Coastal Ecological Survey of Sachs Harbour, NT

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

McNicholl, D.G., Gully, K., and Dunmall, K.M. 2019. Coastal Ecological Survey of Sachs Harbour, NT. Can. Tech. Rep. Fish. Aquat. Sci. 3325: vi + 39 p.

The purpose of the coastal ecological survey of Sachs Harbour was to collect baseline information on coastal fish biodiversity and life history, and characterize fish habitat. The survey was conducted for two weeks in July 2018 in the Sachs Harbour, Northwest Territories area (71°98’51”N, 125º 24’65”W) with the support of the local Hunters and Trappers Committee and the assistance of a community-based technician. Environmental data (i.e., depth, temperature, salinity, conductivity, turbidity, dissolved oxygen, and pH) were collected throughout the harbour and, where possible, information on benthic and pelagic invertebrates was collected for future analysis. The fishes that were collected were identified to species level and were processed for basic biological data (i.e., length, sex, maturity). They were also sub-sampled for aging and for tissues to be used in future studies. Environmental results in this study indicate that deep (> 20 m), hypoxic areas exist in Sachs Harbour while nearshore areas (< 10 m) appear to be most utilized by coastal fishes. Eight species were identified in this survey, while overall abundance of fishes was relatively low (total fish captured n = 67). Shorthorn Sculpin (*Myoxocephalus scorpius* (Linnaeus, 1758)) were the most abundant species, followed by Arctic Char (*Salvelinus alpinus* (Linnaeus, 1758)), while n < 10 individuals were collected for each of the remaining species. Noteworthy observations of Saffron Cod (*Eleginus gracilis* (Tilesius, 1810)) and Pacific Sandlance (*Ammodytes hexapterus* Pallas, 1814) in this study represent recent occurrence for both species at Banks Island, NT. Local fishers indicate that these species have only been observed in the Sachs Harbour area in recent years.

RÉSUMÉ

McNicholl, D.G., Gully, K., and Dunmall, K.M. 2019. Coastal Ecological Survey of Sachs Harbour, NT. Can. Tech. Rep. Fish. Aquat. Sci. 3325: vi + 39 p.

Le but du relevé écologique côtier de Sachs Harbour était de recueillir des données de référence sur la biodiversité et le cycle biologique des poissons côtiers et de caractériser l’habitat du poisson. Le relevé a été effectué pendant deux semaines en juillet 2018 dans la région de Sachs Harbour, dans les Territoires du Nord-Ouest (71° 98’51”N, 125º 24’65”O) avec l’appui du Comité local des chasseurs et des trappeurs et l’aide d’un technicien communautaire. Des données environnementales (profondeur, température, salinité, conductivité, turbidité, oxygène dissous et pH) ont été recueillies dans tout le port ainsi que, dans la mesure du possible, des renseignements sur les invertébrés benthiques et pélagiques aux fins d’analyse future. Les poissons recueillis ont été identifiés selon leur espèce et traités pour obtenir des données biologiques fondamentales (longueur, sexe, maturité). Ils ont également été sous-échantillonnés afin de déterminer leur âge et prélever les tissus qui seront utilisés dans des études futures. Les résultats environnementaux de cette étude indiquent qu’il existe des zones hypoxiques profondes (> 20 m) à Sachs Harbour, et que les zones littorales (< 10 m) semblent être les plus utilisées par les poissons côtiers. Huit espèces ont été identifiées dans ce relevé, avec une abondance globale des poissons relativement faible (nombre total de poissons capturés n = 67). Le chabot à épines courtes (*Myoxocephalus scorpius* (Linnæus 1758)) était l’espèce la plus abondante, suivi de l’omble chevalier (*Salvelinus alpinus* (Linnæus 1758)), et n < 10 individus pour chacune des autres espèces. Les observations dignes de mention du navaga jaune (*Eleginus gracilis* (Tilesius 1810)) et du lançon du Pacifique (*Ammodytes hexapterus* (Pallas 1814)) dans cette étude représentent la présence récente des deux espèces à l’île Banks (T.N.-O.). Selon les pêcheurs locaux, ces espèces ne sont observées dans la région de Sachs Harbour que depuis quelques années.

1.0 INTRODUCTION

The Sachs Harbour coastal survey was designed to characterize fish species diversity and their habitat associations following a sampling protocol developed for the Anguniaqvia niqiqyuam Marine Protected Area (ANMPA) community-based monitoring framework called "Arctic Coast". The goal of the Sachs Harbour program was to better understand the coastal ecosystem and to replicate methods used in other locations to facilitate future spatial comparison of fish community composition and habitat associations. Information gained from the standardized sampling methods in this study can be used to interpret changes at the local scale, relative to those observed throughout coastal communities in the Inuvialuit Settlement Region (ISR) and the Canadian Arctic. Additionally, direct involvement and training of community members were incorporated into the collection of baseline ecological data, and local observations were included to aid in interpretation of recent shifts in biodiversity. Understanding ecosystem components and fish community structure will provide important information relevant to Sachs Harbour subsistence fishes and management implications associated with Thesiger Bay. Samples and environmental data collected from this program complement knowledge gained from other ongoing projects (e.g., Canadian Beaufort Sea – Marine Ecological Assessment (CBS-MEA), Arctic Char community-based research, marine mammal assessments, and the Arctic Salmon monitoring program) in the Beaufort Sea.

1.1 PROGRAM OBJECTIVES

1) Collect coastal fishes to describe species diversity and relative abundance, and collect sub-samples (otoliths, muscle tissue, and stomachs) for follow-on analyses.

2) Examine and interpret environmental data collected from the water column (depth, temperature, salinity, pH, turbidity, and dissolved oxygen).

3) Incorporate local knowledge of fish biodiversity and identify recent changes.

4) Assess transferability of sampling methods developed for ANMPA to a new coastal location.

2.0 METHODS

2.1 SAMPLING AREA

Sachs Harbour is the northernmost coastal community found within the Inuvialuit Settlement Region (ISR), on Banks Island, Northwest Territories (Figure 1). The hamlet of Sachs Harbour is found on the north side of the Sachs Harbour coastal area, which is the outflow of the Sachs River to the west. This harbour is connected to a larger bay found on the southwest side of Banks Island, known as Thesiger Bay. This region is heavily influenced by the oceanographic processes of the Beaufort Sea, such as the break up and formation of sea ice and upwelling from deeper waters.

There have been few coastal surveys conducted in the Sachs Harbour area. Prior work has focused specifically on either Arctic Char (*Salvelinus alpinus* (Linnaeus, 1758)) or benthic invertebrates (Siferd 2001). Sampling for this study was conducted in the inner basin of the harbour, in close proximity to the hamlet (Figure 2). This area was recently identified as a research priority by the Sachs Harbour Hunters and Trappers Committee (SHHTC) and the Fisheries Joint Management Committee in order to better understand the habitat use of local Arctic Char and the ecology of coastal fishes.

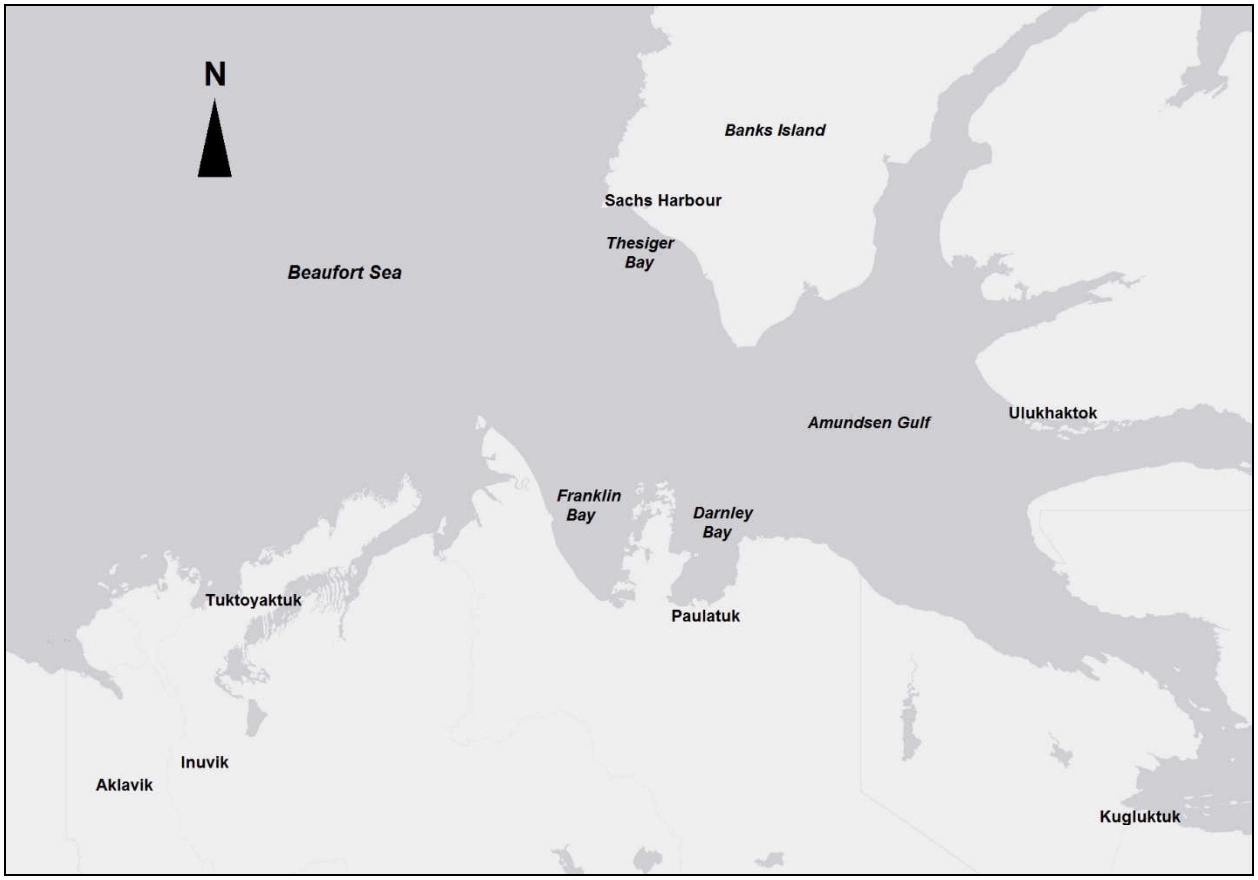

Figure 1. Map of the Beaufort Sea and coastal communities.

The field crew conducted operations out of the Parks Canada Aulavik area office in the summer of 2018. Two DFO Science staff and one community-based technician were involved with sampling. The area covered by the survey was limited due to sub-optimal weather and sea ice in the harbour, which restricted the field crew's ability to travel safely to and from sampling sites.

2.2. ENVIRONMENTAL DATA

2.2.1 Temperature-Salinity Loggers

On July 13th, 2018 a temperature-salinity logger (CT2X-INW Smart Sensor) was deployed 1 m below the surface in the harbour at a site with a maximum depth of 5 m. This location was in close proximity to where local fishers set their nets (71.98293, -125.22800; Figure 2). The logger recorded temperature and salinity data every 30 minutes. The logger was anchored with a buoy at the surface in order to collect time series data over the two weeks of sampling (retrieved July 22nd, at the end of the field program). A second logger was attached to one of the multi-mesh gill nets to collect data at the location where fishes were captured. These data were collected every 15 minutes and were then averaged over the duration of the net set. The data obtained from these loggers provided a measure of the variability in water temperature and salinity, which could be used to describe the conditions where fishes were captured.

2.2.2 YSI Water Profiles and Invertebrate Sampling

A YSI Pro DSS water profiler (equipped with temperature, dissolved oxygen, conductivity, pH and turbidity sensors) was used at multiple sites to collect *in situ* environmental conditions at stations in the harbour. Site selection was dependent on wind and wave height; however, when conditions allowed, it was possible to collect readings at1 m depth intervals, up to depths of 24.4 m. The YSI was deployed over the side of the boat and measurements were recorded at each meter depth until reaching < 1 m off the bottom depth. Sites nearest the shore were approximately 2–5 m in depth, and subsequent sites were chosen based on increasing depth, away from shore. The objective was to obtain at least three sites along a transect of increasing depth in order to generate a projection of oceanographic conditions using data collected from 5 m, 10 m, and 15 m depths, if possible. Over the course of the survey, 27 YSI profile stations were completed. Due to the sheltered nature of Sachs Harbour, it was possible to complete multiple YSI profile transects (Figure 2) across the harbour and laterally towards the Sachs River. Table 1 provides information on the accuracy and range of each of the probes used in developing water profiles. Conductivity measurements were taken in the field and were then converted into practical salinity units (PSU; ODV version 5.1.5) during analyses using corresponding temperature and pressure measurements. Profiles were produced with Ocean Data View 5.1.5 using data compiled from stations located along each transect.

Table 1. Summary of accuracy and range of YSI Pro DSS probes used in the 2018 Sachs Harbour survey.

Sensor/Parameter	Units	Accuracy	Resolution	Range
Temperature	°C	± 0.2°C	0.1°C	-5 to 70°C
pH	pH	± 0.2 pH units	0.01 pH units	0 to 14 pH units
Dissolved Oxygen	% saturation	± 1.0 % of reading	0.1 %	0 to 200%
Conductivity	µS/cm	± 5.0 % of reading	0.1 ± µS/cm	0 to 200000 µS/cm
Turbidity	FNU	± 2.0% of reading	0.1 FNU	0 to 4000 FNU

Once the water profile data were collected, a dredge (15.2 cm x 20.3 cm, weighing approximately 13.6 kg) was used to collect a sample of sediment and benthic epifauna at 11 stations. Organisms were sorted from the dredge using a bucket sieve (2000 µm mesh) and were then frozen to be identified to the lowest possible taxonomic level during subsequent laboratory analyses. Additionally, a sample of sediment was collected from the dredge pull at each station to identify the textural class of the substrate at each site.

