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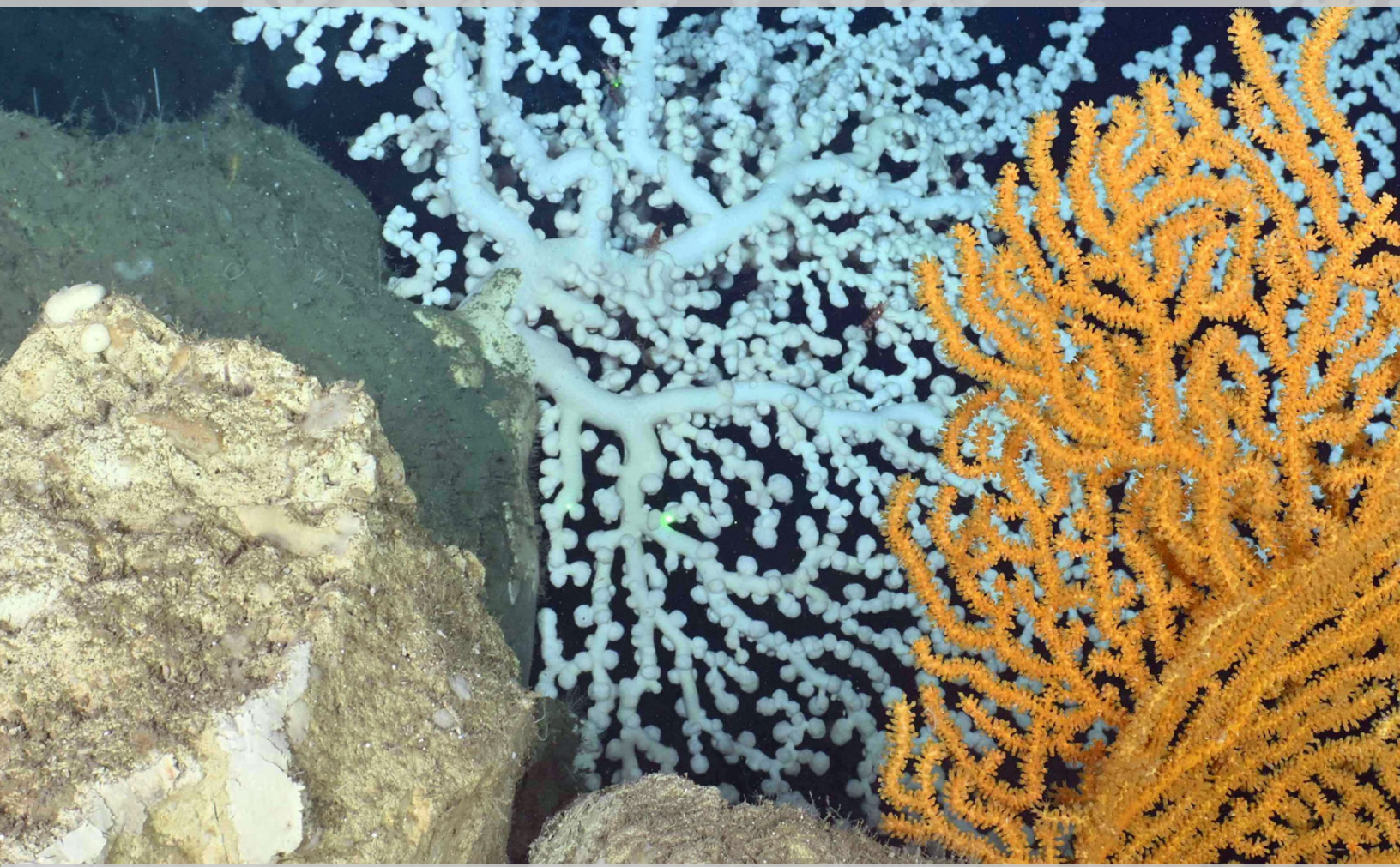

U.S. Department of Commerce • National Oceanic and Atmospheric Administration • National Marine Fisheries Service

Observations and Preliminary Findings from the United States/Canada Transboundary Cruise to the Northwestern Atlantic Canyons and Gulf of Maine (CROCHET; HB-24-05)

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ABSTRACT

The **Cro**ss Border **C**oral **H**abitat **E**xplora**t**ion (CROCHET) mission, the fourth highly successful transnational collaboration between the United States and Canada, was designed to increase understanding of deep-sea coral habitats as well as species' distributions, abundances, diversity and habitat use on both sides of the border. From 18–31 July 2024, a team of international scientists investigated deep-sea coral habitats using the Canadian Remotely Operated Vehicle (ROV) *ROPOS* aboard NOAA Ship *Henry Bigelow*. Survey sites included submarine canyons, marine protected areas, and the Gulf of Maine. During 10 ROV dives, video footage and digital still images were taken; specimens were collected for taxonomy, isotopes, and genomic analyses. Water samples, collected at depth using Niskin bottles attached to the ROV and a CTD rosette deployed from the ship, were processed for eDNA analysis. Additionally, physiological experiments, image acquisition for photogrammetry, and multibeam mapping were conducted. Preliminary dive summaries are included. Observations and preliminary findings in both the canyons and the Gulf of Maine further demonstrate the importance of ongoing collaborative transboundary research and the need to protect these ecosystems.

INTRODUCTION

Managing marine resources effectively requires an understanding of the species and the ecosystem in which they live, regardless of international borders. Collaborative research and surveys on both sides of international boundaries are critical to understanding species' distributions, abundances, diversity, and habitat use. This is particularly true in the deep sea where highly productive and diverse ecosystems occur. For example, deep-sea coral habitats are biodiversity hotspots and provide habitat and other resources for a variety of economically, recreationally, and ecologically important species. However, critical data gaps exist for these ecosystems; basic information such as the location and extent of these habitats and life history information of the species are limited. Deep corals are fragile, long-lived, and slow growing, making them highly susceptible to disturbance. Thus, these ecosystems face increasing threats worldwide as ocean temperatures rise, fisheries expand into deeper waters, and interests in offshore wind and hydrocarbon exploration and development are exploiting deeper depths. This is especially true in the Gulf of Maine, which is among the fastest warming bodies of water in the world (https://doi.org/10.1029/2018EO109467) and an area of high interest for offshore wind siting.

The work proposed was designed to address these transboundary issues by focusing efforts on filling data gaps, groundtruthing newly collected multibeam data, and providing evidence-based scientific advice on the potential impacts to deep-coral habitats in the Northeast Region. An international team of scientists augmented existing datasets with additional sampling using ship-based multibeam sonar and a remotely operated vehicle (ROV) to develop a comprehensive baseline dataset and thorough characterization of the habitat in areas of potential conservation interest. Additionally, important follow-on work in previously designated protected areas was conducted to assess the effectiveness of fisheries closure areas on protecting deep-sea coral habitats. Over the past 10 years, Dr. Martha Nizinski (NOAA Fisheries, Office of Science and Technology, National Systematics Laboratory) and Dr. Anna Metaxas (Dalhousie University) have served as co-lead scientists on United States/Canada transboundary missions. Building on the success of prior collaborative cruises (2014, 2017, 2019), the science team collected multibeam data, video and still imagery, physical samples, and environmental data in areas of interest on both sides of the U.S./Canada marine border, also known as the Hague Line. Sites in the northern Gulf of Maine and Northeast Channel Coral Conservation Area (NECCCA) as well as submarine canyons, including some located in the Northeast Canyons and Seamounts Marine National Monument (NCSMNM) and the Corsair and Georges Canyons Conservation Area, were selected. These data will facilitate and support management decisions to ensure the protection of these habitats and their associated fauna and aid in the design of the proposed Canadian Marine Conservation Area (MCA) network in the Maritimes.

From 18–31 July 2024, a team of international scientists (Fig. 1; Table 1) set sail from Newport, Rhode Island aboard NOAA Ship *Henry Bigelow* to investigate/survey deep-sea coral habitats on both sides of the border using the Canadian ROV *ROPOS*. The Northeast Deep-Sea Coral U.S./Canada Transboundary mission, subsequently named **Cro**ss Border **C**oral **H**abitat **E**xplora**t**ion (CROCHET), sailed under the flag of Challenger 150. Challenger 150 is a global initiative that connects deep-sea scientists to facilitate regional collaborations, build capacity, increase sampling, and broaden the knowledge and understanding of deep-sea ecosystems (https://challenger150.world/). The team adopted the fundamental approach of this initiative and live-streamed ROV video footage on YouTube with accompanying commentary describing the deep-sea coral communities as well as providing in-depth explanations of particular organisms, geology, conservation, methodology, and technology. The link to the livestream was shared daily with interested stakeholders such as the home institutions of the science party, the Department of Fisheries and Oceans Canada (DFO), international networks of scientists (e.g., Challenger 150, DOSI, Jetson), individual artists, and members of the public who received the link via social media or mailing lists. Approximately 40 participants joined each day to watch the dives. Viewers could ask questions and receive answers using a designated email address. This type of outreach proved to be an effective way of sharing the experience with a larger audience. Additionally, the science leads sent daily highlights to interested stakeholders to share on their social media platforms (see Education and Outreach section).

OBJECTIVES

The overall objective of the CROCHET mission (HB-24-05) was to survey and investigate known and suspected deep-sea coral habitats off the northeastern coasts of the United States and Canada (Fig. 2). Specifically, this expedition sought to:

1. Conduct video surveys using the ROV *ROPOS*, with concurrent sampling of environmental parameters (i.e., depth, salinity, hydrography) to characterize benthic habitats and identify areas of coral presence.

2. Identify potential locations of conservation importance, particularly in the Gulf of Maine, for consideration as part of the MCA network in the Canadian Maritimes.

Figure 1. International team of scientists on board NOAA Ship *Henry Bigelow*. From left to right, standing: Maria Rakka, Robin Swanson, Barry Brake, Peter Lockhart, Daniel Gheorgheos, Dave Packer, Craig Brown, Matthew Poti, Javier Murillo-Perez, Elizabeth Shea, Keith Tamburri, and William Glatt. Kneeling: Meri Bilan, Anna Metaxas (Co-lead scientist), and Martha Nizinski (Chief Scientist).

Table 1. List of participants of the CROCHET expedition (HB-24-05) that surveyed deep-sea coral ecosystems in the northwestern Atlantic canyons and Gulf of Maine off the United States and Canada July 18–31, 2024.

Name	Role	Affiliation
Martha Nizinski	Chief Scientist, Cruise Organizer and *Bigelow* Liaison	NOAA-NMFS-OST-NSL, Washington, DC
Anna Metaxas	Co-lead Scientist and *ROPOS* Liaison	Dalhousie University
Dave Packer	eDNA sampling; Gulf of Maine expertise	NOAA-NMFS-NEFSC, Sandy Hook
Matthew Poti	GIS and mapping	NOAA-NOS, Silver Spring
Elizabeth Shea	Specimen processing, data curation, logging, photography	Delaware Museum of Nature and Science
Meri Bilan	Post-doctoral fellow, photogrammetry, data logging	Dalhousie University
Maria Rakka	Post-doctoral fellow, coral physiological experiments, data logging	Dalhousie University
Craig Brown	Opportunistic mapping and processing	Dalhousie University
Javier Murillo-Perez	DFO liaison, benthic ecology, data logging and photography	DFO Canada
Keith Tamburri	Operations Manager, ROV pilot	Canadian Scientific Submersible Facility
Barry Brake	Manager, IT and Navigation	Canadian Scientific Submersible Facility
William Glatt	Manager, Science & User Support, ROV pilot	Canadian Scientific Submersible Facility
Daniel Gheorgheos	Electronics Technician, *ROPOS*, ROV Pilot	Canadian Scientific Submersible Facility
Peter Lockhart	Manager, Mechanical Systems, ROV pilot	Canadian Scientific Submersible Facility
Robin Swanson	Electronics Technician, ROV pilot	Canadian Scientific Submersible Facility

3. Assess faunal diversity, abundances, and distributions.

4. Collect deep-sea corals, sponges, and associated fauna for taxonomic, genetic (e.g., genome skimming, phylogenetic, phylogeographic, and connectivity), and isotopic composition analyses.

5. Conduct physiological experiments to assess thermal tolerance on select species of deep-sea corals.

6. Assess the utility of photogrammetry in long-term monitoring of deep-sea corals in marine protected areas (MPAs).

7. Collect conductivity, temperature, and depth (CTD) data and water samples for eDNA analyses.

8. Groundtruth areas predicted to be coral hotspots based on data provided from habitat suitability models.

9. Conduct mapping operations in areas where multibeam data were missing or incomplete.

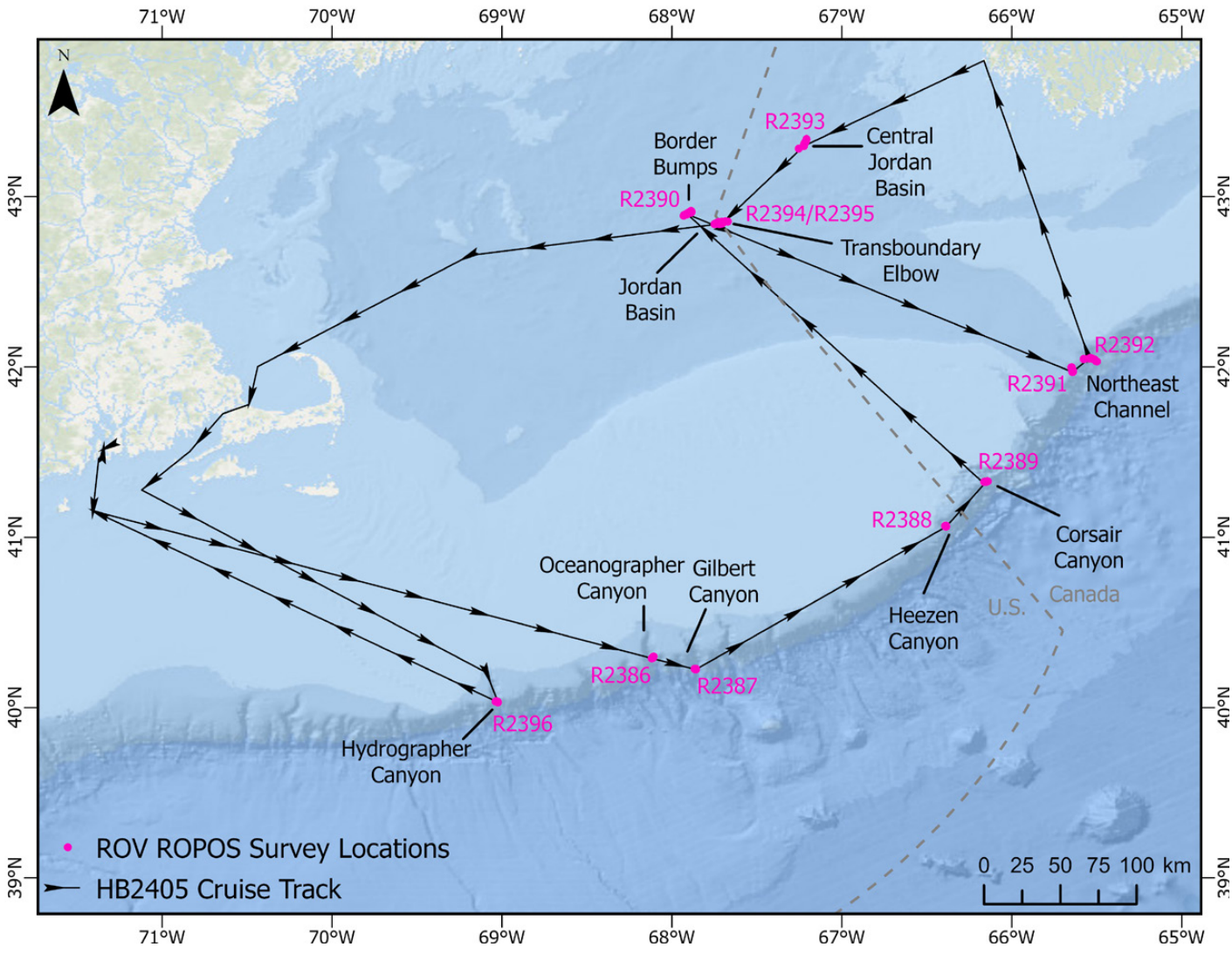

Figure 2. Overview map of the Northeast coast of the United States and Canada where cruise operations were conducted. Cruise track and sampling locations are highlighted.

EXPEDITION SCHEDULE AND METHODOLOGY

Following the standard protocol of previous transboundary missions, the number of days at sea were divided equally between the U.S. and Canadian science teams, with one dive designated as transboundary, where the dive begins in Canadian waters, crosses the border, and continues on in U.S. waters (Table 2). Prior to sailing, priority areas were selected on both sides of the border. Specific dive locations were refined and finalized while at sea based on cruise objectives, data gleaned from multibeam surveys and species distribution models, as well as input from primary stakeholders. Transects, with multiple waypoints, designed to last approximately 8 hours, were constructed using Fleidermaus and ArcGIS. Dive plans were distributed to the ship and the ROV and science teams 12 hours prior to the dive. The dive was narrated in real time for the YouTube audience while simultaneously annotated in the ROV data-logging system. Immediately after ROV recovery, specimens and water samples were retrieved from the ROV and processed.

Table 2. Expedition schedule for CROCHET (HB-24-05) that surveyed deep-sea coral ecosystems in the northwestern Atlantic canyons and the Gulf of Maine in both U.S. and Canadian waters.

Date (Local)	Country	Operations
7/15-16/2024	USA	ROV *ROPOS* arrives at Naval Station Newport for mobilization/setup on NOAA Ship *Henry B. Bigelow*. Open house on ship (16 July 24)
7/17/2024	USA	Science meeting. Departure delayed 4 hours, then rescheduled for 18 July at 1000; *ROPOS* completes dunk test at dock.
7/18/2024	USA	Depart at 1000 for Oceanographer Canyon.
7/19/2024	USA	Oceanographer Canyon: 1 livestreamed ROV dive (R2386), bio sampling, 2 CTD casts, eDNA, multibeam mapping overnight, social media. Begin physiological experiments.
7/20/2024	USA	Gilbert Canyon: 1 livestreamed ROV dive (R2387), bio sampling, 1 CTD cast, eDNA, social media.
7/21/2024	USA	Heezen Canyon: 1 livestreamed ROV dive (R2388), bio sampling, 2 CTD casts, eDNA, social media, multibeam mapping overnight (small part of Corsair Canyon).
7/22/2024	Canada	Corsair Canyon: 1 livestreamed ROV dive (R2389), bio sampling, 1 CTD cast, eDNA, social media. Transit to recently mapped Gulf of Maine, South of Jordan Basin.
7/23/2024	USA	Gulf of Maine "Border Bumps": 1 livestreamed ROV dive (R2390), bio sampling, 1 CTD cast, eDNA, social media. Transit to Northeast Channel.
7/24/2024	Canada	Northeast Channel: 1 livestreamed ROV dive (R2391), NO BIO SAMPLING, 2 CTD casts, eDNA, social media, multibeam mapping in NE Channel overnight. Begin photogrammetry experiments.
7/25/2024	Canada	Northeast Channel: 1 livestreamed ROV dive (R2392), bio sampling, 2 CTD casts, eDNA, social media, real media (Metaxas). No multibeaming due to emergency medical trip to Yarmouth, Canada.
7/26/2024	Canada	Transit to next dive site, multibeam surveys of areas near the U.S.-Canada border.
7/27/2024	Canada	Central Jordan Basin: 1 livestreamed ROV dive (R2393), bio sampling, 2 CTD cast, eDNA, social media, multibeam survey near next dive site.
7/28/2024	USA, Canada	Transboundary Elbow (TBE): multibeam survey of dive site, 2 livestreamed ROV dives (#1 - R2394 and #2 - R2395), bio sampling, 2 CTD casts, eDNA, social media.
7/29/2024	USA	Transit to Hydrographer Canyon through Cape Cod Canal: 1 CTD cast, multibeam survey, social media.
7/30/2024	USA	Hydrographer Canyon: 1 livestreamed ROV dive (R2393), bio sampling, 2 CTD casts, eDNA, social media. Submit import documentation to U.S. Fish and Wildlife Service.
7/31/2024	USA	Arrive at Naval Station Newport at 0800. Demobilization begins. *ROPOS*, samples, and other equipment removed from ship; science staff departs.
8/1/2024	USA	Demobilization continues; science staff departs.
8/2/2024	USA	Remaining science and *ROPOS* personnel depart.

ROV DIVES

The principal objectives for the ROV survey involved characterization of spatial patterns in benthic ecosystem structure with particular emphasis on deep-sea coral habitats and the discovery of new locations highly suitable for protection. Sampling included (1) video transects; (2) digital still photographs; (3) collection of fragments of coral colonies for taxonomic, isotopic, and genetic (phylogenetic, population connectivity, total genome) analyses as well as physiological experiments; (4) collection of coral-associated fauna for taxonomic, isotopic, and genetic (phylogenetic, population connectivity, population genetics) analyses; (5) collection of benthic organisms not readily identifiable on video footage for morphological or molecular identification; and (6) collection of water samples for eDNA analyses.

Science personnel on board the ship directed the dive from two remote command centers. The science team was located in the acoustics laboratory of the *Henry Bigelow*, while the *ROPOS* engineering crew was in a custom container designed specifically for *ROPOS* operations. The active science team consisted of three people. The lead scientist was the narrator and directed the *ROPOS* exploration and sampling. A second scientist served as the data logger and was responsible for annotating the dive in the ROV database Integrated Real-time Logging System (IRLS). Annotations included general comments about the type and density of organisms encountered, the appearance and composition of the substrate, and overall habitat complexity along the dive track. The logger also monitored which sample chambers in the ROV sample boxes (BioBoxes) were open and available for new collections, and annotated sampling activities as well as the high-resolution photography as it was received by the IRLS. A third scientist was responsible for positioning the camera and taking high-resolution digital photographs (DSCs) of important organisms, especially at the time samples were collected. Together, the science team also provided preliminary identifications of deep-sea corals, sponges, and other benthic organisms to the lowest possible taxon. Coral/sponge location data and associated habitat data (e.g., CTD, dissolved oxygen, substrate type) will be geo-referenced and mapped. In-depth video and image analyses, quality assessment and quality control of coral identifications and habitat characterization will occur on shore at both U.S. and Canadian laboratories.

