Sampling protocols for long-term monitoring of epibenthic biodiversity of the Bay of Fundy scallop grounds

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2024

Canadian Manuscript Report of Fisheries and Aquatic Sciences 3295

Fisheries and Oceans Canada Pêches et Océans Canada

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Canadian Manuscript Report of
Fisheries and Aquatic Sciences 3295

2024

SAMPLING PROTOCOLS FOR LONG-TERM MONITORING OF EPIBENTHIC BIODIVERSITY OF THE BAY OF FUNDY SCALLOP GROUNDS

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Cat. No. Fs 97-4/ 3295E-PDF ISBN 978-0-660-74116-1 ISSN 1488-5387

Correct citation for this publication:

Nozères, C., MacDonald, B.W., Sameoto, J.A., Raper, J., Lirette, C., and Kenchington, E. 2024. Sampling protocols for long-term monitoring of epibenthic biodiversity of the Bay of Fundy scallop grounds. Can. Manuscr. Rep. Fish. Aquat. Sci. 3295: iv + 17 p.

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A sampling protocol that serves to monitor temporal changes in the megabenthic fauna associated with the commercial scallop fishing grounds in the Bay of Fundy is documented. The protocol is discussed from several aspects, including the challenges to document presences in the survey catch when using paper forms and digital photos, continuity with previous surveys, and potential changes or updates for future surveys.

RÉSUMÉ

Nozères, C., MacDonald, B.W., Sameoto, J.A., Raper, J., Lirette, C., and Kenchington, E. 2024. Sampling protocols for long-term monitoring of epibenthic biodiversity of the Bay of Fundy scallop grounds. Can. Manuscr. Rep. Fish. Aquat. Sci. 3295: iv + 17 p.

Un protocole d'échantillonnage qui sert à surveiller les changements temporels de la faune mégabenthique associée aux lieux de pêche commerciale du pétoncle dans la baie de Fundy est documenté en vue de son utilisation lors d'un relevé des stocks en 2024. Le protocole est discuté sous plusieurs aspects, y compris les défis de documenter les présences dans les captures lors de l'utilisation de formulaires de papier et de photos numériques, continuité avec les relevés précédents et les changements ou les mises à jour potentielles pour les relevés futurs.

INTRODUCTION

Single species fisheries surveys for assessing commercial stock status may serve as platforms of opportunity to collect data on ancillary, or bycaught, species (Lacasse et al. 2020). As regular occurring activities, stock surveys by Canada's Department of Fisheries and Oceans (DFO) may inform on trends over time and enable monitoring of marine communities. Scallop surveys are an example of such an activity, through bottom sampling (dredging) of epibenthic taxa. In the Bay of Fundy, there have been studies to analyze the sampled benthos and their temporal trends, beginning with scallop surveys in 1970 (Caddy 1970), into the 1990s (Fuller et al. 1998) and the 2000s (Kenchington et al. 2007, Staniforth et al. 2023). In 2024, the Bay of Fundy scallop survey again included a biodiversity component with the goal of conducting sampling that would be comparable to past (1990s and 2000s) surveys. The goal of this report is to describe how the presences of megafaunal species were recorded on the 2024 scallop survey. Documenting the methods related to this sampling establishes a benchmark to enable future monitoring. It can also serve as a reference to facilitate consistency in sample identification for future biodiversity data collection while at sea (see Appendix).

Sampling on a scallop survey involves dredging on the sea bottom, resulting in catches of a variety of mostly benthic epifaunal invertebrates including the target species, the sea scallop, *Placopecten magellanicus*. The Bay of Fundy scallop survey routinely collects data on scallop, lobster, skates, octopus, squid, and commercial groundfish species (Glass 2017). Recording information on other species during the survey is not logistically feasible under normal survey operations. However, in 2024, Marine Conservation Target funds were provided to enable a third DFO science staff on the Bay of Fundy survey. This enabled a biodiversity assessment to be conducted during the inshore scallop survey legs that covered area of St. Marys Bay, Brier Island, Lurcher Shoal, and South West Bank. The objective of this biodiversity assessment was to record the presence of all visible kinds of invertebrates. Traditionally, biodiversity surveys require systematic sample collection and examination, including laboratory work. This is not feasible during a stock survey on a vessel with limited space and only a short delay between sampling sites. Knowing these limitations, a protocol was established to produce data that both follows past efforts while striving to be efficient and reliable, so as not to hinder stock survey operations and objectives.

For the 2024 protocol, several elements were conserved from past surveys, such as recording presences on deck sheets, while new elements were also introduced, notably with the systematic photos of captures. Detailed results on biodiversity from the 2024 survey are not presented in the current report except to inform about the past and present protocols. Other means of data capture are discussed. However, the focus of this report is to document how biodiversity was assessed in 2024.