A small plankton net (200 µm mesh, 50 cm mouth diameter, 220 cm long) was used at five of the YSI stations in nearshore areas (Figure 2). The net was deployed after the YSI profiling was complete to the maximum water depth, and retrieved to the surface at a rate of 1 m/second, to collect pelagic invertebrates and/or larval fishes. The net was rinsed with sea water, and the contents were preserved in Nalgene® vials (10% buffered formalin) for identification during subsequent laboratory analyses. Similarly, four mid-water tows were conducted, where the net was dragged horizontally in the water column (approximately 2 m below the surface) at a rate of approximately 1 m/second to collect mid-water organisms. These were preserved as integrated samples. The feasibility of conducting tows was dependent on the weather conditions and the ability to steadily tow or pull up the net at a consistent rate. Where possible, a vertical haul was conducted at each YSI station in order to assess the presence or absence of pelagic invertebrates and larval fishes. The organisms collected by the plankton net were preserved in 10% formalin for future analyses of zooplankton biodiversity at the DFO Freshwater Institute in Winnipeg.

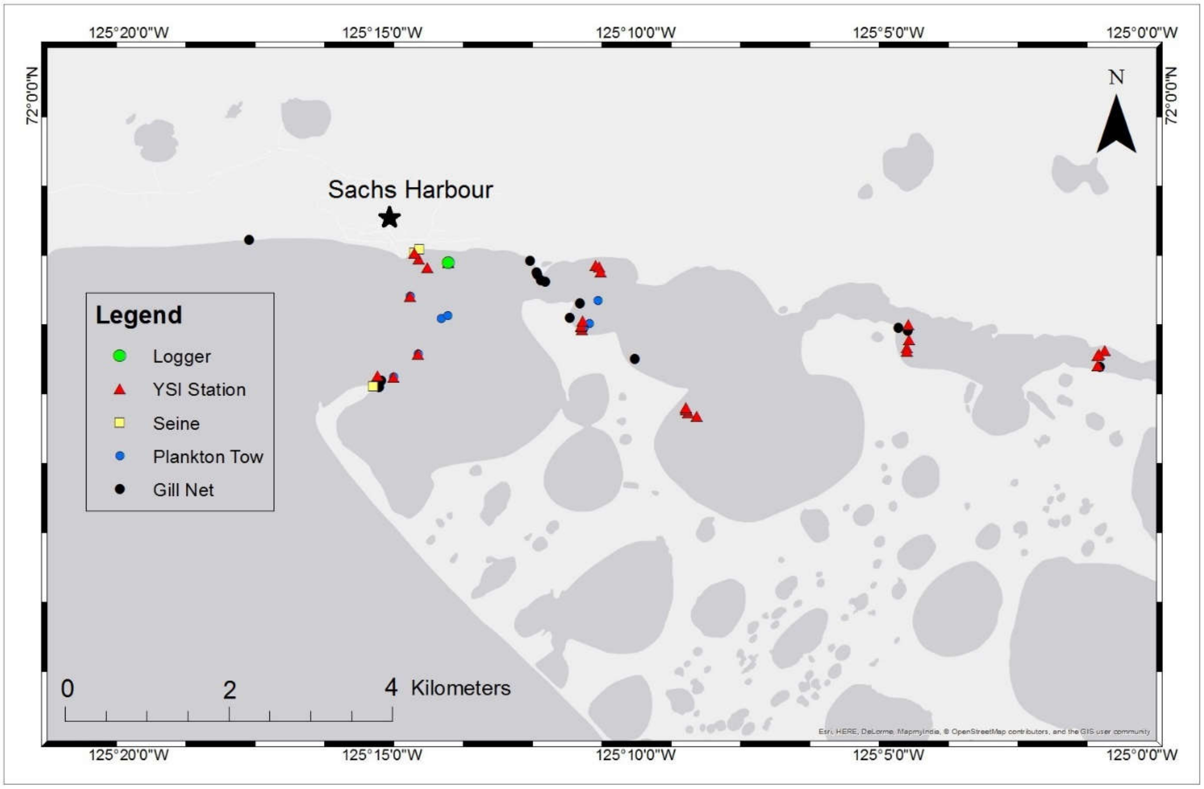

Figure 2. Sampling effort in Sachs Harbour, July 2018. Locations of the anchored logger (●), YSI stations (▲), seine hauls (■), plankton tows (●), and gill nets (●) are shown.

2.3 COASTAL FISH SAMPLING

Fish were collected using two 6 panel multi-mesh gillnets (25, 38, 64, 89, 114, 140 mm stretch; 10 m x 1.5 deep panels) and a beach seine (3/16" delta mesh, 5 x 1.2 x 0.6 m). Fish were collected between July 11th and 22nd. Initially, the gillnets were set for a maximum of 2 hours before they were checked. Once it was determined that nets could be set up to 24 hours without mass mortality of fish, soak times were increased with the permission of the SHHTC. Net placement and effort was guided by the recommendations of the SHHTC, and nets were placed to avoid interference with subsistence harvest of Arctic Char. Effort was also largely dependent on the ability to travel safely to sites and to retrieve nets as sea ice was present in the harbour. Overall, 26 nets sets were completed over the duration of the field program, and 3 seining efforts were conducted to assess if larval fishes were present (Table 2). DFO biologists also provided the option to subsistence fishers to have their catch processed as a part of this study, such that they could be returned for consumption after the samples had been collected.

Table 2. Summary of sampling effort using gill nets and seines for collection of coastal fishes.

Gear Type	Number of Sets
6 panel multi-mesh gillnet (60 m)	26
Delta knotless beach seine (5 m)	3
Total	31

The fishes collected from each net were identified on site and brought back to the Parks Canada Aulavik area office for sampling. Once samples were collected, subsistence species (i.e., Arctic Char, Greenland Cod (*Gadus ogac* Richardson, 1836), and Pacific Herring (*Clupea pallasii* Valenciennes, 1847)) were distributed among community members with the assistance of the SHHTC. All fish collected were dead-sampled for follow-on analysis at the DFO Freshwater Institute in Winnipeg. Fish ages were determined at the Freshwater Institute using whole dried otoliths. Otoliths were aged by examining a sagittal section, and using the break and burn method (Zhu et al. 2015). Only ages from individuals that could be determined with a high level of confidence by two independent readers are provided.

3.0 RESULTS

3.1 ENVIRONMENTAL PARAMETERS

3.1.1 Temperature-Salinity Loggers

The variability in temperature and salinity of the temperature-salinity logger nearest Sachs Harbour during the course of the field program is shown in Figure 3.

Water temperature stayed below 10°C and salinity did not exceed 27.0 PSU between July 13th and 22nd at this location. Mean temperature (+/- SD) during this period was recorded as 3.0 +/- 1.4°C and mean salinity was 23.8 +/- 3.7 PSU. There were periods of time where the logger recorded salinities as low as 9.5 PSU and temperatures also rose to a maximum of 7.7°C. The variability of these conditions was likely the result of sea ice that had drifted into the harbour and grounded near the logger on those days. Based on the inferred data the melting sea ice influenced water temperature and salinity until July 20th, 2018, when the ice dissipated.

3.1.2 YSI Profiles

Water profile data was collected with the YSI Pro DSS water profiler at 27 sites. Appendix B provides data from all sites for temperature (ºC), dissolved oxygen (%), salinity (PSU), pH, and turbidity (FNU). Transects with associated YSI stations are indicated in Figure 4. Data collected along these transects were compiled to produce projections of changing environmental conditions with depth (Figures 5 to 11). Using profile data synthesized from stations between the community of Sachs Harbour and the mouth of the Sachs River (Figure 5), a clear transition between marine conditions to freshened water is observed.

The colder (< 4°C), more saline (approximately 29 PSU), and clear (< 1.0 FNU) marine conditions were observed at the majority of the sampling sites. The influence of the Sachs River was minimal except when in close proximity to the mouth of the river and at depths < 4 m. Stations within Sachs River were generally warmer (> 4°C), more turbid (> 2.5 FNU), and more brackish (< 27 PSU). Along this transect some vertical stratification in the water column was observed, such that the warmer, less saline water from Sachs River could be observed at the mouth of Sachs Harbour.

Individual transects within Sachs Harbour are shown in Figures 6 to 11 and are projected based on distance from shore (km).

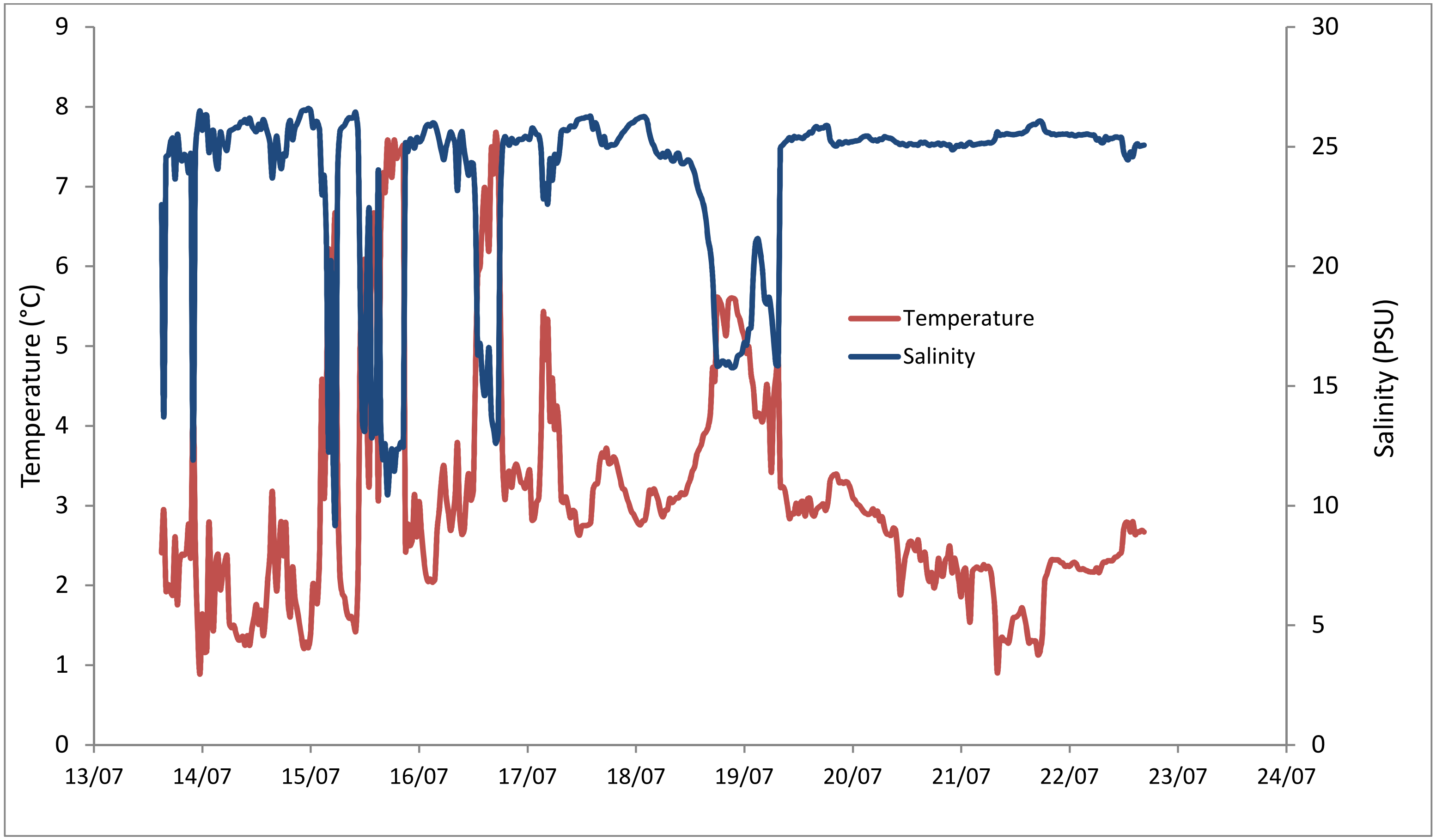

Figure 3. Time series of water temperature and salinity in Sachs Harbour between July 13, 2018 to July 22, 2018. Measurements were recorded with a CT2X-INW Smart Sensor logger every 30 minutes at 1 m depth below the surface.

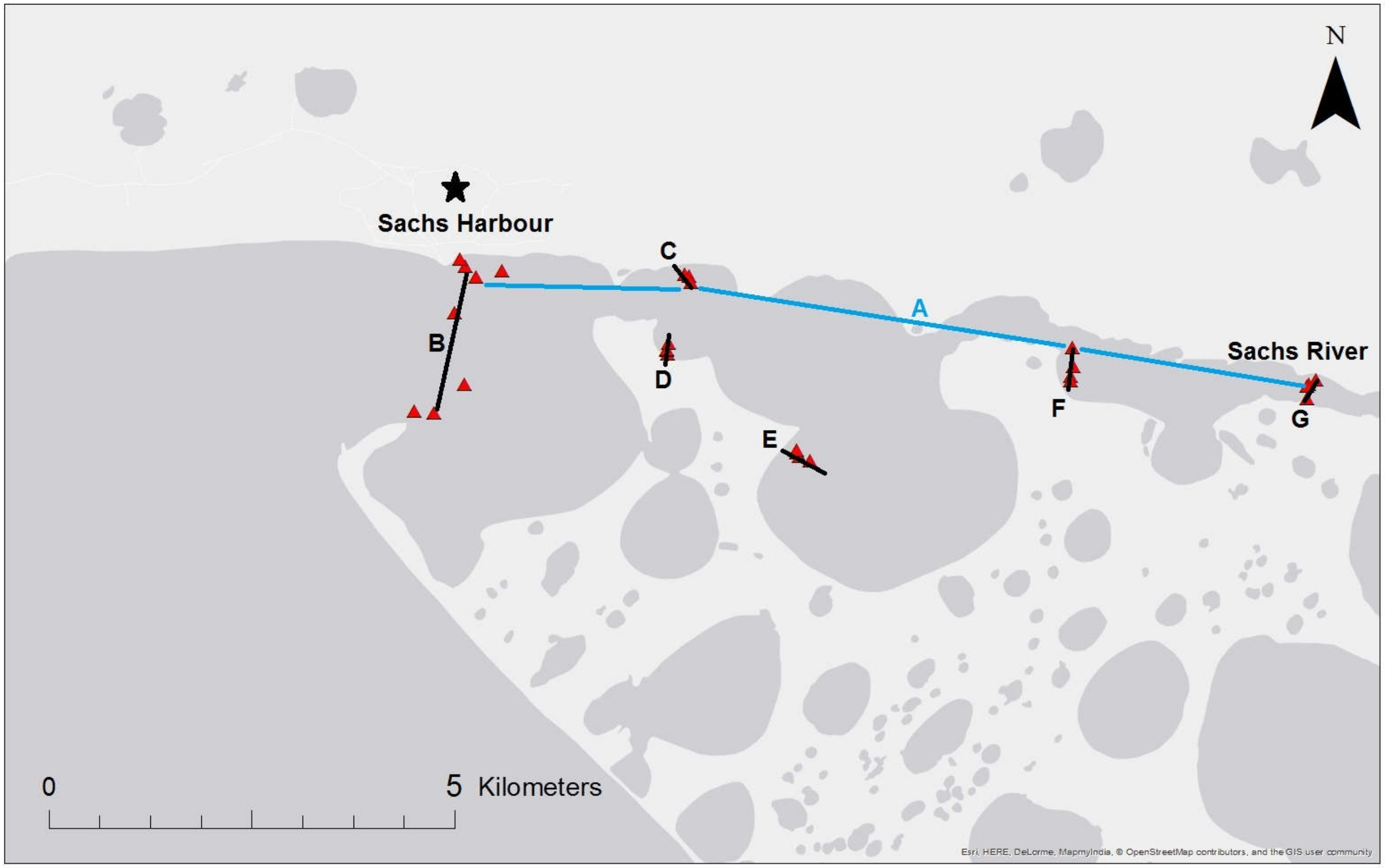

Figure 4. YSI transects across with increasing depth away from shore (black) and transect from the community of Sachs Harbour towards the mouth of the Sachs River (blue). Specific location data, and environmental data at each of the YSI sites (▲) can be found in Appendix B.

