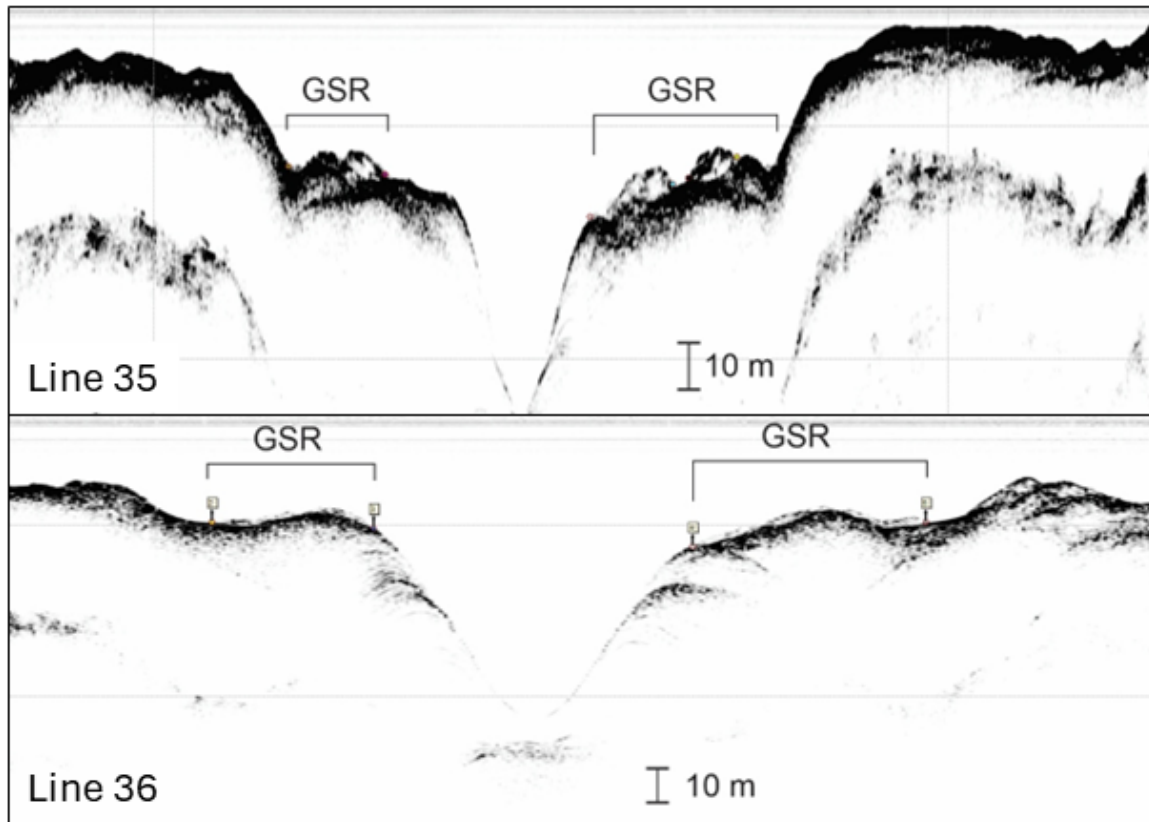


Figure 14. Sub-bottom profiler (3.5 kHz) lines 35 and 36 from Galiano and Mayne Islands survey area showing cross sections through a ridge structure. Glass sponge reef is observed as an acoustically transparent unit that overlays the high amplitude return of the ridge structure. On line 35 the reef structure has an irregular surface and is greater than 5 m thick in places, on line 36 the reef structure is thin with an relatively smooth surface. See Figure 13 for the location of lines 35 and 36.

5 Conclusion

A total of 42 ROV transects were completed across eight RCAs and their reference sites during the PAC2025-037 cruise. Additionally, 47 CTD casts and three seabed mapping surveys were completed. The collected benthic imagery, water property, and seabed mapping data will support a number of different research objectives including oceanographic monitoring and sponge reef mapping.