MATERIALS AND METHODS

Sampling

Inshore scallop stock surveys are conducted in summer months in the Bay of Fundy and approaches, with surveys conducted annually using dredge gear. Further details on the survey history, gear, and survey design can be found in Glass (2017). For 2024, the biodiversity was examined from areas of St. Marys Bay, Brier Island, Lurcher Shoal, and South West Bank. The survey operated from a chartered fishing vessel with nine-gang (drag) toothed miracle scallop gear that was towed for approximately eight minutes at each station; hereafter a location that was sampled with this drag gear is referred to as a tow. Two of the gangs (nos. 3 and 7) are lined with a 38-mm polypropylene mesh to enable retention of smaller specimens. Upon completion of each tow, the catch is emptied onto a dump table on deck. The dump table is divided by metal plates that are approximately 65.5 cm apart and there are 9 dedicated spaces on the dump table, such that the catch from each gang is emptied into a distinct space, thus keeping the catch separate for each gang (Figure 1). The invertebrate fauna is then assessed from the space for gang no. 3. If the gang has no content, then the other lined gang (no. 7), may be used. Scallop, lobster, skates, octopus, squid, and commercial groundfish species are removed, assessed and recorded by the regular survey staff. These data are recorded in the Inshore Scallop Survey database and do not form part of the targeted, epibenthic biodiversity assessment, although they were recorded in the photo data, as were all visible taxa.

Equipment

Documenting biodiversity made use of basic materials: pre-printed sheets on waterproof paper, a clipboard, pencils, paper labels, plastic bags for conserving samples, and a digital camera. In 2024, the camera was a waterproof camera (Olympus TG-5). The camera has a GPS sensor which was not used, in favour of the shipboard GPS for tow locations. The camera also has a macro focusing capability (to 0 cm), which was used for selected specimens. While not done at-sea, additional equipment used was a personal computer with photo cataloguing software (Adobe Lightroom CC). Survey photos were tagged by tow and keyworded by type: *information* (data sheets), *capture* (lined gang), *subcapture* (selection in sorted tray), and *sample* (retained for analyses). Photos were also keyworded for all taxa (scientific name) seen in the field of view.

Documentation

Several steps (keyword in italics below) are performed while at sea, all documented with photos (Table 1, Figure 1). The first step is a photo of the data sheet, with the written *information* on date, survey, area, and tow number. The tow numbers are sequential numbers from 1 and onwards; they do not represent a fixed station numbers in the survey database but are the order in which tows were conducted at sea. The sheet photo serves as a placeholder, to indicate the beginning of an event in the photos. Next follows the *capture* or catch on deck photos for all gangs (wide view), and lined gang no. 3 (closer view). The epibenthos is then examined by sorting through any rocks and scallops from the gang, with a selected *subcapture* of specimens of each kind collected in a bucket, then sorted onto a white plastic tray and photographed with a tow label in view (Figure 2). Additional photos often followed, including macro shots of any species or shape of potential interest, or difficult to identify, that may also be retained for further examination in the lab. To close the event, a final photo is taken of the marked-up data sheet with checks on noted taxa and written comments on the catch. The notes in the marked-up sheet photo could then be used to confirm the taxa seen in the other photos.

Table 1. Summary of at-sea steps using photos to document catch biodiversity.

Step	**Note**
Information: data sheet with tow number	Timestamp to start the event
Capture: total and lined gang views	Document gang contents and substrate
Subcapture: sorted specimens on a tray; may also do close-up views of special kinds	Document taxa to review with data sheet
Information: taxa checked on sheet with written comments on gang and substrate	Timestamp to end the event and record taxa for review with sample photos