SAMPLING

Specimen Collections

Biological samples were collected during every dive, with the exception of Northeast Channel 1, which was dedicated to resurveying a transect after 10 years with a no-stop protocol. Throughout a dive, scientists determined which specimen collections were necessary to meet cruise objectives including taxonomic, isotopic, and genetic analyses, and physiological experiments. Sample collection started with a request from the science team to the ROV pilots. Once the appropriate specimen was determined, a high-resolution digital still image was taken of the organism *in situ* before collection. A small portion of a coral branch, small piece of sponge, or whole specimens of other invertebrates (e.g., crabs, shrimp, sea stars, etc.) was collected using the manipulator arm or suction sampler on the ROV and then placed in a labeled BioBox (Fig. 3). The collection event was logged into the IRLS, which linked the metadata (date, time, latitude, longitude, depth, salinity, temperature) to each collected specimen, and with the location in the ROV BioBox. Once the ROV arrived on deck, the science team quickly re-

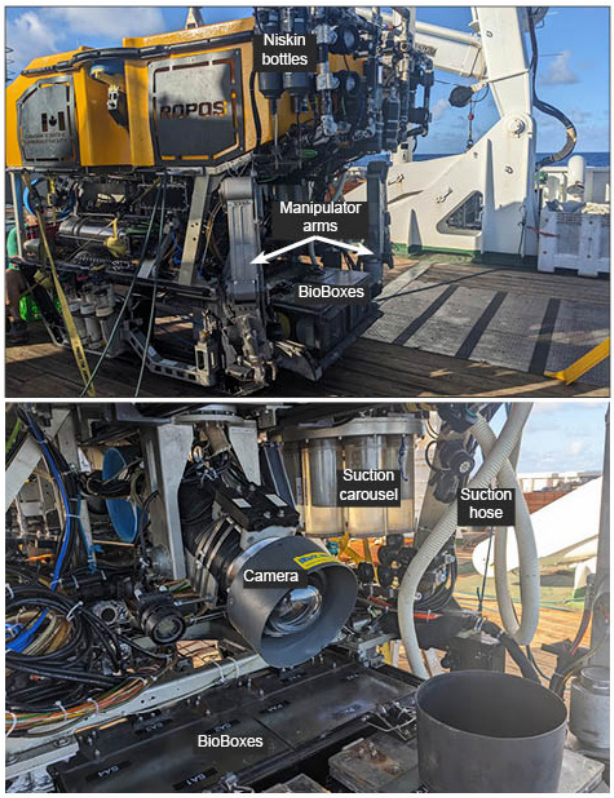

Figure 3. Image of the ROV *ROPOS*. A) Lateral view of the vehicle to show the sampling devices (Niskin bottles and manipulator arms) used during the surveys. Collected specimens were deposited in the BioBoxes. B) Close-up of the main camera, BioBoxes, suction hose, and sample carousel.

moved specimens from each BioBox and placed them into corresponding pre-labeled buckets of cold seawater, which were then stored in a cold room until samples could be further processed. Coral fragments collected for physiological experiments were processed following experimental protocols (see below). For all other samples, buckets were processed one at a time in the wet laboratory. All organisms were extracted from the bucket with each organism considered a separate sample. Each sample was examined for commensal organisms, subsampled for genomics and isotopes, labeled, and photographed. Once photographed and labeled, specimens were preserved in cold, non-denatured, 95 percent ethanol.

Physical samples collected for taxonomy, isotopes, and genetics were dispersed to collaborators, with vouchers deposited in the collections housed at the Smithsonian Institution National Museum of Natural History collections.

CTD Casts and Water Collection

A CTD rosette comprising twelve 10-liter Niskin bottles was deployed each day prior to the ROV deployment. The CTD was lowered at a speed of 10 meters per second to the desired depth. The bottles were triggered 5 meters above the bottom. Three bottles were used for eDNA analysis (see below); the remaining water was used to maintain live corals and support the physiological experiment protocol. A second CTD cast was made prior to beginning multibeam operations to acquire sound velocity profiles of the water column. Water collected on these casts was used to maintain live corals included in the physiological experiments.

Physiological Experiments

Physiological experiments were designed and conducted to study the thermal tolerance of two coral species, *Paragorgia arborea* and *Primnoa resedaeformis*, which are both common to the study area. The experimental setup included four water baths, each equipped with an aquarium controller connected to aquaria heaters and chillers to maintain temperatures at 2, 5, 8 and 12 °C. The water baths were maintained in a dark, thermoregulated room at a temperature between 2 and 5 °C. Each water bath, designed to support nine 1-liter coral chambers (Fig. 4A), was equipped with a 3-liter reservoir filled with seawater to facilitate water changes. Air bubbling provided water circulation in these chambers. Throughout the experiment, corals were maintained in seawater collected by a CTD rosette at depths close to those of coral collection (600–1200 meters).

Colony fragments of *P. arborea* were collected in Oceanographer Canyon and those of *P. resedaeformis* in Heezen Canyon between 700–900 meters depth. Upon arrival onboard, 4–5 smaller nubbins (length 8–10 centimeters) were dissected from each coral colony and then mounted on ceramic bases with epoxy (Fig. 4B). Nubbins were maintained in a 70-liter container at 5 °C for 24 hours to allow them to recover from

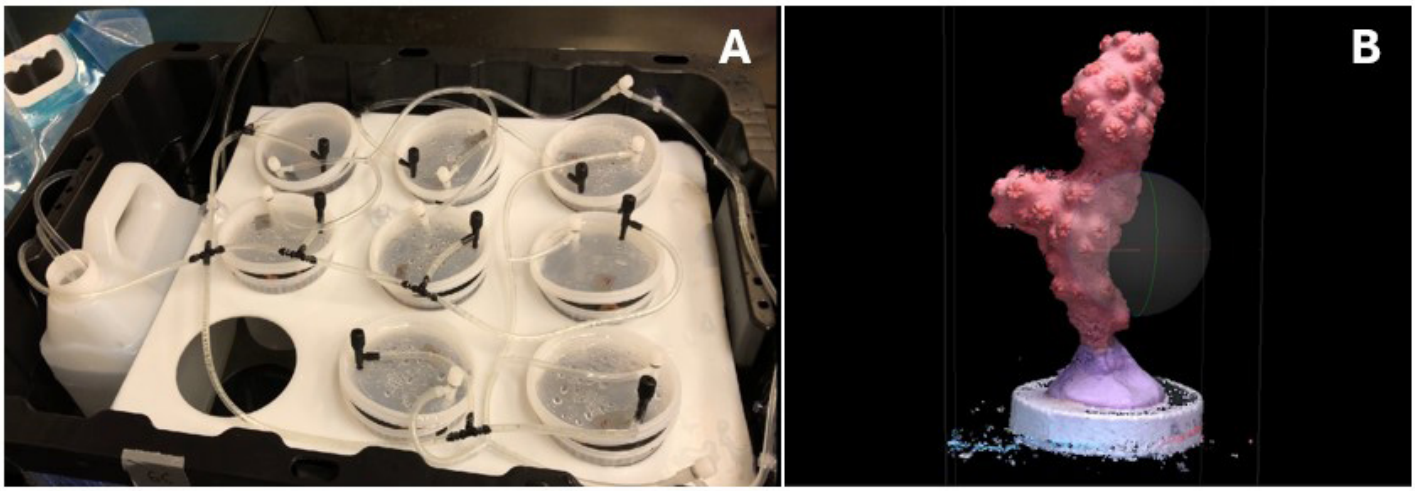

Figure 4. Physiological experiments. A) Experimental water bath, with positions for nine 1-liter chambers connected to an air pump, and a 3-liter sump where seawater was stored for water changes. B) Picture of a 3D model constructed from images of a coral nubbin of the species *Paragorgia arborea*.

collection and fragmentation. Subsequently, coral nubbins were distributed to the experimental water baths. Temperature was slowly adjusted to the respective target temperature by increasing/decreasing it by 2 °C every 6 hours. Corals were maintained at the target temperatures for another 48 hours. During this period, the survival and polyp activity of all coral nubbins were monitored every 6 hours. Water changes were also performed every 6 hours, by adding 250 milliliters of seawater to each experimental flask. At the end of the experiment, closed-cell incubations were performed to measure oxygen consumption, which was used as a proxy of metabolic rate. Additionally, 3-dimensional (3D) models of each coral nubbin will be used to measure tissue loss (Fig. 4B).

Photogrammetry

During the CROCHET cruise, video data were successfully acquired to achieve the objectives set for applying a photogrammetry approach to monitoring deep-sea corals. Two dives, conducted at previously surveyed sites within the Northeast Channel Coral Conservation Area (NECCCA), were dedicated to these objectives.

The first priority was to revisit "the rock," a coral-covered boulder located in an area otherwise barren of hard substrate, to assess changes in coral growth. Video data were collected while the ROV slowly circled around the boulder with the lasers focused primarily on the corals *Paragorgia arborea* and *Primnoa resedaeformis*. Future work includes building a 3D model from data collected on this cruise and comparing it to the model created in 2014 to assess changes in the size of coral colonies and obtain growth rate estimates. Additionally, geometric morphometrics will be used to quantify the change in the shape of the coral colonies over time.

Additionally, video transects were conducted at other locations to assess and monitor the abundance and size of *P. arborea* and *P. resedaeformis* by means of photogrammetry. Three sites, Site 1, Site 2, and Site X, within the NECCCA were surveyed. Ten transects, each 100 meters long and separated by 10 meters were conducted at each site. Future work includes building 3D models for each transect and measuring the size, orientation, and angle of growth of selected coral colonies.

eDNA

Water samples for eDNA analysis were collected at depth using Niskin bottles. Prior to each dive, a CTD rosette equipped with twelve 10-liter bottles was deployed from the ship (see above). Two liters of water, from each of three randomly chosen bottles, was decanted into disposable whirl packs. These samples, taken near the beginning of the transect, were designed to represent a baseline sample for comparison to those samples taken near deep-sea coral assemblages. Additional water samples were collected by the ROV during the dive in high-density coral areas. The ROV was equipped with two sets of two Niskin bottles. Starboard- and port-side Niskin bottles were fired in two distinct, distant locations. Locations were selected based on coral abundance and diversity, loosely based on coral assemblages that were representative of those observed during the dive.

A clean workplace was assembled away from all other sampling to eliminate any cross-contamination. Using a vacuum pump, water was filtered through a 1-micrometer filter. Care was taken to keep the equipment, hands, and instruments clean during processing. After filtering, each filter was placed in a labeled falcon tube and stored in a -20 °C freezer. All samples were transported on dry ice to the Northeast Fisheries Science Center Milford Laboratory for processing.

Multibeam Surveys

Multibeam sonar (MBES) data were collected at six survey locations (Fig. 5) during the research mission: 1) Hydrographer Canyon; 2) Oceanographer Canyon; 3) Corsair Canyon; 4) Northeast Channel; 5) Transboundary area in U.S. waters at the U.S./Canada border; and 6) Jordan Basin (Canadian waters). Additionally, MBES data were acquired on all transits between survey locations.

Surveys were conducted using the hull-mounted EM2040 Mk2 MBES and integrated IMU/GPS system aboard the *Henry Bigelow*. At each survey location prior to data acquisition, a CTD cast was conducted to provide a sound velocity profile for sound speed corrections. MBES data were collected using the onboard Kongsberg Seafloor Information Systems acquisition software (SIS 5), along predetermined survey lines spaced to provide 25–50 percent overlap between lines. The MBES system was operated at 200 kilohertz and data collection was therefore limited to water depths <500 meters.

Following data acquisition, preliminary analysis of bathymetry and backscatter data were conducted aboard the vessel to facilitate ROV dive planning. Bathymetry data were processed using the QPS QIMERA (v2.5.3) software package. The Kongsberg *.all files were loaded for each survey location and processed to generate a preliminary bathymetric digital elevation surface, which was subsequently exported as an ASCII grid for import into ArcGIS. Backscatter data were processed using QPS FMGT (v7.10.2) to generate a

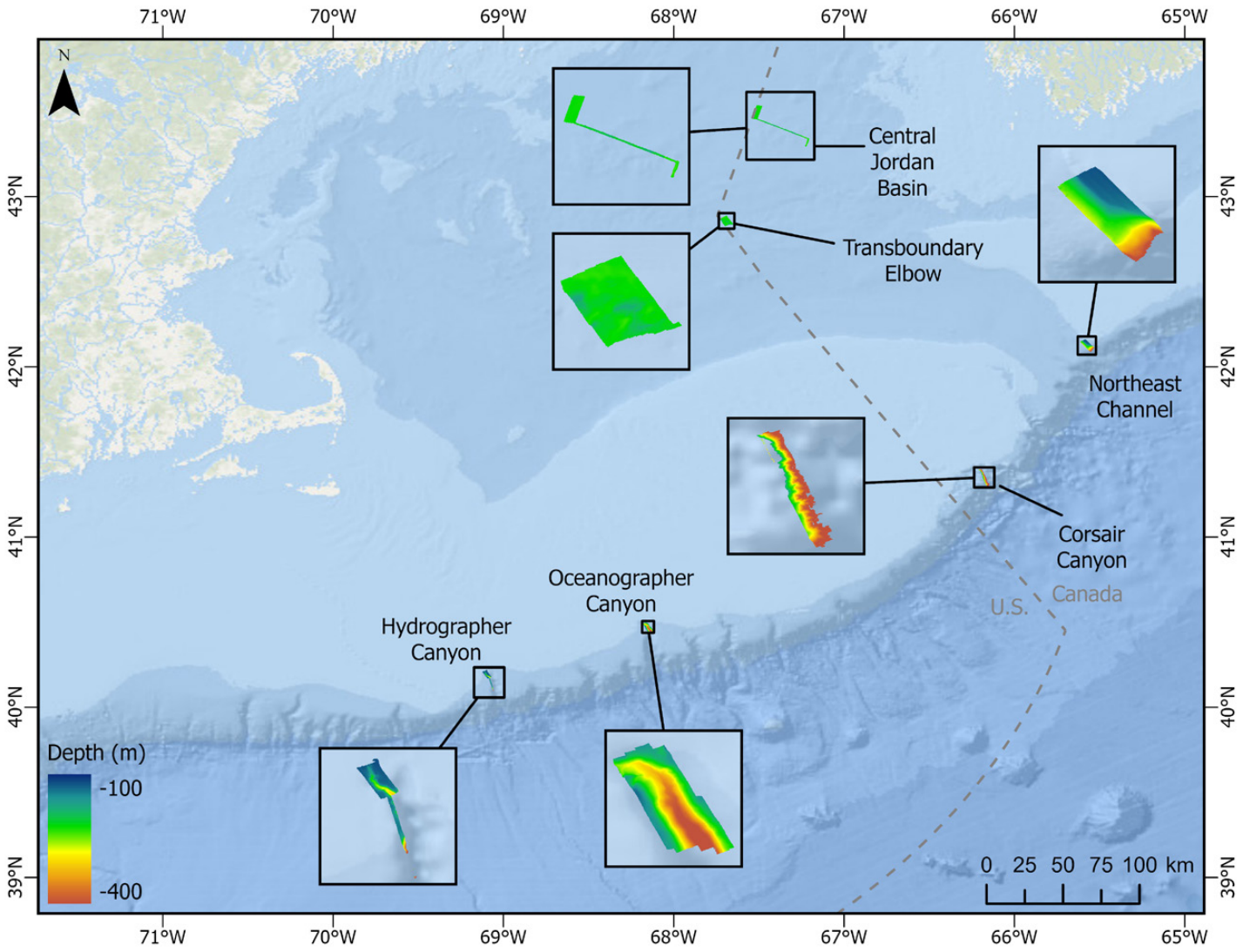

Figure 5. Map showing the location of multibeam surveys. The area surveyed is enlarged to show detailed bathymetry.

corrected backscatter mosaic. Each mosaic was then exported as an ASCII grid for import into ArcGIS to facilitate subsequent survey planning. All bathymetry and backscatter data require further processing and data cleaning.

EDUCATION AND OUTREACH

Live Streaming

The HB-24-05 *ROPOS* dives were livestreamed on YouTube, and approximately 40 participants interacted with scientists on board during the weekdays and about 15 on the weekends. The Delaware Museum of Nature and Science (DelMNS) had the dives running live in the Research Headquarters section of their gallery, with accompanying staff interpretation for visitors.

Social Media

At the conclusion of each day, a short dive summary plus captioned photographs were sent to the communications departments of all collaborating institutions. The DelMNS posted these summaries to Instagram each night and created a website containing all updates. Additionally, DOSI/Challenger150 published the daily highlights on Facebook (2.5K members) and Instagram (6.3K followers). The East-

ern Seaboard (ESB) Thematic Collections Network used an image of *Bathypolypus bairdii* observed during the cruise for their Mollusk of the Month post (Shea). ESB has 1.1K members on Facebook and 320 followers on Instagram. After the cruise ended, NOAA Fisheries posted a summary to social media, including Instagram (107K followers).

Earned Media

The Dalhousie News ran a story on the transnational nature of the cruise (Metaxas), and during the cruise, CBC Main Street conducted a live interview (Metaxas).

Invited Speakers

Cruise participants were invited to give public lectures about the mission and/or their research at a number of locations including the National Museum of Natural History (Nizinski), the Bailey Matthews National Shell Museum and Aquarium (Shea), retirement communities in Delaware and Virginia (Shea and Nizinski), and Kingsmill Yacht Club in Virginia (Shea). Additionally, a cruise summary was presented at Wilmington NerdNite (Shea).

Finally, this cruise was highlighted in a panel celebrating the eighth anniversary of the designation of the NCSMNM that includes Oceanographer and Gilbert canyons (Nizinski).

Web Presence

This mission is featured on a variety of websites:

Delaware Museum of Nature and Science, Science at Sea: delmns.org/science-at-sea

Challenger 150: https://challenger150.world/crochet-cross-border-coral-habitat-exploration/

Deep Sea Life: https://www.dosi-project.org/wp-content/uploads/DSL23_final_small_1.pdf

Dalhousie News: (https://www.dal.ca/news/2024/07/26/coral-cam-captures-coastal-conservation-for-the-curious.html?utm_source=dalnewsWeekly&utm_medium=email&utm_content=595&utm_campaign=dalnewsWeekly)

The Northeast Canyons and Seamounts Marine National Monument anniversary celebration: https://www.youtube.com/watch?v=cFKgbCpUsQQ

RESULTS

ROV Surveys (Table 3)

Ten ROV dives were conducted during the mission, yielding a total bottom time of approximately 92 hours and a linear distance surveyed of approximately 81 kilometers. Depth ranged from 169–1738 meters over the course of the mission.

Specimen Collections (Tables 4 and 5)

A total of 258 biological specimens were collected during the expedition for taxonomy, isotopic, and genetic analyses (Table 4). Specimens collected included corals, sponges, crustaceans, mollusks, echinoderms, polychaetes, bryozoans, brachiopods, anemones, hydroids, forams, nemertean, and zoanthids. Samples were deposited at the Smithsonian Institution National Museum of Natural History. A total of 191 lots were added to the Invertebrate Zoology collection (Table 5).

CTD Casts (Table 6)

Sixteen CTD casts were conducted during the expedition. Ten of these casts provided water samples for eDNA analysis. The remaining six casts, conducted prior to multibeam mapping surveys, provided sound velocity profiles of the water column to improve the accuracy of bathymetry measurements. Maximum depths ranged from 201–1776 m. Thirty water samples collected during the CTD casts were filtered for eDNA analysis.

eDNA Collections (Table 7)

A total of 66 eDNA samples were collected during the expedition. Thirty-six samples were taken at depth via Niskin bottles attached to the ROV. Port and starboard-side Niskin bottles, two on each side, were fired in areas of high coral density, yielding two replicates at each location (n = 36). No samples were taken on dive R2395 (U.S. side of the Transboundary Elbow dive). An additional 30 samples (3 replicates from each of 10 CTD casts deployed at the beginning of each transect), representing background conditions, were taken for comparison and to provide context for samples taken at depth.

Mapping Surveys

An area equivalent to 141 square kilometers was mapped during the expedition to fill in data gaps and continue to build a more complete multibeam coverage in the region (Fig. 5). Swaths were collected in Jordan Basin, Gulf of Maine, Northeast Channel, and heads of Hydrographer, Oceanographer, and Corsair canyons.

Table 3. Summary information for the ROV *ROPOS* dives conducted during the CROCHET expedition (HB-24-05) to the northwestern Atlantic canyons and Gulf of Maine. Dive data provided by the *ROPOS* Integrated Real-Time Logging System (IRLS).

		On Bottom[2]				Off Bottom[3]					
Date (Local EDT)	Dive[1]	Time (UTC)	Latitude	Longitude	Depth (m)	Time (UTC)	Latitude	Longitude	Depth (m)	Bottom time (h:min:sec)[4]	Samples Collected[5]
Oceanographer Canyon, USA											
19-Jul	R2386	14:39:09	N40° 17.0752′	W68° 6.9527′	1259.4	22:40:44	N40° 17.8758′	W68° 6.6971′	845.9	8:01:35	29
Gilbert Canyon, USA											
20-Jul	R2387	13:51:56	N40° 13.6009′	W67° 51.3852′	1738.5	22:11:35	N40° 13.5178′	W67° 51.6383′	1526.0	8:19:39	20
Heezen Canyon, USA											
21-Jul	R2388	13:01:20	N41° 3.7358′	W66° 23.1147′	950.3	22:54:51	N41° 4.2076′ [6]	W66° 23.8356′ [6]	638.56	9:53:31	28
Corsair Canyon, Canada											
22-Jul	R2389	12:56:14	N41° 19.7756′	W66° 8.5222′	906.8	23:09:10	N41° 19.7372′	W66° 9.6558′	461.9	10:12:56	19
Gulf of Maine, Border Bumps, USA											
23-Jul	R2390	12:22:48	N42° 54.882′	W67° 53.1342′	243.1	23:07	N42° 53.8412′	W67° 54.9296′	169.6	10:45:05	11
NE Channel #1, Canada											
24-Jul	R2391	13:01:55	N41° 59.8999′	W65° 39.0334′	431.4	23:06:41	N41° 58.5849′	W65° 38.3643′	859.6	10:04:46	2
NE Channel #2, Canada											
25-Jul	R2392	12:52:25	N42° 2.7871′	W65° 34.5632′	479.3	22:00:13	N42° 2.7039′	W65° 31.622′	771.9	9:07:48	17
Central Jordan Basin, Canada											
27-Jul	R2393	12:21:22	N43° 20.309′	W67° 12.4461′	223.3	23:10:31	N43° 18.8427′	W67° 12.9675′	211.7	10:49:09	33
Transboundary Elbow (TBE) #1, Canada											
28-Jul	R2394	12:28:23	N42° 51.1746′	W67° 40.482′	220.2	18:07:26	N42° 50.5719′	W67° 42.6318′	185.6	5:39:03	4
Transboundary Elbow (TBE) #2, USA											
28-Jul	R2395	19:45:17	N42° 50.4338′	W67° 43.148′	210.1	23:15:56	N42° 50.9289′	W67° 43.589′	188.1	3:30:39	2
Hydrographer Canyon, USA											
30-Jul	R2396	12:40:52	N40° 2.2046′	W69° 2.2093′	961.4	21:01:17	N40° 1.7554′	W69° 1.4614′	748.7	8:20:25	16

[1]Dive number: this number is a sequential dive identifier provided by *ROPOS*.

