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Exposure of Juveniles of Four Marine Fish Species to Hydrocarbon Discharges from Oil and Gas Production Platforms on the Grand Banks

Exposition de juvéniles de quatre espèces de poissons marins aux rejets d'hydrocarbures provenant de plateformes de production pétrolière des Grands Bancs

Canada

December 2018

Exposure of Juveniles of Four Marine Fish Species to Hydrocarbon Discharges from Oil and Gas Production Platforms on the Grand Banks

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"SAFETY AT SEA"

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Executive Summary

LGL Limited (LGL) of St. John's, Newfoundland and Labrador (NL) was funded by the Environmental Studies Research Fund (ESRF) to study the effects of exposure of juvenile stages of four marine fish species to routine, regulated discharges from oil and gas production platforms in the NL. Discharges such as deck drainage, drill muds and cuttings and produced water routinely contain regulated levels of hydrocarbon contaminants. Of these, produced water represents the largest of the discharge streams. Species included Atlantic cod (*Gadus morhua*), American plaice (*Hippoglossoides platessoides*), capelin (*Mallotus villosus*) and sand lance (*Ammodytes* sp.). The health bioindicators 'Mixed Function Oxygenases (MFO) activity' and 'Polycyclic Aromatic Hydrocarbons (PAH) metabolites' were used as a means of determining exposure of the juvenile fishes to organic pollutants, known to occur in produced water. The primary objective of the study was to determine if MFO activity and PAH metabolite responses can be detected in juvenile fishes captured in the vicinity of operating oil production platforms, and if so, how results compare to those associated with fishes collected within a reference area.

Specimens of juvenile fishes were collected in the NL offshore during July 18–29, 2017 using two types of trawl: (1) Campelen 900 bottom trawl; and (2) International Young Gadoid Pelagic Trawl (IYGPT), a midwater trawl. Baited pots were also used during the first two days of sampling but based on their observed ineffectiveness, this method was abandoned, and focus was put on trawling. Sampling was conducted at three Treatment Areas (i.e., vicinities of Hibernia [HIB], Terra Nova [TN] and White Rose [WR] production platforms) and within one Reference Area consisting of three separate sites. The three Reference Area Sites were located >20 km from all Treatment Areas, located northeast of Hibernia and Terra Nova, and west-northwest of White Rose. All sampling was conducted from the FV *Joyful Sound*, a commercial fishing vessel. A total of 94 trawls, 40 bottom trawls and 54 midwater trawls, were conducted. Water temperature and salinity profiles were collected at each sampling area using a Conductivity-Temperature-Density (CTD). All juvenile fish specimens were visually examined, measured for total length, bagged and frozen immediately in dry ice. Specimens were delivered immediately to the analytical laboratory, Oceans Ltd. of St. John's, NL upon return to St. John's. Oceans Ltd. conducted the MFO activity and PAH metabolite analyses on the juvenile fish specimens. The resultant data were statistically analyzed by both the analytical laboratory (One-Way ANOVA, Kruskal-Wallis, ANCOVA, pairwise comparisons) and LGL (GLM, pairwise comparisons).

A total of 1,020 juvenile fish specimens were collected during the field work; 136 Atlantic cod, 269 American plaice, 287 capelin and 328 sand lance. Juvenile fishes with a total length range of 3–10 cm were initially targeted during sampling but it was necessary to extend that range in order to collect a sufficient number of specimens. The ranges of total length for the specimens collected are 6.0–16.5 cm for Atlantic cod, 7.0–18.0 cm for American plaice, 5.5–14.5 cm for capelin, and 5.5–19.0 for sand lance. Total length of all species except Atlantic cod showed statistically significant differences between sampling areas.

The term MFO is a generic expression and a functional definition is often applied, depending on the specific catalytic activity being assayed. One of the more convenient and sensitive assays uses 7-ethoxyresorufin as a substrate with the enzyme activity referred to as 7-ethoxyresorufin *O*-deethylase (EROD). Considering the relatively small size of the specimens, it was necessary to pool similarly-sized specimens of the same species in order to attain a sufficient amount of liver tissue for the EROD analysis. Three specimens were pooled for American plaice, capelin and sand lance, while only two specimens were pooled for Atlantic cod. This reduced the overall sample sizes for the EROD analysis to 70 Atlantic cod, 90 American plaice, 96 capelin and 111 sand lance. While no significant differences in EROD level between sampling areas was observed for Atlantic cod, differences were observed for the other three species.