This cruise represents the first stage of data collection recommended in the RCA monitoring advice (DFO 2026). The benthic imagery collected on this cruise will be a critical component for the evaluation of long-term RCA effectiveness, to address whether inshore rockfish and lingcod within RCAs have shown measurable recovery compared to unprotected areas since the baseline periods of 2009–2011. However, based on the power analysis we completed during survey planning (see Section 3.1.2), we have not yet collected sufficient data to complete an assessment of RCA effectiveness. Additional research cruises to re-survey more of the early

transects that were completed between 2009 and 2011 will be needed to increase our sampling effort. When collecting additional data, we recommend focusing not only on re-surveying the 88 transects not completed on this cruise, but also additional early transects completed off the west and north coast of Vancouver Island (Haggarty et al. 2017) to increase the geographic scope.

6 Acknowledgements

Many thanks to the captain and crew of the CCGS Vector for their support in cruise planning and operations as well as their flexibility and commitment to the scientific objectives of the cruise. Thanks to Matthew Siegle, Ben Snow, Dustin Schornagel, Andrew Vanier and Edith Kraus for their participation in data collection. We also thank Katherine Charles and Edith Kraus for their thoughtful reviews that improved this manuscript. Finally, thanks to Ocean Networks Canada for facilitating video streaming and archiving.

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APPENDIX A Maps of transect locations by RCA