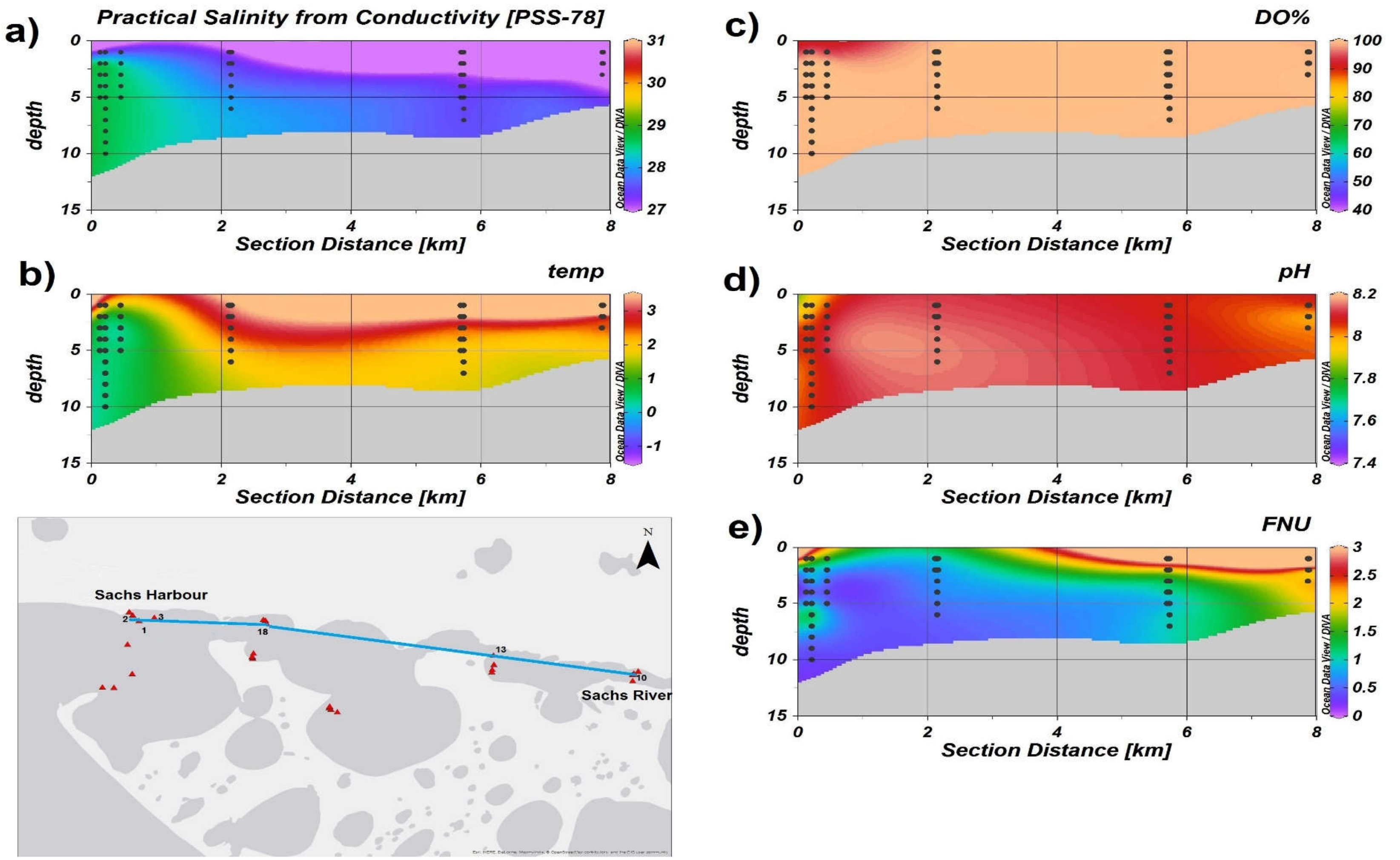

Figure 5. Cross section of water column properties between Sachs Harbour and mouth of Sachs River, NT, where section distance (km) starts at station 2. Profiles represent a) salinity (PSU), b) temperature (°C), c) dissolved oxygen (DO%), d) pH, and e) turbidity (FNU). Grey space represents the sea floor; specific values for each site can be found in Appendix B (stations 1, 2, 3, 18, 13 and 10).

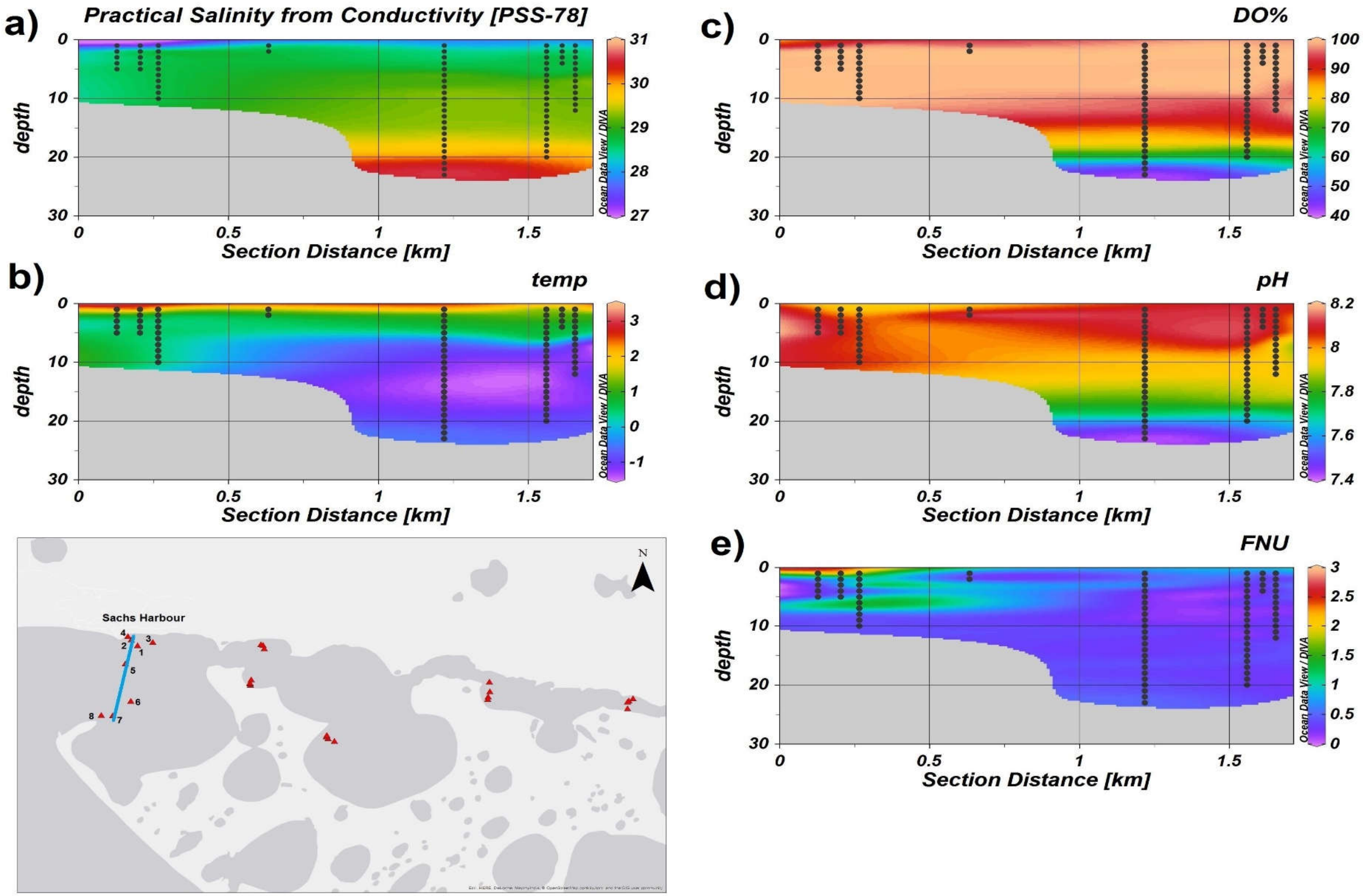

Figure 6. Transect B cross section of water column properties of a) salinity (PSU), b) temperature (°C), c) dissolved oxygen (DO%), d) pH, and e) turbidity (FNU); specific values for each site can be found in Appendix B (stations 1–8). Section distance starts at station 4, closest to the hamlet of Sachs Harbour.

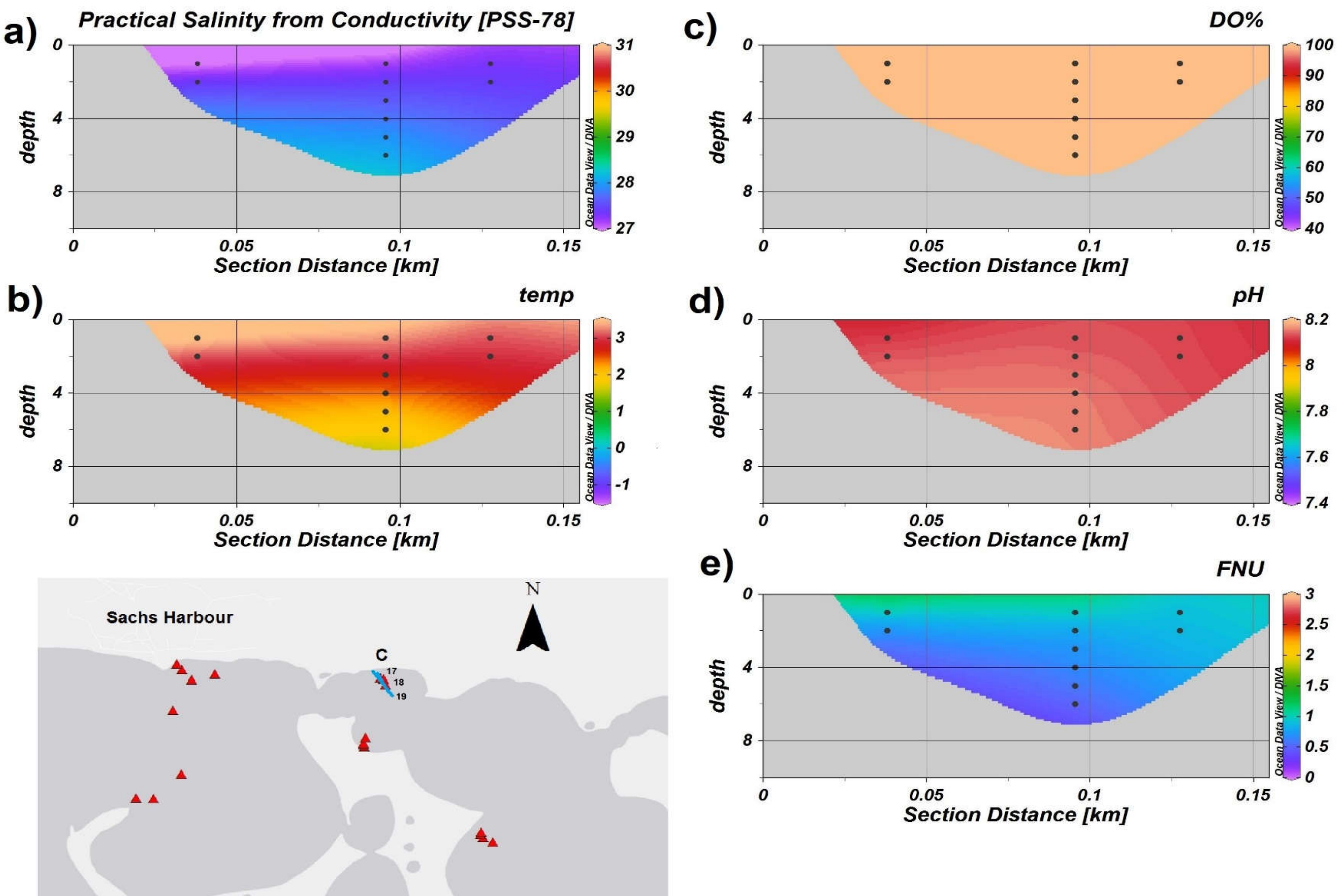

Figure 7. Transect C cross section of water column properties based on compiled YSI data. Profiles represent a) salinity (PSU), b) temperature (°C), c) dissolved oxygen (DO%), d) pH, and e) turbidity (FNU). Grey space represents the sea floor; specific values for each site can be found in Appendix B (stations 17–19); section distance begins at station 17 closest to the northern shoreline.