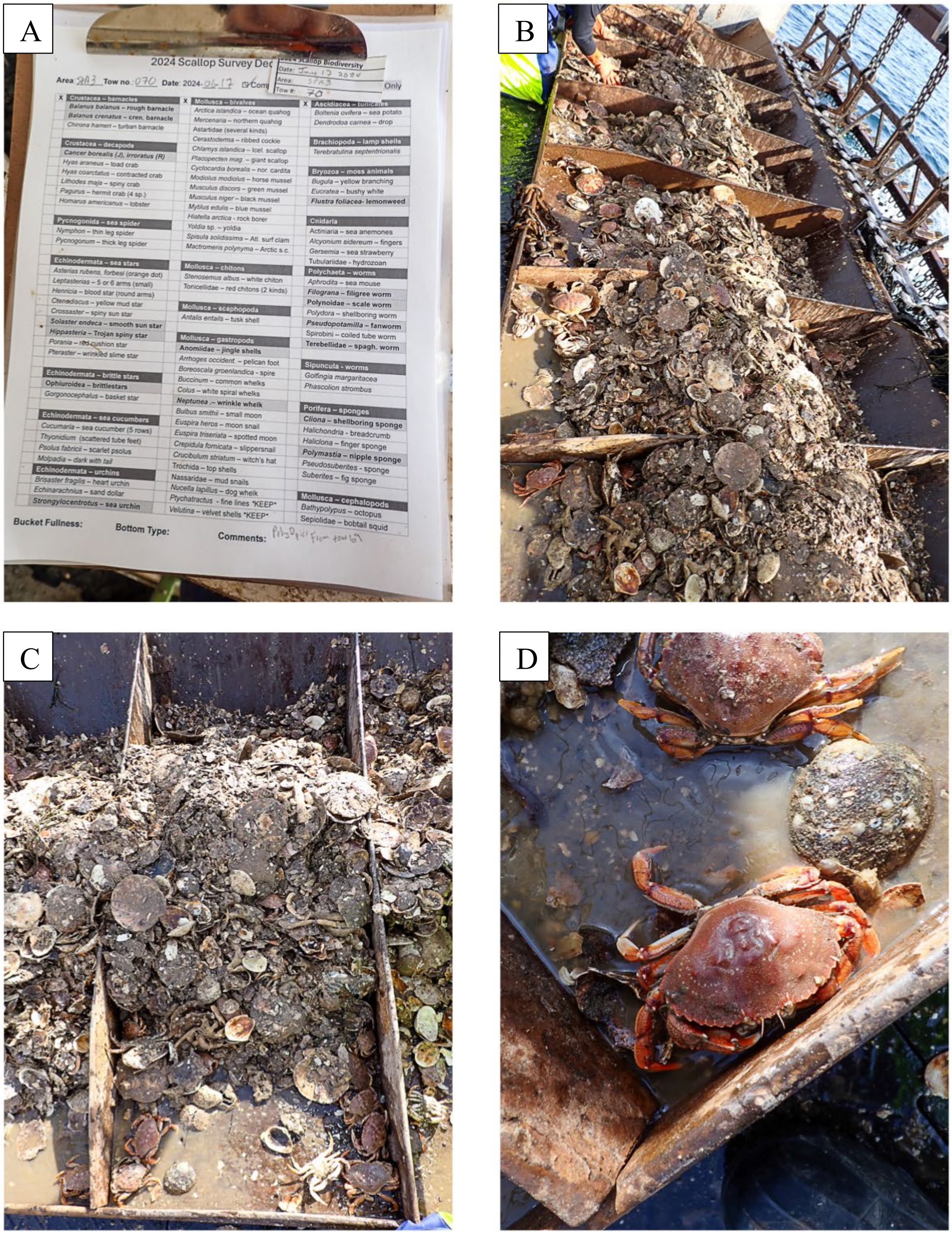

Figure 1. Photos of steps for recording catch biodiversity – part I: A) data sheet and label, B) capture from gangs on ship deck, C) capture from lined gang, D) common species seen on deck but not retained for tray (*subcapture*) photos - see Figure 2.

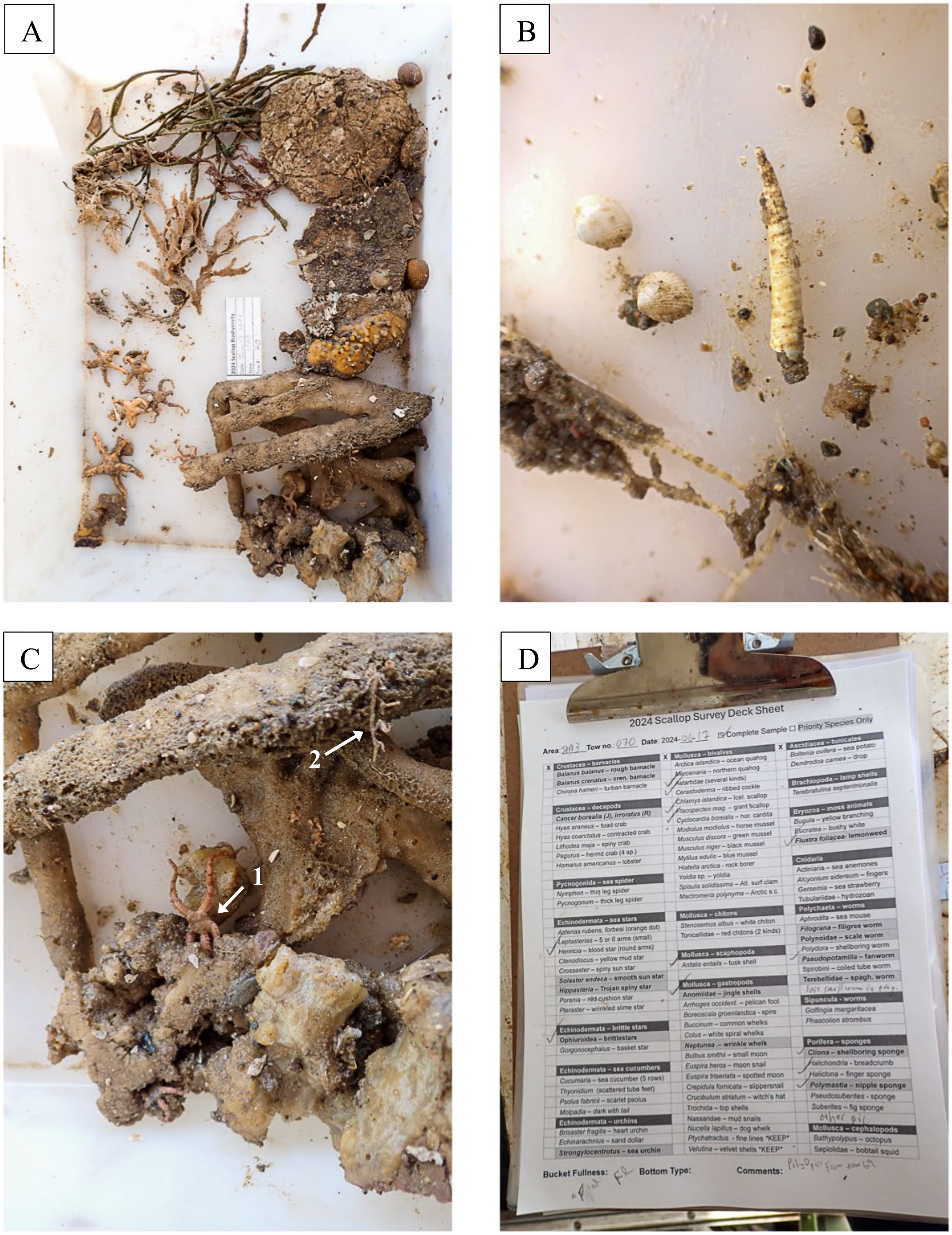

Figure 2. Photos of steps for recording catch biodiversity – part II: A) *subcapture* sample on a tray with a label, B) close view of some species recorded on both sheet and photo, C) close view including taxa not named on sheet: (1) Ophiuroidea – modified to *Ophiopholis aculeata*, and (2) *Caprella* – added to photo, D) sheet marked-up for taxa and including written notes on catch.