- American plaice collected at the Hibernia Treatment Area had significantly lower EROD levels (arithmetic mean = 18.392 pmol/min/mg of protein) than those collected at the Reference Area (arithmetic mean = 36.856 pmol/min/mg of protein) and the Terra Nova and White Rose Treatment Areas.
- Capelin collected at the Hibernia Treatment Area had significantly lower EROD levels (arithmetic mean = 1.091 pmol/min/mg of protein) than those collected at the Reference Area (arithmetic mean = 1.485 pmol/min/mg of protein), and the Terra Nova Treatment Area. The EROD levels in capelin collected at the White Rose Treatment Area did not differ significantly from those in capelin collected at the other three sampling areas.
- Sand lance collected at both the Terra Nova Treatment Area and the White Rose Treatment Area had significantly lower EROD levels (arithmetic means = 0.337 and 0.166 pmol/min/mg of protein, respectively) than those collected at the Reference Area (arithmetic mean = 0.236 pmol/min/mg of protein).
- Sand lance collected at the Hibernia Treatment Area had significantly higher EROD levels (arithmetic mean = 0.409 pmol/min/mg of protein) than those collected at the White Rose Treatment Area (arithmetic mean = 0.166 pmol/min/mg of protein).

Statistical analyses determined that there were both sampling area and total length effects on observed EROD levels. Another potential reason for the observed differences between sampling areas could be differences in the composition of produced water at each production platform. However, fish mobility and the considerable distance between sampling and produced water discharge (at least 1 km) tend to confound interpretation of the data.

Polycyclic aromatic hydrocarbon (PAH) metabolite analyses on the fish bile determined levels of five compounds: (1) protein; (2) 2-Naphthol; (3) 9-Phenanthrol; (4) 1-OH Pyrene; and (5) Benzo-a-pyrene (BaP). Significant statistical differences due to sampling area were observed for capelin and sand lance only.

- Capelin collected at the Terra Nova Treatment Area had significantly higher protein levels (arithmetic mean = 34.36 mg/ml) than those collected within the Reference Area (arithmetic mean = 25.91 mg/ml).

- Sand lance collected at the Hibernia Treatment Area had significantly lower protein levels (arithmetic mean = 34.91 mg/ml) than those collected within the Reference Area (arithmetic mean = 43.86 mg/ml).
- Sand lance collected at the Hibernia Treatment Area had significantly higher BaP levels (arithmetic mean = 144.2 F.U./mg protein) than those collected within the Reference Area (arithmetic mean = 108.7 F.U./mg protein).

The difference in BaP concentration measured in sand lance collected at the Hibernia Treatment Area is likely due to the difference in biliary protein concentration measured in the same fish since PAH metabolites were standardized to the biliary protein concentration.

Water temperature and salinity profiles collected during the study showed considerable variability between sampling areas in terms of thermocline position, depth range of maximal salinity variability, and general pattern of the vertical profile. Minimum and maximum water temperatures and salinities were quite similar between sampling areas. Despite some of the differences in the water temperature and salinity data between sampling areas, they cannot be conclusively regarded as potential reasons for differences in fish catches and observed bioindicator levels between sampling areas.

In summary, neither of the two health bioindicators (i.e., MFO activity and PAH metabolite levels) provided a clear signal that could be attributed to exposure to hydrocarbon-containing discharges from the production platforms.

Résumé

LGL Limited (LGL) de St. John’s, Terre-Neuve-et-Labrador (T.-N.-L) a obtenu un financement du Fonds pour l’étude de l’environnement (FEE) afin d’étudier les effets de l'exposition de juvéniles à divers stades appartenant à quatre espèces de poissons marins aux rejets réguliers et réglementés des plateformes de production pétrolière et gazière au large de T.-N.-L. Les rejets tels que le drainage de pont, les boues et les débris de forage et l’eau extraite contiennent couramment des niveaux réglementés de contaminants d’hydrocarbures. L’eau extraite représente la plus importante des voies d’évacuation. Les espèces étudiées comprennent la morue (*Gadus morhua*), la plie canadienne (*Hippoglossoides platessoides*), le capelan (*Mallotus villosus*) et le lançon (*Ammodytes sp.*). Les bioindicateurs de santé « Activité des oxygénases à fonction mixte (OFM) » et « Métabolite d’hydrocarbures aromatiques polycycliques (HAP) » ont été utilisés pour déterminer l’exposition des poissons juvéniles à des polluants organiques, connus pour se retrouvés dans les eaux extraites. L’étude avait pour objectif premier de déterminer si des réactions d’activité des OFM et de métabolite d’HAP pouvaient être détectées chez les poissons juvéniles capturés à proximité des plateformes de production en service et, le cas échéant, comment les résultats se comparaient à ceux associés aux poissons recueillis dans une zone de référence.