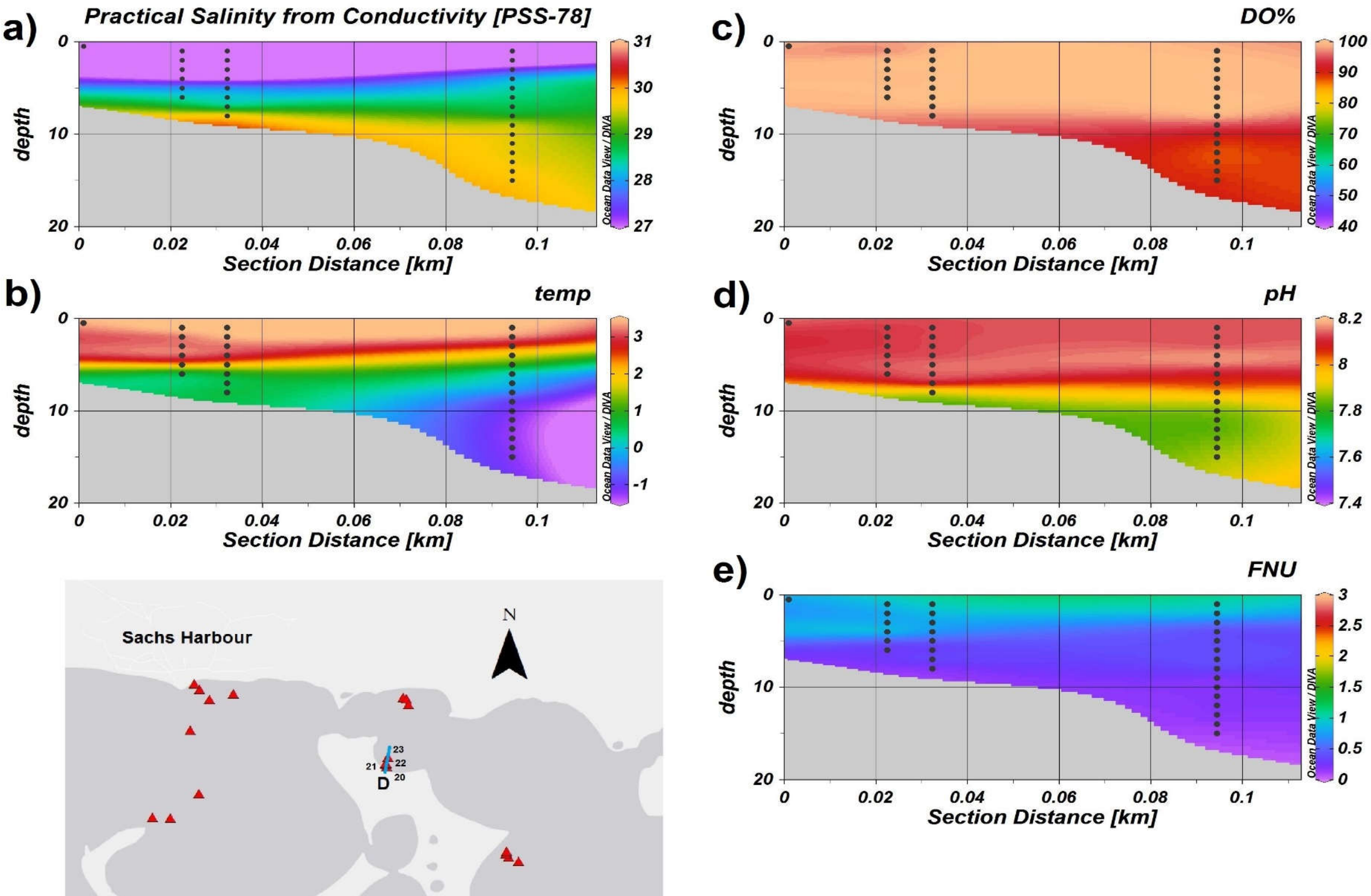

Figure 8. Transect D cross section of water column properties based on compiled YSI data. Profiles represent a) salinity (PSU), b) temperature (°C), c) dissolved oxygen (DO%), d) pH, and e) turbidity (FNU). Grey space represents the sea floor; specific values for each site can be found in Appendix B (stations 20 to 23); section distance begins at station 20, closest to the southern shore.

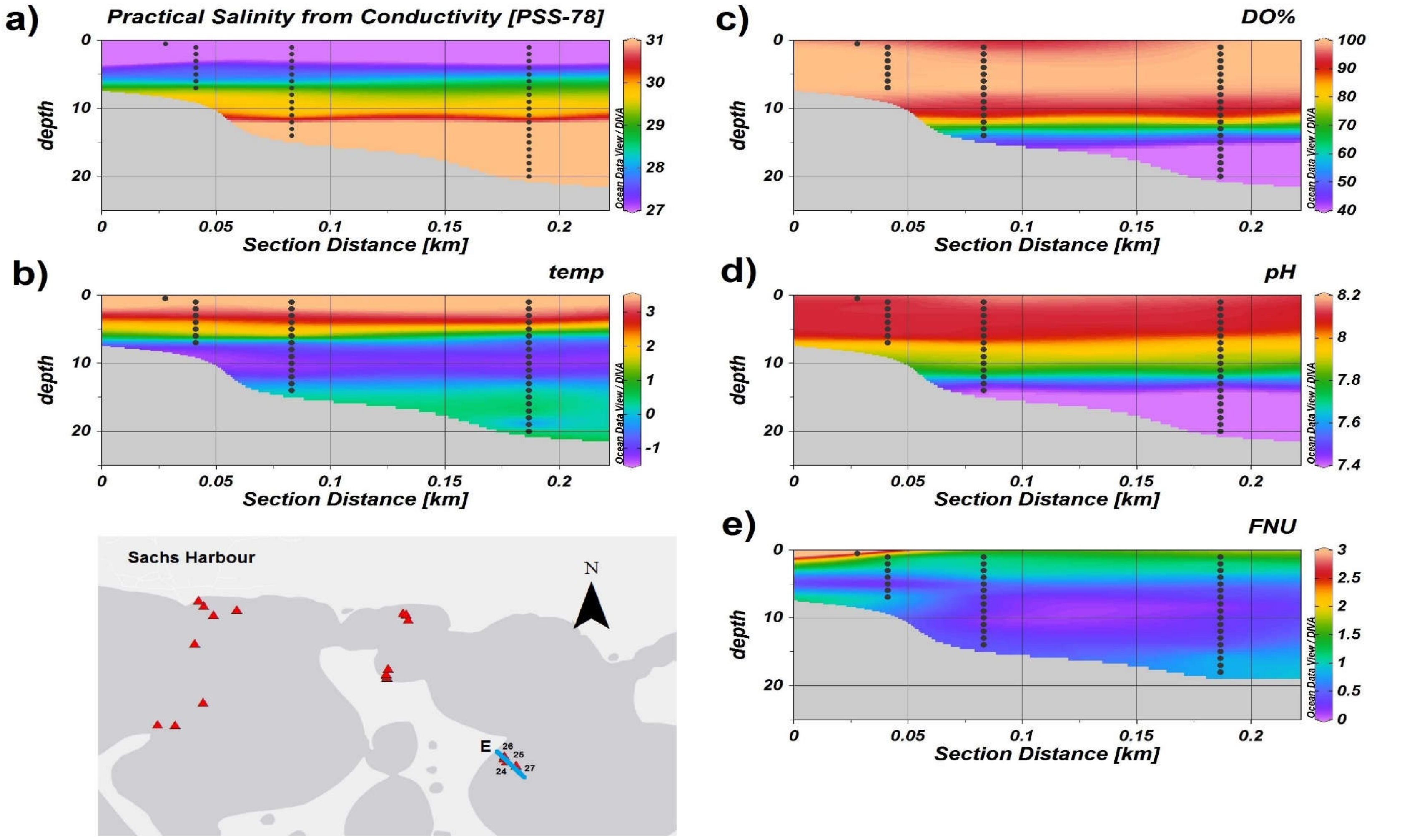

Figure 9. Transect E cross section of water column properties based on compiled YSI data. Profiles represent a) salinity (PSU), b) temperature (°C), c) dissolved oxygen (DO%), d) pH, and e) turbidity (FNU). Grey space represents the sea floor; specific values for each site can be found in Appendix B (stations 24 to 27); section distance begins at station 26, closest to the shoreline.

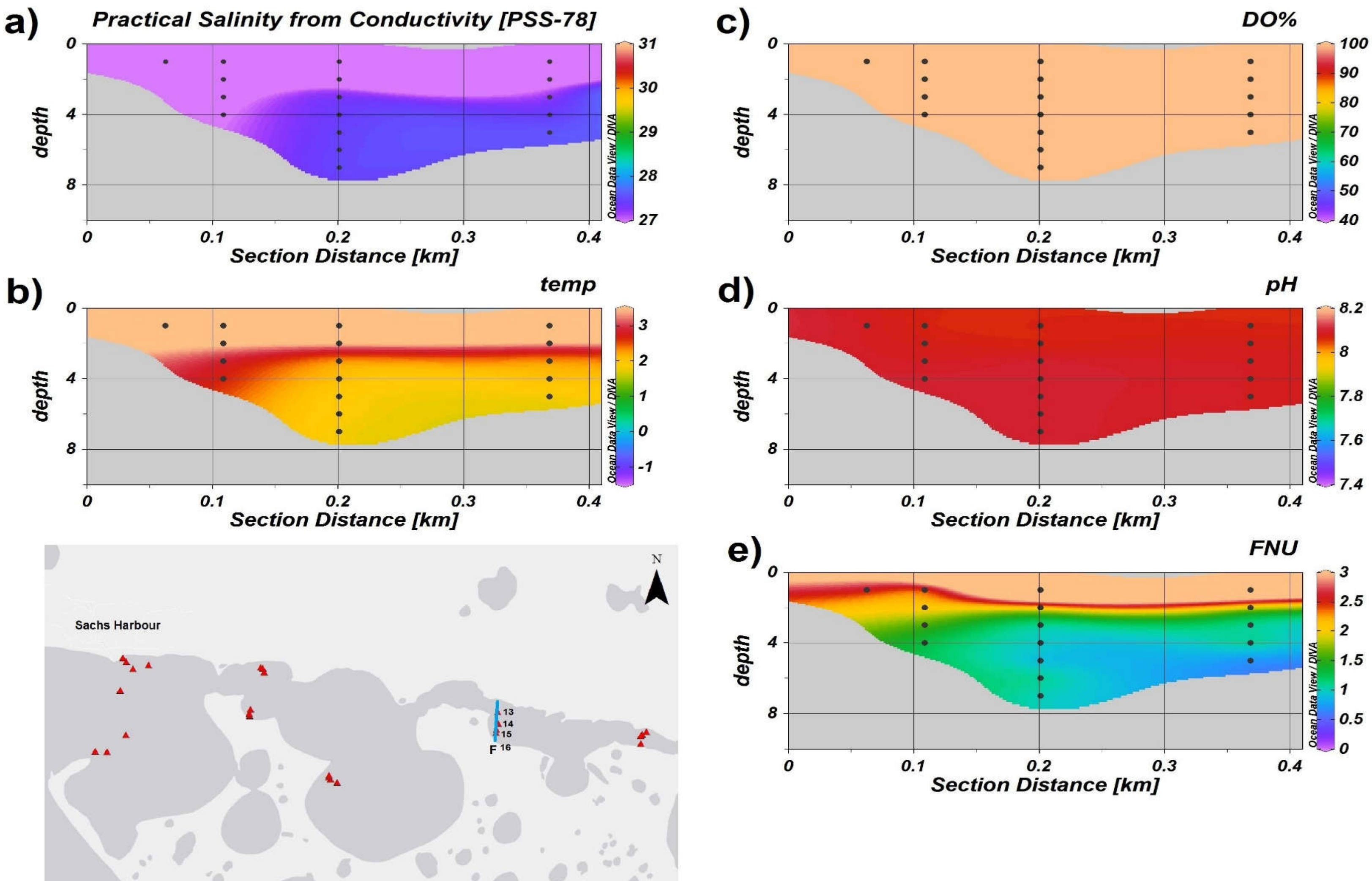

Figure 10. Transect F cross section of water column properties based on compiled YSI data. Profiles represent a) salinity (PSU), b) temperature (°C), c) dissolved oxygen (DO%), d) pH, and e) turbidity (FNU). Grey space represents the sea floor; specific values for each site can be found in Appendix B (stations 13 to 16); section distance begins at station 16, closest to the southern shoreline.

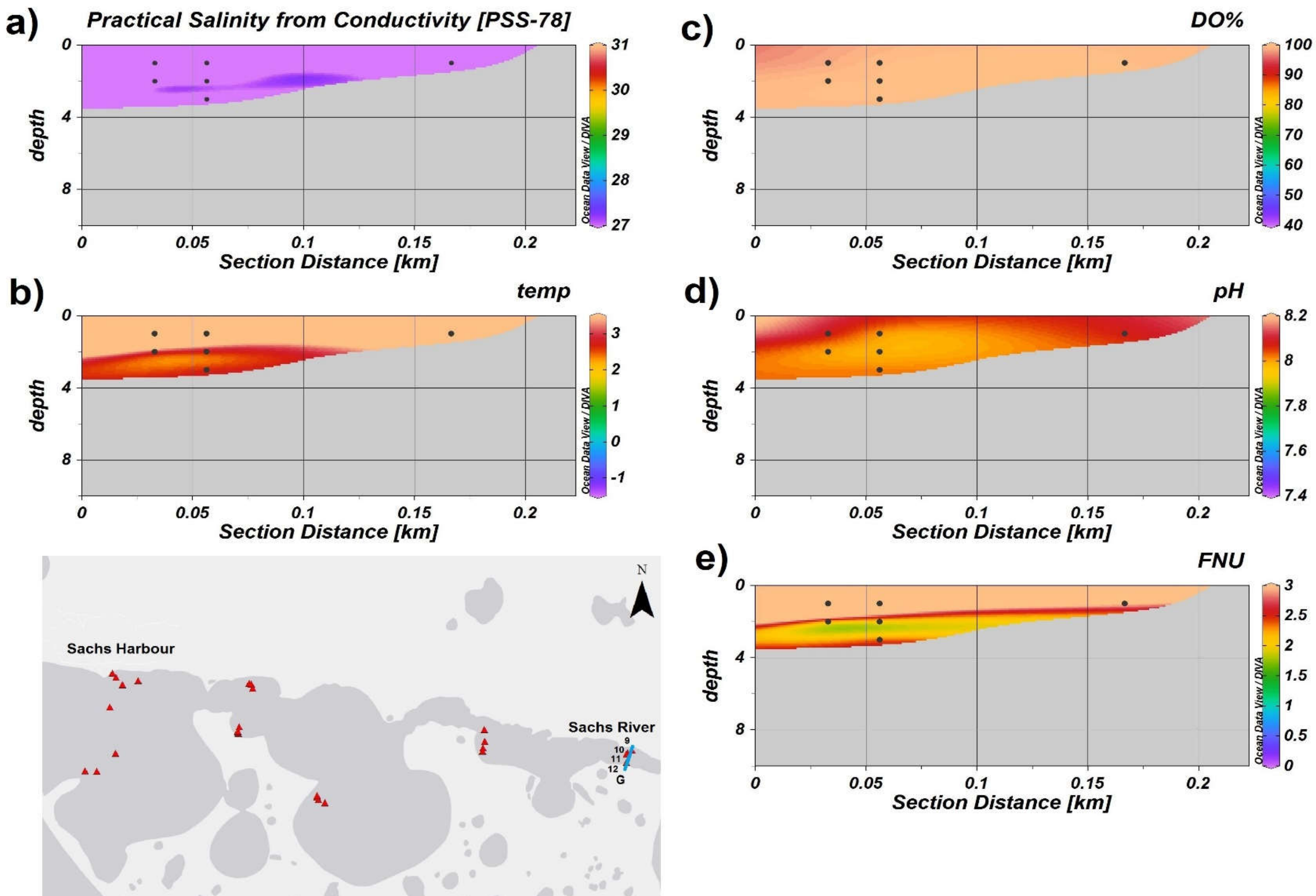

Figure 11. Transect G cross section of water column properties based on compiled YSI data. Profiles represent a) salinity (PSU), b) temperature (°C), c) dissolved oxygen (DO%), d) pH and e) turbidity (FNU). Grey space represents the sea floor; specific values for each site can be found in Appendix B (stations 9 to 11); section distance begins at station 9 on the northern shoreline.