Ballenas Island

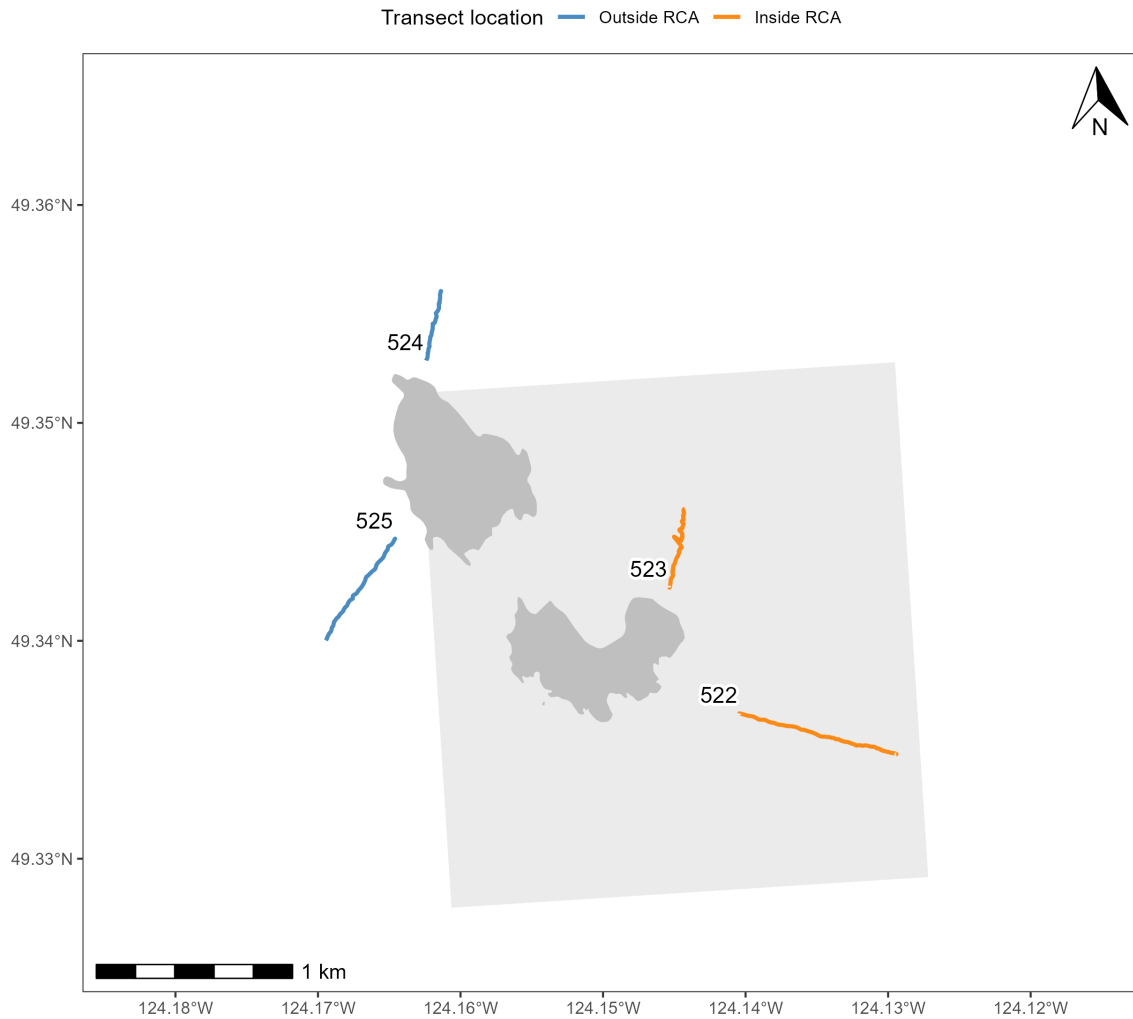


Figure A.1. Locations of ROV transects inside and outside Ballenas Island RCA.

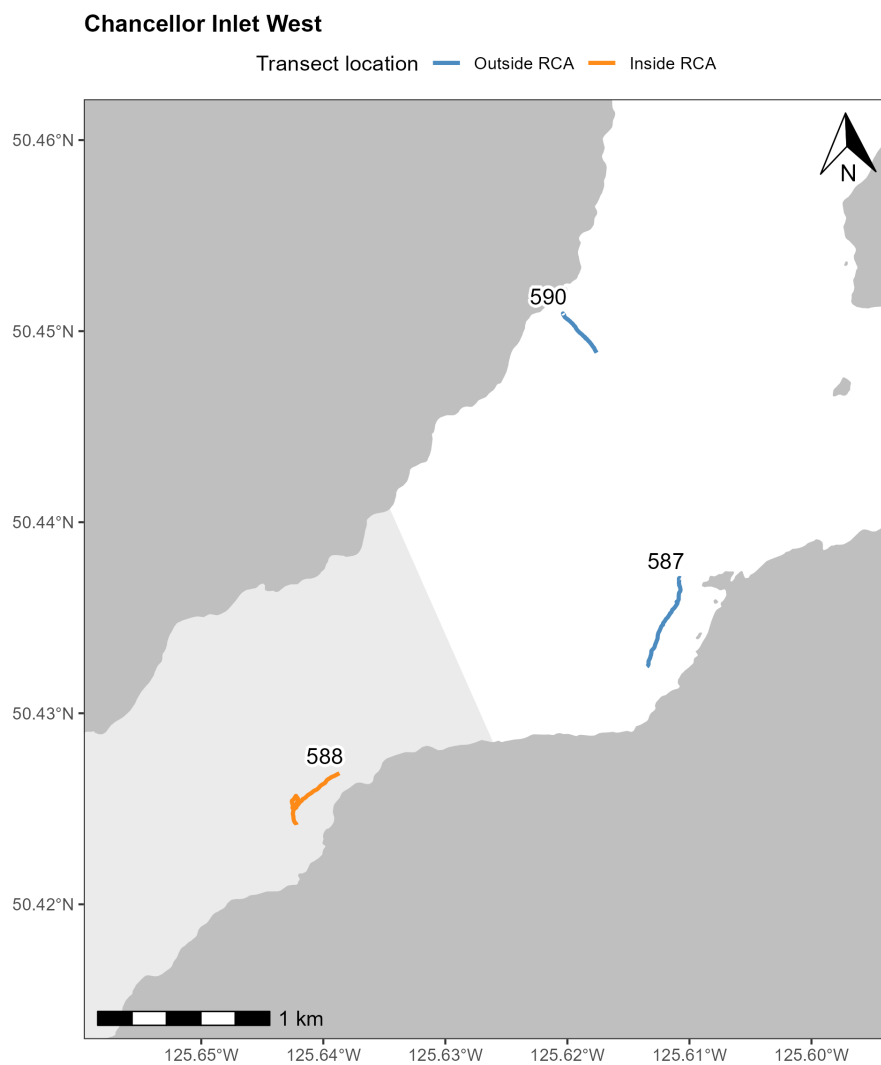


Figure A.2. Locations of ROV transects inside and outside Chancellor Inlet West RCA.