Des spécimens de poissons juvéniles ont été recueillis au large de T.-N.-L du 18 au 29 juillet 2017 à l'aide de deux types de chaluts : 1) chalut de fond Campelen 900; 2) chalut pélagique de type Essais internationaux de chaluts pélagiques pour les jeunes gadidés (IYGPT). Des casiers appâtés ont également été utilisés pendant les deux premiers jours d'échantillonnage, mais cette méthode s’étant avérée inefficace a été abandonnée et l’accent a été mis sur le chalutage. L’échantillonnage a été effectué dans trois zones de traitement (c’est-à-dire à proximité des plateformes de production d’Hibernia [HIB], Terra Nova [TN] et White Rose [WR]) et dans une zone de référence constituée de trois sites distincts. Les trois sites de référence se trouvaient à plus de 20 km de toutes les zones de traitement, situées au nord-est d’Hibernia et de Terra Nova et à l'ouest-nord-ouest de White Rose. Tous les échantillons ont été prélevés à bord du FV Joyful Sound, un navire de pêche commerciale. En tout, 94 traits de chalut ont été réalisés, soit 40 traits de chalut de fond et 54 traits de chalut pélagiques. Les profils de température et de salinité de l'eau ont été recueillis dans chaque zone d'échantillonnage à l'aide d'un instrument de mesure de conductivité-température-densité (CTD). Tous les spécimens de poissons juvéniles ont été examinés visuellement, mesurés sur leur longueur totale, mis en sac et immédiatement congelés dans de la glace sèche. Les échantillons ont été immédiatement livrés au laboratoire d’analyse Oceans Ltd. de St. John’s (T.-N.-L.) à leur arrivée à St. John’s. Oceans Ltd. a effectué des analyses d'activité des OFM et de métabolite d’HAP sur des spécimens de poissons juvéniles. Les données résultantes ont été analysées statistiquement par le laboratoire d'analyse (ANOVA One Way, Kruskal-Wallis, ANCOVA, comparaisons par paires) et par LGL (GLM, comparaisons par paires).

Au total, 1 020 spécimens de poissons juvéniles ont été recueillis au cours des travaux sur le terrain; 136 morues, 269 plies canadiennes, 287 capelans et 328 lançons. Les poissons juvéniles d’une longueur totale allant de 3 à 10 cm ont été ciblés au départ lors de l’échantillonnage, mais il a fallu

élargir cette fourchette de taille afin de prélever un nombre suffisant de spécimens. La longueur totale des spécimens recueillis varie de 6 à 16,5 cm pour la morue, de 7 à 18 cm pour la plie canadienne, de 5,5 à 14,5 cm pour le capelan et de 5,5 à 19 cm pour le lançon. La longueur totale de toutes les espèces, à l'exception de la morue, présentait des différences statistiquement significatives entre les zones d'échantillonnage. Le terme OFM est une expression générique et une définition fonctionnelle est souvent appliquée, en fonction de l'activité catalytique particulière testée. L'un des tests les plus pratiques et les plus sensibles utilise la 7-éthoxyrésorufine comme substrat avec l'activité enzymatique appelée 7-éthoxyrésorufine déséthylase (EROD). Compte tenu de la taille relativement petite des échantillons, il a fallu regrouper des échantillons de tailles similaires de la même espèce afin d'obtenir une quantité suffisante de tissu hépatique pour l'analyse EROD. Trois spécimens ont été regroupés pour la plie canadienne, le capelan et le lançon, tandis que deux spécimens seulement ont été regroupés pour la morue. Cela a réduit la taille globale des échantillons pour l'analyse EROD à 70 morues, 90 plies canadiennes, 96 capelans et 111 lançons. Bien qu'aucune différence significative du niveau d'EROD entre les zones d'échantillonnage n'ait été observée pour la morue, des différences ont été relevées pour les trois autres espèces.

- Les plies canadiennes recueillies dans la zone de traitement d'Hibernia présentaient des niveaux d'EROD nettement inférieurs (moyenne arithmétique = 18,392 pmol/min/mg de protéine) par rapport à celles recueillies dans la zone de référence (moyenne arithmétique = 36,856 pmol/min/mg de protéine) et dans les zones de traitement de Terra Nova et de White Rose.
- Les capelans recueillis dans la zone de traitement d'Hibernia présentaient des niveaux d'EROD nettement inférieurs (moyenne arithmétique = 1,091 pmol/min/mg de protéine) par rapport à ceux recueillis dans la zone de référence (moyenne arithmétique = 1,485 pmol/min/mg de protéine) et dans la zone de traitement de Terra Nova. Les niveaux d'EROD des capelans recueillis dans la zone de traitement de White Rose ne différaient pas de manière significative de ceux des capelans recueillis dans les trois autres zones d'échantillonnage.
- Les lançons recueillis dans la zone de traitement de Terra Nova et dans la zone de traitement de White Rose présentaient des niveaux d'EROD nettement inférieurs (moyennes arithmétiques = 0,337 et 0,166 pmol / min / mg de protéine, respectivement) par rapport à ceux recueillis dans la zone de référence (moyenne arithmétique = 0,236 pmol/min/mg de protéine).
- Les lançons recueillis dans la zone de traitement d'Hibernia présentaient des niveaux d'EROD nettement supérieurs (moyenne arithmétique = 0,409 pmol/min/mg de protéine) par rapport à ceux recueillis dans la zone de traitement de White Rose (moyenne arithmétique = 0,166 pmol/min/mg de protéine).