The water column data provided valuable information on the available habitat for fishes in proximity of Sachs Harbour. Transects B and E indicate areas of increasing depth and decreasing dissolved oxygen, relative to other transects in which oxygen is generally high (> 80%). Areas that are > 20 m depth, with low oxygen (< 40%) also had decreased pH to 7.4 or lower. It is possible that these hypoxic conditions, with relatively lower pH, are the result of respiration driven by bacteria. Additional research would be required to determine if bacteria are responsible for modifying/driving the patterns water chemistry in these areas.

In total, 11 dredges were completed at corresponding YSI stations in Sachs Harbour (Table 3). The dredge was able to collect a variety of small benthic invertebrates such as bivalves, amphipods and some polychaete worms. The contents from these dredges (sediment samples and bulk invertebrates) were frozen and were preserved at the DFO Freshwater Institute in Winnipeg for future analyses.

A total of 9 plankton tows were conducted to assess pelagic invertebrates in this study. The details of the collection sites are summarized in Table 3.

Table 3. Summary of the contents, date, location, and depth at which invertebrates were collected in Sachs Harbour, NT. Samples collected during this survey were preserved and kept for identification at a later date. Stations with a * represent sites where tows were taken in the proximity of the YSI station but not at the same specific location.

Date	Site	Gear Type	Latitude (DD)	Longitude (DD)	Comments	Maximum Depth (m)
14-Jul-18	1b*	midwater	71.970825	-125.250072	pelagic invertebrates	N/A
18-Jul-18	2b*	midwater	71.976334	-125.183529	pelagic invertebrates	N/A
18-Jul-18	9b*	vertical	71.976669	-125.181880	pelagic invertebrates	14.8
18-Jul-18	3b*	midwater	71.979043	-125.178995	pelagic invertebrates	N/A
18-Jul-18	10b*	vertical	71.977218	-125.230580	pelagic invertebrates	15.1
18-Jul-18	4b*	midwater	71.977532	-125.228449	pelagic invertebrates	N/A
14-Jul-18	5	vertical	71.979521	-125.240592	pelagic invertebrates	3.4
14-Jul-18	6	vertical	71.973578	-125.238094	pelagic invertebrates	24.4
14-Jul-18	7	vertical	71.971277	-125.246235	pelagic invertebrates	20.5
13-Jul-18	1	dredge	71.982401	-125.234985	sediment only	10.1
13-Jul-18	2	dredge	71.983332	-125.237812	sediment only	6.3
13-Jul-18	3	dredge	71.982926	-125.228208	amphipods, polychaetes	6.2
14-Jul-18	5	dredge	71.979521	-125.240592	bivalves and polychaetes	3.4
17-Jul-18	9	dredge	71.974007	-125.012052	sediment only	1.1
17-Jul-18	12	dredge	71.972436	-125.014384	sediment only	1.5
17-Jul-18	13	dredge	71.976635	-125.076654	sediment only	5.6
17-Jul-18	14	dredge	71.975102	-125.076493	bivalves	7.0
17-Jul-18	15	dredge	71.974293	-125.077161	bivalves	4.2
19-Jul-18	25	dredge	71.967954	-125.150004	no sediment, macroalgae	7.1
19-Jul-18	26	dredge	71.968193	-125.149844	sediment only	1.0

Bulk samples collected from the plankton tows on July 14th were primarily composed of copepods, including *Metridia longa, Oithona similis,* and *Psuedocalanus* spp. The neritic diatom *Chaetoceros silmilis* was also very prevalent in the pelagic tows. Quantitative data on these species will be made available in future analyses.

3.2 FISHES

Figure 2 provides an overview of the sampling locations in the Sachs Harbour area. The summary of gillnet sets and their corresponding depth and environmental conditions is provided in Table 4.

The average temperature of all net set locations did not exceed 5ºC, and the salinity ranged between 22.1 and 28.7 PSU at all sites (Table 4). Although nets were all set close to shore, some nets were set along a dramatic change in depth (e.g., Set #9 was set between 1.0 to 12.3 m) over a short distance (60 m).

Table 4. Gear type**,** date, time, total soak time (hr:min), location, depth (for end farthest from shore) and mean (+/- SD) temperature and salinity for respective gill nets set in Sachs Harbour, NT.

Set	Gear	Date set (Y-M-D)	Time set	Time retrieved	Total time (hr:min)	Latitude (DD)	Longitude (DD)	Depth (m)	Mean temperature (°C) +/- SD	Mean salinity (PSU) +/- SD
1	Gill Net	2018-07-11	16:41	18:45	2:04	71.976214	-125.079934	10.5	-1.1 +/- 0.0	N/A
2	Gill Net	2018-07-12	10:55	17:13	6:18	71.986644	-125.250705	3.7	1.0 +/- 0.2	N/A
3	Gill Net	2018-07-12	11:28	17:22	5:54	71.985188	-125.293793	3.3	N/A	N/A
4	Gill Net	2018-07-13	17:18	20:30	27:12	71.986644	-125.250705	3.7	1.1 +/- 0.1	N/A
5	Gill Net	2018-07-13	17:25	17:00	23:35	71.985188	-125.293793	3.3	N/A	N/A
6	Seine	2018-07-13	15:18	15:24	N/A	71.983907	-125.239372	N/A	N/A	N/A
7	Seine	2018-07-13	15:27	15:32	N/A	71.984252	-125.237689	N/A	N/A	N/A
8	Gill Net	2018-07-14	10:13	15:30	5:17	71.97025	-125.251048	10.4	-1.0 +/- 0.1	28.7 +/- 0.0
9	Gill Net	2018-07-14	10:35	15:46	5:11	71.97025	-125.251048	12.3	N/A	N/A
10	Seine	2018-07-14	10:55	11:07	N/A	71.970324	-125.252907	N/A	N/A	N/A
11	Gill Net	2018-07-15	16:09	10:33	18:24	71.981124	-125.197754	3.2	N/A	N/A
12	Gill Net	2018-07-15	16:22	10:16	17:54	71.981669	-125.198813	4.0	1.2 +/- 0.2	27.6 +/- 0.3
13	Gill Net	2018-07-15	10:30	15:15	4:45	71.981669	-125.198813	4.0	1.5 +/- 0.4	27.4 +/- 0.5
14	Gill Net	2018-07-15	11:37	15:24	3:47	71.983078	-125.201364	2.0	N/A	N/A
15	Gill Net	2018-07-15	15:25	20:00	4:35	71.981669	-125.198813	3.5	2.3 +/- 0.4	N/A
16	Gill Net	2018-07-15	15:27	19:50	4:23	71.983078	-125.201364	2.0	N/A	N/A
17	Gill Net	2018-07-16	10:05	17:33	7:28	71.983078	-125.201364	3.0	N/A	N/A
18	Gill Net	2018-07-16	10:20	17:52	7:32	71.97726	-125.18811	8.2	-0.5 +/- 0.1	28.5 +/- 0.1
19	Gill Net	2018-07-17	12:13	17:31	5:18	71.972312	-125.013797	4.6	1.8 +/- 0.1	26.2 +/- 0.2
20	Gill Net	2018-07-17	12:44	18:36	5:52	71.975944	-125.076964	8.2	1.7 +/- 0.1	N/A
21	Gill Net	2018-07-18	10:04	14:34	4:30	71.980933	-125.196229	5.5	2.7 +/- 0.2	27.1 +/- 0.1
22	Gill Net	2018-07-18	10:14	14:27	4:13	71.978769	-125.184949	1.8	N/A	N/A
23	Gill Net	2018-07-19	14:32	10:14	19:42	71.978769	-125.184949	1.8	N/A	N/A
24	Gill Net	2018-07-19	14:44	9:45	19:01	71.980933	-125.196229	5.5	2.7 +/- 0.4	22.1 +/- 6.8
25	Gill Net	2018-07-22	10:32	16:10	77:38	71.973116	-125.166818	2.8	3.3 +/- 0.5	N/A
26	Gill Net	2018-07-22	12:10	16:23	76:13	71.981876	-125.199219	3.6	2.6 +/- 0.4	26.1 +/- 0.4

3.2.1 Species Diversity and Abundance

The species numbers, scientific name and proportion of total fishes collected are illustrated in Figure 12 and summarized in Table 5.

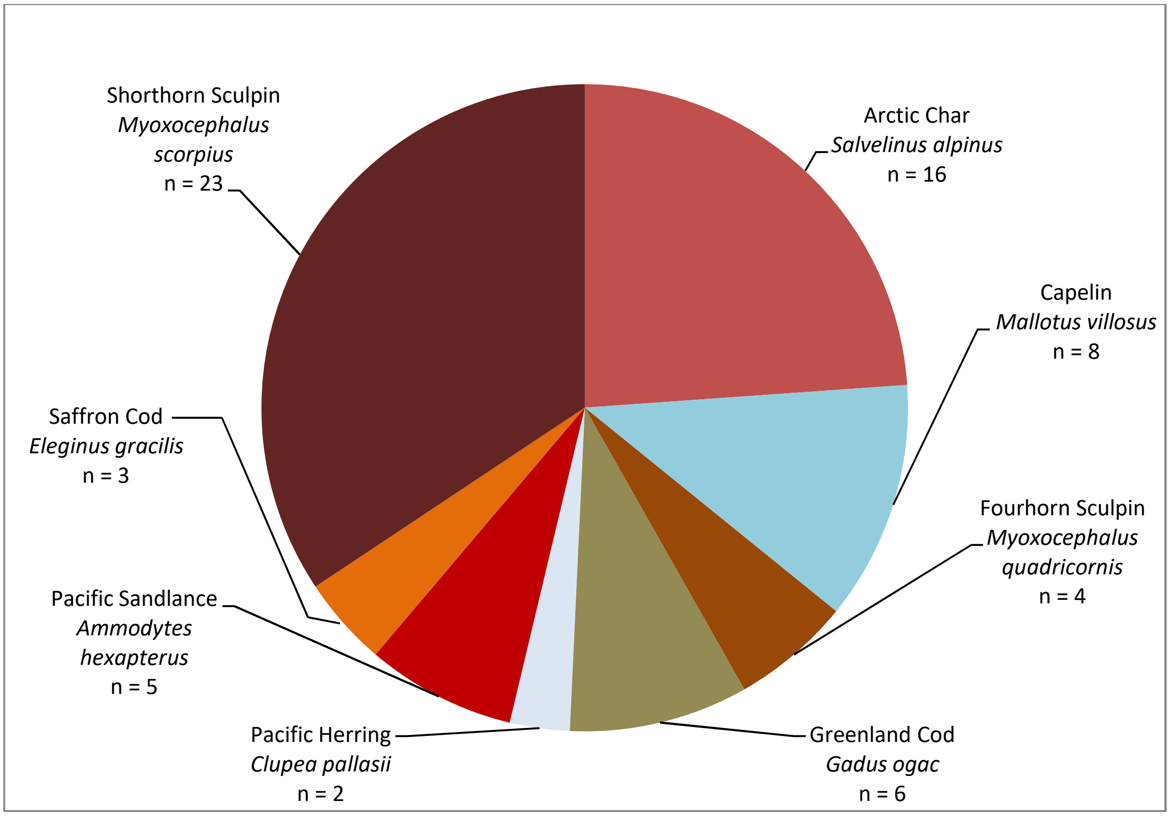

Figure 12. Composition and *n* of fishes collected in Sachs Harbour, NT in July 2018.

Table 5. Summary of species collected for each net set during the 2018 field program in Sachs Harbour, NT. The total number of individuals for each net and for each species are indicated in bold. Species scientific names are presented in Figure 12.

Set #	ARCH	CPLN	FHSC	GRCO	PCHR	PCSL	SFCD	SHSC	Total
1	1								**1**
2			1						**1**
3									**0**
4	3			2					**5**
5									**0**
6									**0**
7									**0**
8									**0**
9									**0**
10									**0**
11	1	1						4	**6**
12	3	1			1	5		1	**11**
13			1						**1**
14	2								**2**
15	1								**1**
16		2							**2**
17	1								**1**
18	1			2					**3**
19									**0**
20								1	**1**
21								2	**2**
22									**0**
23								4	**4**
24			1		1			2	**4**
25								6	**6**
26		4	1				3	3	**11**
Subsistence	3			2					**5**
									67

*ARCH = Arctic Char; CPLN = Capelin; FOSC = Fourhorn Sculpin; GRCO = Greenland Cod; PCHR = Pacific Herring; PCSL = Pacific Sandlance; SFCD = Saffron Cod; SHSC = Shorthorn Sculpin.

Five additional fish were provided to the study by a subsistence fisher, who was interested in having Greenland Cod and Arctic Char sampled as a component of the study.