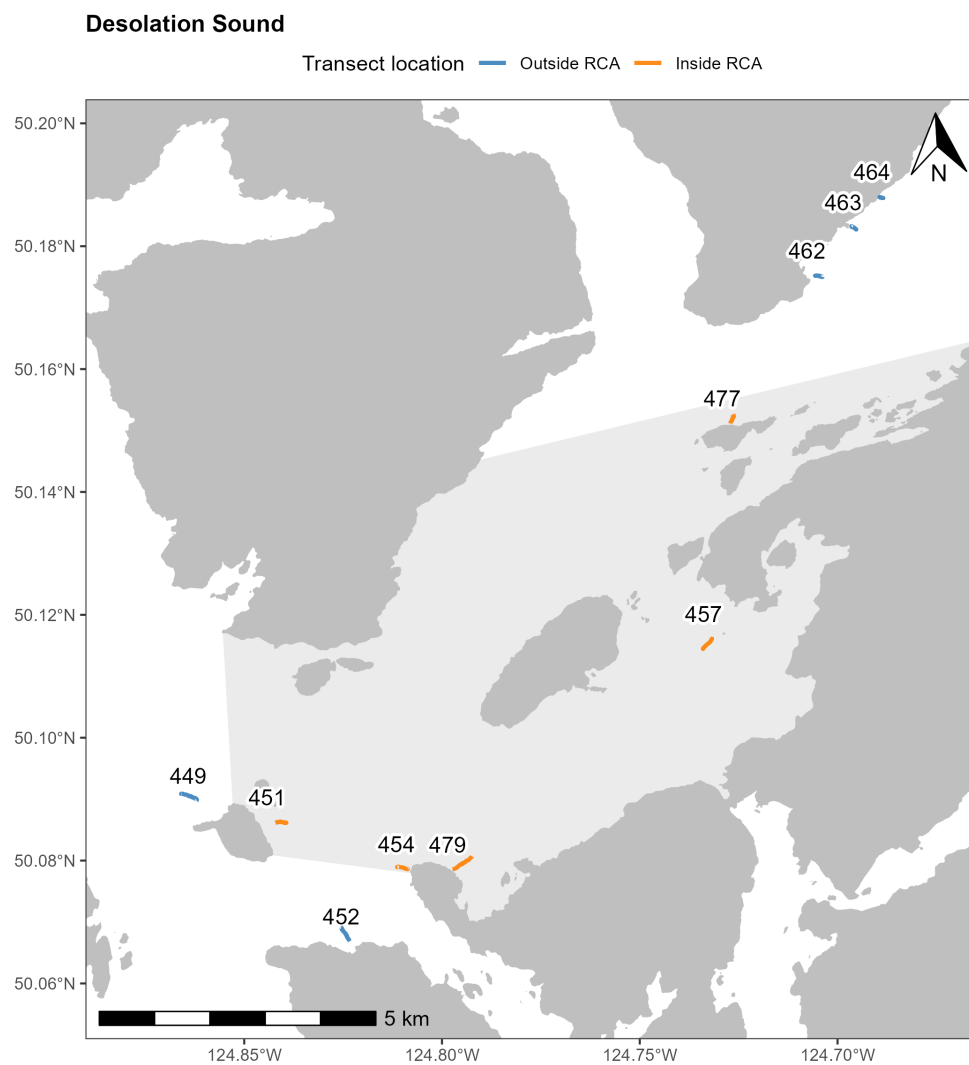


Figure A.3. Locations of ROV transects inside and outside Desolation Sound RCA.