Les analyses statistiques ont montré que la zone d'échantillonnage et la longueur totale influaient sur les niveaux d'EROD observés. Une autre raison possible des différences observées entre les zones d'échantillonnage pourrait être des différences dans la composition de l'eau extraite à chaque plateforme de production. Cependant, la mobilité des poissons et la distance considérable qui sépare l'échantillonnage de l'écoulement d'eau extraite (au moins 1 km) tendent à brouiller l'interprétation des données.

Des analyses de type métabolite d'hydrocarbures aromatiques polycycliques (HAP) de la bile des poissons ont permis de déterminer des concentrations de cinq composés: 1) protéine; 2) 2-naphtol; 3) 9-phénanthrol; 4) 1-OH pyrène; 5) benzo-a-pyrène (BaP). Des différences statistiques significatives dues à la zone d'échantillonnage ont été observées uniquement pour le capelan et le lançon.

- Les capelans recueillis dans la zone de traitement de Terra Nova présentaient des niveaux de protéine nettement supérieurs (moyenne arithmétique = 34,36 mg/ml) par rapport à ceux recueillis dans la zone de référence (moyenne arithmétique = 25,91 mg/ml).
- Les lançons recueillis dans la zone de traitement d'Hibernia présentaient des niveaux de protéines nettement inférieurs (moyenne arithmétique = 34,91 mg/ml) par rapport à ceux recueillis dans la zone de référence (moyenne arithmétique = 43,86 mg/ml).
- Les lançons recueillis dans la zone de traitement d'Hibernia présentaient des niveaux de BaP nettement supérieurs (moyenne arithmétique = 144,2 F.U./mg de protéine) par rapport à ceux recueillis dans la zone de référence (moyenne arithmétique = 108,7 F.U./mg de protéine).

La différence de concentration de BaP mesurée dans le lançon recueilli dans la zone de traitement d'Hibernia est probablement due à la différence de concentration de protéine biliaire mesurée chez le même poisson depuis que les métabolites d'HAP ont été normalisés relativement à la concentration de protéine biliaire.

Les profils de température et de salinité de l'eau relevés au cours de l'étude ont montré une variabilité considérable entre les zones d'échantillonnage en ce qui concerne la position de la thermocline, la profondeur de variabilité maximale de la salinité et le profil général du profil vertical. Les températures et les salinités minimales et maximales de l'eau étaient assez similaires entre les zones d'échantillonnage. Malgré certaines différences dans les données sur la température et la salinité de l'eau entre les zones d'échantillonnage, elles ne peuvent pas être considérées de manière concluante comme des raisons potentielles des différences de captures de poisson et des niveaux de bioindicateur observés entre les zones d'échantillonnage.

En résumé, aucun des deux bioindicateurs de santé (c'est-à-dire activité des OFM et niveau de métabolite d'HAP) n'a fourni de signal clair pouvant être attribué à l'exposition aux rejets d'hydrocarbures provenant des plateformes de production.

Acknowledgements

This study required the cooperation and expertise of many people. During preparation of the study design, the operators of the Hibernia, Terra Nova and White Rose production fields were consulted to determine the extents of the Safety Zones within which sampling was not permitted, and the typical water currents throughout the water column during summer time. The IYGPT (midwater trawl) was provided by Fisheries and Oceans Canada, NL Region. The following subcontractors and personnel provided important services without which this study could not have been successfully completed.

- Oceans Ltd. (St. John's, NL) – Juan Pérez-Casanova;
- Fisheries and Marine Institute of Memorial University of Newfoundland (St. John's, NL) – Philip Walsh;
- Narwhal Environmental Consulting Services Inc. (St. John's, NL) – Narcissus Walsh; and
- FV *Joyful Sound* (Port de Grave, NL) – Captain Matthew Petten and crew.

LGL marine biologist Andrew Murphy was also an integral part of the study team that conducted the at-sea sampling. LGL biologist Scott Raborn conducted the General Linear Model statistical analyses.

1.0 Introduction

LGL was funded by the Environmental Studies Research Funds (ESRF) to conduct a study of the potential impacts of oil production in the Grand Banks on juvenile marine fishes (ESRF-2016-01S). This study is primarily focused on the potential impacts of exposure to produced water being discharged at each production platform although other routine regulated discharges do occur, as outlined in Table 1 below.

Table 1. Primary Grand Banks Production Platform Discharges to the Marine Environment.

Discharge Stream	Hibernia GBS	Terra Nova FPSO	White Rose FPSO
Produced water [1]	Yes	Yes	Yes
Deck drainage[2]	Yes	Yes	Yes
Segregated cooling water[3]	Yes	Yes	Yes
Oil storage displacement water[4]	Yes	No	No
Segregated ballast water[5]	No	Yes	Yes
Drill mud/cuttings [6]	No	No	No

Note: All discharges governed by Offshore Waste Treatment Guidelines (C-NLOPB 2010).