3.2.2 Basic Biological Characteristics

The summary of first-order data (i.e., length, weight, sex, maturity) is summarized in Table 6. Most Arctic Char were female. However, given the low sample size, it is not possible to interpret any ecological significance. The other species sampled displayed a relatively equal sex ratio. The fish were primarily adults, and both Pacific Herring and Capelin (*Mallotus villosus* (Müller, 1776)) displayed characteristics of spawning (ripe gonads and expelling milt).

Table 6. Basic biological characteristics of fishes captured in Sachs Harbour, NT. Maturity classification is outlined in Appendix A and scientific names are presented in Figure 12.

Species	*n*	Total Length ± SD (mm)	Fork Length ± SD (mm)	Mean Mass ± SD (g)	Liver Mass ± SD (g)	Gonad Mass ± SD (g)	Sex (M:F)	Maturity (M:F)				
								Unknown	Immature	Mature	Ripe	Spent
Arctic Char	16	532.0 ± 192.4	431.1 ± 92.4	533.0 ± 192.4	11.7 ± 14.2	8.8 ± 18.5	5:10	1	0:6	1:2	0:0	0:0
Capelin	8	160.2 ± 6.6	150.3 ± 4.7	25.5 ± 3.9	0.38 ± 0.1	3.6 ± 1.9	1:5	0:0	0:0	0:0	4:1	0:0
Pacific Sandlance	5	126.2 ± 9.0	N/A	126.2 ± 9.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Fourhorn Sculpin	4	216.7 ± 50.9	N/A	111.3 ± 71.8	3.7 ± 2.0	4.4 ± 3.4	1:2	0:0	0:1	2:0	0:0	0:0
Greenland Cod	6	481.5 ± 55.5	N/A	913.4 ± 222.7	35.4 ± 15.7	35.0 ± 14.0	3:3	0:0	0:0	1:3	0:0	0:0
Pacific Herring	2	313.5 ± 7.8	N/A	237.3 ± 6.8	2.4 ± 0.1	17.0 ± 19.0	2:0	1:0	0:0	0:0	0:1	0:0
Saffron Cod	3	261.3 ± 64.5	N/A	165.4 ± 133.5	8.9 ± 9.3	5.0 ± 5.9	1:1	0:0	1:0	0:1	0:0	0:0
Shorthorn Sculpin	23	299.7 ± 73.2	N/A	297.1 ± 156.3	8.6 ± 5.5	6.7 ± 7.4	10:9	0:0	1:0	5:8	1:0	0:1

3.2.3 Fish Ages

Figures 13 to 17 describe the age-length relationship for each species. Increasing total length with respect to age was observed among species with larger sample sizes and a greater number of ages were reflected. Ages of individuals where the number captured was n < 5 are summarized in Table 7.

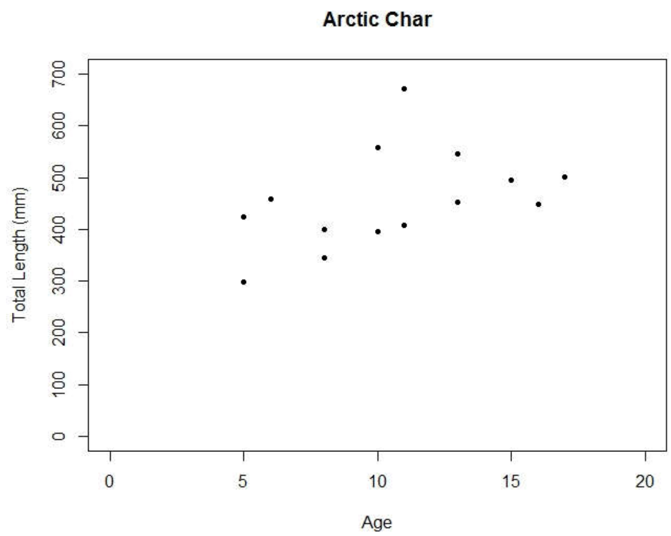

Figure 13. Total length (mm) versus age of Arctic Char collected in Sachs Harbour, NT, in July 2018 (n = 14).

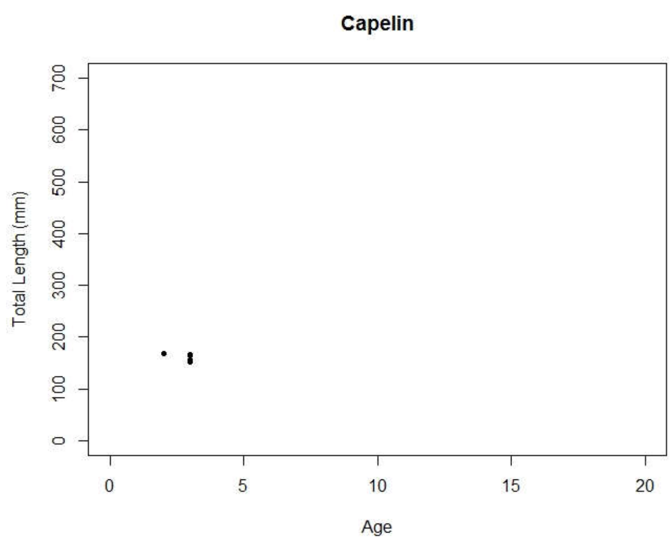

Figure 14. Total length (mm) versus age of Capelin collected in Sachs Harbour, NT, in July of 2018 (n = 8).

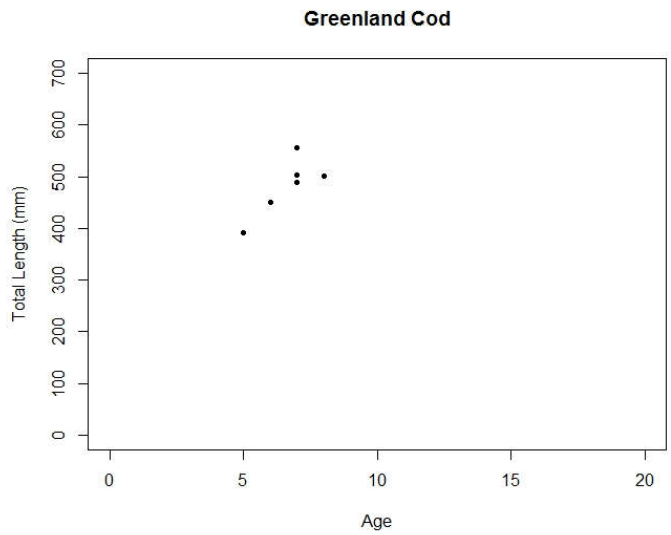

Figure 15. Total length (mm) versus age of Greenland Cod collected in Sachs Harbour, NT, in July of 2018 (n = 6).

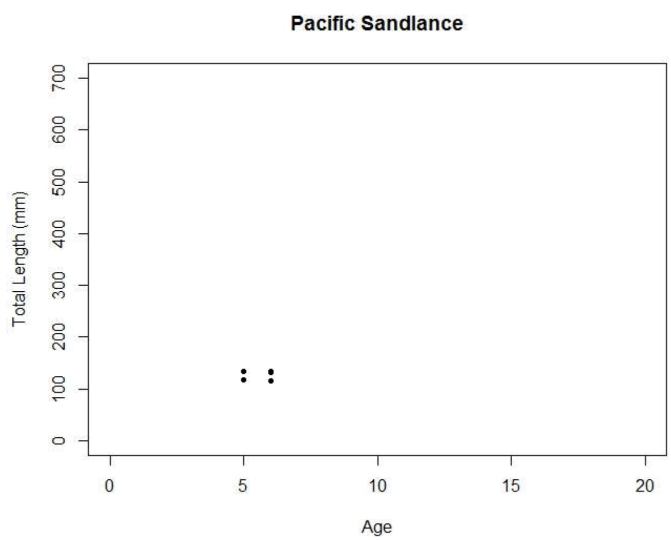

Figure 16. Total length (mm) versus age of Pacific Sandlance collected in Sachs Harbour, NT, in July of 2018 (n = 5).

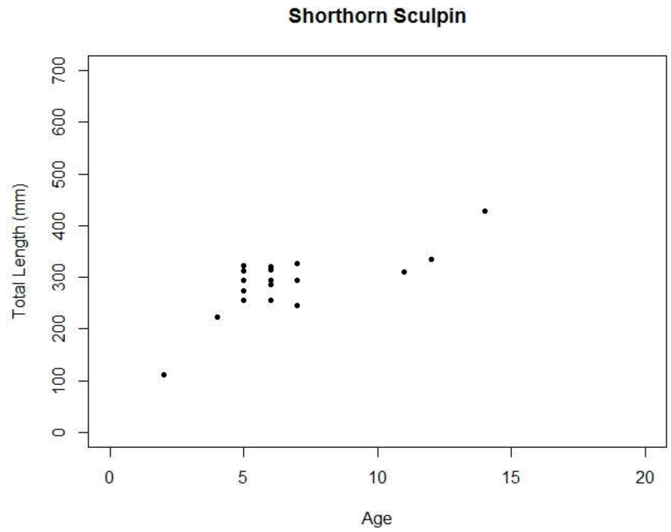

Figure 17. Total length (mm) versus age of Shorthorn Sculpin collected in Sachs Harbour, NT, in July of 2018 (n = 20).

Table 7. Mean total length and age of fishes collected in Sachs Harbour, where n<5. Each line for the respective species represents an individual fish.

Species	Age	Total Length (mm)
Fourhorn Sculpin	2	-
	3	158
	5	248
	5	244
Pacific Herring	6	319
	11	308
Saffron Cod	2	215
	3	234
	4	335

4.0 DISCUSSION

4.1 ENVIRONMENT

Sachs Harbour, and the connecting embayments leading to the mouth of the Sachs River, vary in their habitat characteristics. The most notable finding in this study was the presence of hypoxic conditions with relatively low pH (7.4) at deep water sites (> 20 m), potentially the result of bacterial respiration (Siferd 2001). The bathymetry and invertebrate life at these locations was previously described as "Arctic dead zones" (Siferd 2001) and it is unlikely that these areas would support substantive benthic biodiversity.

The combination of temperature and salinity data acquired from net sets, with YSI profile data, provides a general overview of the available habitat for fishes in the area. Stations along the shoreline of the harbour that were < 10 m depth were oxygen-rich, more turbid, and with temperature > 1ºC. These habitats likely serve as a corridor for anadromous fishes to travel between the marine habitat and freshwater bodies connected by Sachs River. Additionally, these areas serve as important foraging and rearing habitat for coastal marine species where the freshwater habitat transitions into marine.

Although the available information for invertebrates and zooplankton is limited in this study, it indicates that a variety of bivalves and benthic invertebrates are present in Sachs Harbour. There were no adult females observed of larger zooplankton species such as *Calanus glacialis* or *C. hyperboreus,* which are common in other coastal embayments of the Beaufort Sea (McNicholl et al. 2016). Future research dedicated to identifying the biodiversity of such organisms and their contribution to fish diet is required in order to determine their ecological significance.

The summer of 2018 was a challenging year for travel and fishing among coastal communities within the Inuvialuit Settlement Region due to presence of sea ice, and this was especially noticeable in Sachs Harbour given the limitations with setting nets for this study. Therefore no clear gradients could be observed between Sachs Harbour and Sachs River with regards to fish biodiversity.

4.2 FISHES

Baseline knowledge of fish diversity and associated biological characteristics is limited in the Canadian Arctic. The data presented here are important for classifying the life history characteristics and habitat associations of data poor species. The Sachs Harbour coastal survey has provided life history information on all observed species that can be compared among other coastal marine environments of the western Canadian Arctic.

Fish abundance was low for the eight species that were observed in this survey. Although the presence of ice in the bay influenced the ability to set nets, the catches were generally low. Generally, the age-at-length information among fishes in this study are comparable to the results of the same species collected at other Beaufort Sea sites, specifically to those aged from Darnley Bay, NT (McNicholl et al. 2017a). It is possible that the presence of ice this year may have affected habitat use and associations of coastal fishes, thus these baseline results should be compared with ice-free surveys in the future to determine the level of variability. The extent of spatial and temporal variability with respect to fish diversity, abundance, and habitat use on the Banks Island coast is largely unknown.

4.2.1 Salmonidae

Arctic Char Salvelinus alpinus *(Linnaeus, 1758)*: Arctic Char exhibit both anadromous and lake-locked life histories, and are harvested as a subsistence fish throughout Nunavut and in the Northwest Territories, east of the Mackenzie River (Sawatzky et al. 2007; Scott and Crossman 1973). Among coastal fishes of Banks Island, Arctic Char are likely the most studied and most culturally important subsistence fish to the community of Sachs Harbour (Stephenson 2010; Babaluk et al. 2018). This species is locally known as Iqalukpik (Inuvialuktun-Siglit).

Relative to other species captured in this study, Arctic Char were the second most abundant, although overall numbers were relatively low (n=16). The largest individual (maximum total length = 671 mm) was collected through subsistence harvest, and was allowed to be sampled by a local fisher. The largest individual observed in this study had a greater fork length (644 mm) than the char observed in lakes associated with the Sachs River in Babaluk et al. 2018 (maximum observed fork length 545 mm). Char collected from Banks Island lakes in Babaluk et al. (2018) were described as having a bi-modal distribution of ages between < 5+ years or 10+ to 15+ years, however in this study all char were > 5+ years and all were < 20+ years, which is a consistent maximum age for anadromous Arctic Char in Nunavut locations (Johnson 1976). Anadromous Arctic Char, and resident freshwater Arctic Char in the Sachs Harbour area are known to exhibit variability in maximum size, but generally fit the expected pattern of growth relative to populations outside of the Inuvialuit Settlement Region (Knopp et al. 2012; Stephenson 2010; Babaluk et al. 2018). In this study, the available samples of Arctic Char were too few to observe any significant age-length trends. Arctic Char were collected when water temperature was between -1.1ºC and 2.7ºC and the salinity between 27.3 PSU and 28.6 PSU, in the proximity of Sachs River and on the marine side of Sachs Harbour.