[2]Time, latitude, longitude, and depth taken from IRLS when the *ROPOS* first saw bottom.

[3]Time, latitude, longitude, and depth taken from IRLS at the time the ROV left the bottom to be recovered.

[4]Bottom time (h:min:sec): duration in hours, minutes, and seconds the ROV spent on the bottom, calculated by subtracting the on-bottom time from the off-bottom time.

[5]Number of specimens collected: based on output from IRLS. Actual number reported may be different due to aborted sample collections or subsampling of existing collections for associates.

[6]Delayed entry in IRLS observation log. May be slightly off.

Table 4. Specimens collected during the CROCHET expedition (HB-24-05) to the northwestern Atlantic canyons and Gulf of Maine. Vouchers of biological specimens were deposited at the Smithsonian Institution, National Museum of Natural History. Other samples (i.e., isotopes, genetics, eDNA) were dispersed to collaborators for further analysis. IRLS = *ROPO*S data logging system. MBES = Multi-Beam Echo Sounder.

			Samples					
Date	Dive	Locality	Actual and (IRLS)	# of spms	# of eDNA	Sample Type and Custodian	Multibeam associated	Comments
7/19/2024	R2386	Oceanographer Canyon	26 (29)	24	2	Nizinski (genetics, stable isotope, vouchering); Rakka (physiology —*Paragorgia*); Packer (eDNA)	yes	One sample lost during recovery, one sample aborted, one IRLS sample record was a duplicate. MBES log notes transect was ended early to head to CTD location.
7/20/2024	R2387	Gilbert Canyon	18 (20)	16	2	Nizinski (genetics, stable isotope, vouchering); Packer (eDNA)		Two samples were lost during recovery
7/21/2024	R2388	Heezen Canyon	28 (28)	26	2	Nizinski (genetics, stable isotope, vouchering); Rakka (physiology —*Primnoa*); Shea (vouchering); Packer (eDNA)		
7/22/2024	R2389	Corsair Canyon	19 (19)	17	2	Nizinski (vouchering); Packer (eDNA)	yes	
7/23/2024	R2390	Gulf of Maine, Border Bumps	9 (10)	7	2	Nizinski (genetics, stable isotope, vouchering); Packer (eDNA)		One sample of sea stars ended up being taken with a pinch sample and a suction sample. They should be considered a single sample.
7/24/2024	R2391	NE Channel # 1	2 (2)	0	2	Packer (eDNA)	yes	All video transecting today, no stopping for samples. MBES logs notes “sound velocity probe broken?”
7/25/2024	R2392	NE Channel # 2	17 (17)	15	2	Nizinski (genetics, stable isotope, vouchering); Rakka (Physiology — *Primnoa*); Packer (eDNA)		
7/27/2024	R2393	Central Jordan Basin, Canada	33 (33)	32	1	Nizinski (genetics, stable isotope, vouchering): Shea (vouchering); Packer (eDNA)	yes	MBES log calls this West Jordan Basin
7/28/2024	R2394	Transboundary Elbow (TBE) #1	4 (4)	3	1	Nizinski (genetics, stable isotope, vouchering); Packer (eDNA)		MBES log calls this “TBE”
7/28/2024	R2395	Transboundary Elbow (TBE) #2	2 (1)	2	0	Nizinski (genetics, stable isotope, vouchering)		rock was logged during dive as a single sample, but processed as 2 samples (white sponge and yellow sponge) for genetics and stable isotope
7/30/2024	R2396	Hydrographer Canyon	16 (16)	14	2	Nizinski (genetics, stable isotope, vouchering); Packer (eDNA)	yes	

Table 5. List specimens collected during the CROCHET expedition (HB-24-05) that were deposited and cataloged in the Invertebrate Zoology collection at the Smithsonian Institution National Museum of Natural History (USNM). Specimens with an HB2405 sample number have been subsampled for stable isotopes and genetics. Specimens without an HB2405 number were deposited in the collection without subsampling.

Sample Number	Scientific Name	Date Collected	Latitude	Longitude	Depth (m)	USNM Catalog number
HB2405-001	*Paramuricea* sp.	19-Jul-24	40.291522	-68.113686	974.23	1739303
HB2405-002	*Paramuricea* sp.	19-Jul-24	40.291339	-68.114044	987.54	1739302
HB2405-003	*Paramuricea* sp.	19-Jul-24	40.291861	-68.112536	952.27	1739305
HB2405-004	*Paramuricea* sp.	19-Jul-24	40.290061	-68.116561		1739294
HB2405-005	*Paramuricea* sp.	19-Jul-24	40.286078	-68.116344	1236.75	1739291
HB2405-006	*Paragorgia* sp.	19-Jul-24	40.294394	-68.111636	886.85	1739312
HB2405-007	*Paramuricea* sp.	19-Jul-24	40.287011	-68.114797	1132.38	1739293
HB2405-008	*Paramuricea* sp.	19-Jul-24	40.291611	-68.113536	968.97	1739304
HB2405-009	*Paramuricea* sp.	19-Jul-24	40.291353	-68.114039	988.07	1739301
HB2405-010	*Acanthogorgia* sp.	19-Jul-24	40.291147	-68.114889	1024.81	1739300
HB2405-011	*Thouarella* sp.	19-Jul-24	40.286439	-68.116486	1240.97	1739292
HB2405-012	*Paramuricea* sp.	19-Jul-24	40.291108	-68.11497	1030.01	1739299
HB2405-013	*Thouarella* sp.	19-Jul-24	40.294289	-68.111644	884.92	1739308
HB2405-014	*Paramuricea* sp.	19-Jul-24	40.290744	-68.115703	1066.67	1739297
HB2405-015	Ophiuroidea	19-Jul-24	40.290744	-68.115703	1066.67	1739298
HB2405-016	Porifera	19-Jul-24	40.293953	-68.111544	870.48	1739306
HB2405-017	Hydrozoa	19-Jul-24	40.290644	-68.115764	1071.79	1739295
HB2405-018	Zoanthidea	19-Jul-24	40.290644	-68.115764	1071.79	1739296
HB2405-019	*Paragorgia* sp.	19-Jul-24	40.294225	-68.111536	880.75	1739307
HB2405-020	*Paragorgia* sp.	19-Jul-24	40.294378	-68.111694	884.35	1739313
HB2405-021	*Paragorgia* sp.	19-Jul-24	40.294394	-68.111636	886.67	1739310
HB2405-022	*Paragorgia* sp.	19-Jul-24	40.294381	-68.111597	886.4	1739309
HB2405-023	*Paragorgia* sp.	19-Jul-24	40.294394	-68.111636	886.85	1739311
HB2405-024	*Paragorgia* sp.	19-Jul-24	40.294375	-68.111697	884.96	1739315
HB2405-025	*Paragorgia* sp.	19-Jul-24	40.294372	-68.111706	888.18	1739314
HB2405-026	*Paramuricea* sp.	20-Jul-24	40.22508	-67.862303	1428.87	1739337
HB2405-027	*Paramuricea* sp.	20-Jul-24	40.224136	-67.85878	1485.39	1739335
HB2405-028	*Paramuricea* sp.	20-Jul-24	40.225114	-67.858619	1581.84	1739329
HB2405-029	*Paramuricea* sp.	20-Jul-24	40.224539	-67.859147	1485.57	1739331
HB2405-030	*Paramuricea* sp.	20-Jul-24	40.225314	-67.857494	1646.76	1739326
HB2405-031	Ophiuroidea	20-Jul-24	40.225314	-67.857494	1646.76	1739327
HB2405-032	*Paramuricea* sp.	20-Jul-24	40.225319	-67.857094	1676.77	1739321
HB2405-033	Ophiuroidea	20-Jul-24	40.225319	-67.857094	1676.77	1739322
HB2405-034	*Paramuricea* sp.	20-Jul-24	40.225964	-67.857089	1698.29	1739318
HB2405-035	Ophiuroidea	20-Jul-24	40.225964	-67.857089	1698.29	1739319
HB2405-036	*Paramuricea* sp.	20-Jul-24	40.224586	-67.859289	1496.83	1739332
HB2405-037	*Paramuricea* sp.	20-Jul-24	40.22453	-67.859186	1499.23	1739330
HB2405-038	*Paragorgia* sp.	20-Jul-24	40.224586	-67.859289	1497.33	1739333

Table 5. Continued.

Sample Number	Scientific Name	Date Collected	Latitude	Longitude	Depth (m)	USNM Catalog number
HB2405-039	Actiniaria	20-Jul-24	40.224586	-67.859289	1497.33	1739334
HB2405-040	*Thouarella* sp.	20-Jul-24	40.225336	-67.85736	1660.31	1739323
HB2405-041	Ophiuroidea	20-Jul-24	40.225336	-67.85736	1660.31	1739324
HB2405-042	Ophiuroidea	20-Jul-24	40.225336	-67.85736	1660.31	1739325
HB2405-043	Porifera	20-Jul-24	40.22597	-67.857094	1698.27	1739316
HB2405-044	Ophiuroidea	20-Jul-24	40.22597	-67.857094	1698.27	1739317
HB2405-046	Isididae	20-Jul-24	40.225297	-67.857522	1645.81	1739328
HB2405-047	*Balticina* sp.	20-Jul-24	40.224131	-67.858764	1485.39	1739336
HB2405-048	Decapoda	20-Jul-24	40.225292	-67.856986	1685.77	1739320
HB2405-049	Ophiuroidea	20-Jul-24	40.225292	-67.856986	1685.77	1739523
HB2405-050	*Paramuricea* sp.	21-Jul-24	41.065378	-66.389836	751	1739350
HB2405-051	*Primnoa* sp.	21-Jul-24	41.068539	-66.395664	744.83	1739357
HB2405-052	*Paramuricea* sp.	21-Jul-24	41.065656	-66.391172	741.19	1739355
HB2405-053	*Paramuricea* sp.	21-Jul-24	41.065631	-66.390578	744.95	1739353
HB2405-054	*Primnoa* sp.	21-Jul-24	41.064561	-66.389511	773.15	1739347
HB2405-055	*Primnoa* sp.	21-Jul-24	41.06444	-66.389539	795.64	1739344
HB2405-056	*Primnoa* sp.	21-Jul-24	41.063547	-66.38869	829.57	1739339
HB2405-057	*Paramuricea* sp.	21-Jul-24	41.063172	-66.388478	829.42	1739338
HB2405-058	*Paramuricea* sp.	21-Jul-24	41.064906	-66.389256	771.73	1739346
HB2405-059	*Primnoa* sp.	21-Jul-24	41.064894	-66.389225	772.97	1739345
HB2405-060	*Primnoa* sp.	21-Jul-24	41.068672	-66.395797	739.2	1739358
HB2405-061	*Paramuricea* sp.	21-Jul-24	41.065614	-66.390678	738.26	1739354
HB2405-062	*Paramuricea* sp.	21-Jul-24	41.065081	-66.389511	754.64	1739349
HB2405-063	*Primnoa* sp.	21-Jul-24	41.064419	-66.389561	797.21	1739343
HB2405-064	Bivalvia	21-Jul-24	41.064419	-66.389561	797.21	1739342
HB2405-065	*Primnoa* sp.	21-Jul-24	41.065428	-66.389964	749.04	1739351
HB2405-066	*Paramuricea* sp.	21-Jul-24	41.065453	-66.389978	750.96	1739352
HB2405-067	*Paramuricea* sp.	21-Jul-24	41.065664	-66.391172	745.38	1739356
HB2405-068	*Primnoa* sp.	21-Jul-24	41.068822	-66.395894	730.61	1739359
HB2405-069	*Paramuricea* sp.	21-Jul-24	41.065106	-66.389494	755.55	1739348
HB2405-070	Porifera	21-Jul-24	41.063731	-66.389211	804.04	1739340
HB2405-071	Ophiuroidea	21-Jul-24	41.063731	-66.389211	804.04	1739341
HB2405-072	*Primnoa* sp.	21-Jul-24	41.068997	-66.395928	725.7	1739360
HB2405-073	*Acesta* sp.	21-Jul-24	41.061878	-66.385547	911.98	1742035
HB2405-074	*Clavularia* sp.	21-Jul-24	41.061878	-66.385547	911.98	1742040
HB2405-075	Polychaeta	21-Jul-24	41.070475	-66.398381	743.32	1739361
HB2405-076	*Primnoa* sp.	22-Jul-24	41.325969	-66.146131	706.25	1739370
HB2405-077	*Paramuricea* sp.	22-Jul-24	41.328564	-66.143253	844.55	1739365
HB2405-078	*Paramuricea* sp.	22-Jul-24	41.328247	-66.143353	819.5	1739367
HB2405-079	*Primnoa* sp.	22-Jul-24	41.328294	-66.143311	823.14	1739366

Table 5. Continued.

Sample Number	Scientific Name	Date Collected	Latitude	Longitude	Depth (m)	USNM Catalog number
HB2405-080	*Primnoa* sp.	22-Jul-24	41.329056	-66.14244	883.54	1739363
HB2405-081	*Paramuricea sp.*	22-Jul-24	41.329294	-66.142356	894.12	1739362
HB2405-082	*Paramuricea sp.*	22-Jul-24	41.328786	-66.142878	869.3	1739364
HB2405-083	*Primnoa* sp.	22-Jul-24	41.328144	-66.151086	655.76	1739376
HB2405-084	*Primnoa* sp.	22-Jul-24	41.326039	-66.146953	690.2	1739371
HB2405-085	*Primnoa* sp.	22-Jul-24	41.326103	-66.15039	599.6	1739372
HB2405-086	*Primnoa* sp.	22-Jul-24	41.328181	-66.151161	655.1	1739377
HB2405-087	*Primnoa* sp.	22-Jul-24	41.327219	-66.150853	608.6	1739374
HB2405-088	*Primnoa* sp.	22-Jul-24	41.328314	-66.150706	664.57	1739375
HB2405-089	*Primnoa* sp.	22-Jul-24	41.328036	-66.151081	650.63	1739378
HB2405-090	Cladorhizidae	22-Jul-24	41.326006	-66.151028	600.11	1739373
HB2405-091	Nephtheidae	22-Jul-24	41.327903	-66.144289	801.4	1739368
HB2405-092	Decapoda	22-Jul-24	41.329278	-66.160331	499.45	1739379
HB2405-093	*Polymastia uberrima*	23-Jul-24	42.908847	-67.89794	203.97	1739380
HB2405-094	Porifera	23-Jul-24	42.907522	-67.898631	204.93	1739381
HB2405-095	*Ophiopholis aculeata*	23-Jul-24	42.907522	-67.898631	204.93	1739382
HB2405-096	*Asterias rubens*	23-Jul-24	42.905528	-67.902369	201.08	1739383
HB2405-097	Porifera	23-Jul-24	42.900936	-67.905931	198.98	1739385
HB2405-098	Ophiuroidea	23-Jul-24	42.900936	-67.905931	198.98	1739386
HB2405-099	Pectinidae	23-Jul-24	42.901061	-67.906111	196.4	1739387
HB2405-100	Porifera	23-Jul-24	42.898914	-67.908186	182.76	1739388
HB2405-101	Porifera	23-Jul-24	42.898469	-67.908361	179.56	1739391
HB2405-102	Crinoidea	23-Jul-24	42.898469	-67.908361	179.56	1739390
HB2405-103	Ophiuroidea	23-Jul-24	42.898469	-67.908361	179.56	1739389
HB2405-104	Nemertea	23-Jul-24	42.90311	-67.906331	195.15	1739384
HB2405-105	*Primnoa* sp.	25-Jul-24	42.047328	-65.57622	493.21	1739392
HB2405-106	*Primnoa* sp.	25-Jul-24	42.047144	-65.576497	485.81	1739408
HB2405-107	*Primnoa* sp.	25-Jul-24	42.047306	-65.576311	491.31	1739393
HB2405-108	*Primnoa* sp.	25-Jul-24	42.047269	-65.576372	490.23	1739395
HB2405-109	Alcyonacea	25-Jul-24	42.050058	-65.543525	733.38	1739410
HB2405-110	Zoanthidea	25-Jul-24	42.051797	-65.538181	785.4	1739412
HB2405-111	*Primnoa* sp.	25-Jul-24	42.047228	-65.576375	489.37	1739396
HB2405-112	Zoanthidea	25-Jul-24	42.050044	-65.543539	733.1	1739411
HB2405-113	*Primnoa* sp.	25-Jul-24	42.047181	-65.576369	488.2	1739397
HB2405-114	*Primnoa* sp.	25-Jul-24	42.047131	-65.576286	486.3	1739399
HB2405-115	Ophiuroidea	25-Jul-24	42.047131	-65.576286	486.3	1739400
HB2405-116	Maxillopoda	25-Jul-24	42.047131	-65.576286	486.3	1739398
HB2405-117	Hydrozoa	25-Jul-24	42.047131	-65.576286	486.3	1739401
HB2405-118	*Primnoa* sp.	25-Jul-24	42.047106	-65.576439	487.02	1739409
HB2405-119	*Primnoa* sp.	25-Jul-24	42.047308	-65.576339	491.61	1739394

Table 5. Continued.

Sample Number	Scientific Name	Date Collected	Latitude	Longitude	Depth (m)	USNM Catalog number
HB2405-120	*Primnoa* sp.	25-Jul-24	42.04711	-65.576336	487.21	1739402
HB2405-121	*Primnoa* sp.	25-Jul-24	42.047081	-65.576228	486.14	1739404
HB2405-122	Maxillopoda	25-Jul-24	42.047081	-65.576228	486.14	1739405
HB2405-123	Ophiuroidea	25-Jul-24	42.047081	-65.576228	486.14	1739406
HB2405-124	Decapoda	25-Jul-24	42.047081	-65.576228	486.14	1739407
HB2405-125	Ophiuroidea	25-Jul-24	42.047097	-65.576258	486.89	1739403
HB2405-126	*Paramuricea* sp.	27-Jul-24	43.334131	-67.20875	218.76	1739444
HB2405-127	*Primnoa* sp.	27-Jul-24	43.314892	-67.21603	211.1	1739448
HB2405-128	*Paramuricea* sp.	27-Jul-24	43.338278	-67.207953	223.14	1739413
HB2405-129	*Paramuricea* sp.	27-Jul-24	43.338281	-67.207947	223.09	1739414
HB2405-130	*Paramuricea* sp.	27-Jul-24	43.33822	-67.207828	217.27	1739421
HB2405-131	*Paramuricea* sp.	27-Jul-24	43.33822	-67.207831	217.25	1739420
HB2405-132	*Paramuricea* sp.	27-Jul-24	43.338331	-67.207764	218.29	1739422
HB2405-133	*Paramuricea* sp.	27-Jul-24	43.3383	-67.207764	218.28	1739423
HB2405-134	*Paramuricea* sp.	27-Jul-24	43.338336	-67.207764	218.3	1739424
HB2405-135	*Paramuricea* sp.	27-Jul-24	43.338128	-67.208106	222.24	1739425
HB2405-136	*Paramuricea* sp.	27-Jul-24	43.338128	-67.20811	222.19	1739426
HB2405-137	*Paramuricea* sp.	27-Jul-24	43.338128	-67.20811	222.25	1739427
HB2405-138	*Paramuricea* sp.	27-Jul-24	43.338044	-67.20831	225.79	1739428
HB2405-139	*Paramuricea* sp.	27-Jul-24	43.338044	-67.208303	225.91	1739429
HB2405-140	*Acanthogorgia* sp.	27-Jul-24	43.338044	-67.208297	225.9	1739430
HB2405-141	*Paramuricea* sp.	27-Jul-24	43.338044	-67.208286	225.6	1739431
HB2405-142	Porifera	27-Jul-24	43.337897	-67.20803	216.9	1739432
HB2405-143	*Paramuricea* sp.	27-Jul-24	43.332122	-67.209036	222.28	1739447
HB2405-144	*Paramuricea* sp.	27-Jul-24	43.337692	-67.207997	215.72	1739433
HB2405-145	*Paramuricea* sp.	27-Jul-24	43.337694	-67.207997	215.73	1739434
HB2405-146	*Paramuricea* sp.	27-Jul-24	43.337697	-67.208003	215.79	1739435
HB2405-147	*Paramuricea* sp.	27-Jul-24	43.336942	-67.207894	213.91	1739436
HB2405-148	*Paramuricea* sp.	27-Jul-24	43.336942	-67.207894	213.93	1739437
HB2405-149	*Paramuricea* sp.	27-Jul-24	43.336944	-67.207894	214.12	1739438
HB2405-150	*Paramuricea* sp.	27-Jul-24	43.335975	-67.20872	217.71	1739439
HB2405-151	*Paramuricea* sp.	27-Jul-24	43.335972	-67.208714	217.87	1739440
HB2405-152	*Paramuricea* sp.	27-Jul-24	43.335969	-67.208714	217.93	1739441
HB2405-153	*Paramuricea* sp.	27-Jul-24	43.33506	-67.208806	213.33	1739442
HB2405-154	*Paramuricea* sp.	27-Jul-24	43.33506	-67.208797	213.42	1739443
HB2405-155	*Paramuricea* sp.	27-Jul-24	43.333714	-67.208814	223.64	1739445
HB2405-156	*Paramuricea* sp.	27-Jul-24	43.333714	-67.208814	223.69	1739446
HB2405-157	*Terebratulina* sp.	27-Jul-24	43.338281	-67.207947	223.1	1739415
HB2405-158	Ophiuroidea	27-Jul-24	43.338281	-67.207947	223.1	1739417
HB2405-159	*Paramuricea* sp.	28-Jul-24	42.842397	-67.706956	196.08	1739449

Table 5. Continued.