1 Discharged at 30 ppm weighted average over 30 days, and ≤44 ppm averaged over 24 hours.

2 Discharged from hazardous and non-hazardous drains and marine oily water separators at ≤15 ppm.

3 Segregated discharge stream with no hydrocarbon contaminants.

4 Discharged at ≤15 ppm.

5 Segregated discharge stream with no hydrocarbon contamination.

6 No drilling discharges from these platforms; drilling conducted by semi-submersible platforms as required with discharge criterion of 6.9g/100g oil on wet solids.

Cooling water is circulated in segregated piping systems to cool platform machinery and equipment as need, and hence is not subject to hydrocarbon contamination. However, biocides may be added at prescribed concentrations to control corrosion-inducing microorganisms.

As indicated in Neff et al. (2011), the composition of produced water from different sources is highly variable. In addition, discharged produced water dilutes rapidly, often by more than 100-fold within 100 m of the discharge location. Based on studies of environmental impacts of produced water and drilling waste discharges from the Norwegian offshore petroleum industry, Bakke et al. (2013) indicated that toxic concentrations of constituents of produced water seem to be restricted to <2 km from the produced water discharge location.

The effects of environmental contamination can be viewed at different levels of biological organization, extending from the molecular or biochemical level to effects on organ physiology and histology at the individual animal level and ultimately to the population or community level. During the past few years, there has been increasing emphasis on the use of individual-level indicators of chemical stress to obtain an appreciation of the degree, extent and severity of potential health effects on populations. These indicators are commonly referred to as bioindicators or health effect indicators. Use of such indicators at the sub-organismal or organismal level has the potential to identify sub-lethal effects in advance of responses at the population level and as such can provide an early warning of problems and adverse health effects (Schlenk et al. 2008; Tillitt and Papoulias 2003; Adams 2002; Peakall 1992; SETAC Special Publication Series, 1992).

A general overview of the acute and chronic effects of waste associated with offshore oil and gas production, including effects observed in fish is provided in Holdway (2002). Payne et al. (2003) and Hylland (2006) also reviewed the effects of exposure to PAH on fishes. A variety of sub-lethal effects has also been observed in fish chronically exposed to produced water in the laboratory (Pérez-Casanova et al. 2010, 2012; Lee et al. 2011; Holth et al. 2010; Payne et al. 2005).

On the Newfoundland Grand Banks, Husky, Suncor and Exxon-Mobil all include fish health indicators in their Environmental Effects Monitoring (EEM) programs. Some results from these studies have been published (Mathieu et al. 2011) and include measurements of MFO and, in some cases, the measurement of PAH metabolites in fish bile. These bioindicators have been extensively used with various fish species in environmental assessments, and studies on MFO enzymes and PAH metabolites in fish bile have been specifically endorsed by agencies such as the Oslo Paris Commission (OSPAR) for use in environmental monitoring and assessment programs (Collier et al. 2012; Stagg 1998).

The MFO system refers to a family of enzymes that transforms the structure of organic chemicals and performs a critical role in detoxification and other physiological processes. The system, which has iron-containing hemoproteins (i.e., cytochromes P-450) as terminal oxidases, is also referred to as cytochrome P-450-dependent MFO. The activity of this enzyme system commonly increases in animals exposed to certain classes of organic pollutants. An increase in activity or induction of this enzyme system can therefore be used to monitor exposure to low levels of such pollutants.

Both field and laboratory studies have demonstrated that MFO induction can be a useful index for assessing exposure to various types of mixed organic pollutants, such as petroleum hydrocarbons, in fish (Payne et al. 1987). In previous studies of petroleum contamination, MFO has been measured during field studies around oil rigs in the North Sea (Balk et al. 2011; Stagg and McIntosh 1996; Stagg et al. 1995) as well as in connection with major oil spills such as the Exxon Valdez in Alaska (Woodin et al. 1997), the Braer spill in the Shetland Islands (George et al. 1995) and the Prestige oil spill in Spain (Martínez-Gómez et al. 2006, 2009). Attention has also been given to the MFO induction potential of produced water. This has included both field (Vega-López et al. 2009; Abrahamson et al. 2008; Zhu et al. 2008; Förlin and Hylland 2006; King et al. 2005; Aas and Klungsøyr 1998) and laboratory studies (Abrahamson et al. 2008; Olsvik et al. 2007; Casini et al. 2006; Hurst et al. 2005; Payne et al. 2005).

The term MFO is a generic expression and a functional definition is often applied, depending on the specific catalytic activity being assayed. One of the more convenient and sensitive assays uses

7-ethoxyresorufin as a substrate with the enzyme activity referred to as 7-ethoxyresorufin *O*-deethylase (EROD) (Vega-López et al. 2009; Whyte et al. 2000).