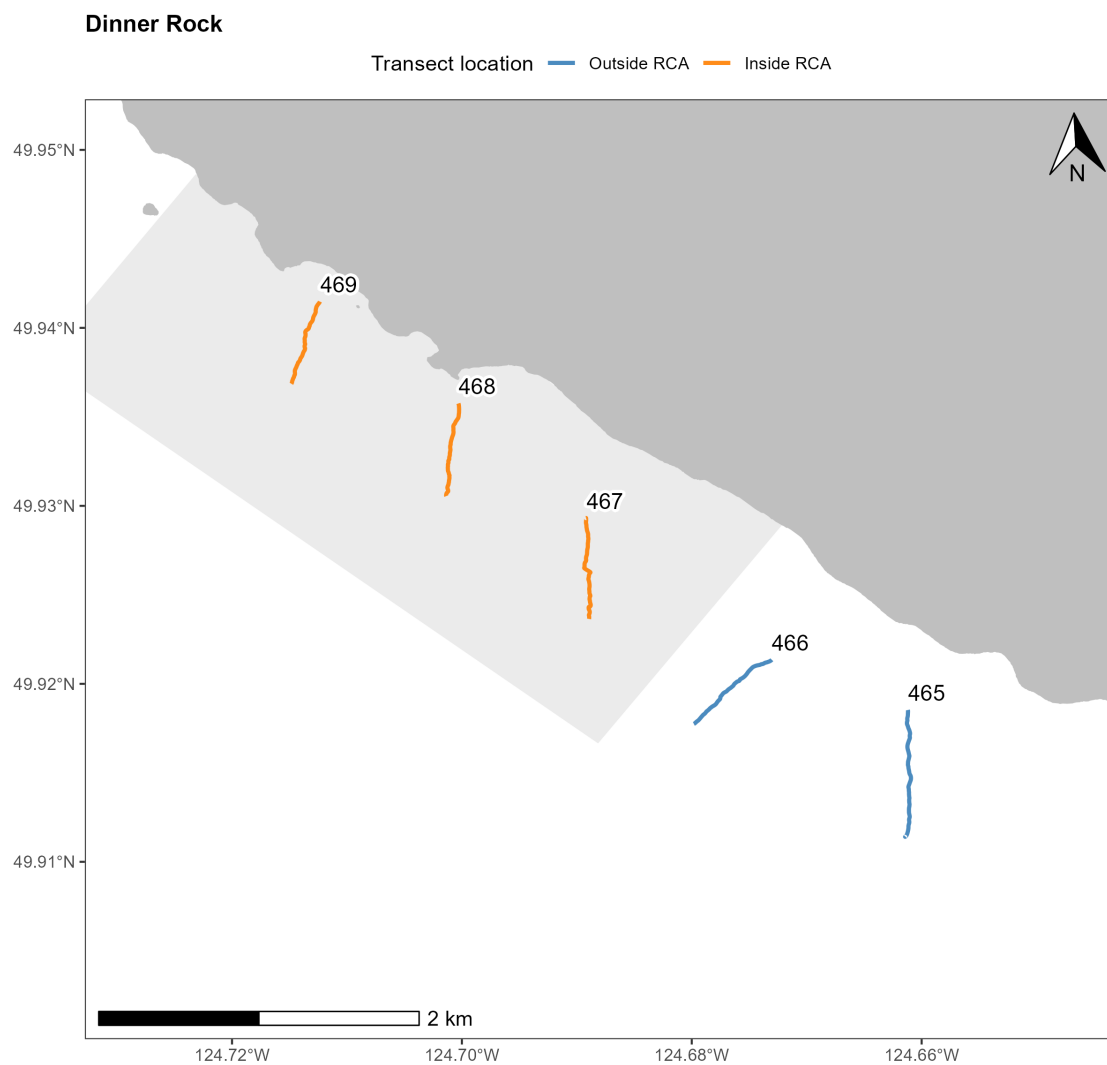


Figure A.4. Locations of ROV transects inside and outside Dinner Rock RCA.