4.2.2 Gadidae

Greenland Cod *Gadus ogac* Richardson, 1836: Greenland Cod are distributed throughout the Canadian Arctic and are generally found in nearshore (< 20 m depth) areas. Locally, they are known as Rock Cod or Uugavik (Inuvialuktun-Siglit). Greenland Cod have been documented in Sachs Harbour in the past (Fisheries Joint Management Committee 1995); however, there is limited knowledge of their life history and biology on Banks Island. Next to Arctic Char, Greenland Cod were the second largest fish observed in this study (maximum total length 555 mm), and are also harvested for subsistence by the community of Sachs Harbour. Although the abundance of Greenland Cod was generally low in this study, Greenland Cod are considered an important marine subsistence species and are consumed by community members in Sachs Harbour, particularly during the spring. All individuals were adult, between ages +5 and +7 which is within the known biological range observed in other Arctic locations (Coad and Reist 2018). Greenland Cod in the Beaufort Sea are opportunistic, generalist feeders that display substantive variability in prey sources (Brewster et al. 2018). On one occasion in this study, a whole, adult Shorthorn Sculpin was found in the stomach of a Greenland Cod, emphasizing the ability of this species to consume larger prey. Greenland Cod in this study were captured at depths between 3.7 and 8.2 m, at temperatures between -0.6ºC and 1.2ºC, and where salinity was 28.5 $\pm$ 0.1 PSU.

Saffron Cod *Eleginus gracilis* (Tilesius, 1810): This is the first published record of Saffron Cod in Sachs Harbour and at Banks Island. Observations from subsistence fishers indicate that this species is relatively new to the area (within the last ten years) and has not been captured for subsistence in the past. On the mainland in the Inuvialuit Settlement Region, Saffron Cod are commonly caught in subsistence nets and are known as Tom Cod (Uugaq in Inuvialuktun-Siglit). They are typically found in coastal waters (< 60 m depth; Pathy et al. 2004), and are known to occur in both brackish and marine water. Given that there were so few individuals collected, it is not possible to determine any trends associated with their age at length; however, data are within the known biological range for this species. All these individuals were collected in the same net (#26) set from shore to a maximum depth of 3.6 m, where mean temperature ($\pm$ SD) was 2.6 $\pm$ 0.4ºC and salinity was 26.1 $\pm$ 0.4 PSU.

4.2.3 Cottidae

Shorthorn Sculpin *Myoxocephalus scorpius* (Linnaeus, 1758): Shorthorn Sculpin is a common coastal species found throughout the Canadian Arctic and was the most abundant species captured in this study (33% of total catch). Locally, sculpin are known as Kanayuq or devil fish and are typically not harvested for subsistence. Juvenile fish of this species are a common prey source for other predatory fishes, such as Arctic Char and Greenland Cod. They have been observed in the Sachs Harbour area in the past, as well as on the eastern coast of Banks Island in Prince of Wales Straight (Coad and Reist 2018). Much of the known life history information of this species in the western Canadian Arctic, however, has been obtained from fishes collected in the Mackenzie Delta region (Majewski et al. 2011; Lowdon et al. 2011; Craig 1984), or in Darnley Bay (McNicholl et al. 2017a). All individuals collected and aged in Darnley Bay were between age +1 and +8 and did not exceed 450 mm in total length. Although total length was similar among Sachs Harbour Shorthorn Sculpin (maximum total length 427 mm), the maximum observed age was +14. Fishes were primarily < age +10; however, there were three individuals that exceeded this age. In this Sachs Harbour survey, Shorthorn Sculpin were captured at depths up to 8.2 m, at water temperatures between 1.0ºC and 3.8ºC, and at salinities between 15.3 PSU and 28.9 PSU.

Fourhorn Sculpin *Myoxocephalus quadricornis* (Linnaeus, 1758): Similar to Shorthorn Sculpin, Fourhorn Sculpin are commonly found in coastal, benthic habitats of the Canadian Arctic, and have been documented on Banks Island and in Sachs Harbour in the past (Sutherland and Golke1978; Stephenson 2010). This species is also known locally as Kanayuq, the same term used for all sculpins and they are also commonly referred to as devil fish. The abundance of Fourhorn Sculpin observed in this study was relatively low, representing 6% of the total catch. The two individuals captured in this study were ages +2 and +5; in Darnley Bay, however, this species is known to exceed age +10 (McNicholl et al. 2017a). Fourhorn Sculpin collected in this survey were captured at depths up to 5.5 m, at water temperatures between 1.1ºC and 3.1ºC, and salinities between 15.3 PSU and 28.9 PSU.

4.2.4 Osmeridae

Capelin *Mallotus villosus* (Müller, 1776): Capelin is a forage fish species that is ubiquitous throughout the northern hemisphere, and is typically associated with more temperate waters. As a mid-trophic forage fish species, Capelin serve as an important prey source for marine mammals, sea birds, and predatory fish such as Arctic Char (Dempson et al. 2002). Although established populations of Capelin already exist in Darnley Bay (McNicholl et al. 2017b) and in the eastern Arctic (McNicholl et al. 2018), it is believed that this species will continue to shift their distribution north in response to warming temperature (Gaston et al. 2003; Rose 2005). In the western Arctic, the distribution of Capelin and their life history characteristics are largely unknown. For instance, it is unknown where they overwinter and where their larval life history stage is reared. Most records of Capelin in the Canadian Arctic are found in the east. Western Canadian Arctic observations are more sporadic, and the northern-most observation of Capelin in the west was found in Sachs Harbour (Douglas 1964; Usher 1966; Fraker et al. 1979). Capelin collected in the present study were observed at temperatures between 1.4ºC and 3.0ºC, and salinities of 25.7 PSU and 27.9 PSU.

It is uncertain if Capelin spawn at other locations on Banks Island. However, given that all of the individuals collected in this study were ripe, this seems plausible. The individuals collected at Sachs Harbour were found off a sandy shoreline, which is typical spawning habitat for this species. Sheltered embayments in the western Arctic, such as those also observed in Darnley Bay (McNicholl et al. 2017a,b) and potentially also near Ulukhaktok (E. Lea, personal communication, July 2017), and Franklin Bay (A. Majewski, personal communication) may serve as important spawning grounds.

4.2.5 Clupeidae

Pacific Herring *Clupea pallasii* Valenciennes, 1847: Pacific Herring are a pelagic fish found throughout the coastal Beaufort Sea, and to a lesser extent, in parts of western Nunavut. This species has been observed in Sachs Harbour in the past (International Institute for Sustainable Development 1999-2000), is harvested for subsistence in the community, and is locally known as “blue herring” (Piqquaqtitaq in Inuvialuktun-Siglit). Few individuals were collected in this study, representing 3% of the total catch. Pacific Herring in other Beaufort Sea locations, such as Darnley Bay, were generally between age +5 and +15 (McNicholl et al. 2017a), which is consistent with the individuals observed in this Sachs Harbour study. Although there were only two individuals collected in this study, one of them was ripe, and local knowledge indicates that this species spawns in July in shallow sheltered areas of the bay. Pacific Herring in this survey were captured at depths up to 5.5 m, temperatures between 1.0 ºC and 3.1ºC, and salinities between 15.3 PSU and 28.9 PSU.

4.2.6 Ammodytidae

Pacific Sandlance *Ammodytes hexapterus* Pallas, 1814: This is the first published record of Pacific Sandlance at Banks Island and in Sachs Harbour. Pacific Sandlance are small forage fish that live in the sediments of coastal areas and serve as an important prey source for many marine mammals, sea birds, and piscivorous fishes. Generally, sandlance are elusive to directed sampling efforts in the western Arctic and are instead typically observed in the stomach contents of their predators. Historical observations of this species in the Beaufort Sea have occurred in Franklin Bay (Coad and Reist 2018), and more recently in Darnley Bay (McNicholl et al. 2017b) and in Ulukhaktok (Loseto et al. 2018). In this study, Pacific Sandlance ages were ages +5 and +6, which is consistent with *Ammodytes* sp. collected recently from beluga stomachs in Ulukhaktok, NT (Loseto et al. 2018). These individuals were collected in a single gill net set. This net was set on shore (#12) up to a depth of 4 m, where mean temperature ($\pm$ SD) was 1.5 $\pm$ 0.4ºC, and mean salinity was 27.4 $\pm$ 0.5 PSU.

4.2.7 Other Fishes

Although Pacific salmon were not collected in this study, community-based monitoring efforts (Dunmall and Reist 2018) and subsistence harvest indicate that Pacific salmon are increasing in the area, and are co-occurring with Arctic Char in the Sachs Harbour area.

4.3 LOCAL OBSERVATIONS

Coastal fishes are an important subsistence food source for the people of Sachs Harbour, and therefore their ecology is closely observed by local fishers. The following excerpts were prepared by K. Gully, based on his experience growing up in Sachs Harbour and fishing in the region.

4.3.1 Fish Targeted for Subsistence in Sachs Harbour

I almost exclusively fish for char because they are my favorite fish to eat besides salmon. That being said it depends on the size and colour of the fish when it comes to Lake Trout. For example, if I catch a large trout with or without reddish colouring I would keep it for making dry fish. That also goes for average sized trout but only if they have reddish in colouring. The preference in the reddish colouring is because personally I find white trout to have a swampy or bland taste as to the reddish or even pink variety which I find have a more savoury flavour. I only really mention the two fish because I mostly go lake fishing and those are the only two fish I've ever seen in lakes on Banks Island besides whitefish which are only found in some lakes I am familiar with. Whitefish are very hard to come by, for example; in the summer my extended family would go for a daytrip lake hopping with ATVs just to attempt to catch whitefish. Personally I do not care for whitefish to me they sit between trout and char; however, they are greatly appreciated amongst elders. Greenland Cod are caught in the harbour but are often treated as a "TV dinner" as in when you want them they're easy to catch and you know where to find them all year round. In the end it all comes down to convenience, for example; I am used to throwing back trout; however, there are many people in Sachs Harbour who do not have the time or the resources to travel to locations such as Middle Lake that are rich in char so when they travel upriver or even to lakes just outside of town they are happy in just taking a few trout home regardless of size.

Seasons are important when it comes to trout. People generally throw trout back in the summer while rod fishing or netting. In the winter, however, people hoard those same fish while ice fishing. This is largely because they do not have to worry about the fish rotting or working on them with in the same day of catching. Although I am not a fan of ice fishing, plenty of people prefer it to rod fishing.

4.3.2 Fishing Locations and Methods

I am only familiar with netting in certain areas of the river and harbour, because of my grandfather and father's efforts of finding the best yielding net locations in attempts to catch more ocean char [anadromous Arctic Char] *so as far as different species and locations my knowledge is limited. There are plenty of trout in the river but we try to avoid areas that yield more trout than char when it comes to netting. However, when it comes to ocean char in Sachs Harbour, I am no stranger. The netting locations used today are so desired amongst netters that people often fight over rights to use such locations. The best locations are found along the cut-banks off the point.*

As far as I am aware of, my father is the only one I know in Sachs Harbour who has a preference in nets or at least to the extent of getting custom nets made. Generally, in Sachs people use multifilament nets because of their availability, low cost and better at holding onto fish. My father however prefers monofilament nets primarily on the fact that they keep fish alive while they are caught so they remain fresh longer or can even be tossed back as well as they are easier to remove from nets.

4.3.3 Recent Changes to the Community of Coastal Fishes

I remember it was big news that Greenland Halibut were being captured in nets roughly 15 years ago because I was a teenager. My friend and I thought it was the weirdest thing that the fish had both eyes on one side of its body. In the last decade we have started seeing Pacific salmon in Sachs Harbour. Before that, growing up in Sachs, I have never seen a salmon at least not on Banks Island. I heard people mention they caught them at some point in past but I have only ever seen one in Sachs, 4 years ago. Regarding ocean char in the harbour, I have never noticed a consistency from year to year, one year we would catch like 50 in a month and the next we would catch like 20 over the two months.

There are plenty of variables when it comes to netting in the harbour. Some summers, people in Sachs have almost no opportunity to even set nets in the harbour or river opening because of the sea ice. Although free of sea ice for the majority of most summers, the ocean is continuously pulling the sea ice in and out of the harbour throughout the summer, which makes it extremely inconvenient for netting and sometimes even weeks would go by where no one has any nets set. The only consistency when netting in the harbour would be the sculpin and by that I mean we get dozens of them along with a few cod.

It all depends on lakes when involving fish species. For example, Fish Lake would have a catch rate ratio of roughly 1:3 char to trout whereas Middle Lake has roughly a 3:2 char to trout ratio. Middle Lake is one of the only lakes that I am aware of that yields more char than trout. In fact, that's why my family built our cabin there over two decades ago. Despite Fish Lake remaining relatively consistent, it is the only lake I've seen change because it connects to the river. For example, in the summer of 2017 me and my brother were rod fishing on Fish Lake and he reeled a salmon which was the only salmon I have ever seen in the lakes.

5.0 CONCLUSION

This study successfully collected summer baseline environmental data and documented the biodiversity and life history of coastal fishes in the area at this time of year. Water profile data also provided insight into available fish habitats and the conditions in which fish were captured. Hypoxic areas at depths > 20 m, with more acidic conditions, suggest that bacterial respiration was present; however, future studies are required to better understand this environment.

This study confirmed the presence of Saffron Cod and Sandlance, two coastal fishes that have been recently observed by the fishers from Sachs Harbour but are not included in the scientific literature. This is another noteworthy result of this study. Although overall fish catches were generally low, these sampling efforts reflected common species based on community observations, and also included species that are considered to be new to the area. Further studies are needed in this region to evaluate spatial and temporal changes in the fish community, and to document the occurrence and characteristics of species that appear to be new to the region such as Saffron Cod and Pacific salmon. Repeated studies of this kind would be beneficial in order to assess the variability and potential trends in fish diversity over time.

Baseline knowledge of fish biodiversity and habitat associations will be necessary when developing future ecologically and biologically significant areas (EBSAs), or marine protected areas (MPAs) in the Canadian Arctic. Knowledge gained from this study will contribute to a greater understanding of, species biodiversity, spawning or rearing habitats, prey availability and migratory corridors, in order to effectively manage these areas in the future.