Data sheet

The paper sheet is double-sided, with example pages shown in Appendix. The front page is pre-filled with a set of commonly expected species as determined from previous surveys, listed by scientific name and grouped by type, for example, Crustacea, Mollusca, or Porifera. These did not include all the taxa caught on those surveys, but those that were selected for comparative analyses in the publications on temporal changes (Kenchington et al. 2007, Staniforth et al. 2023). The back page summarizes the catch protocol and gives special instructions, for example, to collect special taxa if seen in 2024. Following the photos for *capture* and *subcapture* (sample tray), the paper sheet is marked by pencil for each benthic kind listed on the sheet that was noticed in the capture. Notes are also written on the sheets, including the fraction (proportion) of drag fullness (in biodiversity gang and other gangs) and the type of substrate material in the drag (rock, mud, etc). After the survey, the sheets are scanned in a photocopier to produce a PDF for reviewing and archiving.

Specimens

As no freezer was available on board the survey ship, plastic coolers filled with ice were used to conserve some specimens for later review. For several tows, a selection of specimens was sampled as representative taxa or to confirm difficult species, such as sponges, placed together in a plastic bag with a label identifying the tow number. When the ship docked in port, the cooler was transported to the Bedford Institute of Oceanography (Dartmouth, Nova Scotia), to be frozen (~ -20°C) then later examined individually in the laboratory. Upon review, some specimens were photographed and tissues subsampled into vials with 95% ethanol, for further analyses under dissecting microscopes or potentially for genetic analyses.

Database

The data sheet PDF was visually examined for entry into a spreadsheet. Previous surveys had records in a data matrix, with tows as rows and taxa as columns. The present spreadsheet follows a standard ‘flat file’ spreadsheet approach, with columns as variables and rows as records listing the individual presences of taxa by tow. The layout may be readily transposed to form a matrix when needed. As the paper records consisted of checkmarks and handwritten notes, it was not pertinent to do OCR (optical character recognition) on the PDF and manual entry was performed. As the tows also had photos of capture, tray, and specimens, the two sources (sheets and photos) were consulted to compile a list of presences by tow number. To distinguish the source, each taxon was recorded in separate columns for both sheets and photos. The sheets sometimes had written notes that were recorded verbatim (as is) in the data sheet column (e.g., ‘small clam’). The names in the data sheet column were matched with taxonomic terms listed in the photo column. Wherever possible, the variables followed the format of the biodiversity standard, DarwinCore (https://dwc.tdwg.org/). For example, notes were entered as *identificationRemarks* and *occurrenceRemarks*, and links to online photos in *associatedMedia*.

In most cases, the names were identical in both the datasheet and photos columns, indicating that the same species marked on the sheet was also seen in the photos. In some cases, the names would differ, indicating a correction in the identification in the photo column. In those instances where additional taxa were seen in photos but not marked on the sheets, the lines were added to the spreadsheet, leaving the cells empty under the data sheet column. Occasionally, the datasheet indicated presence of some taxa that could not be confirmed (not seen) and were not listed in the photo column (empty cells). These records are to be evaluated and either accepted (marked as unconfirmed) or discarded (not included in the final biodiversity dataset).

Public images

Photos of several specimens were published on the iNaturalist citizen science web portal, (https://inaturalist.ca/people/dfo_ocean_ecology_maritimes) to show examples of species and forms and enabling discussions, including validation of identifications. Links to the observations are recorded in the dataset under *associatedMedia*. These observations are meant to assist with comparisons using photos, and do not replace the full dataset. When iNaturalist members agree to an identification, the record is considered 'research grade' and becomes linked to biodiversity data portals such as https://www.gbif.org/dataset/50c9509d-22c7-4a22-a47d-8c48425ef4a7.

Taxonomic names

All records in the photo column displayed taxonomic names matched to currently accepted versions in the column *scientificName*, obtained from the World Register of Marine Species (WoRMS, https://www.marinespecies.org/). Descriptors that were not taxonomic terms, e.g., eggs, were noted using the column for *lifeStage*. Unknown kinds were labelled to their closest taxonomic level, e.g., Mollusca, Animalia, or Biota. Some names in the data sheet were taxonomic names, however, they referred to debris. When judged to be non-living examples or errors, the name was excluded from the photo column, with a comment in *occurrenceRemarks.* Certain records may be renamed in the future with further laboratory examination, genetic analyses, or discussion of public records. For revised identifications, the current name from 2024 will be retained in the dataset as *verbatimIdentification*. A summary of issues encountered with names is listed in Table 2. Note that non-taxonomic terms were also used as keywords in the catalogued photos.

Table 2. Issues with assigning scientific names for database records.