Sample Number	Scientific Name	Date Collected	Latitude	Longitude	Depth (m)	USNM Catalog number
HB2405-160	*Paramuricea* sp.	28-Jul-24	42.842408	-67.706964	195.78	1739450
HB2405-161	*Paramuricea* sp.	28-Jul-24	42.842406	-67.706972	195.85	1739451
HB2405-162	Porifera	28-Jul-24	42.845956	-67.727811	202.89	1739452
HB2405-163	Porifera	28-Jul-24	42.845956	-67.727811	202.89	1739453
HB2405-164	Isididae	30-Jul-24	40.036989	-69.036892	968.05	1739454
HB2405-165	*Paramuricea* sp.	30-Jul-24	40.036806	-69.036542	959.74	1739455
HB2405-166	*Paramuricea* sp.	30-Jul-24	40.036947	-69.036072	925.05	1739456
HB2405-167	*Paramuricea* sp.	30-Jul-24	40.036814	-69.034619	875.41	1739462
HB2405-168	*Paramuricea* sp.	30-Jul-24	40.037108	-69.03456	852.42	1739463
HB2405-169	Cladorhizidae	30-Jul-24	40.035839	-69.031022	850.41	1739465
HB2405-170	*Paramuricea* sp.	30-Jul-24	40.036547	-69.032322	829.24	1739464
HB2405-171	*Paramuricea* sp.	30-Jul-24	40.03536	-69.030892	842.56	1739467
HB2405-172	Ophiuroidea	30-Jul-24	40.03536	-69.030892	842.56	1739466
HB2405-173	*Paramuricea* sp.	30-Jul-24	40.036144	-69.026897	670.4	1739468
HB2405-174	*Paramuricea* sp.	30-Jul-24	40.032197	-69.02586	809.47	1739470
HB2405-175	*Paramuricea* sp.	30-Jul-24	40.032372	-69.02342	702.19	1739471
HB2405-176	*Paramuricea* sp.	30-Jul-24	40.030456	-69.023289	678.01	1739472
HB2405-177	Alcyonacea	30-Jul-24	40.036981	-69.035831	906.48	1739459
HB2405-178	Decapoda	30-Jul-24	40.036981	-69.035831	906.48	1739460
HB2405-179	Polychaeta	30-Jul-24	40.036981	-69.035831	906.48	1739461
HB2405-180	Porifera	30-Jul-24	40.036981	-69.035831	906.48	1739457
HB2405-181	Polychaeta	30-Jul-24	40.036981	-69.035831	906.48	1739458
HB2405-182	Cladorhizidae	30-Jul-24	40.034856	-69.02706	770.59	1739469
jar1	Mysida	27-Jul-24	43.338281	-67.207947	223.1	1739416
jar1	Bryozoa	27-Jul-24	43.338281	-67.207947	223.1	1739418
jar1	Decapoda	27-Jul-24	43.338281	-67.207947	223.1	1739419
SF1/SF2	Ascidiacea	22-Jul-24	41.327903	-66.144289	801.4	1739369
	Placiphorella sp.	21-Jul-24	41.061878	-66.385547	911.98	1742036
	Gastropoda	21-Jul-24	41.061878	-66.385547	911.98	1742037
	Gastropoda	21-Jul-24	41.061878	-66.385547	911.98	1742038
	Ophiuroidea	21-Jul-24	41.061878	-66.385547	911.98	1742041
	Crinoidea	21-Jul-24	41.061878	-66.385547	911.98	1742042
	Porifera	21-Jul-24	41.061878	-66.385547	911.98	1742043

Table 6. Inventory of CTD casts conducted during the CROCHET expedition (HB-24-05) to the northwestern Atlantic canyons and Gulf of Maine. CTD number: this unique code is a combination of the CTD name plus the cruise code and the cast number taken from the Oceanography Station Operations Log on the *Bigelow*. If the cast is cited without the prefix CTD, it could potentially get mixed up with the Smithsonian stable isotope sampling which follows the same protocol. Date and time are converted from GMT (CTD logs) to Eastern Daylight Time (below).

CTD Number	Dive associated	Locality	Date (EDT)	Start time (EDT)	Latitude (N)	Longitude (W)	Lat/long marked at start of cast or sample?	Depth (m) of Bottom/ sample	Water sample Temp (°C)	eDNA samples taken?
CTD-HB2405-001	R2386	Oceanographer Canyon	7/19/2024	0625	40° 17.4101	68° 07.2095	cast	1217/1205	n/a	yes
CTD-HB2405-002	none	Oceanographer Canyon	7/19/2024	2120	40° 27.563	68° 8.624	cast	420/410	n/a	no
CTD-HB2405-003	R2387	Gilbert Canyon	7/20/2024	0635	40° 13.715	67° 51.445	sample	1787/1776	3	yes
CTD-HB2405-004	R2388	Heezen Canyon	7/21/2024	0617	41° 3.636	66° 23.196	sample	876/870	4	yes
CTD-HB2405-005	R2389	Corsair Canyon	7/21/2024	2220	41° 18.588	66° 9.427	sample	368/372	6	no
CTD-HB2405-006	R2389	Corsair Canyon	7/22/2024	0615	41° 19.675	66° 7.946	sample	840/810	4	yes
CTD-HB2405-007	R2390	Gulf of Maine, Border Bumps	7/23/2024	0652	42° 55.072	67° 52.963	sample	207/201	8	yes
CTD-HB2405-008	R2391	NE Channel #1	7/24/2024	0705	41° 59.671	65° 38.612	sample	533/505	6	yes
CTD-HB2405-009	none	prep for multi-beam	7/24/2024	2127	42° 6.536	65° 33.665	cast	262/x	x	no
CTD-HB2405-010	R2392	NE Channel #2	7/25/2024	0614	42° 2.968	65° 33.559	sample	613/602	4	yes
CTD-HB2405-011	none	prep for multi-beam	7//25/2024	2033	43° 31.622	67° 29.654	cast	223/x	x	no
CTD-HB2405-012	R2393	Central Jordan Basin, Canada	7/27/2024	0605	43° 20.491	67° 12.656	sample	228/221	8	yes
CTD-HB2405-013	none	Transboundary Elbow (TBE) #1	7/27/2024	2303	42° 52.829	67° 42.820	cast	226/x	x	no
CTD-HB2405-014	R2394	Transboundary Elbow (TBE) #1	7/28/2024	0635	42° 51.455	67° 40.046	sample	214/206	9	yes
CTD-HB2405-015	none	Hydrographer Canyon	7/30/2024	0014	40° 11.478	69° 6.000	cast	214/x	x	no
CTD-HB2405-016	R2396	Hydrographer Canyon	7/30/2024	0629	40° 2.609	69° 2.216	sample	917/907	4	yes

Table 7. Summary of eDNA samples collected during the CROCHET expedition (HB-24-05) to the northwestern Atlantic canyons and Gulf of Maine. The CTD-associated samples had 3 replicates, and the port and starboard Niskin bottles each had 2 replicates. Samples were taken to the Northeast Fisheries Science Center's Milford Lab for further analysis.

Site Name	IRLS sample No.	Ship CTD sample #	Niskin bottle position	eDNA sample #	# bottles	Date (local)
Oceanographer Canyon	n/a	HB2405-001	n/a	CTD_R2386-1, -2 , -3	3	19-Jul-24
Oceanographer Canyon	R2386-3	n/a	starboard	R2386-3a-forward	1	19-Jul-24
Oceanographer Canyon	R2386-3	n/a	starboard	R2386-3b-aft	1	19-Jul-24
Oceanographer Canyon	R2386-5	n/a	port	R2386-5a-forward	1	19-Jul-24
Oceanographer Canyon	R2386-5	n/a	port	R2385-5b-aft	1	19-Jul-24
Gilbert	n/a	HB2405-003	n/a	CTD_R2387 -1, -2 , -3	3	20-Jul-24
Gilbert	R2387-3	n/a	starboard	R2387-3a-forward	1	20-Jul-24
Gilbert	R2387-3	n/a	starboard	R2387-3b-aft	1	20-Jul-24
Gilbert	R2387-15	n/a	port	R2387-15a-forward	1	20-Jul-24
Gilbert	R2387-15		port	R2387-15b-aft	1	20-Jul-24
Heezen	n/a	HB2405-004	n/a	CTD_R2388 -1, -2 , -3	3	21-Jul-24
Heezen	R2388-4	n/a	starboard	R2388-4a-forward	1	21-Jul-24
Heezen	R2388-4	n/a	starboard	R2388-4b-aft	1	21-Jul-24
Heezen	R2388-18	n/a	port	R2388-18a-forward	1	21-Jul-24
Heezen	R2388-18	n/a	port	R2388-18b-aft	1	21-Jul-24
Corsair	n/a	HB2405-006	n/a	CTD_R2389-1, -2, -3	3	22-Jul-24
Corsair	R2389-5	n/a	starboard	R2389-5a-forward	1	22-Jul-24
Corsair	R2389-5	n/a	starboard	R2389-5b-aft	1	22-Jul-24
Corsair	R2389-11	n/a	port	R2389-11a-forward	1	22-Jul-24
Corsair	R2389-11	n/a	port	R2389-11b-aft	1	22-Jul-24
Gulf of Maine, Border Bumps	n/a	HB2405-007	n/a	CTD_R2390-1, -2, -3	3	23-Jul-24
Gulf of Maine, Border Bumps	R2390-10	n/a	starboard	R2390-10a-forward	1	23-Jul-24
Gulf of Maine, Border Bumps	R2390-10	n/a	starboard	R2390-10b-aft	1	23-Jul-24
Gulf of Maine, Border Bumps	R2390-11	n/a	port	R2390-11a-forward	1	23-Jul-24
Gulf of Maine, Border Bumps	R2390-11	n/a	port	R2390-11b-aft	1	23-Jul-24
NE Channel #1	n/a	HB2405-008		CTD_R2391-1, -2, -3	3	24-Jul-24
NE Channel #1	R2391-1	n/a	starboard	R2391-1a-forward	1	24-Jul-24
NE Channel #1	R2391-1	n/a	starboard	R2391-1b-aft	1	24-Jul-24

Table 7. Continued from previous page.

Start time[1] (UTC)	Latitude[1]	Longitude[1]	Max. depth (m)[2]	Depth of water samples (m)[1]	Notes from IRLS/CTD Notes
			1217	1205	
7/19/2024 17:30	N40° 17.2149′	W68° 6.9004′		1148.95	two starboard side niskins
7/19/2024 17:30	N40° 17.2149′	W68° 6.9004′		1148.95	
7/19/2024 17:56	N40° 17.2155′	W68° 6.8666′		1118.52	2 Port Niskins
7/19/2024 17:56	N40° 17.2155′	W68° 6.8666′		1118.52	
			1787	1776	
7/20/2024 14:45	N40° 13.5175′	W67° 51.4192′		1689.94	2 Niskins bottles. STBD.
7/20/2024 14:45	N40° 13.5175′	W67° 51.4192′		1689.94	
7/20/2024 17:31	N40° 13.4724′	W67° 51.5489′		1484.84	Fired 2 port niskin bottles for eDNA, close to aggregation of *Desmophyllum*, *Telopathes*, *Paramuricea*, Bamboo corals
7/20/2024 17:31	N40° 13.4724′	W67° 51.5489′		1484.84	
			876	870	
7/21/2024 14:03	N41° 3.7158′	W66° 23.1446′		879.09	2 Starboard Niskins triggered
7/21/2024 14:03	N41° 3.7158′	W66° 23.1446′		879.09	
7/21/2024 17:37	N41° 3.9276′	W66° 23.402′		746.8	Two port niskin bottles fired
7/21/2024 17:37	N41° 3.9276′	W66° 23.402′		746.8	
7/22/2024 10:15	N41° 19.675′	W66° 07.946′	840	810	
7/22/2024 14:11	N41° 19.714′	W66° 8.5831′		840.42	STBD Niskins for David in the *Paragorgia* Face Waypoint.
7/22/2024 14:11	N41° 19.714′	W66° 8.5831′		840.42	
7/22/2024 17:08	N41° 19.5721′	W66° 8.8762′		649.3	Port Niskins closed over a field of purple soft coral
7/22/2024 17:08	N41° 19.5721′	W66° 8.8762′		649.3	
1052	N42° 55.072	W67° 52.963	207	201	bottom temp 8 °C
7/23/2024 21:29	N42° 53.8083′	W67° 54.6195′		175.8	EKS addition: This is the correct lat/long/depth. The entry for sample #10 in IRLS was done after the actual sample which was entered as an observation (#2385)
7/23/2024 21:29	N42° 53.8083′	W67° 54.6195′		175.8	
7/23/2024 22:52	N42° 53.8636′	W67° 54.9475′		180.34	Niskins - Port side.
7/23/2024 22:52	N42° 53.8636′	W67° 54.9475′		180.34	
1105	N41° 59.671	W65° 38.612	533	505	
7/24/2024 17:35	N41° 59.3677′	W65° 38.8656′		622.25	Starbord niskins over high density
7/24/2024 17:35	N41° 59.3677′	W65° 38.8656′			

[1]Data from ROPOS IRLS system.

[2]Data from Bigelow CTD system.

Table 7. Continued.

Site Name	IRLS sample No.	Ship CTD sample #	Niskin bottle position	eDNA sample #	# bottles	Date (local)
NE Channel #1	R2391-2	n/a	port	R2391-2a-forward	1	
NE Channel #1	R2391-2	n/a	port	R2391-2b-aft	1	
NE Channel #2	n/a	HB2405-010		CTD_R2392-1, -2, -3	3	
NE Channel #2	R2392-4	n/a	starboard	R2392-4a-forward	1	
NE Channel #2	R2392-4	n/a	starboard	R2392-4b-aft	1	
NE Channel #2	R2392-14	n/a	port	R2392-14a-forward	1	
NE Channel #2	R2392-14	n/a	port	R2392-14b-aft	1	
Central Jordan Basin	n/a	HB2405-012		CTD_R2393-1, -2, -3	3	
Central Jordan Basin	R2393-6		starboard	R2393-6a-forward	1	
Central Jordan Basin	R2393-6		starboard	R2393-6a-aft	1	
Transboundary Elbow (TBE) #1	n/a	HB2405-014		CTD_R2394-1, -2, -3	3	
Transboundary Elbow (TBE) #1	R2394-4		starboard	R2394-4a-forward	1	
Transboundary Elbow (TBE) #1	R2394-4		starboard	R2394-4b-aft	1	
Transboundary Elbow (TBE) #2	none					
Transboundary Elbow (TBE) #2	none					
Hydrographer Canyon	n/a	HB2405-016		CTD_R2396-1, -2, -3	3	30-Jul-24
Hydrographer Canyon	R2396-4		starboard	R2396-4a-forward	1	30-Jul-24
Hydrographer Canyon	R2396-4		starboard	R2396-4b-aft	1	30-Jul-24
Hydrographer Canyon	R2396-16		port	R2396-16a-forward	1	30-Jul-24
Hydrographer Canyon	R2396-16		port	R2396-16b-aft	1	30-Jul-24

Table 7. Continued from previous page.

Start time[1] (UTC)	Latitude[1]	Longitude[1]	Max. depth (m)[2]	Depth of water samples (m)[1]	Notes from IRLS/CTD Notes
7/24/2024 23:04	N41° 58.5904′	W65° 38.3369′		873.05	PORT Niskins. Very strong current. Difficult to hold position. EKS addtion: Taken at "the Rock" which has been imaged and videoed multiple times over the past 20 years. Current was exceptionally fast, difficult to hold position. Although the sub was close to the rock, the water sample may be from away.
7/24/2024 23:04	N41° 58.5904′	W65° 38.3369′		873.05	
1014			613	602	
7/25/2024 14:04	N42° 2.8379′	W65° 34.5783′		491.43	2 Niskins bottles - STBD EKS addition: taken from *Primnoa* field that was sampled for physiology, genetics, and stable isotopoes, during a pause in transect operations because the current pushed us off transect.
7/25/2024 14:04	N42° 2.8379′	W65° 34.5783′		491.43	
7/25/2024 19:13	N42° 2.9848′	W65° 32.7449′		716.55	Niskins Port EKS: no photo associated in IRLS
7/25/2024 19:13	N42° 2.9848′	W65° 32.7449′		716.55	
1005	N43° 20.491	W67° 12.656	228	221	
7/27/2024 13:03	N43° 20.2939′	W67° 12.468′		217.19	2 Niskins bottle STBD. *Paramuricea* field.
7/27/2024 13:03	N43° 20.2939′	W67° 12.468′		217.19	
1035	N42° 51.455	W67° 40.046	214	206	
7/28/2024 17:28	N42° 50.5492′	W67° 42.4211′		196.83	Niskins STBD; over small *Paramuricea* field.
7/28/2024 17:28	N42° 50.5492′	W67° 42.4211′		196.83	
	N40°02.609′	W69°02.216′	917	907	
	N40° 02.217′	W69° 2.1644′		925.42	Coral Garden
	N40° 02.217′	W69° 2.1644′		925.42	Coral Garden
	N40° 1.8253′	W69° 1.4088′		672.23	*Paragorgia*
	N40° 1.8253′	W69° 1.4088′		672.23	*Paragorgia*

[1]Data from ROPOS IRLS system.

[2]Data from Bigelow CTD system.

Dive Summaries

Dive Number: **R2386**
Locality: **Oceaographer Canyon, United States**
Date: **19 July 2024**

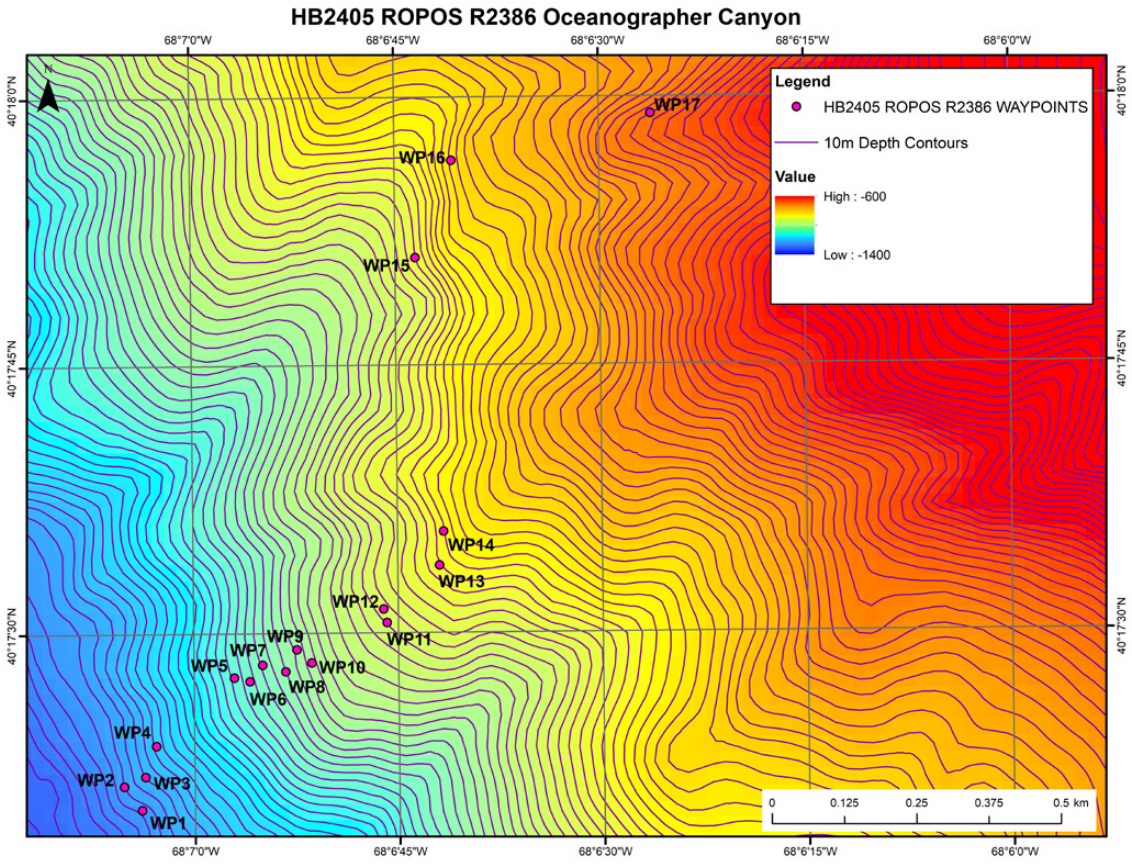

Figure 6. Proposed dive plan, Oceanographer Canyon. The actual track was modified due to field conditions.

Oceanographer Canyon

This was the site of the first CROCHET dive on 19 July 2024 at a depth of 885–1235 meters. The U.S. Fish and Wildlife Service and Mystic Aquarium selected Oceanographer, the largest of the three canyons in the NCSMNM, as a priority since there are limited opportunities to monitor changes in deep-sea coral assemblages. The main objective for the dive was to conduct a video transect in the same area as HOV *Alvin* dives 1035 and 3702 and Deep Discoverer dive 13 (EX1304, L2) in 1980, 2001, and 2013, respectively. The ROV arrived on bottom at 14:39 UTC, but the dive was delayed temporarily due to technical problems resulting in the loss of navigation and the inability to store video footage. The ROV, ship, and science personnel decided that the dive could proceed cautiously with the ROV team navigating the vehicle manually instead of using the ultra-short baseline (USBL) underwater acoustic positioning system. Video capture began at approximately 16:00 UTC. During the dive, fields of the corals *Paramuricea* and *Thouarella* and a spectacular wall covered with the bubble gum coral *Paragorgia* were observed. Additionally, the corals *Swiftia*, *Acanthogorgia*, *Anthomastus*, *Thouarella*, cup corals (*Desmophyllum dianthus*), and *Parantipathes* were quite common. A few fish species were observed, including but not limited to, black dogfish, *Cottunculus*, synaphobranchid eels, grenadiers, longfin hake, and a Greenland halibut.