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APPENDIX A – Fish Maturity Indices

Maturity State	Female (2)		Male (1)	
	Code	Description	Code	Description
Immature	1	- Ovaries granular in texture - Hard and triangular in shape - Up to full length of body cavity - Membrane full - Eggs distinguishable	6	- Testes long and thin - Tubular and scalloped shape - Up to full body length - Putty-like firmness
Mature	2	- Current year spawner - Ovary fills body cavity - Eggs near full size but not loose - Eggs not expelled by pressure	7	- Current year spawner - Testes large and lobate - White to purplish color - Centers may be fluid - Milt not expelled by pressure
Ripe	3	- Ovaries fill body cavity - Eggs full size and transparent - Eggs expelled by slight pressure	8	- Testes full size - White and lobate - Milt expelled by slight pressure
Spent	4	- Spawning complete - Ovaries ruptured and flaccid - Developing oocytes visible - Some retained eggs	9	- Spawning complete - Testes flaccid with some milt - Blood vessels obvious - Testes violet-pink in color
Resting	5	- Ovary 40-50% of body cavity - Membrane thin, loose, and semi-transparent - Healed from spawning - Developing oocytes apparent with few atretic eggs - Some eggs may be retained in body cavity	10	- Testes tubular, less lobate - Healed from spawning - No fluid in center - Usually full length - Mottled and purplish in color
Female or Male				
Unknown	0	- Cannot be sexed - Gonads long or short and thin - Transparent and translucent	11	- Resting fish - Spawning complete, gonads not regenerated - Sexing not possible

APPENDIX B- YSI Profile Data

Date	Site	Latitude (DD)	Longitude (DD)	Maximum Depth (m)	Depth (m)	Temperature (°C)	Dissolved Oxygen (%)	Salinity [PSS-78]	pH	Turbidity (FNU)
13/07/2018	1	71.982401	-125.23498	10.1	1	1.2	99	27.56927	7.97	1.3
					2	0.5	100	28.70294	8.01	1.2
					3	0.4	100	28.68623	8.03	1.6
					4	0.4	100	28.70331	8.04	0.3
					5	0.5	100	28.69484	8.04	1.2
					6	0.4	100	28.70161	8.05	1.4
					7	0.4	100	28.70239	8.05	1.2
					8	0.4	100	28.70577	8.05	0.5
					9	0.4	100	28.70264	8.06	0.4
					10	0.4	100	28.69886	8.06	0.4
13/07/2018	2	71.983332	-125.237812	6.3	1	3.4	93.2	27.09165	7.93	3.0
					2	1.4	100	28.75146	8	0.5
					3	0.6	100	28.60855	8.08	0.3
					4	0.6	100	28.63089	8.08	0.3
					5	0.5	100	28.69288	8.09	0.5
13/07/2018	3	71.98293	-125.22820	6.2	1	1.8	93	27.5686	8.05	1.6
					2	0.9	100	28.35659	8.08	0.8
					3	0.4	100	28.52658	8.11	0.4
					4	0.3	100	28.55856	8.12	0.4
					5	0.5	100	28.62959	8.13	0.4
14/07/2018	4	71.970812	-125.25002	13.2	1	1.8	99	28.213	8.09	0.7
					2	1.1	100	28.5501	8.07	0.3
					3	1	100	28.58922	8.06	0.5
					4	0.7	100	28.7196	8.07	0.3
					5	0.6	100	28.73358	8.07	0.4
					6	-0.1	100	28.93305	8.01	0.3
					7	-1	99	29.23335	7.95	0.2

Date	Site	Latitude (DD)	Longitude (DD)	Maximum Depth (m)	Depth (m)	Temperature (°C)	Dissolved Oxygen (%)	Salinity [PSS-78]	pH	Turbidity (FNU)
					8	-1.1	98	29.21514	7.94	0.2
					9	-1.2	97.1	29.21963	7.94	0.3
					10	-1.2	96.8	29.23574	7.94	0.3
					11	-1.2	96.7	29.23903	7.94	0.3
					12	-1.1	96.5	29.2771	7.94	0.3
14/07/2018	5	71.97952	-125.24059	3.4	1	1.6	96	28.5332	8.03	0.5
					2	0.9	100	28.6906	8.13	0.3
14/07/2018	6	71.973578	-125.23809	24.4	1	2.1	99	28.1256	8.1	0.6
					2	1.1	100	28.4917	8.11	0.5
					3	0.9	100	28.5479	8.11	0.7
					4	0.7	100	28.6686	8.11	0.3
					5	0.4	100	28.7758	8.1	0.2
					6	-0.3	100	29.1367	8.07	0.2
					7	-0.7	100	29.0803	8.04	0.2
					8	-0.9	100	29.1407	8.02	0.2
					9	-1	98.4	29.3114	7.98	0.2
					10	-1.2	96.5	29.2852	7.97	0.3
					11	-1.2	96	29.2904	7.97	0.4
					12	-1.3	95.6	29.3072	7.96	0.3
					13	-1.4	93.3	29.3062	7.92	0.3
					14	-1.4	90.8	29.3357	7.9	0.3
					15	-1.4	87.3	29.3403	7.87	0.3
					16	-1.3	85	29.4568	7.84	0.4
					17	-1.2	82	29.5668	7.8	0.4
					18	-1.1	78.6	29.7205	7.75	0.3
					19	-1	73.7	29.8123	7.71	0.4
					20	-0.9	65.5	30.068	7.6	0.4
					21	-0.7	55.1	30.401	7.51	0.4

Date	Site	Latitude (DD)	Longitude (DD)	Maximum Depth (m)	Depth (m)	Temperature (°C)	Dissolved Oxygen (%)	Salinity [PSS-78]	pH	Turbidity (FNU)
					22	-0.6	46.3	30.5486	7.45	0.5
					23	-0.6	42.4	30.5831	7.14	0.5
14/07/2018	7	71.971277	-125.24623	20.5	1	1.4	100	28.21764	8.11	0.7
					2	1.3	100	28.49268	8.11	0.5
					3	1	100	28.67579	8.12	0.3
					4	0.8	100	28.72373	8.12	0.2
					5	0.7	100	28.72105	8.12	0.2
					6	0.6	100	28.78598	8.11	0.4
					7	-0.2	100	29.13061	8.07	0.2
					8	-0.9	100	29.15999	8.02	0.2
					9	-1.1	99.1	29.24539	7.99	0.2
					10	-1.2	96.3	29.26459	7.96	0.3
					11	-1.3	94.7	29.26411	7.95	0.2
					12	-1.4	93.5	29.2747	7.94	0.2
					13	-1.4	92.4	29.29333	7.92	0.4
					14	-1.4	91	29.2966	7.91	0.3
					15	-1.3	89.4	29.37652	7.89	0.4
					16	-1.3	87.4	29.40414	7.87	0.4
					17	-1.3	85.1	29.49202	7.84	0.3
					18	-1.1	76.3	29.68113	7.74	0.3
					19	-0.9	70.3	29.95094	7.67	0.3
					20	-0.9	66.3	30.00911	7.63	0.3
14/07/2018	8	71.971382	-125.25137	4.8	1	1.5	97.9	28.41324	8.1	0.4
					2	1.2	100	28.57708	8.11	0.3
					3	1	100	28.76239	8.12	0.3
					4	0.7	100	28.71306	8.12	0.3
17/07/2018	9	71.974007	-125.01205	1.1	0.5	9.7	96.5		8.23	7.5
17/07/2018	10	71.97364	-125.014	2.3	1	8.8	98.7		8.09	7.6

Date	Site	Latitude (DD)	Longitude (DD)	Maximum Depth (m)	Depth (m)	Temperature (°C)	Dissolved Oxygen (%)	Salinity [PSS-78]	pH	Turbidity (FNU)
					2	2.9	100	26.0712	8	2.1
17/07/2018	11	71.97346	-125.014	3.5	1	5.4	100	21.87532	8	5.1
					2	2.8	100	26.02995	7.99	2.1
					3	2.7	100	26.14888	8.02	2.4
17/07/2018	12	71.97244	-125.014	1.5	1	5.7	100	24.01186	8.08	3.1
17/07/2018	13	71.97664	-125.077	5.6	1	5.3	100	22.45537	8.07	4.4
					2	3.4	100	26.3003	8.08	1.9
					3	2.3	100	27.19723	8.09	1.1
					4	2.1	100	27.41752	8.09	1.1
					5	1.8	100	27.58508	8.09	0.7
17/07/2018	14	71.9751	-125.076	7	1	5.4	100	19.10063	8.07	4.8
					2	3.5	100	26.02342	8.07	2.1
					3	2.3	100	27.27181	8.1	1.1
					4	2.1	100	27.39444	8.1	1.0
					5	1.9	100	27.45701	8.1	0.9
					6	1.9	100	27.46377	8.1	1.1
					7	1.8	100	27.49135	8.1	1
17/07/2018	15	71.97429	-125.077	4.2	1	4.8	100	24.76627	8.07	2.4
					2	3.6	100	25.95048	8.08	2.1
					3	2.9	100	26.68943	8.09	1.6
					4	2.7	100	26.9223	8.1	1.3
17/07/2018	16	71.97388	-125.077	1.8	1	4.8	100	24.59991	8.09	2.6
17/07/2018	17	71.98262	-125.18	2	1	3.1	100	27.32278	8.13	0.9
					2	3	100	27.40178	8.13	0.9
17/07/2018	18	71.98249	-125.179	6.7	1	3.3	100	27.11291	8.14	1.0
					2	3.1	100	27.48326	8.14	0.8
					3	2.7	100	27.57853	8.15	0.7
					4	2.5	100	27.75037	8.16	0.7
					5	2.1	100	27.98478	8.16	0.6

Date	Site	Latitude (DD)	Longitude (DD)	Maximum Depth (m)	Depth (m)	Temperature (°C)	Dissolved Oxygen (%)	Salinity [PSS-78]	pH	Turbidity (FNU)
					6	1.9	100	28.06555	8.16	0.5
17/07/2018	19	71.98196	-125.178	2.5	1	3.6	100	26.88104	8.12	1
					2	3.1	100	27.41342	8.14	0.7
17/07/2018	20	71.97613	-125.184	0.8	0.5	3.4	98.8	25.80524	8.14	0.8
17/07/2018	21	71.97638	-125.184	6.6	1	3.6	97.2	25.62209	8.12	0.9
					2	3.2	100	26.03516	8.12	0.8
					3	3.2	100	26.15715	8.12	0.8
					4	3.2	100	26.85946	8.13	0.9
					5	2.3	100	27.91604	8.14	0.5
					6	0.6	100	28.33614	8.13	0.3
17/07/2018	22	71.976479	-125.184	8.4	1	3.6	100	25.41416	8.13	1
					2	3.5	100	25.71726	8.13	0.9
					3	3.2	100	26.01686	8.13	0.8
					4	3	100	26.81286	8.13	0.7
					5	2.1	100	27.89226	8.15	0.5
					6	0.9	100	28.32248	8.14	0.3
					7	0.6	100	28.3839	8.12	0.4
					8	0.7	97.5	29.77274	7.91	0.2
17/07/2018	23	71.977	-125.184	15.3	1	3.5	99.3	25.18853	8.14	1
					2	3.3	100	26.18161	8.14	0.9
					3	2.6	100	27.35248	8.14	0.6
					4	1.7	100	28.12003	8.17	0.4
					5	1.1	100	28.35637	8.16	0.4
					6	0.1	100	28.50893	8.09	0.4
					7	0	100	28.69028	8.06	0.4
					8	-0.3	100	28.78404	8.01	0.4
					9	-1	95.5	29.5532	7.91	0.2
					10	-1.1	92.1	29.57055	7.87	0.2

Date	Site	Latitude (DD)	Longitude (DD)	Maximum Depth (m)	Depth (m)	Temperature (°C)	Dissolved Oxygen (%)	Salinity [PSS-78]	pH	Turbidity (FNU)
					11	-1.2	89.6	29.57138	7.84	0.2
					12	-1.2	88.2	29.60613	7.84	0.2
					13	-1.3	87.5	29.58276	7.83	0.2
					14	-1.2	89	29.63582	7.87	0.2
					15	-1.2	90	29.86912	7.88	0.1
17/07/2018	24	71.96767	-125.149	14.7	1	3.9	95	25.99815	8.15	1.2
					2	3.4	98	26.66018	8.12	1.1
					3	3	98.8	26.99566	8.11	1
					4	2.6	100	27.44936	8.11	0.9
					5	2	100	27.75429	8.1	0.5
					6	1.6	100	28.09262	8.09	0.5
					7	-0.5	100	29.03752	8.03	0.3
					8	-0.8	97.5	29.48752	7.94	0.3
					9	-1.1	94.9	29.68107	7.9	0.3
					10	-1.2	93.5	29.74858	7.88	0.2
					11	-1.2	91	29.87719	7.82	0.2
					12	-1	84.4	30.6028	7.72	0.3
					13	-0.3	67	32.07039	7.49	0.4
					14	0	55	32.42076	7.43	0.4
17/07/2018	25	71.96795	-125.15	7.1	1	3.6	98.5	25.69364	8.11	1.4
					2	3.3	99.7	26.37384	8.12	1.2
					3	3	100	26.99699	8.11	0.9
					4	2.3	100	27.54876	8.11	0.6
					5	1.9	100	27.73957	8.11	0.2
					6	1.3	100	28.0644	8.1	0.6
					7	-0.4	100	29.11027	7.99	0.9
17/07/2018	26	71.96819	-125.15	1	0.5	4.5	97.7	21.19126	8.13	2.9
17/07/2018	27	71.96726	-125.146	20.2	1	3.8	99.7	25.52871	8.13	1.5

Date	Site	Latitude (DD)	Longitude (DD)	Maximum Depth (m)	Depth (m)	Temperature (°C)	Dissolved Oxygen (%)	Salinity [PSS-78]	pH	Turbidity (FNU)
					2	3.4	100	26.49942	8.11	1.1
					3	3.2	100	26.74308	8.11	1.1
					4	2.6	100	27.35068	8.1	0.8
					5	1.7	100	27.89562	8.1	0.6
					6	0.2	100	28.5922	8.04	0.4
					7	-0.6	99	29.03299	7.97	0.4
					8	-0.8	97.7	29.33662	7.94	0.2
					9	-1.1	94.5	29.69265	7.89	0.2
					10	-1.2	92.8	29.76978	7.87	0.3
					11	-1.1	90.1	29.91093	7.81	0.3
					12	-0.9	84	30.52095	7.7	0.3
					13	-0.2	64.5	32.06163	7.5	0.4
					14	0.2	51.6	32.49814	7.42	0.4
					15	0.3	45.6	32.64127	7.39	0.5
					16	0.4	37.7	32.72875	7.34	0.9
					17	0.5	33	32.8061	7.32	0.8
					18	0.6	28.2	32.86466	7.3	0.8
					19	-0.6	24.5	32.47748	7.28	2.7
					20	0.5	12.8	33.034	7.25	3.4