Issue	**Example**	**Action**
not organism	whelk egg	Divide into taxon and *lifeStage*, or else exclude for analysis
dead	*Cliona* holes in shells	Note in *occurrenceRemarks* as debris and exclude for analysis
construction	tube worms	Retain name, noting in *occurrenceRemarks* is presumed alive
uncertain	*Haliclona/Isodictya*	Retain name, give closest taxon possible in photos, e.g., Porifera
fish	*Sebastes*	Some fish species already recorded by the scallop survey
other	*Hippasteria*	Seen in total capture, exclude from analysis of lined gang
general	colonial kinds	Note that Hydrozoa and Bryozoa could be refined over time
algae	*Lithothamnion*	Only record Animalia in photos, not seaweed debris or algae

RESULTS

Comparison between surveys

Named taxa from the 2024 survey were matched to two previous biodiversity survey lists, from 1970 and 2007. An exact match was not always possible, as sometimes a name was reported to the species level while another was reported to a genus level. In addition, some identifications have been adjusted, e.g., *Bugula* in 2007 were *Caberea ellisii* identified in 2024. Thus, the matched results here are the presumed equivalents, not in the original tables. The 2024 photos totaled 161 taxa in this exercise, with some modified here because of presumed family and genera names used to accomplish the matching between the three surveys. The Lurcher Shoal-St. Marys Bay 2024 survey shared 80 taxa with all areas in the 1970 survey (the 1970 survey had 160 names in total) and 57 taxa with the 2007 survey in the similar area of Lurcher Shoal-St. Marys Bay (the 2007 survey had 75 names in total). Across all survey years, 48 taxa were shared.

Comparisons between sources

From the 2024 survey of Lurcher Shoal-St. Marys Bay, all 150 tows were reviewed. The current spreadsheet totals 2,508 records, with 1,889 named from the datasheets and 2,468 from photos. The data sheets had 1 to 24 types (taxa and unknown kinds) per tow, for about 13 types on average. The photos had 1 to 31 taxa per tow, with about 17 on average. The total number recorded on datasheets was 96 types (taxa and special notes), from the 92 taxa pre-written on the form that was based on the expected kinds to record. The photos recorded all kinds that were visibly noticed, for a total of 149 taxa (scientific names-only). Confirmation of the exact number and types of taxa, especially of sponges, will be presented in a future publication. As of autumn 2024, 3,250 photos were catalogued of the at-sea survey and during lab review of retained samples from 49 tows.

Community identifications

As of autumn 2024, 150 observations of 97 species were posted to the account on iNaturalist. Identifications based on the posted photos were discussed with 19 participants. Useful changes included revisions of sponges, sea stars, chitons and bivalves. Some changes may still be expected with further review, especially for the sponges, for those that were physically sampled and can be identified further with taxonomic keys.

DISCUSSION

Data sheets

Recording captures from surveys on paper forms is done with either blank or pre-filled forms. When there are many and uncertain taxa in a capture, a blank form is filled in with names as noted in the catch. However, this requires more time to use, to find, and to write out species names, and often presumes experience and adequate knowledge of the user. When a survey has a few known taxa, a pre-filled form can save time and help less-experienced users to identify a specimen by displaying expected species names. However, it then becomes a challenge on how to choose and present the names on a list to be helpful for the user. The names encountered on past surveys were used to pre-fill the form for 2024 (Appendix). Some changes were made, by updating taxonomic names (e.g., *Cerastoderma* = *Parvicardium*) or adjusting identifications (e.g., *Pseudosuberites* = Suberitida, *Harmothoe* = Polynoidae). Some names were listed at a general level, like Ophiuroidea or Astartidae, because it was not expected to reliably identify the species while at sea.

Having paper sheets permitted changes that could be incorporated as needed while at-sea. For example, some crabs were historically only recorded to genus *Cancer*, and so the datasheet presented that name. However, once the 2024 survey had begun, the user found it easy to distinguish between the two species, Rock Crab and Jonah Crab, and noted them (R or J) instead of simply placing a checkmark to the name *Cancer*. These and other cases were then interpreted and correctly entered as taxa in the biodiversity database. Such entries can later by amalgamated for comparison with historical data or used to give a more complete biodiversity census for other applications.

The significance of notes and marks on paper is that the sheets cannot be read as-is (verbatim), but rather requires effort to decode for data entry, therefore extending the time it takes to put records into a database. Having handwritten marks also reduces the ability to use OCR and machine learning to do the output. For this survey, it required several weeks to review the records, compare with photos, and enter in a spreadsheet suitable for a database. Having blank forms that are handwritten has similar time challenges for data input, again requiring interpretation of names and notes. This may also depend on the user doing the initial records and then the data entry. In some surveys, identification specialists use blank forms and then enter the data. On stock surveys, it is common to have pre-filled forms given to non-experts that then pass on the forms to data personnel. This requires confidence or validation of the produced records, preferably with a review of the names and photos by a specialist. Pre-filled forms also enable the at-sea technician to focus on the key taxa needed for monitoring purposes.

Photos

Digital photos have become widespread for documenting biodiversity, including on stock surveys (Nozères and Roy 2020). In previous years, photos may have been used sporadically, only informing on some specimens. For the 2024 survey, photos were used systematically to document specimens from each tow, and for the conserved samples in the lab. The value of photos is revealed when they are catalogued (by tow number and taxon), then used to compare with the names recorded on catch sheets. As seen in results, on average, the tows had additional taxa not noted on paper but visible in photos. This had an impact on the total cumulative diversity, with about 50% more taxa recorded through photos than was noted by the user on the deck sheets. In some instances, taxa were noted on paper, but these could be re-interpreted as other taxa because of the photos. Thus, all examples of Ophiuroidea (brittlestars) were revealed to be the species *Ophiopholis aculeata* and were renamed in the database. Similarly, all presences of Astartidae could be assigned to individual species based on the photos, replacing the family name in deck sheets to three types in photos. Having photos as a complement to datasheets thereby reduced the ‘pressure’ to have the right choice of pre-filled names, as the data entries would be adjusted based on the taxa seen in photos, regardless of general or misidentified kinds.