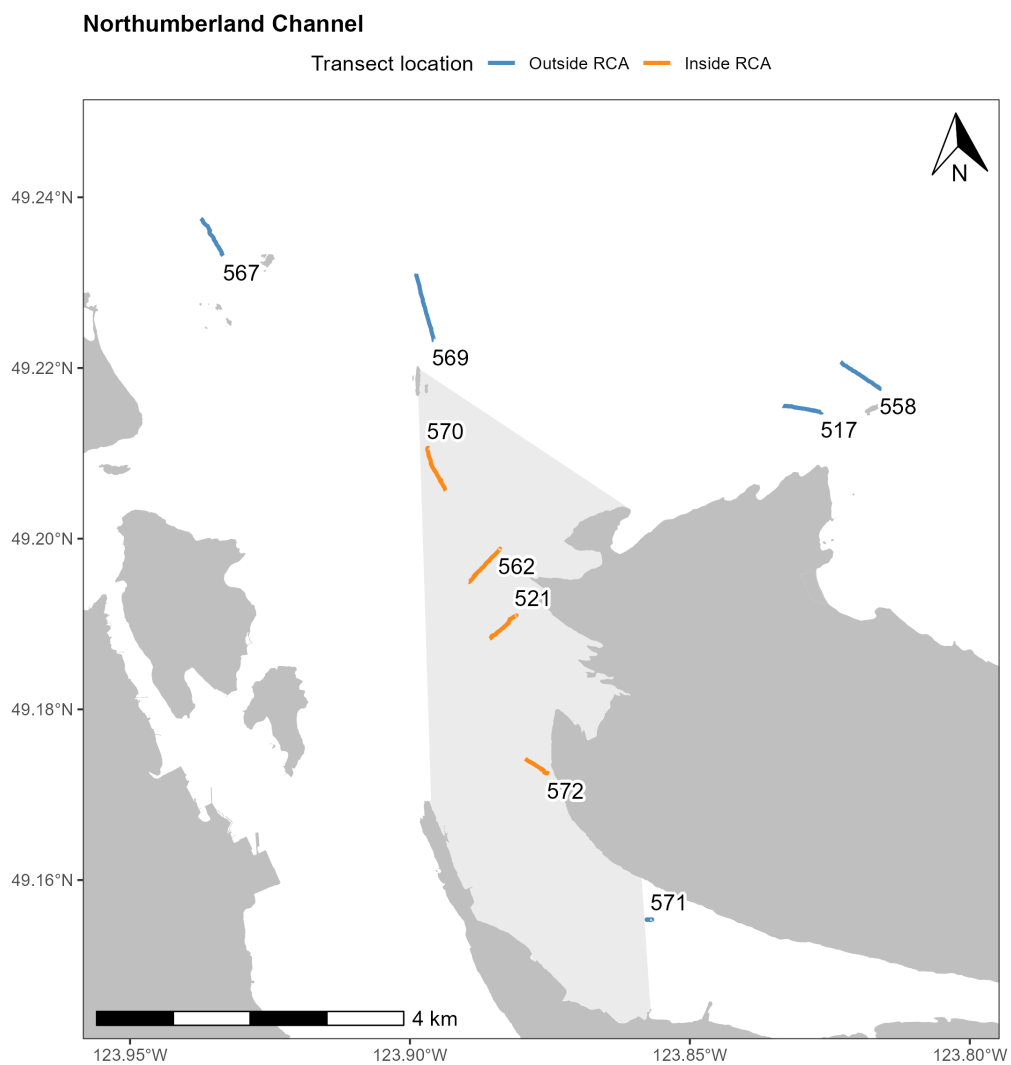


Figure A.5. Locations of ROV transects inside and outside Northumberland Channel RCA.