Polycyclic aromatic hydrocarbon compounds do not accumulate to any extent in body tissues due to the high metabolic capacity of the tissue, and therefore the exposure of fish to PAH is difficult to detect by chemical analyses of liver or flesh. PAHs are metabolized in the liver and their metabolites are mainly excreted into the bile and concentrated there. Since the PAHs and their metabolites display strong and characteristic fluorescent properties, measures of such compounds can be obtained by fluorescence analyses of bile samples (Beyer et al. 2010; Aas et al. 2000b). Analysis of PAH metabolites in fish bile has been shown to be a sensitive method for detection of PAH contamination (Aas et al. 2000a, 2000b; Gagnon and Holdway 2000; Aas and Klungsøyr 1998; Krahn et al. 1986, 1987) and is now included in a number of international monitoring programs (Collier et al. 2012; Cheevaporn and Beamish 2007; Stagg 1998).

The monitoring of the presence of PAHs in the aquatic environment has been conducted worldwide because some of these compounds are known carcinogens and mutagens (Pampanin et al. 2016). Metabolic effects of exposure of marine fishes to PAHs include: (1) the triggering of ethoxyresorufin *O*-deethylase (EROD) activity in liver tissue; and (2) the subsequent presence of PAH metabolites in the bile. Polycyclic aromatic hydrocarbons accumulate in fatty tissue, including fish liver, where they are metabolized (Bostrom et al. 1992 *in* Pampanin et al. 2016). The metabolism of the PAHs occurs within hepatocytes where they are oxidized and become more water soluble. The hydrophilic metabolites are predominantly excreted via the bile. Therefore, the presence of PAH metabolites in fish bile is regarded as a biological marker of recent exposure (i.e., within a few days) to PAHs (Bostrom et al. 1992 *in* Pampanin et al. 2016). In other words, it is within a short period of time during which detection of the biomarker of recent exposure to PAHs is possible.

The primary objective of this ESRF study is to determine if EROD and PAH metabolite responses can be detected in juvenile life stages of fishes captured in the vicinity of operating oil production platforms, and if so, how they compare to those associated with fishes collected at a reference area. In the current study, MFO enzymes and PAH metabolites in juvenile stages of Atlantic cod (*Gadus morhua*), American plaice (*Hippoglossoides platessoides*), capelin (*Mallotus villosus*), and sand lance (*Ammodytes* sp.) were examined. Of these species, the offshore operators have used adult American plaice in their detailed studies on the fish health components of their environmental effects monitoring programs that have been conducted around their production sites offshore Newfoundland and Labrador for a number of years. A representative discussion of the results of this work for the Terra Nova production operation is published in Neff et al. (2014).

Routine discharges containing regulated levels of hydrocarbon contaminants include deck drainage, drill muds and cuttings and produced water. Of these, produced water is the largest discharge stream. Produced water is either the formation water brought up with the hydrocarbons during operations at producing offshore oil fields in the NL offshore, and any seawater injected into a reservoir to maintain the reservoir pressure. The complex composition of produced water is typically characterized by several compounds, including PAHs. Past scientific studies suggest numerous potential effects of exposure to PAHs (Neff et al. 2011), including DNA damage (Aas et al. 2000a), oxidative stress (Sturve et al. 2006), cardiac function defects (Incardona et al. 2004), embryotoxicity (Carls et al. 2008), and the formation of DNA adducts and neoplasia in fish liver through metabolic intermediates (Myers et al. 1991).

Juveniles of the four marine fish species identified above were collected in the vicinities of the Hibernia, White Rose and Terra Nova oil production fields in the NL offshore, and at reference area sites located at least 20 km from any of the production fields during the period of July 19–28, 2018. Although the Hebron production platform was in place just north of the Terra Nova field at the time of fish sampling, production had not yet begun and therefore was not an influence on results of analysis of the Terra Nova samples. The targeted total length range of collected specimens was 3–10 cm. Collected specimens were delivered to a certified laboratory (i.e., Oceans Ltd.) where EROD activity and bile PAH metabolite level analyses were conducted on specimen liver tissue and bile, respectively.

2.0 Methods and Materials

The methods and materials used during this study are presented under the following three tasks: (1) Task 1 – Study Design and Logistics; (2) Task 2 – Mobilization and Study Implementation; and (3) Task 3 – Data Analysis and Final Reporting.

2.1 Task 1 – Study Design and Logistics

The primary activities associated with Task 1 included:

- Finalization of study design;
- Selection of marine vessel to serve as the sampling platform during the Study;
- Acquisition of Fisheries and Oceans Canada (DFO) experimental fishing licence and Species at Risk permit; and
- Preparation of a Field Execution Plan (FEP), including the Health, Safety and Environment (HSE) plan.