The use of photos also relieves pressure on the necessity for correct identifications while at sea. On some surveys, especially deep-sea ones with long intervals between sampling tows, there is ample time and resources (e.g., lab space, internet access) to identify specimens from a catch. The scallop surveys represent the other extreme, with very little time or working space. For both specialist and novice, it is not possible to identify all taxa in the catches between scallop survey tows. As a result, often the catch biodiversity is either not monitored, or else is only done for selected taxa that can be recorded quickly and reliably. As we saw with the comparison with results, the aspect of reliability could remain a challenge, even with experts and limited taxa.

Despite their value, the use of photos can also be limiting, either because of the field of view (e.g., poor angle, focus, or detail), or in the case for cryptic taxa, because normal images are ineffective for species identification. There were also instances when photos were not taken, either forgotten, or more often, because they were large and common species that were released quickly, like lobsters and crabs, rather than collecting them for a group photo on the sampling tray. The organisms were either seen in the deck capture photos, or sometimes recorded on deck sheets with note for 'no photo'. Regarding poor images, this can be improved with training, experience, and more suitable cameras (e.g., with good lighting and close-up functions).

Even with clear photos of all kinds, some taxa may be of special interest but cannot be documented at sea and require lab analysis. This is especially true for two groups observed on scallop surveys: sponges and polychaete worms. While some sponges can have characteristic shapes, others require microscopic measurements of their elements. This was the case for two very common 'finger' sponges called *Haliclona oculata* and *Isodictya palmata*. While routinely named as *Haliclona oculata* in this and previous surveys, an examination from the first tow revealed the presence instead of *I. palmata*. Thus, all presences of this sponge, even if photographed, must be validated through the examination of spicules from collected specimens.

Specimens

Specimens present a special situation in biodiversity surveys, especially at the beginning of a study. As discussed above, datasheets can document several taxa, though preferably confirmed and corrected with photos. Photos may also reveal additional taxa, often of smaller and rarer taxa, that would otherwise be missed, especially under the time- and space-restraints of a scallop survey. However, some taxa will require examination in the lab, either under magnification or even through genetic analyses. The challenge is deciding what is needed to sample for lab work as preparation time and storage space is limited. From the previous studies, it was evident that sponges were present as several types, some unknown and others perhaps confused or misidentified. For 2024, it was decided to sample some of each noticeable type of sponge, and repeated sampling of the confusing *Haliclona/Isodictya* finger sponges. This special effort with samples is expected to confirm most if not all types of sponges seen in 2024. In the past (Caddy 1970), up to 20 sponge taxa were identified by experts, and a similar number is expected from this survey. Upon confirmation of the uncertain taxa, establishing those that are practical to identify from photos will reduce the need for sampling specimens on future surveys.

Other presences

During the review of photos and specimens, it was not always evident how to record observations for some species presences. This was especially true for the tubes and holes in shells built by polychaete worms and boring sponges, as these represent habitat constructions, and not necessarily the presence of live organisms. Photos may sometimes reveal if an organism was debris or fresh. Other times, the information may come from a written note on the deck sheet. For 2024, any significant trace of an organism was usually treated as a presence, and sometimes noted if suspicious (i.e., dead debris) in the standard data field of *occurrenceRemarks.* Similarly, egg cases were named then noted in the field of *lifeStage.* In a few cases, the organism was presumed because of known behaviour. For example, the tusk shell, *Antalis entale*, would be visible, but was presumed to be debris when occupied by the peanut worm, *Phascolion strombus*. The record of *A. entale* would then be renamed for *P. strombus* in the photo record. Future surveys will need guidance on how to determine the status and utility of recording these other kinds of observations.

Suitability

The present report documents how species presences were recorded, however, the categories of occurrences also require comment, as it affects what is to be done at sea. The deck sheet was designed to record taxa that were previously recorded from a 50-year period, with three targeted monitoring events (Staniforth et al. 2023). Photos revealed that many more taxa could potentially be identified, but perhaps not all taxa are always of interest, for example if rare. For the first situation with the datasheet list, there were two groups of interest that were difficult to record, namely the polychaete worms and sponges. While some names could be listed, more taxa than just those on the datasheet were present, but this only became apparent because photos were taken. There was also the major issue of debris, as discussed above; both sponges and worms (or their tubes) could be 'present' as mere traces but were not present as viable organisms. It may be preferable not to have some sponges and tube worms on the list, and instead give instructions on how to decide when they are sufficiently present to record them and how to validate the name (e.g., through a photo and retained specimen).

The question of utility becomes raised with photos because new taxa could be recorded that had not been included when developing the 'practical' at-sea deck list. This is most evident with sessile and colonial kinds of hydrozoans and bryozoans, nearly all of which are likely to go unnoticed or are too difficult to identify while at-sea but may be possible to identify with careful review of suitable images. Also, these taxa may become of interest for future analyses. For example, erect hydrozoans and bryozoans may be important structures for larval scallops, while other taxa may either help or hinder growth because of biofouling (e.g., Claereboudt et al. 1994). Some encrusting bryozoans may also represent records of introduced nuisance species, as in recent cases of *Juxtacribrilina mutabilis*, https://inaturalist.ca/taxa/1564222-Juxtacribrilina-mutabilis.