HB2405 *ROPOS* Dive R2386 Oceanographer Canyon, USA 19 July 2024

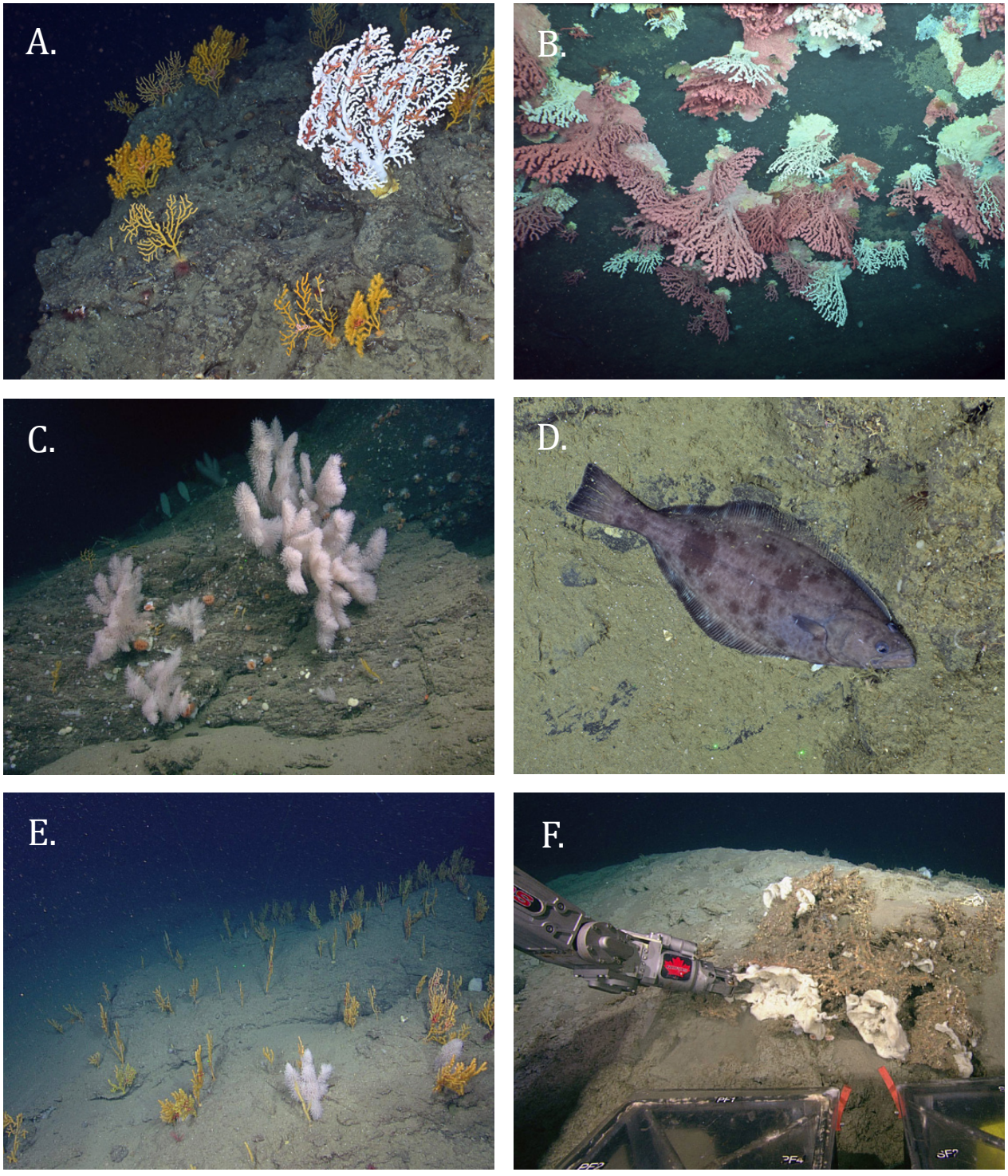

Figure 7. Oceanographer Canyon. A) Several colonies of *Paramuricea* with one white *Paragorgia* colony with ophiuroid associates. B) A spectacular wall of bubblegum coral. C) Multiple, large *Thouarella* colonies. D) Greenland halibut. E) A field of *Paramuricea* with two *Thouarella* colonies. F) Collecting a large white sponge.

Dive Number: R2387
Locality: Gilbert Canyon, United States
Date: 20 July 2024

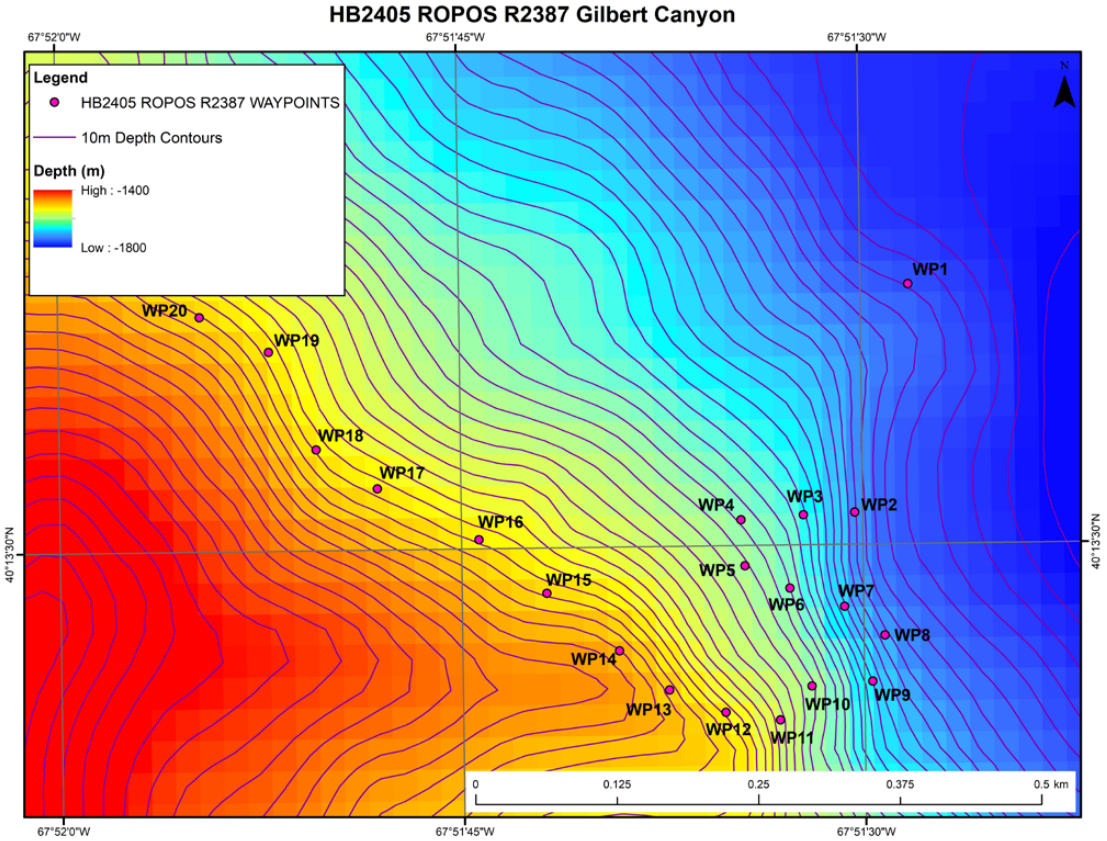

Figure 8. Proposed dive plan, Gilbert Canyon. The actual track was modified due to field conditions.

Gilbert Canyon

This is the smallest of the three canyons in the NCSMNM. Previous towed-camera surveys conducted in 2012 (TC12-19) revealed high biodiversity of deep-sea corals in this canyon. The main objectives of dive R2387 were to characterize the canyon's geomorphology and benthic habitats, with emphasis on deep-sea coral and sponge communities at a depth of 1526–1745 meters as well as assess faunal diversity, abundances, and distributions. The ROV arrived on bottom at 13:52 UTC at a depth of 1738 meters. The transect began on muddy bottom at the base of an outcrop colonized by *Paramuricea* and *Anthomastus* and then transitioned to hard substrate with a sediment drape. The bottom transitioned between hard and soft substrates throughout the dive. High abundances of *Paramuricea*, with *Swiftia* and sponges interspersed, were observed on hard substrates. Edges of large outcrops hosted *Paragorgia*, bamboo corals, the solitary stony coral *Desmophyllum dianthus*, and the black coral *Parantipathes*. Several other corals including *Solenosmilia*, *Thouarella*, *Psuedobathypathes*, *Swiftia*, *Telopathes*, *Clavularia*, and *Acanthogorgia* were observed along the transect, particularly on steep vertical walls and outcrops. Overall, a diverse suite of corals was observed; *Paramuricea* was the numerically dominant species. Toward the end of the dive, the ROV encountered a rock (subsequently named Kim's Rock in memory of Dr. Kim Juniper) colonized by a diverse assemblage of corals and sponges, including *Paragorgia*, *Anthomastus*, *Paramuricea*, *Desmophyllum dianthus*, *Parantipathes*, and a glass sponge (Family Euplepctellidae). More fields of *Paramuricea*, interspersed with colonies of *Swiftia* and *Parantipathes*, as well as brittle stars, were observed before the dive ended at 22:12 UTC at 1523 meters depth.

HB2405 *ROPOS* Dive R2387 Gilbert Canyon, USA 20 July 2024

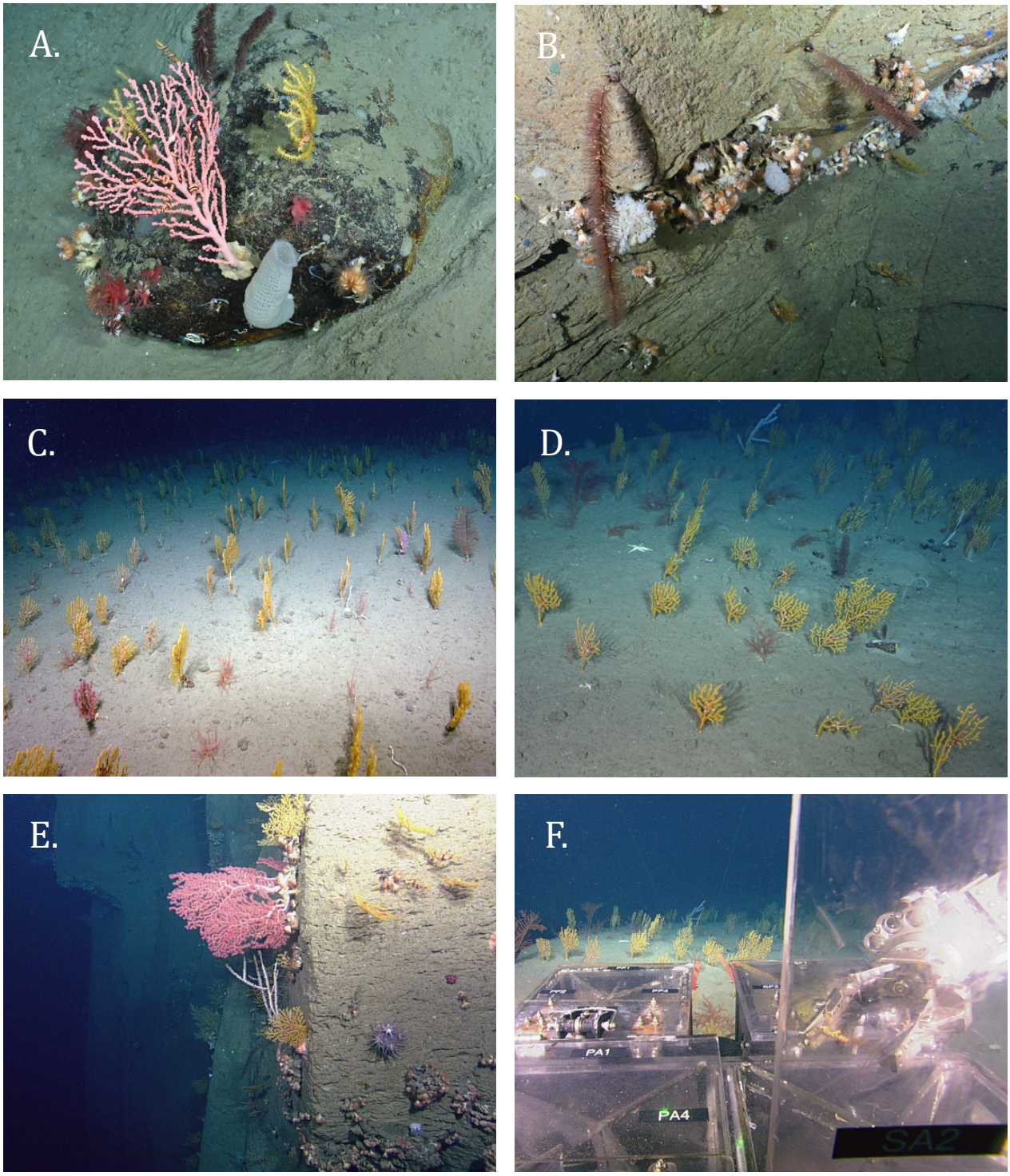

Figure 9. Gilbert Canyon. A) Kim's Rock covered in a diverse assemblage of corals and sponges. B) *Desmophyllum dianthus* and *Parantipathes* corals and sponges found along the edge of an outcrop. C and D) Fields of *Paramuricea* interspersed with *Telopathes*, *Psuedobathypathes*, *Swiftia*, and bamboo corals on soft bottom. E) Steep wall colonized by a diverse assemblage of organisms including corals and anemones. F) Collecting *Paramuricea* using the *ROPOS* manipulator arm.

Dive Number: **R2388**
Locality: **Heezen Canyon, United States**
Date: **21 July 2024**

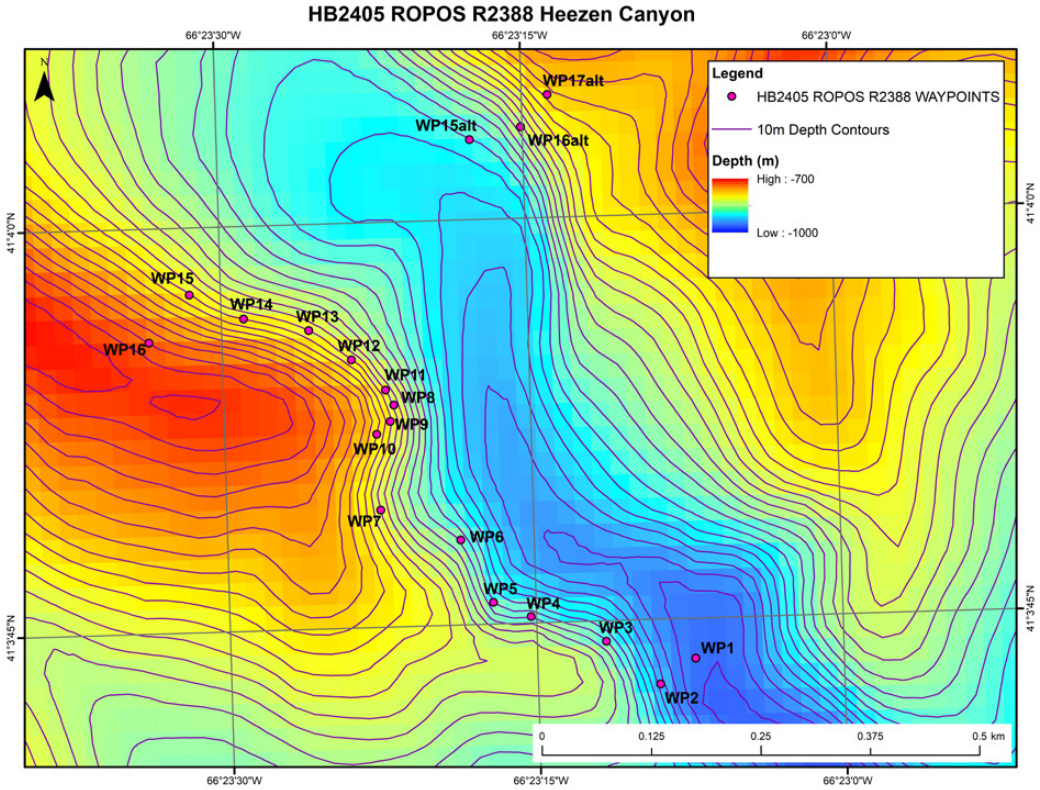

Figure 10. Proposed dive plan, Heezen Canyon. The actual track was modified due to field conditions.

Heezen Canyon

This canyon is located in U.S. waters just south of the Hague Line. The main objective of this dive was to continue the characterization of the canyon's geomorphology and benthic habitats as well as assess faunal diversity, abundances, and distributions. This dive focused on deep-sea coral and sponge communities at a depth of 725–960 meters. Locating the "the coral forest" waypoint plotted during a 2013 mission was also a priority to assess the overall condition of the large colonies of *Paragorgia* previously observed. The ROV arrived on bottom at 13:02 UTC at 915 meters depth. Almost immediately, a sparsely populated, large vertical wall was observed. The wall was relatively clean of sediments with the majority of organisms attached to overhangs or observed in cracks and crevices. Abundances of the organisms attached to the canyon wall varied depending on the level of sedimentation and the stability of the underlying rock. Faunal assemblages ranged from dense and diverse colonization to dense monotypic stands, scattered colonies of mixed or monotypic taxa, and solitary coral colonies. At approximately 796 meters between waypoints 7 and 8, the ROV arrived at what was likely "the coral forest." Here, numerous, large, healthy colonies of *Paragorgia* were observed attached to the steep canyon wall. Overall, this canyon has an impressive geomorphology with high relief, rugged terrain, and abrupt transitions between vertical wall and soft substratum. Heezen Canyon supports a high diversity of corals and is home to extremely large colonies of *Paramuricea*, *Primnoa*, and *Paragorgia*—truly a coral forest! *Desmophyllum pertusum* (formally *Lophelia pertusa*), *D. dianthus*, *Acanthogorgia*, *Anthothela*, *Clavularia*, and *Solenosmilia* were also observed. Cephalopods (octopods and sepiolids), many of which were small and possibly juveniles, were encountered regularly. Few fish species were observed, with synaphobranchid eels, found swimming along the canyon wall, being the numerically dominant fish species.

HB2405 *ROPOS* Dive R2388 Heezen Canyon, USA 21 July 2024

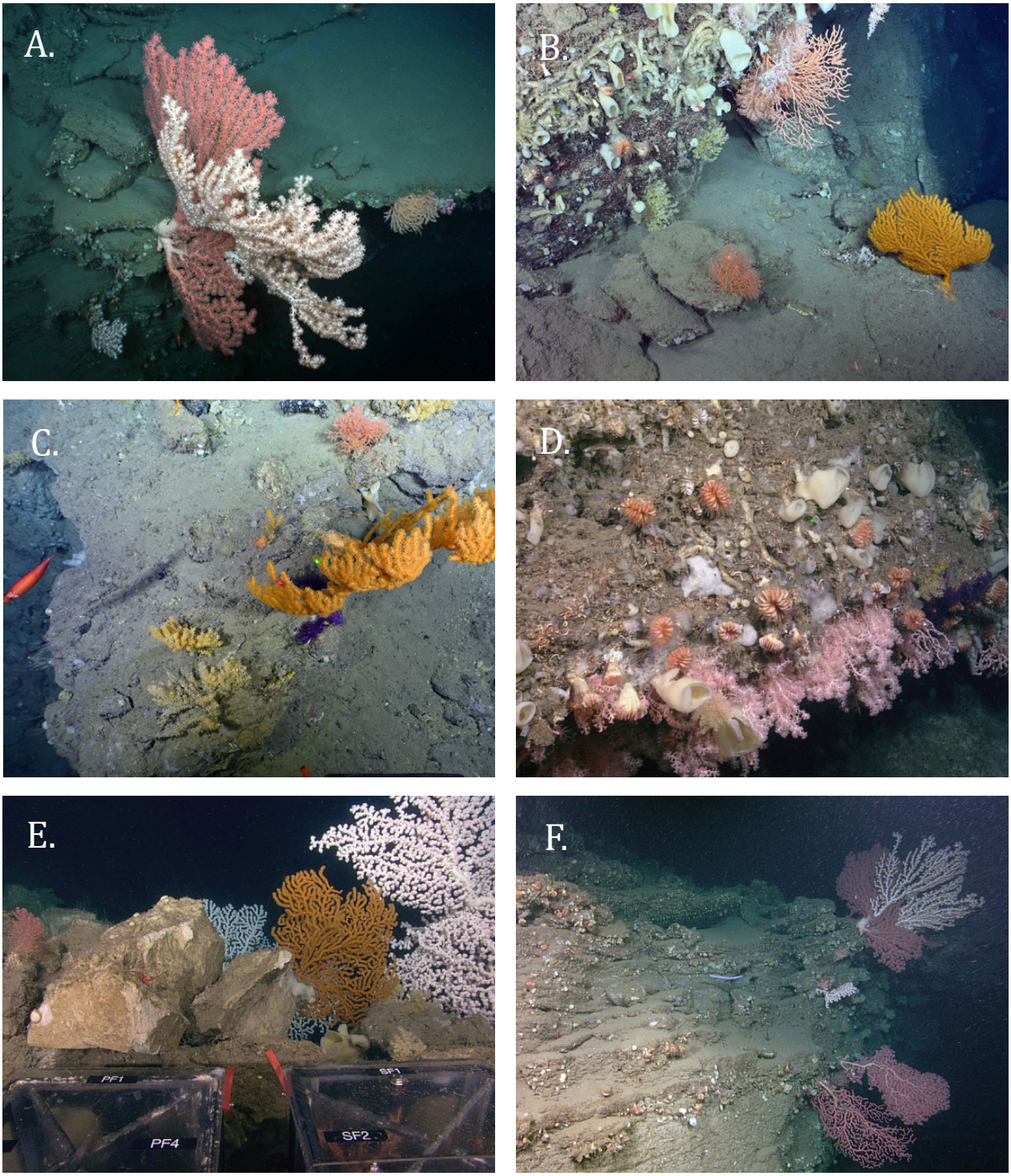

Figure 11. Heezen Canyon. A) Large colonies of *Paragorgia* highlighting two colormorphs. B) *Paramuricea*, *Anthothela*, *Acanella*, and worm tubes growing on an exposed vertical rock face. C) *Paramuricea* and *Acanthogorgia*, *Acanella*, *Clavularia*, and a squid, possibly *Gonatus*. D) *Anthothela* and sponges on the edge of a steep overhang. E) Preparing to sample *Paragorgia* and *Paramuricea* behind large rocks. F) *Paragorgia* on the edge of a terraced outcrop.

Dive Number: **R2389**
Locality: **Corsair Canyon, Canada**
Date: **22 July 2024**

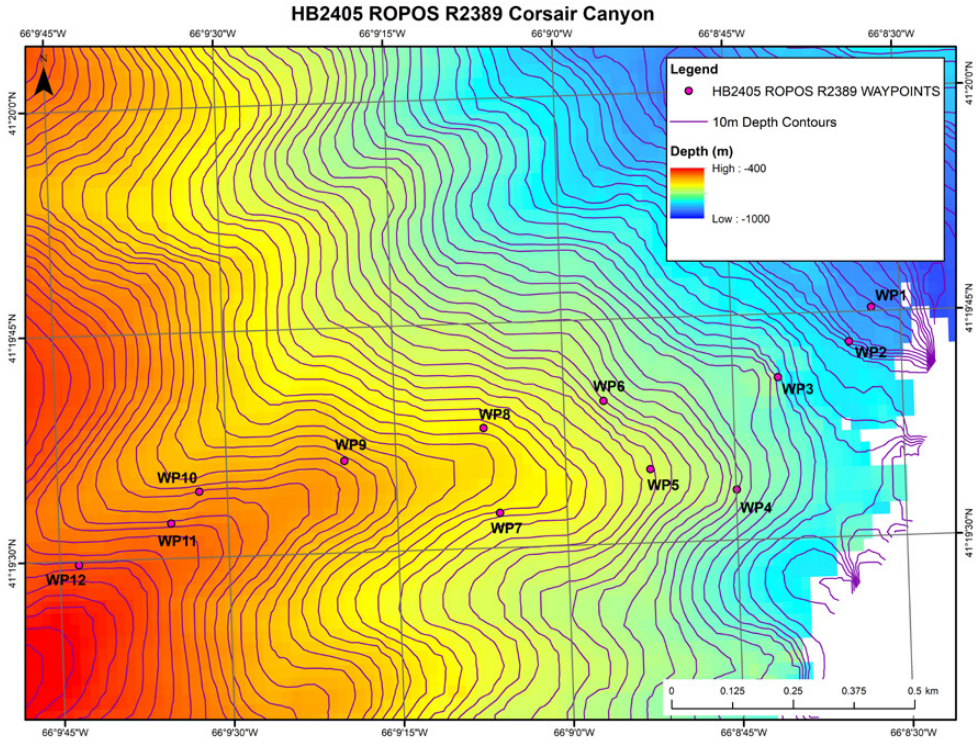

Figure 12. Proposed dive plan, Corsair Canyon. The actual track was modified due to field conditions .