All of the above tasks were successfully completed prior to mobilization for the field work. Close consultation with the operators of each production field was necessary during the finalization of the study design in order to better understand both the specifics of the discharge of produced water at each production platform, and the typical July water currents at each production field. The Study Area proposed for this work is comprised of four components: (1) Hibernia Treatment Area; (2) Terra Nova Treatment Area; (3) White Rose Treatment Area; and (4) Reference Area (Figures 1 and 2). Approximate location coordinates for the four sampling areas proposed in the study design included:

- Hibernia Treatment Area – 46°45’2” N; 48°46’59” W
- Terra Nova Treatment Area – 46°28’30” N; 48°28’46” W
- White Rose Treatment Area – 46°47’19” N; 48°00’54” W
- Reference Area - 46°58’48” N; 48°15’31” W

Initially, the location of the Reference Area was planned at the coordinates indicated above. However, once at sea, it was necessary to expand the areal extent of the Reference Area in order to collect a sufficient number of juvenile fish samples, resulting in a Reference Area with the three sampling Sites A, B and C (Figure 2). The location of Reference Area Site A corresponds to the coordinates indicated above for the bulleted ‘Reference Area’. Representative coordinates for Reference Area Sites B and C are as follow:

- Reference Area Site B – 46°47’00” N; 48°17’00” W
- Reference Area Site C - 47°02’00” N; 48°10’00” W

Reference Area Sites B and C are located approximately 22 km south of Reference Area Site A and 9 km northeast of Reference Area Site A, respectively. All three sampling sites associated with the Reference Area are located more than 20 km from all three production installation Treatment Areas (Figure 2).

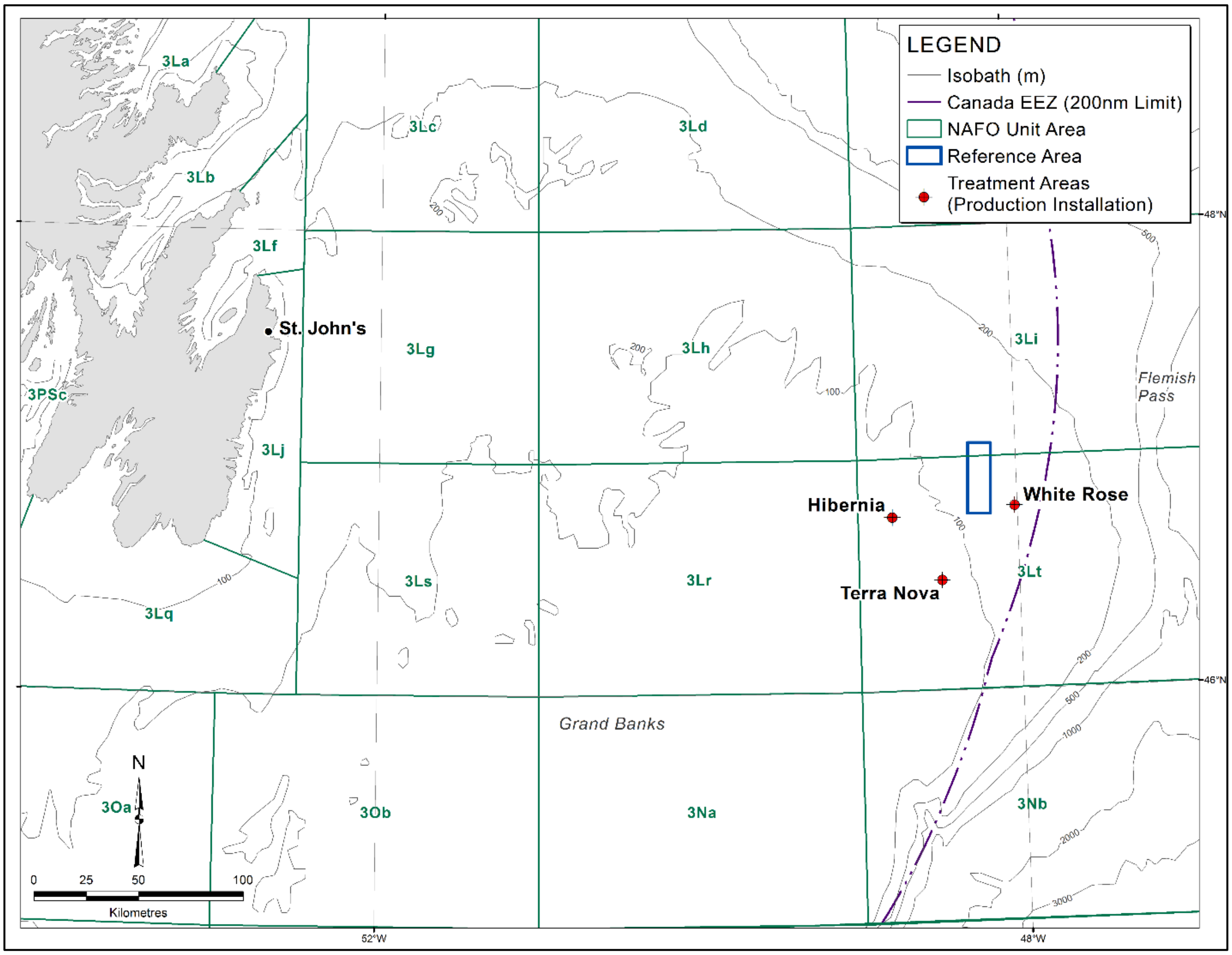

Figure 1. Locations of the study sampling areas relative to St. John's NL.