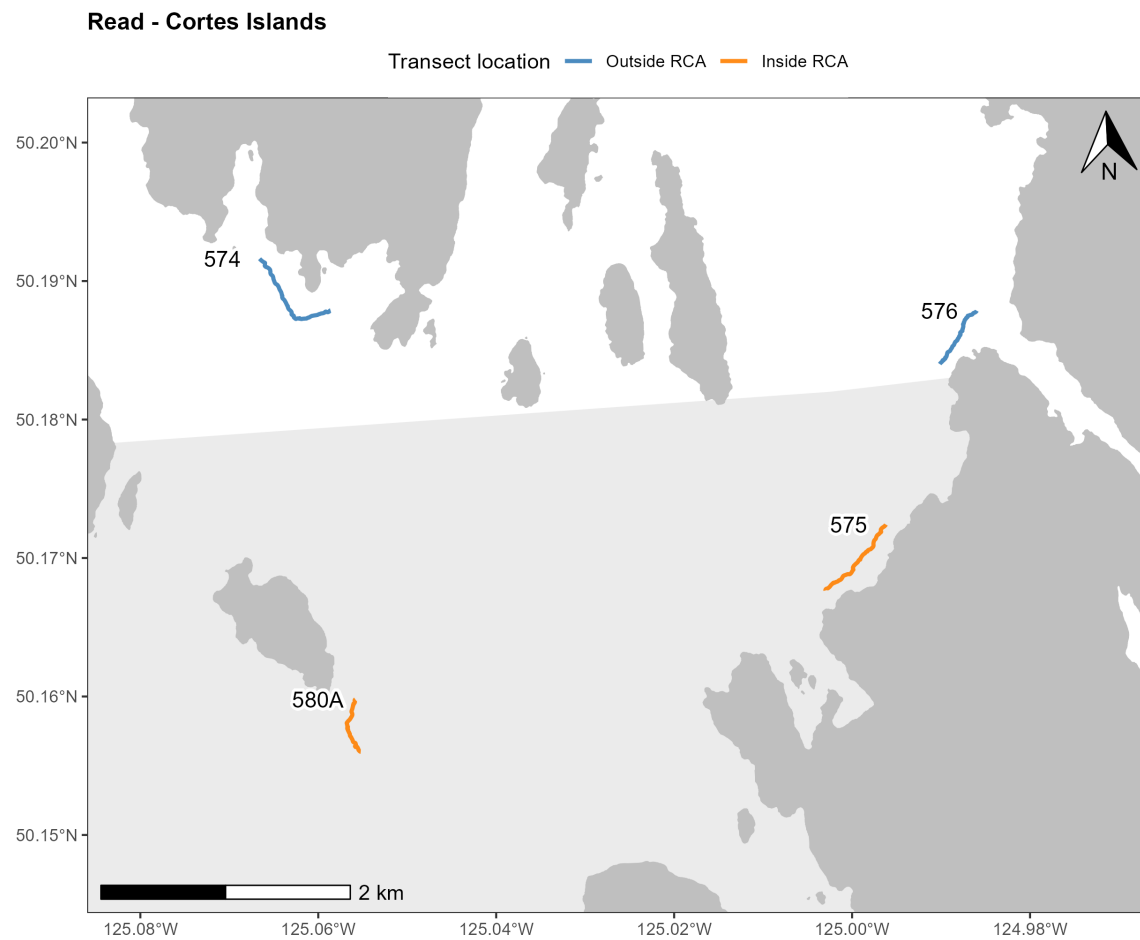


Figure A.6. Locations of ROV transects inside and outside Read / Cortes Islands RCA.