Corsair Canyon

The Corsair and Georges Canyons Conservation Area, an area located just north of the Hague Line, is closed to bottom fishing. Since previous work in Corsair Canyon focused on the eastern canyon wall, the main objective on this dive was to explore and document the distribution and abundances of deep-sea corals on the western side of the canyon. The ROV reached bottom at 12:56 UTC at 907 meters depth. The transect began on soft bottom and quickly transitioned to gravel and pebbles scattered over soft substrates and then to a vertical canyon wall. The western canyon wall supported dense, luxuriant forests of the bubblegum coral *Paragorgia*. These colonies were present in a variety of sizes but at 860 meters depth, enormous colonies reaching at least 3 meters tall and wide were observed. A high diversity of corals, including, *Anthomastus*, *Primnoa*, *Desmophyllum pertusum* (= *Lophelia pertusa*), *Solenosmilia*, *Paramuricea*, *Desmophyllum dianthus*, *Anthothella*, *Clavularia*, and bamboo corals, were observed on the canyon wall as well as on ledges and under overhangs. An hour into the dive, at approximately 881 meters, the bottom type changed to boulders and cobbles between a softer, gravelly substratum. Sponges, sea anemones, and an occasional coral colony covered the boulders. The remainder of the dive continued over a combination of steep slopes/vertical wall and areas of soft sediments/consolidated sediments. Around 500 meters, the habitat changed to softer sediments where high abundances of soft coral likely in the Family Nephtheidae (possibly *Duva*) were observed. The ROV left bottom at 23:09 UTC from a depth of 462 meters. Observations made during this dive reinforced the ongoing need for the protection of Corsair Canyon.

HB2405 *ROPOS* Dive R2389 Corsair Canyon, Canada 22 July 2024

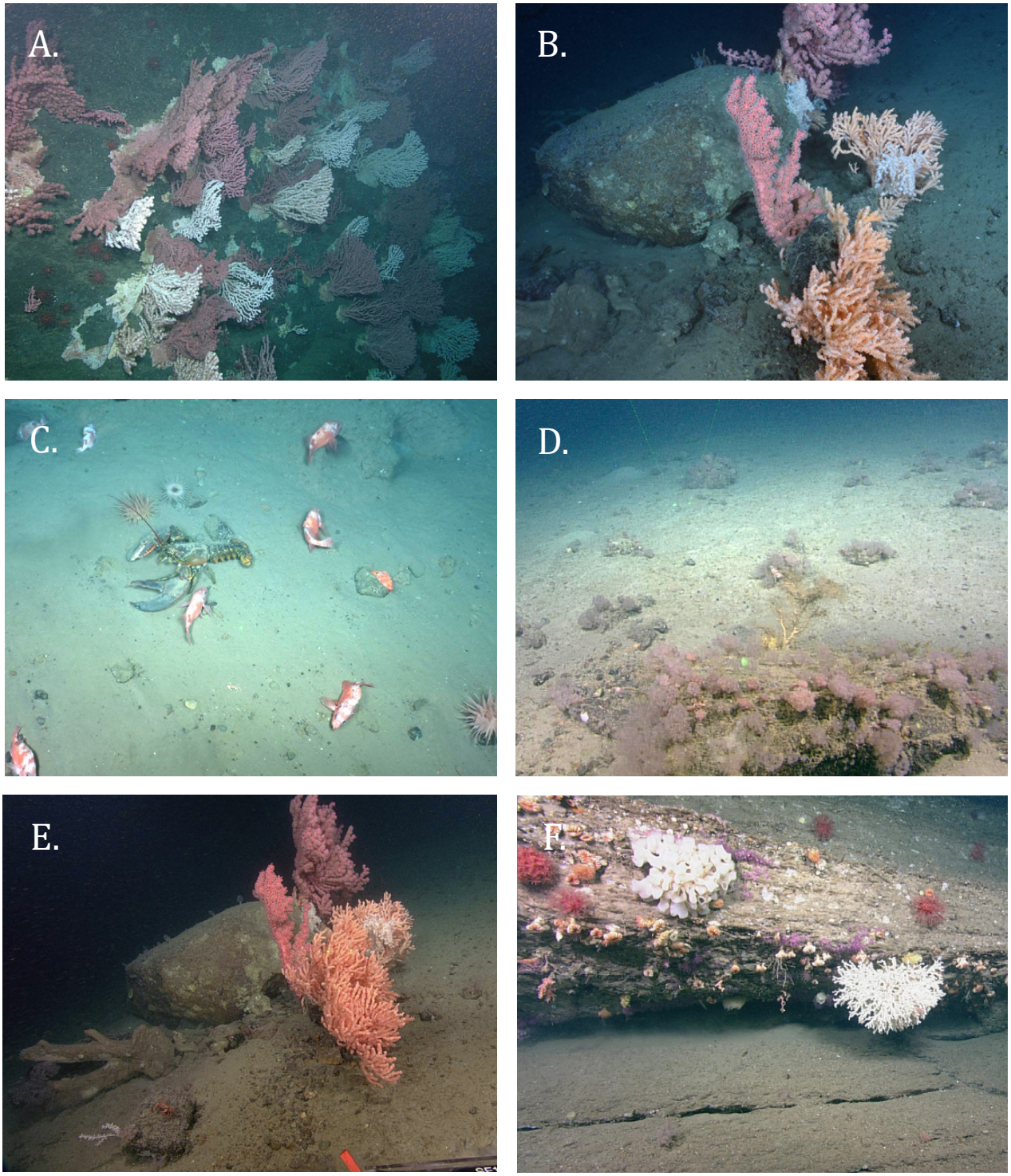

Figure 13. Corsair Canyon. A) Wall of dense *Paragorgia* colonies with white, pink, and red colormorphs. B) A diverse assemblage of corals including *Primnoa* and *Paragorgia* on a boulder. C) Lobster surrounded by redfish on soft bottom. D) Soft coral, possibly *Duva*, on an outcrop. E) *Primnoa*, *Paragorgia,* and a large skeleton of *Paragorgia* at the base of a boulder. F) *Desmophyllum pertusum* (center), *Anthomastus*, sponges, and *Clavularia* (purple) on a ledge.

Dive Number: **R2390**
Locality: **Gulf of Maine Border Bumps, United States**
Date: **23 July 2024**

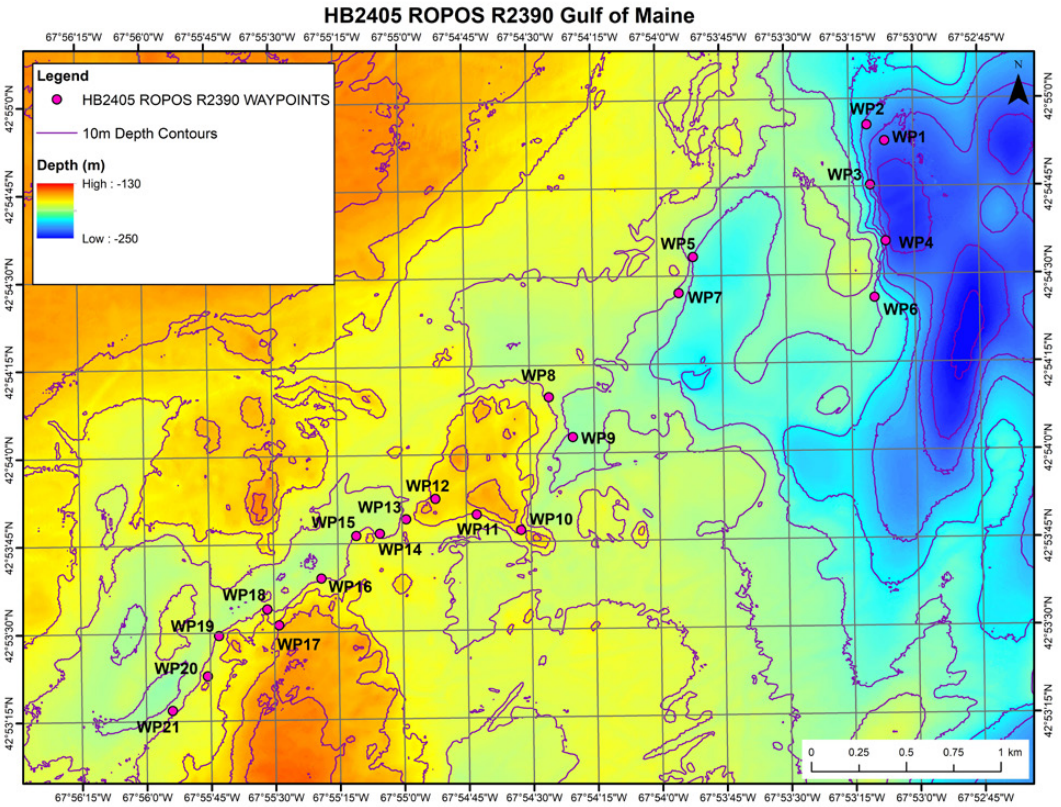

Figure 14. Proposed dive plan, Gulf of Maine "Border Bumps." The actual track was modified due to field conditions.

Gulf of Maine "Border Bumps"

This area of rugged topography, located near the Hague Line in U.S. waters, is characterized by clusters of rounded features and long ridges, all with steep slopes. These features or "bumps" were revealed earlier this year by multibeam mapping conducted by *Saildrone*. Bottom topography had many features characteristic of known deep-sea coral habitats. Thus, groundtruthing of this area was a high priority for the mission. The dive began 00:00 UTC at 243 meter depth. The ROV generally stayed around and below 200 meter throughout the first half of the dive. Here, cobbles and borders covered the highly sedimented seafloor. Anemones and sponges were observed along the transect. Later, the ROV deviated from the 200-meter contour to survey at slightly shallower depths (~180–190 meters). The ROV zig-zagged up and down the outcrops to provide a more complete survey of the steep rock faces and flat plateaus on top of the outcrops. Although the bumps and boulders had all the prerequisites that would suggest suitable habitat for corals, no corals were found. The massive outcrops with tortuous topography were impressive. However, many of the outcrops were almost barren, with scattered attached epifauna like sponges and anemones. Sponges included *Vazella pourtalesii* (Russian hat), vase, polymastiids, encrusting, and other unidentified sponges. Several types of sea stars as well as jonah (*Cancer*) and spider (*Lithodes*) crabs were also observed. Sea stars, sea pens, and cerianthid anemones were observed on soft substrates. Fishes, including Acadian redfish, monkfish, hake, skate, dogfish, and cusk, as well as lobster, and octopus were observed. A school of pollock followed the ROV throughout the last half of the dive. Trawl scars were noted on several of the rock faces. However, no evidence to support the historical occurrence of corals at this site was apparent.

HB2405 *ROPOS* Dive R2390 Gulf of Maine Border Bumps, USA 23 July 2024

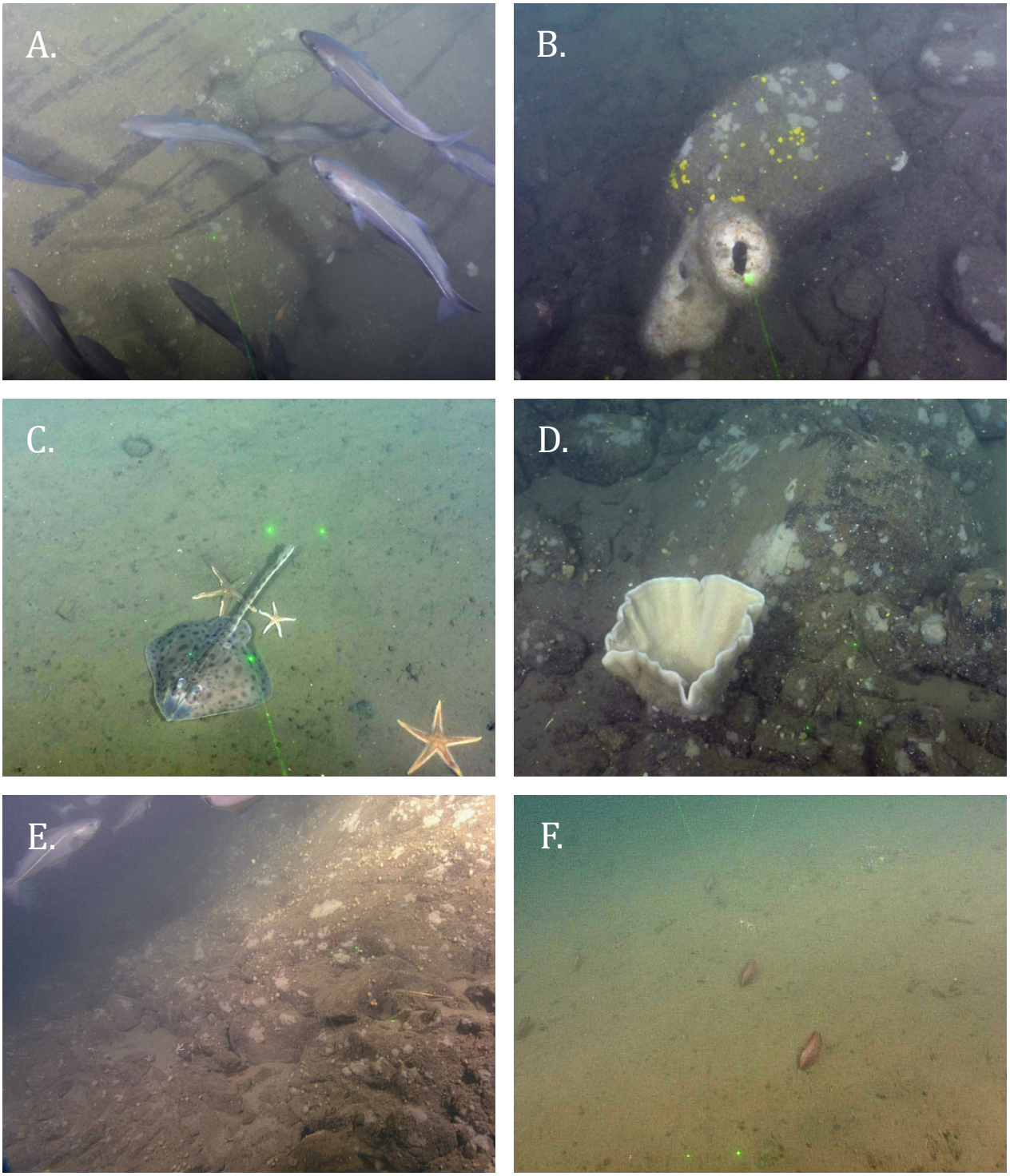

Figure 15. Gulf of Maine "Border Bumps". A) Pollock swimming over trawl marks. B) Large Russian hat sponge with smaller yellow and white encrusting sponges attached to a boulder. C) Skate and starfish on soft bottom. D) Large vase sponge with smaller white encrusting sponges on rocky outcrop. E) Pollock swimming over steep terrain with attached sponges. F) Sea pens on soft bottom.

Dive Number: R2391
Locality: Northeast Channel 1, NECCCA 1, Canada
Date: 24 July 2024

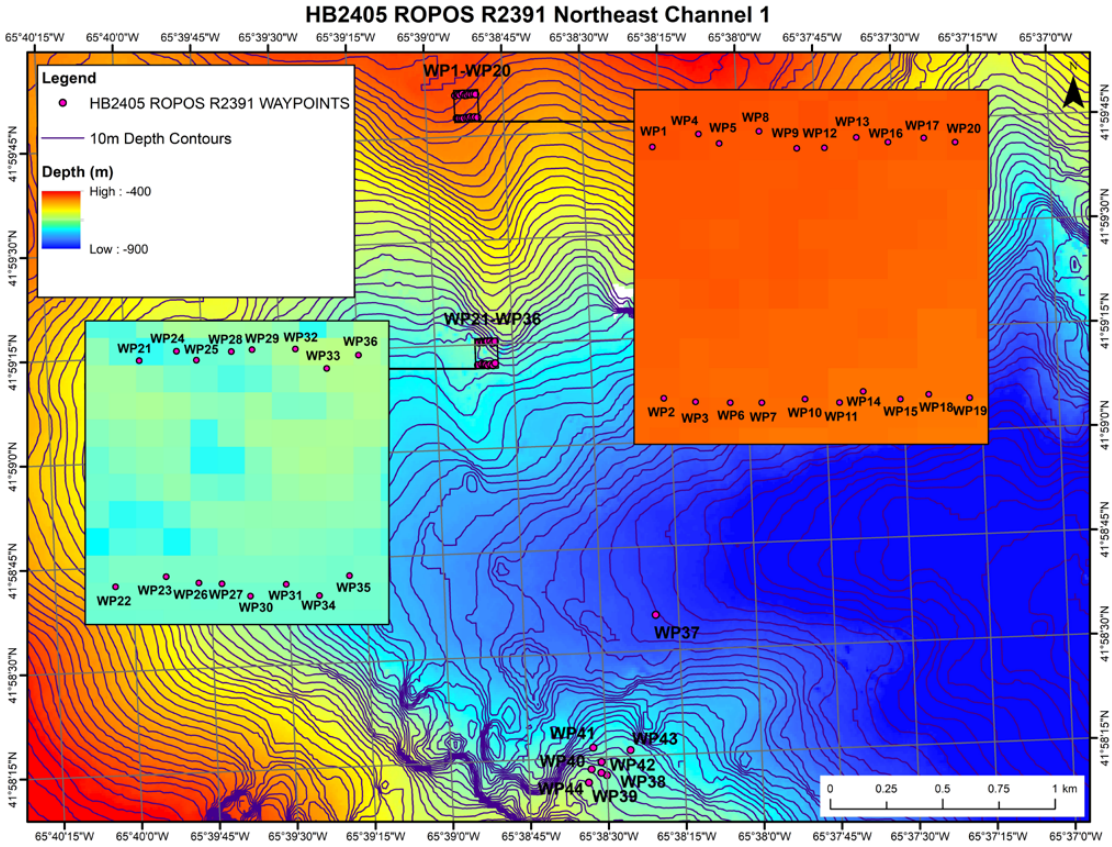

Figure 16. Proposed dive plan, NECCCA 1. The actual track was modified due to field conditions.

NECCCA 1

The NECCCA was established in 2002 as a refuge to protect two numerically dominant octocoral species in the region, *Primnoa resedaeformis* and *Paragorgia arborea*. This site was a priority for the DFO and researchers at Dalhousie University. The main objectives for this dive were to conduct a video survey at Site 1 along a 100-meter × 100-meter grid; conduct a video survey at Site X along a 100-meter × 100-meter grid; and revisit "the rock" to take video footage for photogrammetry. These sites were last visited 10 years ago, and the data gathered here will be used to gage the effectiveness of these closure areas. The ROV was on bottom at 13:02 UTC at 431 meters depth. The bottom, characterized by boulders and cobbles on soft substrates, was covered with massive amounts of brittle stars. Anemones and large colonies of *Paragorgia* and *Primnoa* were attached to small boulders. The ROV maneuvered into position to run the survey grid at Site 1. The survey ended at 16:40 UTC at 461 meters. The ROV then began transiting to Site X. *Primnoa* and *Paragorgia* colonies were observed during transit. The ROV arrived at Site X at 17:46 UTC at 656 meters depth and began the survey. The survey ended at 20:05 UTC at 690 meters depth. The ROV then transited to "the rock" and arrived at 22:37 UTC at 868 meters depth. The survey consisted of moving slowly around the rock, taking video footage and digital still images. The ROV left bottom at 23:06 at a depth of 860 meters. Images and video footage will be used to determine recruitment, growth, and overall health of the coral assemblage.

HB2405 *ROPOS* Dive R2391 NECCCA 1, Canada 24 July 2024

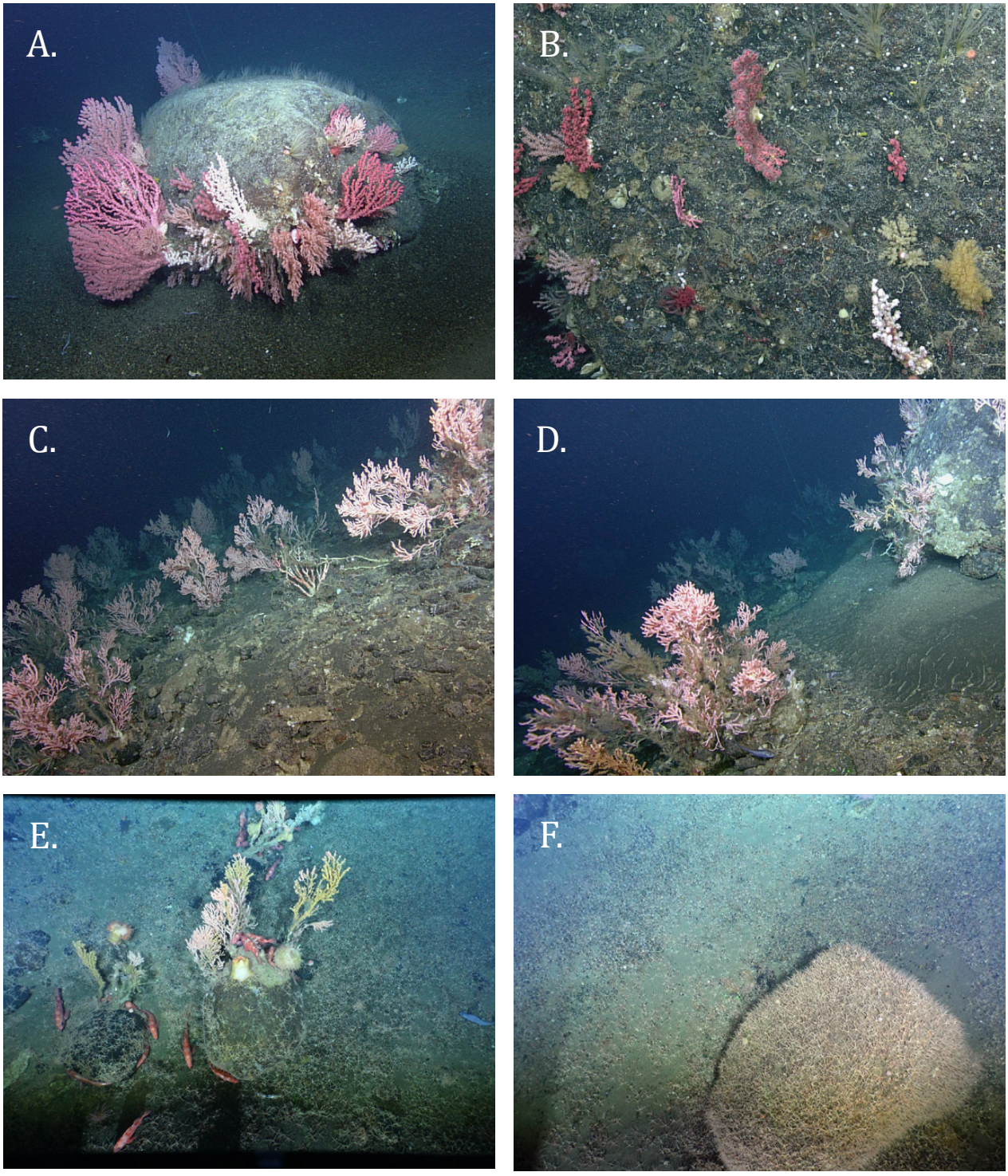

Figure 17. NECCCA 1. The first Northeast Channel dive revisited three survey sites, “the rock”, Site X, and Site 1, last surveyed in 2014. A) “The rock” where the photogrammetry experiment was conducted. B) Close up of “the rock” to highlight new coral recruits. C) Dense aggregation of *Primnoa* at Site X. D) Colonies of *Primnoa* colonized by hydroids (brown) and zoanthids (golden) at Site X. E) *Primnoa*, some overgrown by zoanthids (yellow), on a boulder with brittle stars and associated red fish at Site 1. F) Seafloor and boulder carpeted with brittle stars at Site 1.