Another aspect of suitability concerns the apparent rarity of some species. The dredge is designed to collect commercially viable sea scallops that are several cm in size. Several species recorded on sheets or in photos may be very rare because of either their capturability in the dredge (e.g., small, cryptic, or fragile) or being overlooked by the user when sorting through the catch. These infrequent records are then suitable for establishing presence in an area, but not for analyses by individual tow. The impact on the protocol could be to exclude these 'rare' types from the sheet list. Conversely, confusion with common taxa may hide rare taxa; therefore, it may be important to list these rarer taxa to reduce misidentifications on the datasheet. An example is with a sepiolid cephalopod (either *Rossia palpebrosa* or *Semirossia tenera*) seen in photos (https://inaturalist.ca/observations/225220548). The 1970 survey listed *Rossia* and *Bathypolypus,* a small octopus that is often confused with sepiolids. The 2007 survey only listed the octopus, which may have resulted in some misidentifications. Similarly, a small, whitish chiton was presumed to be a nearshore species, *Stenosemus albus*. Photos again revealed a lesser-known, offshore species, *Hanleya hanleyi* (https://inaturalist.ca/observations/234790644).

Replicability

A final consideration for developing and adjusting the biodiversity protocol is to strive for continuity with previous surveys. To do a study using biodiversity survey data, analysts may update names with revised taxonomies and make decisions to either split or regroup some taxa. These changes and decisions may have impacts on the listed names for a deck sheet. An example discussed above was with crabs. While two species of *Cancer* are present (*C. borealis, C. irroratus*), these were only recorded separately in 2024. While perhaps necessary for retrospective studies, in some cases, the effect of merging to a broader group would have repercussions for future analyses and thus the separate identifications should be continued. Important examples include the barnacles in genus *Balanus* and the crabs in genus *Hyas*. These are often grouped because of the difficulty to identify to species, and thus records at-sea may be suspect. Both groups contain two species in the survey area, but perhaps only one of each was recorded in 2024 (*i.e., Balanus crenatus, Hyas coarctatus*), with the second, colder-water species either absent or very rare (*i.e., Balanus balanus*, *Hyas araneus*), which could be important findings, considering that past records may have included more presences of the colder kinds in the area.

Changes in names across surveys may happen because of taxonomic updates, but in some cases, there could be modifications by presuming the correct species intended in the past. Such assumptions are tricky when samples were not retained, stressing the importance of keeping voucher specimens whenever possible to allow for re-examination. This kind of comparative review will be presented in future publications but is of interest here for the protocol for two reasons. First, if ever there is continuity with survey personnel, it is important to use names or explain how they have changed. In 2024, the updated names on the deck sheet were at times confusing for the user with names provided of taxa that were not encountered, or perhaps were misidentified in the past. In one example, the sheet listed the erect bryozoan *Bugula* sp., although photo review only revealed *Caberea ellisii* (https://inaturalist.ca/observations/60545519).

Future data entry

The discussion on how to use and update the current protocol for recording biodiversity data has another aspect, which is to prepare for digital data entry on future surveys. Currently, the paper sheets are useful for being easy and quick to use at sea, important features for scallop surveys. The challenges with recording some taxa, and the time for reviewing post-survey, might be lessened if a digital entry system was both available and practical. Photos are already partly a digital system, but not part of a catch database. Across DFO regions, several stock surveys have begun incorporating a new data entry system, ANDES, to replace the previous internal systems used by each group in past decades (Ricard et al. 2024). While initially conceived for the main offshore research surveys, ANDES is also available for smaller surveys and vessels. In 2024, the scallop survey in the Gulf of St. Lawrence used ANDES for the first time to record both catch measurements of the targeted species and occurrences of biodiversity (presences, counts, or weights, depending on the species). The system can work with a digital tablet for data entry, including the use of the camera module to attach a photo to the record. With a new system will come new challenges, and inevitably different problems. However, it may be hoped that digital entry tools will soon make it possible to supplant both paper sheets and separate cameras while improving biodiversity records from surveys.

CONCLUSIONS

This report documents the protocol for recording presences of epibenthic macrofauna on the Bay of Fundy scallop survey for monitoring of temporal change in community composition. The use of paper deck sheets with selected species lists is a practical method to documenting epibenthic taxa. However, the systematic use of photos for each tow and selected retention of samples for laboratory examination is strongly recommended to give confidence in the sheet records. While the present protocol will assist with the near-future and help to understand past surveys, a digital entry system could improve efficiency and reliability while operating at sea and expand the utility of the data to include more comprehensive biodiversity assessments.

ACKNOWLEDGEMENTS

Thanks are extended to all the crew members of the F/V *Brittany* and *Madison V*. The project is funded through the DFO Marine Conservation Target (MCT) project funding as part of project 2609: Development of protocols and procedures for epibenthic assemblage sampling from the Inshore Scallop Survey: preserving knowledge and enabling knowledge transfer for comparative monitoring to support MCT. Thanks also to reviewers Francisco Javier Murillo and Mariève Bouchard Marmen for their useful comments that improved the manuscript.