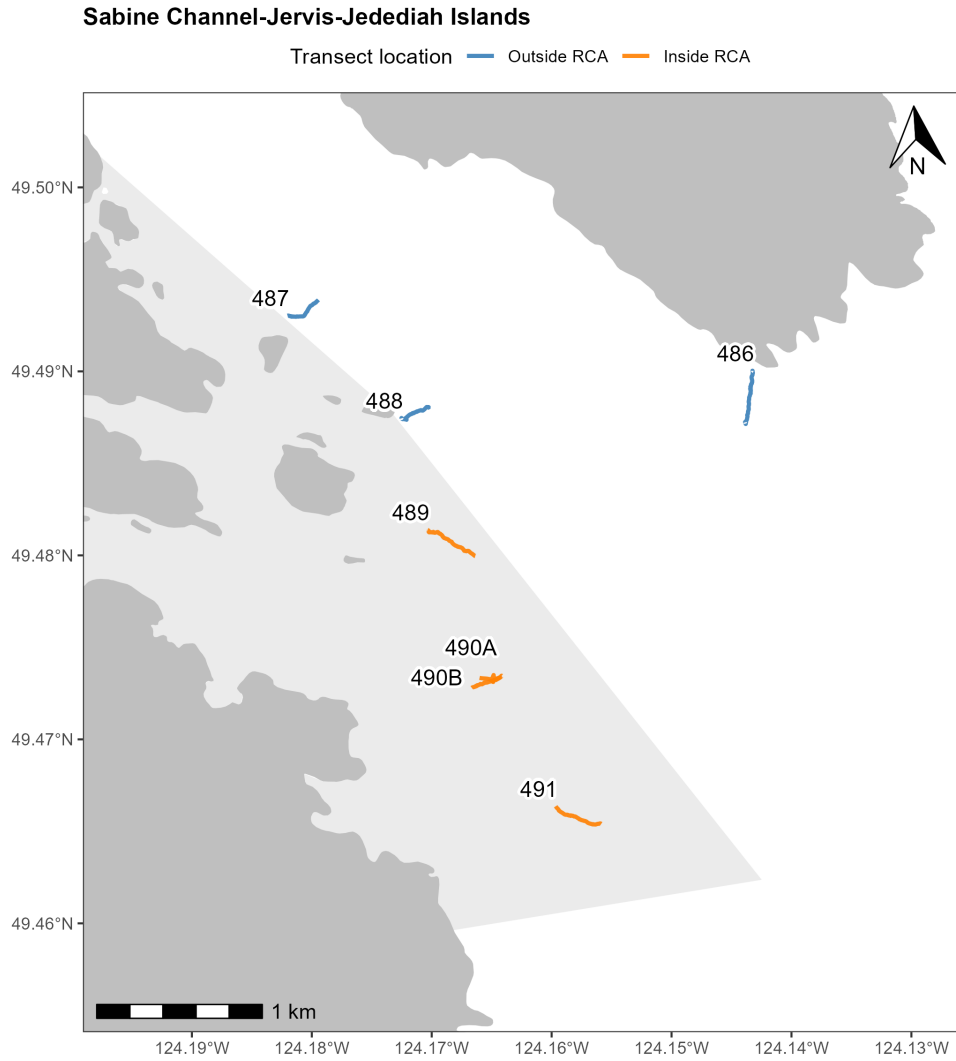


Figure A.7. Locations of ROV transects inside and outside Sabine Channel / Jervis Jedediah Islands RCA.

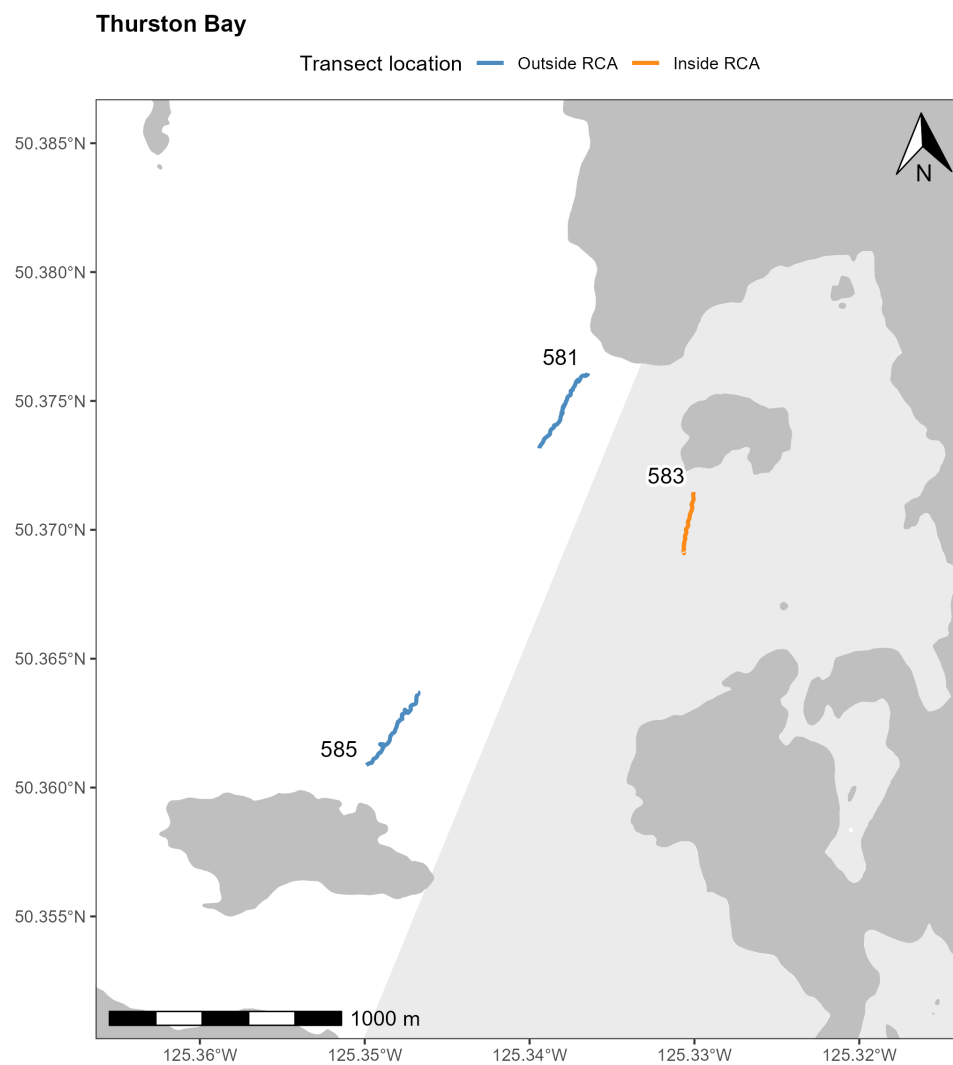


Figure A.8. Locations of ROV transects inside and outside Thurston Bay RCA.