Dive Number: R2392
Locality: Northeast Channel 2 (NECCCA 2), Canada
Date: 25 July 2024

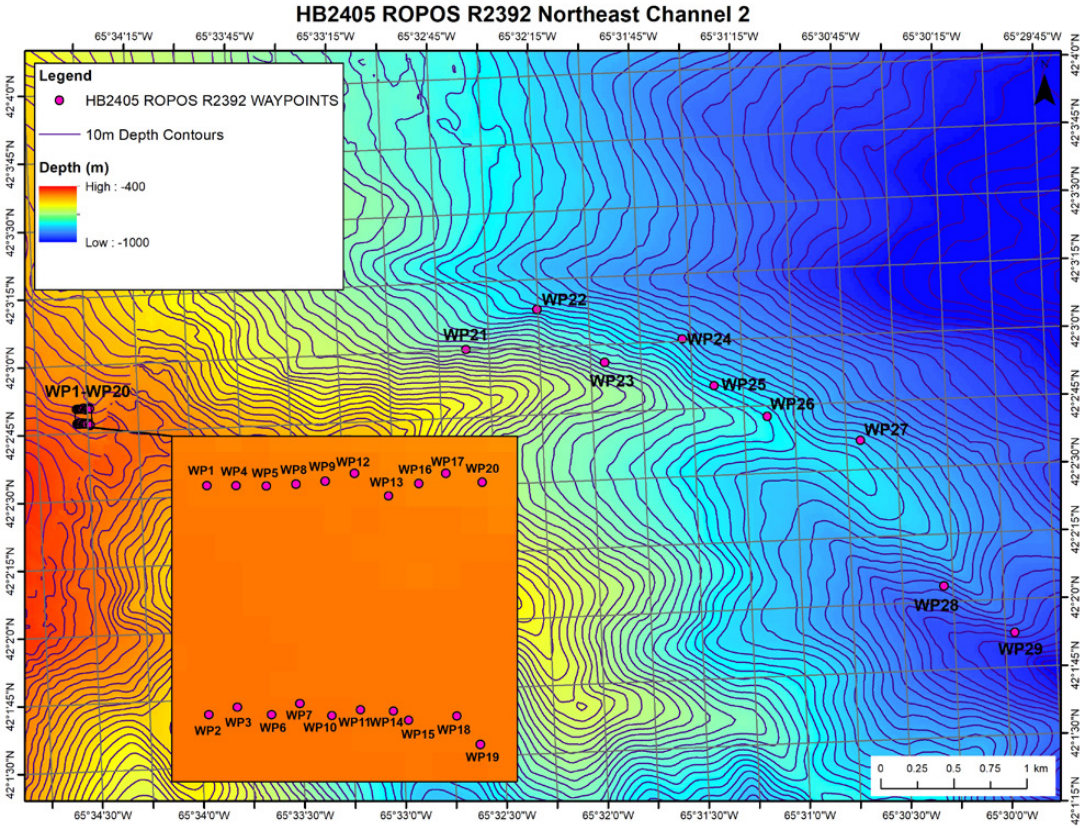

Figure 18. Proposed dive plan, NECCCA 2. The actual track was modified due to field conditions.

NECCCA 2

Dive two continued to assess the effectiveness of the current fishing closure area and determine the need to increase the size of the closure area. The main objectives for this dive were to conduct a video survey at Site 2 along a 100-meter × 100-meter grid and measure the size of select coral colonies; collect specimens for physiological experiments, taxonomy, and genetic analyses; and conduct a video survey along a transect moving from inside to outside the closure area. The ROV was on bottom at 12:52 UTC at 479 meters depth. The seafloor was covered with cobbles and boulders, some of which were colonized by *Primnoa* and sea anemones. Notably, the bottom was also covered with massive aggregations of brittle stars. The survey began at 13:21 UTC at 483 meters depth, but strong currents made it difficult for the ROV to follow the transect lines. The survey was suspended until conditions improved. In the interim, samples of *Primnoa* were collected for physiological experiments, taxonomy, genomics, and stable isotope analyses. At 15:18 UTC, the ROV still struggled against the current. Several coral colonies were measured while waiting for the current to diminish. The survey resumed at 16:50 UTC at a depth of 496 meters and ended at 17:46 UTC at 492 meters depth. The ROV then began transiting through the fishery closure area toward the newly proposed bottom longline exclusion zone. High densities of *Primnoa* and *Paragorgia* were observed. Around 800 meters, fields of *Primnoa* with an occasional *Paragorgia* were present. Fishing line was observed and documented. At approximately 660 meters, *Paragorgia* became more prominent. At 18:59 UTC, the fishery closure boundary was crossed. Extensive gardens of *Paragorgia* and *Primnoa* were prevalent outside the closure area. Habitat then shifted to softer sediments with smaller colonies of *Paragorgia* present. The bottom was mostly clay/mud, but areas of cobbles, pebbles, and shell remains hosted coral colonies. A variety of bottom types were surveyed, but *Primnoa* and *Paragorgia* remained abundant throughout. Small recruits were observed as well as fishing line. The ROV left bottom at 22:00 UTC from a depth of 772 meters.

HB2405 *ROPOS* Dive R2392 NECCCA 2, Canada 25 July 2024

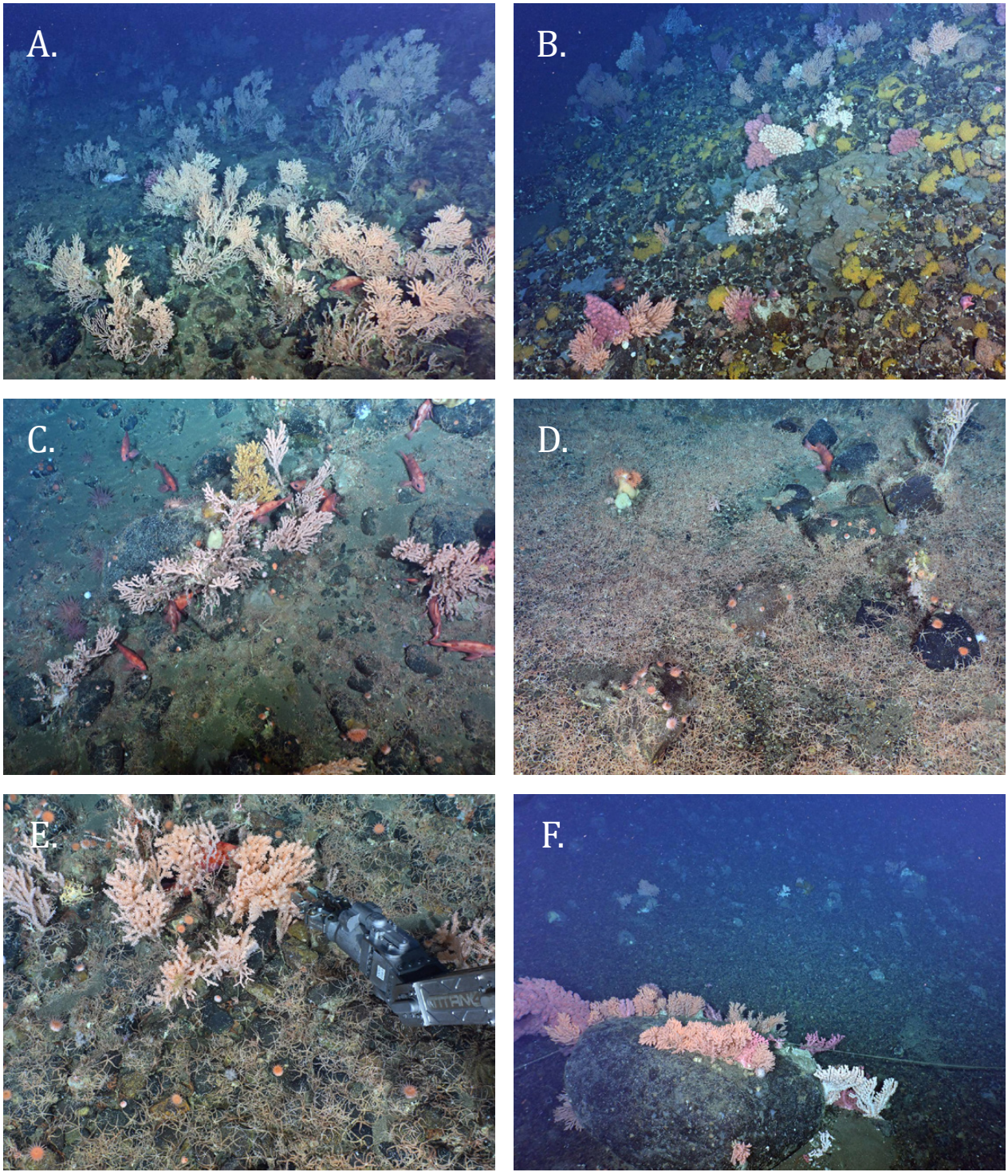

Figure 19. NECCCA 2. The second NE Channel dive revisited Site 2, and then continued outside the closure area. A) Dense aggregation of *Primnoa* on the rugged sea floor just outside the boundary of the closure area. B) Diverse assemblage of *Paragorgia*, *Primnoa*, and yellow stoloniferous coral and sponges outside the closure area. C) Redfish congregate near a stand of *Primnoa* at Site 2. D) Brittle stars carpet the seafloor near Site 2. E) Collecting *Primnoa* near Site 2. F) Fishing line draped over a rock colonized by *Paragorgia*, *Primnoa*, and sponges outside the closure area.

Dive Number: **R2393**
Locality: **Central Jordan Basin, Canada**
Date: **27 July 2024**

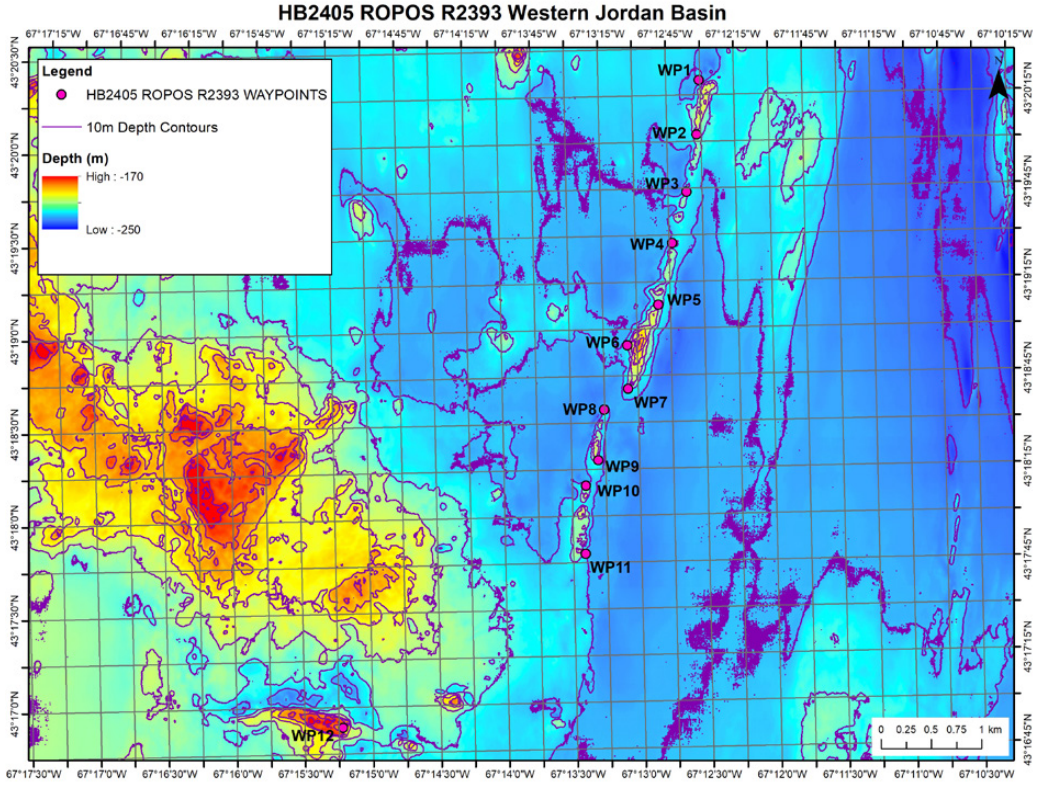

Figure 20. Proposed dive plan, Central Jordan Basin. The actual track was modified due to field conditions.

Central Jordan Basin

This basin was also a high priority site for the DFO. In support of the goal to protect 30 percent of Canada's coastal and marine areas by 2030, DFO wanted to learn more about this location for potential inclusion in their MPA network. A dive track was selected based on recently collected multibeam data that would allow for a number of features to be surveyed during the dive. The ROV was on bottom at 12:21 UTC at a depth of 223 meters. The ROV navigated to the first feature where a lightly sedimented steep wall with several colonies of *Paramuricea* attached, was observed. This coral was observed in extremely high densities throughout the entire dive. Three colormorphs were present: yellow, purple, and an intermediate, pink form; yellow colonies were the most abundant. Interspersed between the *Parmuricea* colonies were large numbers of brachiopods and small anemones. Samples of all colormorphs of *Paramuricea* were collected for taxonomy, genomics, and isotope analyses with one example of the yellow form collected for whole genome analysis. One colony of *Primnoa* was also sampled for whole genome analysis. Biodiversity was low at this site with *Paramuricea*, anemones, and brachiopods comprising the characteristic assemblage observed during this dive. Additionally, xenophyophores were present, no ophiuroids were found in association with *Paramuricea*, and a large school of pollock followed the ROV for most of the dive. The ROV left the bottom at 23:10 UTC at 212 meters depth.

HB2405 *ROPOS* Dive R2393 Central Jordan Basin 27 July 2024

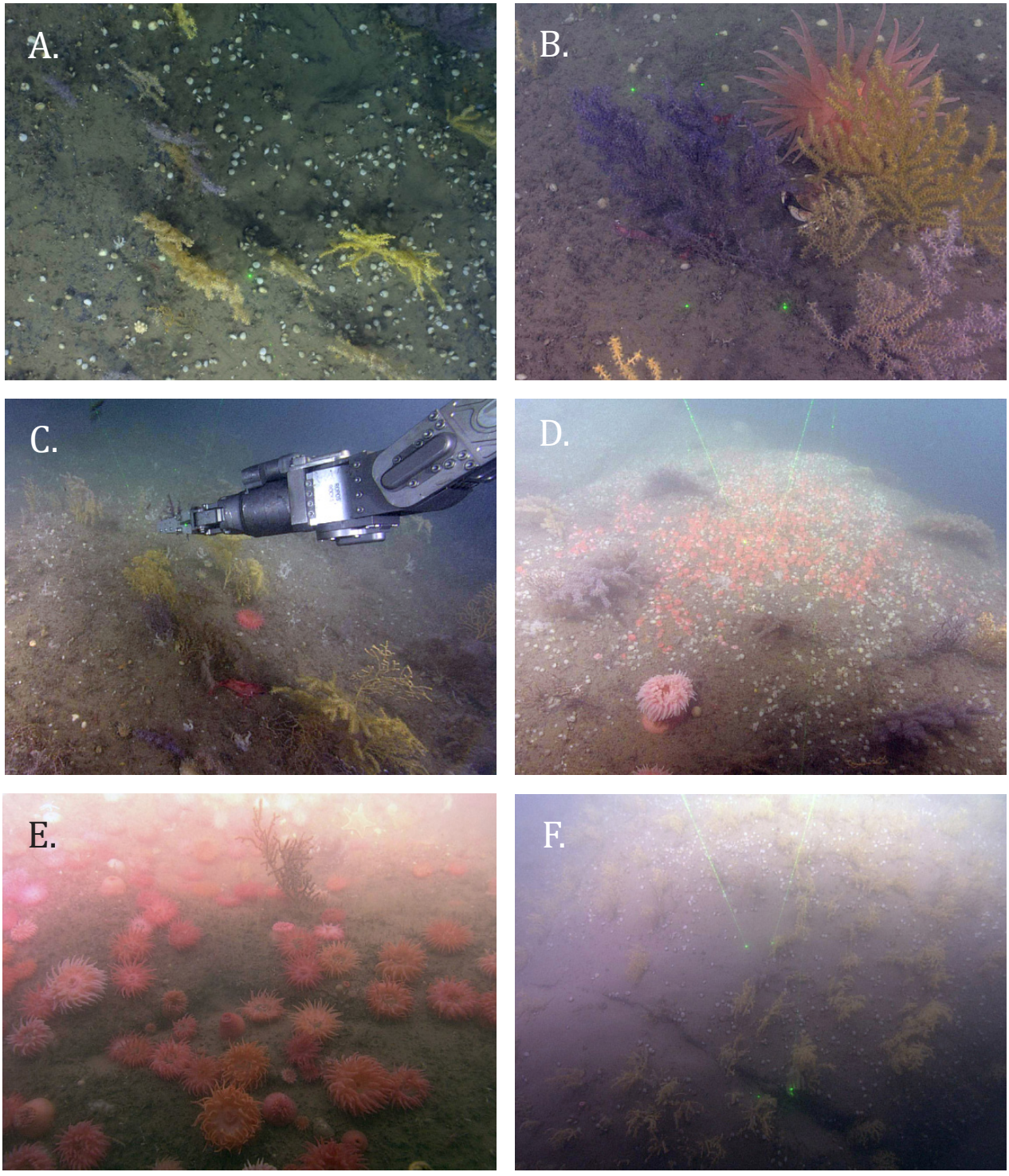

Figure 21. Central Jordan Basin. A) View from above of brachiopods and *Paramuricea* on hard bottom draped in sediment. B) Purple, yellow, and pink colormorphs of *Paramuricea*. C) Collecting *Paramuricea.* D) Small, pink anemones, *Paramuricea,* and brachiopods. E) Large, colorful anemones characteristic of the Gulf of Maine. F) View of high relief habitat colonized by *Paramuricea*.

Dive Number: **R2394 (Canada) and R2395 (United States)**
Locality: **Transboundary Elbow, Canada and United States**
Date: **28 July 2024**

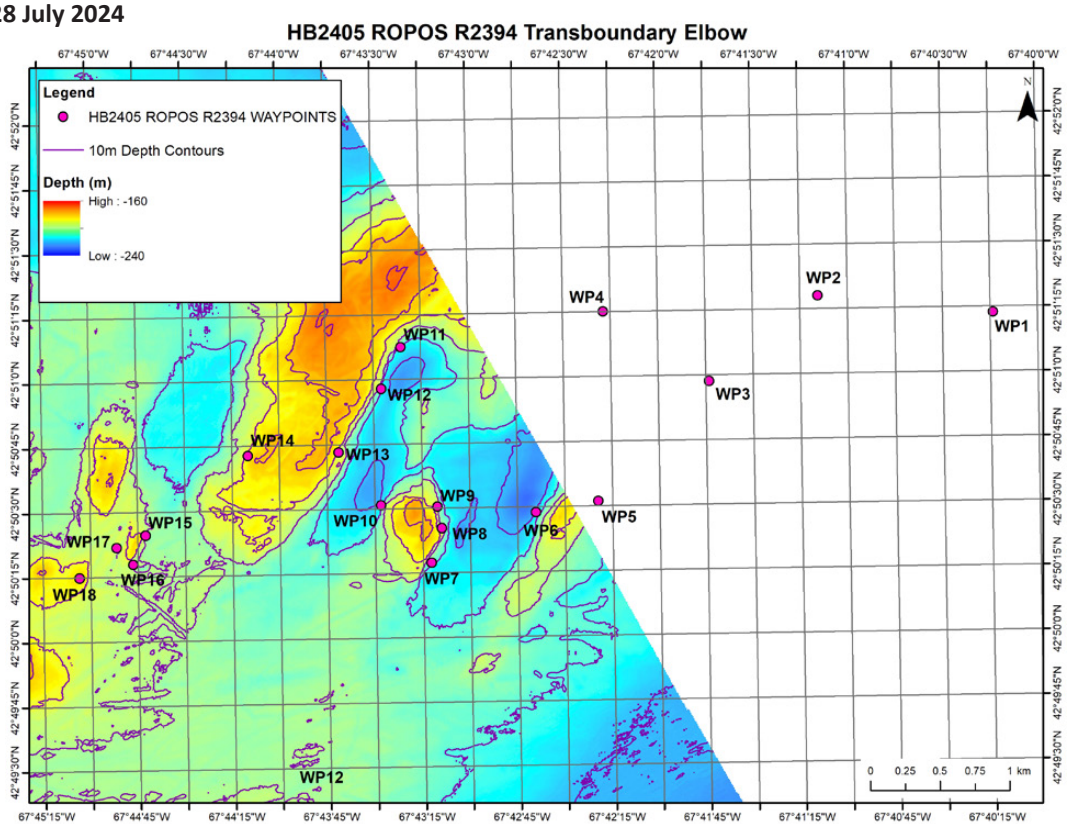

Figure 22. Proposed dive plan, Transboundary Elbow. The actual track was modified due to field conditions.