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APPENDIX

Examples of the 2024 data sheet – front and back page

2024 Scallop Survey Deck Sheet

Area: ______**Tow no.**: _____ **Date**: 2024-___-___ ☐ Complete Sample ☐ Priority Species Only

X	**Crustacea – barnacles**	X	**Mollusca – bivalves**	X	**Ascidiacea – tunicates**
	***Balanus balanus* – rough barnacle**		*Arctica islandica* – ocean quahog		*Boltenia ovifera* – sea potato
	***Balanus crenatus* – cren. barnacle**		*Mercenaria* – northern quahog		*Dendrodoa carnea* – drop
	Chirona hameri – turban barnacle		Astartidae (several kinds)		
			Parvicardium – ribbed cockle		**Brachiopoda – lamp shells**
	Crustacea – decapods		*Chlamys islandica* – Icel. scallop		*Terebratulina septentrionalis*
	Cancer borealis (J), irroratus (R)		*Placopecten mag.* – giant scallop		
	Hyas araneus – toad crab		*Cyclocardia borealis* – nor. cardita		**Bryozoa – moss animals**
	Hyas coarctatus – contracted crab		*Modiolus modiolus* – horse mussel		Various encrusting kinds
	Lithodes maja – spiny crab		*Musculus discors* – green mussel		*Bugula* – branching
	Pagurus – hermit crab (4 sp.)		*Musculus niger* – black mussel		*Eucratea* – bushy
	Homarus americanus – lobster		*Mytilus edulis* – blue mussel		*Flustra foliacea* – lemonweed
			Hiatella arctica - rock borer		**Cnidaria**
	Pycnogonida – sea spider		*Yoldia* sp. – yoldia		Actiniaria – sea anemones
	Nymphon – thin leg spider		*Spisula solidissima* – Atl. surf clam		*Alcyonium sidereum* – fingers
	Pycnogonum – thick leg spider		*Mactromeris polynyma* – Arctic s.c.		*Gersemia* – sea strawberry
					Tubulariidae - hydrozoan
	Echinodermata – sea stars		**Mollusca – chitons**		**Polychaeta – worms**
	Asterias rubens, forbesi (orange dot)		*Stenosemus albus* – white chiton		*Aphrodita* – sea mouse
	Leptasterias – 5 or 6 arms (small)		Tonicellidae – red chitons (2 kinds)		***Filograna* – filigree worm**
	Henricia – blood star (round arms)				**Polynoidae – scale worm**
	Ctenodiscus – yellow mud star		**Mollusca – scaphopoda**		*Polydora* – shellboring worm
	Crossaster – spiny sun star		*Antalis entails* – tusk shell		***Pseudopotamilla* – fanworm**
	***Solaster endeca* – smooth sun star**				Spirobini – coiled tube worm
	***Hippasteria* – Trojan spiny star**		**Mollusca – gastropods**		**Terebellidae – spagh. worm**
	Porania – red cushion star		**Anomiidae – jingle shells**		
	Pteraster – wrinkled slime star		*Arrhoges occident.* – pelican foot		**Sipuncula - worms**
			Boreoscala groenlandica - spire		*Golfingia margaritacea*
	Echinodermata – brittle stars		*Buccinum* – common whelks		*Phascolion strombus*
	Ophiuroidea – brittlestars		*Colus* – white spiral whelks		
	Gorgonocephalus – basket star		***Neptunea* .– wrinkle whelk**		**Porifera – sponges**
			Bulbus smithii – small moon		***Cliona* – shellboring sponge**
	Echinodermata – sea cucumbers		*Euspira heros* – moon snail		*Halichondria* - breadcrumb
	Cucumaria – sea cucumber (5 rows)		*Euspira triseriata* – spotted moon		*Haliclona* – finger sponge
	Thyonidium drummondii (many rows)		*Crepidula fornicata* – slippersnail		***Polymastia* – nipple sponge**
	Psolus fabricii – scarlet psolus		*Crucibulum striatum* – witch's hat		*Pseudosuberites* - sponge
	Psolus phantapus – beige, tailed kind		Trochida – top shells		*Suberites* – fig sponge
	Echinodermata – urchins		Nassariidae – mud snails		
	Brisaster fragilis – heart urchin		*Nucella lapillus* – dog whelk		**Mollusca – cephalopods**
	Echinarachnius – sand dollar		*Ptychatractus ligatus* *KEEP*		*Bathypolypus* – octopus
	***Strongylocentrotus* – sea urchin**		*Velutina* – velvet shells *KEEP*		Sepiolidae – bobtail squid

Bucket Fullness: **Bottom Type:** **Comments:**

2024 Scallop Survey Deck Sheet

Protocol – normal

1. From a lined basket and **select** at least 1 of each kind of animal into a bucket or pan.
   Ignore dead shells and debris unless have useful examples of encrusting organisms.
   If large and abundant (*Cucumaria*, urchins), take photo on deck—**do not collect**.

2. Take sorted catch examples to side of boat to do a **group photo with a label of tow #**.
   If notice special kinds, take photos with a tow label in view.

3. Note the **presence** of each kind on the deck sheet (make a mark in column '**x**').
   For Grand Manan and Lurcher/St Mary's Bay, the priority is for taxa in **gray cells**

4. **Save** special/uncertain small specimens in a plastic bag containing **a label with tow #.**
   If soft-bodied (won't do well on ice for days), do not save, but take photos

   Special requests: KEEP small gastropods: velvet shells (**velutinids**) and ***Ptychatractus ligatus*** for taxonomic analyses currently underway by experts.

5. At end of day, **photograph the deck catch sheets** as a digital 'backup' of the data.

Protocol – for Lurcher Shoal and Grand Manan only

- Note the **special monitoring species** on the sheet.
- Be alert to new species that are not on the data sheet. These could be species responding to climate change. Keep all new or unknown in a plastic bag with label of tow number and date.