Transboundary Elbow

It has become a tradition during these joint United States/Canada missions to conduct a true transboundary survey in the Gulf of Maine. A line near the crook or "elbow" of the Hague Line near Sewell Ridge and Crowell Basin was chosen this year. *Saildrone* had mapped the American side recently, so the *Henry Bigelow* mapped the Canadian side immediately prior to the dive to provide the bathymetry needed to plan the survey. The survey started in Canadian waters and headed west, with focus on areas of steep and high relief. A rocky, sediment-covered bottom was encountered at 220 meters, followed by a gentle slope upwards. White and yellow encrusting sponges were extremely abundant. The ROV then surveyed up and down steep bedrock features, covered in a sediment drape, that were interspersed with flatter areas of cobble, boulders, and soft substrates. Trawl marks were evident everywhere on the hard bottom areas, although less so closer to the Hague Line. Fishing line and trash were also observed. Major fauna included a variety of sponges, in particular white and yellow encrusting sponges, sea stars, anemones, sea pens (soft bottom areas), zoanthids, redfish, and a school of pollock. A single, small *Paramuricea* colony was observed in one of the flat areas along the transect, followed by a handful of solitary *Paramuricea* colonies further along. Just before crossing the border, an area of small-sized, but abundant *Paramuricea* colonies with all colormorphs represented, was encountered at ~196 meters depth. After the ROV crossed the border, it was discovered that the mount holding the starboard Niskin bottles was broken and that it was necessary to recover the vehicle for repair. An hour later, the ROV was re-deployed and continued the American portion of the transboundary dive. The ROV was on bottom at 19:45 UTC at a depth of 210 meters and navigated to waypoint 8 where the habitat was very similar to that on the Canadian side. The habitat was characterized by steep walls, some with ledges, interspersed with a rocky, sediment-covered bottom. White and yellow encrusting sponges were extremely abundant. Sea stars and anemones were present in relatively high abundances; sea stars were particularly diverse. Red fish were present in high abundances as well. Trawl marks were evident on hard substrates, and a lobster trap was noted. Unfortunately, and remarkably, no corals were observed before the dive ended at 23:16 UTC at 188 meters depth.

HB2405 *ROPOS* Dives R2394 & 2395 Transboundary Elbow 28 July 2024

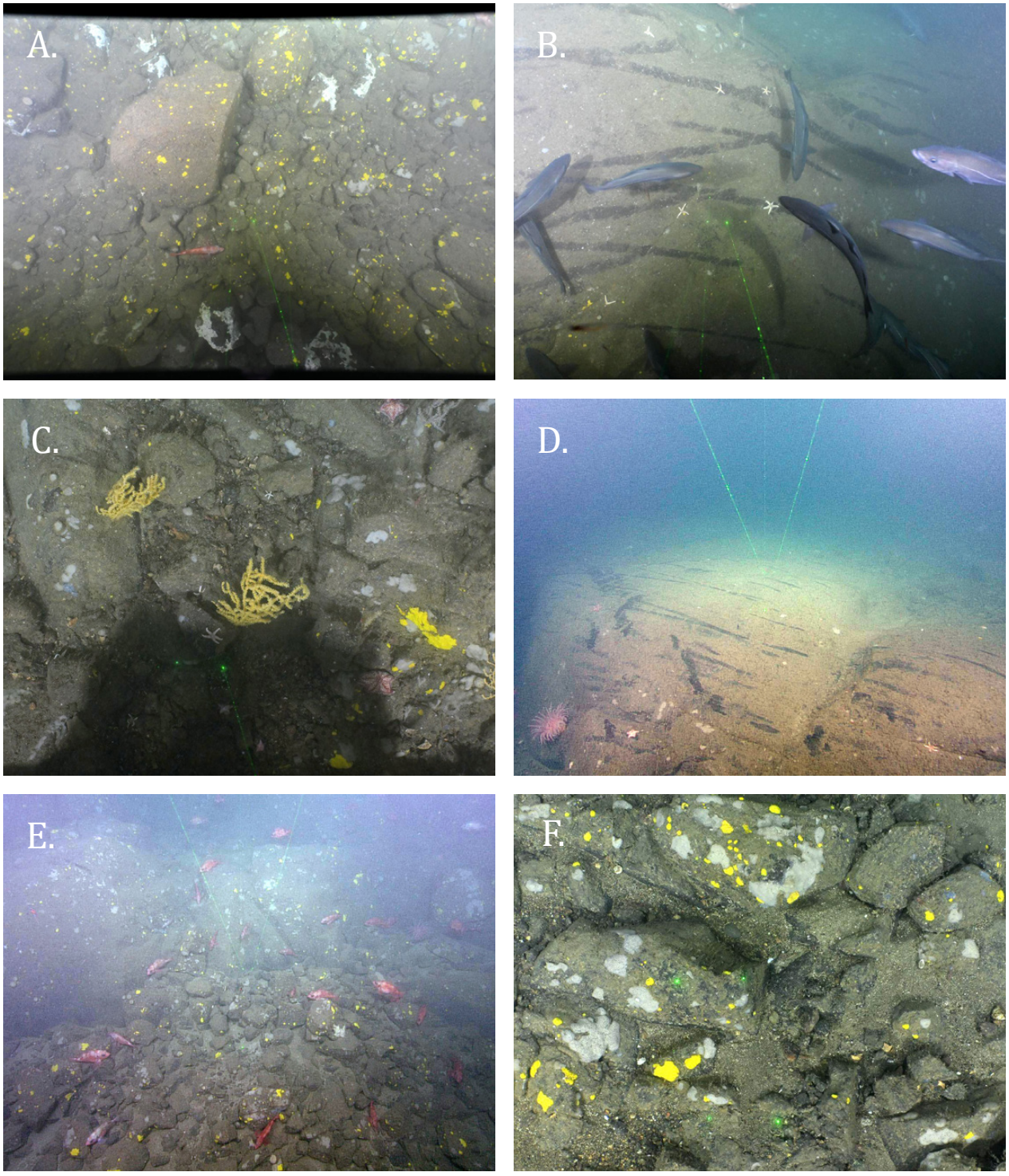

Figure 23. Transboundary Elbow. Leg 1, Canada (R2394): A) Yellow and white encrusting sponges. B) Pollock swimming over trawl marks on hard substrate. C) *Paramuricea* and white sponges on a rocky outcrop. Leg 2, United States (R2395): D) Sea stars and an anemone on hard substrate with trawl marks. E) Yellow and white sponges with red fish on cobble bottom. F) Close-up of yellow and white encrusting sponges.

Dive Number: **R2396**
Locality: **Hydrographer Canyon, United States**
Date: **30 July 2024**

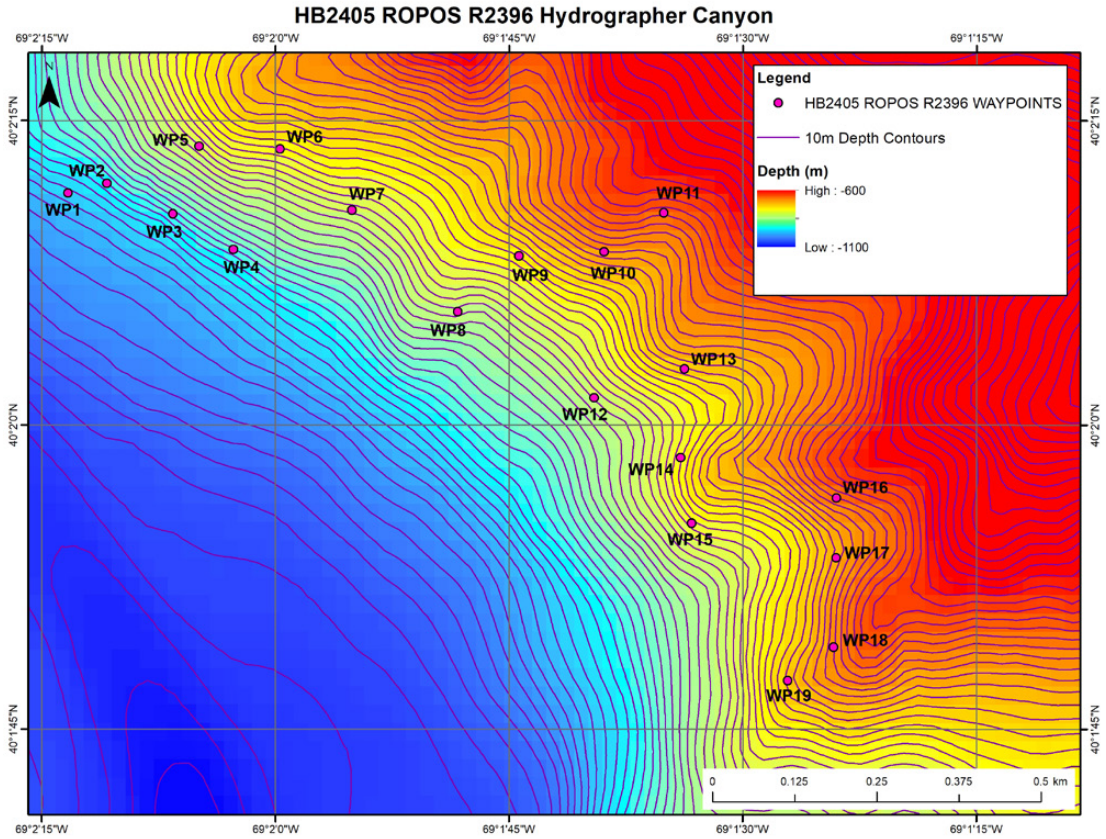

Figure 24. Proposed dive plan, Hydrographer Canyon. The actual track was modified due to field conditions.

Hydrographer Canyon

This canyon was added to the cruise plan when weather conditions in the Gulf of Maine deteriorated. Hydrographer had not been surveyed since 2013 and was close to Newport, Rhode Island, making it an ideal alternative. The ROV was on bottom at 12:41 UTC at a depth of 961 meters. Immediately, a gently sloping, lightly sedimented, canyon wall hosting a high diversity of corals, including *Paramuricea*, *Solenosmilia*, *Thouarella*, *Acanthogorgia*, and solitary cup corals (*Desmophyllum dianthus* and *Javania*), followed by a field of bamboo coral was observed. Throughout the dive, we encountered sections of the vertical wall that were covered in colonies of *Paragorgia* of various sizes, but most were ≥ 3 meters. Several coral taxa were observed in high abundances, producing localized monotypic gardens. Muddy bottom habitat with fly trap anemones and synaphobranchid eels swimming through the water column were encountered between steeper rock faces, some of which were highly sedimented. In other areas, the canyon wall was terraced with ledges and overhangs that supported diverse and abundant invertebrate fauna. Of particular note, multiple species of cephalopods were regularly encountered, few anemones were observed, recruits of *Paramuricea*, *Swiftia*, and *Paragorgia* were frequently noted, and a field of carnivorous sponges was observed. At least two times, *Paragorgia* in flow-through "caves" was encountered. Towards the end of the dive, at 714 meters, another steep wall covered with medium to large colonies of *Paragorgia* was observed. The ROV traversed from about 720–775 meters, observing band after band of bubblegum corals. The dive ended at 21:01 UTC at 749 meters in front of a large colony of *Paragorgia*, the last image of the cruise!

HB2405 *ROPOS* Dive R2396 Hydrographer Canyon, USA 30 July 2024

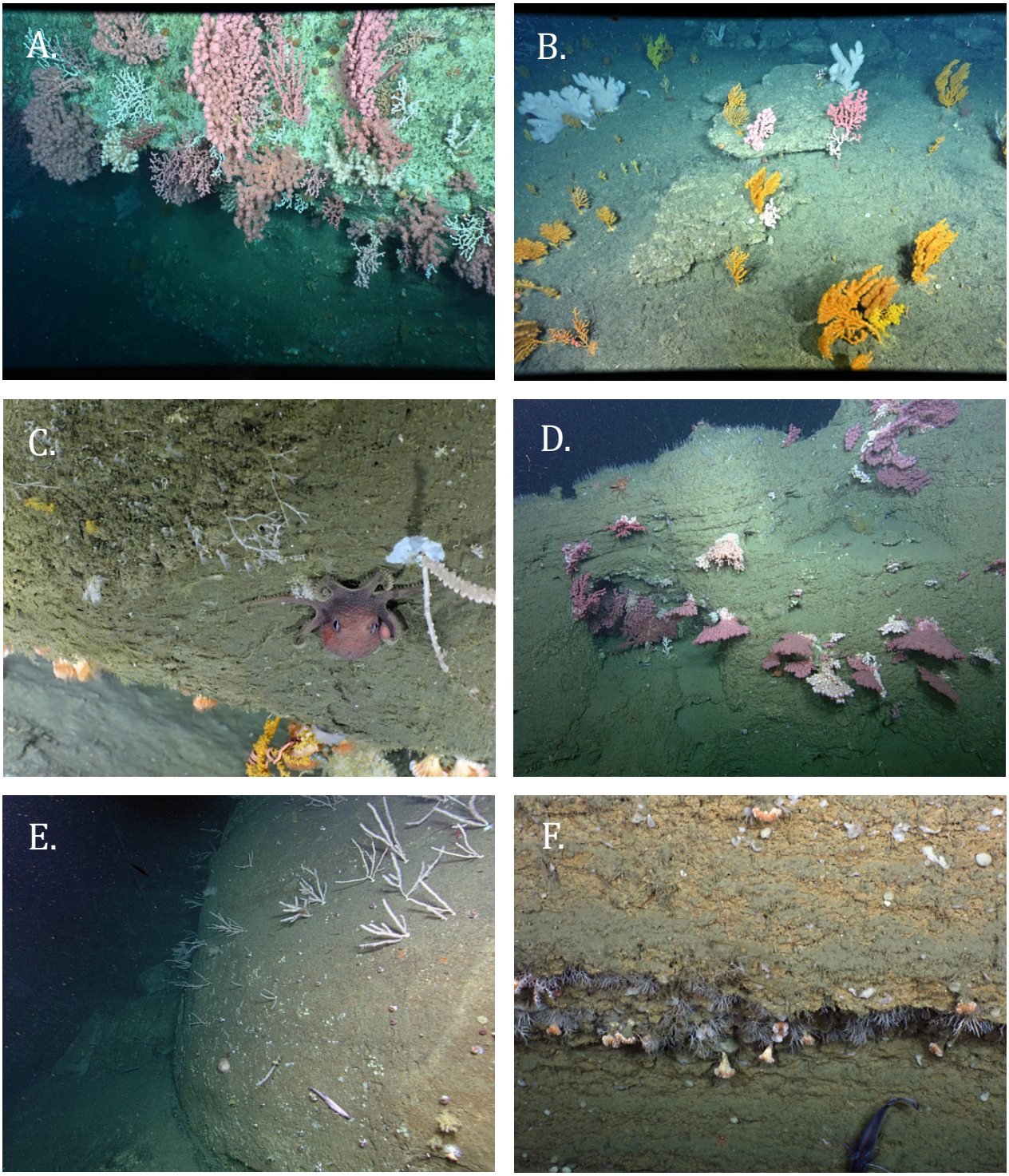

Figure 25. Hydrographer Canyon. A) Dense aggregation of *Paragorgia* on a vertical wall. B) A diverse assemblage of corals including *Paramuricea, Paragorgia,* and *Thouarella*. C) Octopus, bamboo coral, and carniverous sponge on a steep slope. D) *Paragorgia* in a flow-through "cave." E) Bamboo coral on a vertical wall. F) Carnivorous sponges and *Desmophyllum dianthus* under a ledge.

HIGHLIGHTS

- Large colonies of the bubblegum coral *Paragorgia arborea* were observed covering the walls of multiple canyons (e.g., Oceanographer, Heezen, Hydrographer, Corsair canyons).
- These were some of the highest abundances and largest colonies of *P. arborea* ever seen by the science team.
- High densities (or fields) of *Paramuricea* and *Primnoa* were observed.
- Video data provide further evidence that canyons are hotspots of biodiversity.
- Species composition and/or the numerically dominant species of corals differ depending on the canyon and/or the depth of the survey.
- Presence of small colonies of *Paramuricea*, *Paragorgia*, and *Swiftia* suggest relatively recent recruitment events.
- Ten-year checkup at four dive locations provided evidence that the overall health of the coral colonies appears to be good.
- Benthic octopods and sepiolids plus mesopelagic squids were seen regularly throughout the canyons. There was one rare sighting of a mesopelagic glass squid, Family Cranchiidae.
- Trawl marks were evident at Gulf of Maine dive locations on both sides of the U.S./Canadian border.
- Newly collected multibeam bathymetry at the Gulf of Maine Border Bumps indicated prime habitat for corals based on the high slope and rugged terrain, but corals were absent at this location.
- Three colormorphs (yellow, purple, and pink) of *Paramuricea* are represented at the Gulf of Maine study sites.
- Large aggregations of sea anemones dominate the benthic landscape on some hard bottom habitats in the Gulf of Maine.
- Groundtruthing newly collected multibeam bathymetry and surveying previously unexplored locations support improvements to species distribution models.
- An estimated 141 square kilometers of multibeam sonar data were collected in areas where data were missing or incomplete.

SUMMARY

The CROCHET 2024 mission was the fourth highly successful transnational collaboration between the United States and Canada. Data were collected in support of all stated objectives and provided valuable information necessary to address specific research questions as well as broader topics of interest to stakeholders. For example, surveys in the Monument provided a 10-year checkup on the corals in Oceanographer Canyon and observations in a previously unexplored portion of Gilbert Canyon. These data support the mission and directives of the resource managers tasked with managing these canyons as well as numerous deep-sea coral research projects focused on canyons in the Northeast Region. Conservation objectives in Canadian waters were met through multiple surveys designed to assess the effectiveness of fishery closure areas, determine if the size of the closure areas was sufficient, and find new locations worthy of protection. Areas of rugged terrain revealed by the *Saildrone* multibeam initiative were groundtruthed, and additional multibeam data were collected to fill in data gaps. Samples were collected for taxonomy, isotopes, and genomics and water for eDNA analysis. Hours of video footage and hundreds of digital still images will be analyzed to provide the data necessary to support the research interests of the participating scientists as well as aid local, regional, and federal stakeholders in management decisions. We shared our science with our peers, stakeholders, and the public through telepresence, social media, interviews, presentations, and publications. Additionally, every dive presented something new and/or exciting. Whether discovering a new location where corals are present, deciphering the absence of corals in areas where we would expect them to occur, discovering an amazing assemblage of corals, or observing animals *in situ*, we increased our knowledge of these habitats and the natural history/behaviors of deep-sea organisms that live in and around coral habitats. Ongoing collaborative work on both targeted projects and exploratory surveys further demonstrates the importance of canyons, the Gulf of Maine, and the need to protect these ecosystems.

ACKNOWLEDGMENTS

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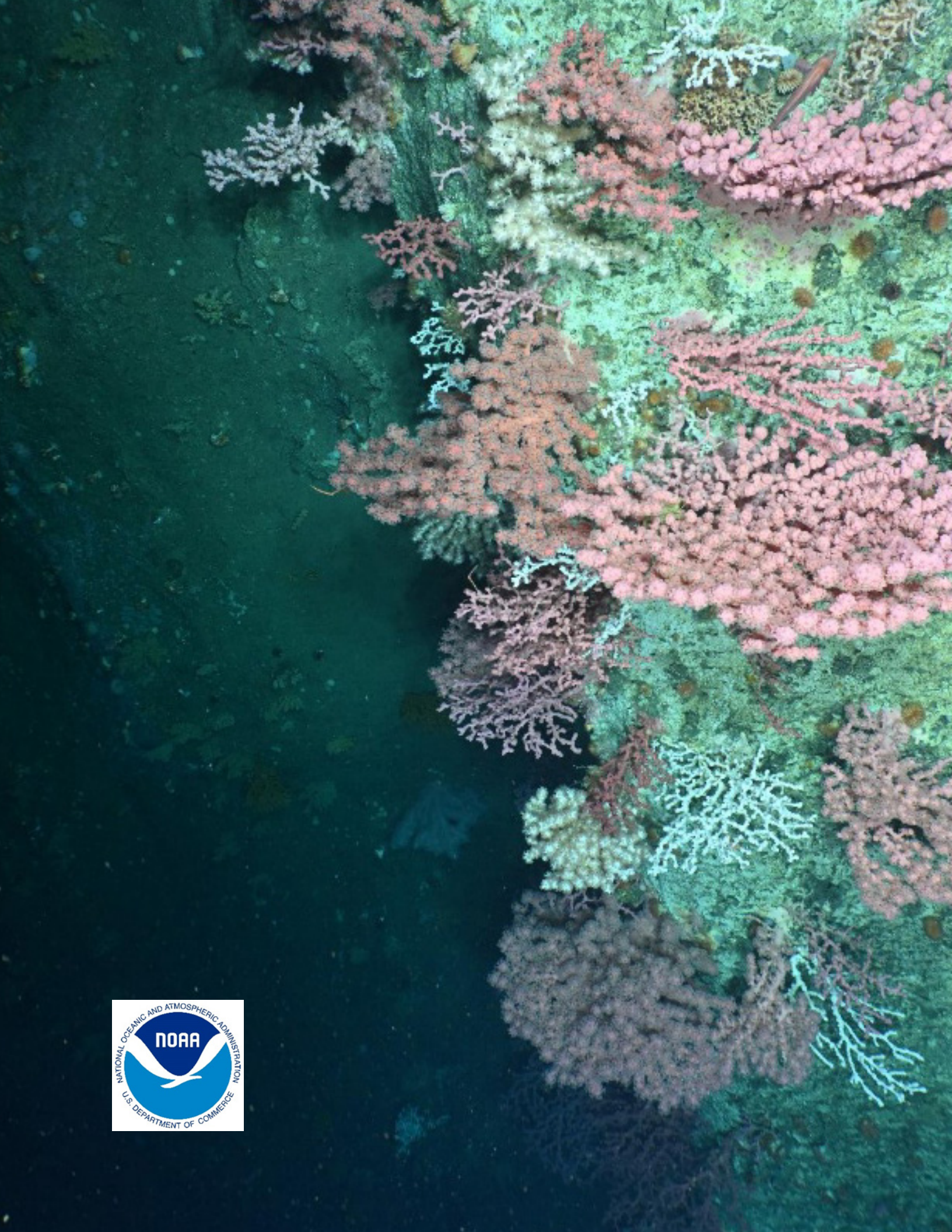
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