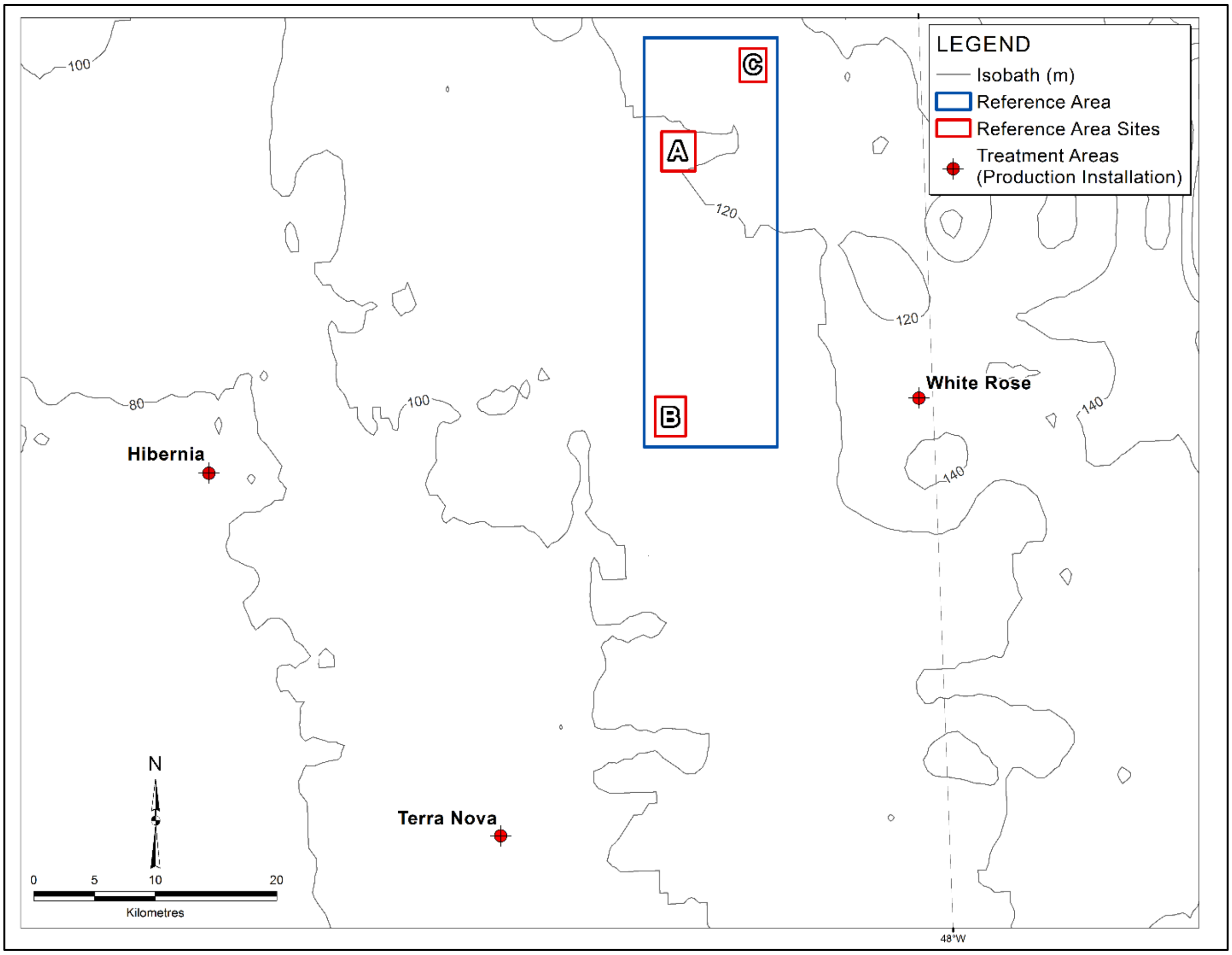

Figure 2. Locations of the Study Area components at a larger scale.

Figures 3–5 show the study design systematic sampling grids at the Hibernia, Terra Nova, and White Rose Treatment Areas, respectively. Note that the locations of the sampling grids relative to the Safety Zones at the Treatment Areas are based on consultations with the operators at each production site and the understanding of typical water currents at each site during the summer to ensure that the sampling grids are downstream of the produced water discharges. The intention was to separate adjacent trawl transects by 500 m, between which the fixed fleet of baited pots would be deployed. The same systematic sampling approach was also planned for the Reference Area.

Note that operators establish safety zones around production platform surface and subsea infrastructure to protect equipment and help ensure marine safety. Depending on a platform's subsea infrastructure, these zones can extend 10s or 100s of metres to several kilometres. An overview of these zones can be found at ***www.oneocean.ca***. In the specific cases of the Hibernia, Terra Nova and White Rose production platforms, these zones are shown in Figures 3–5.

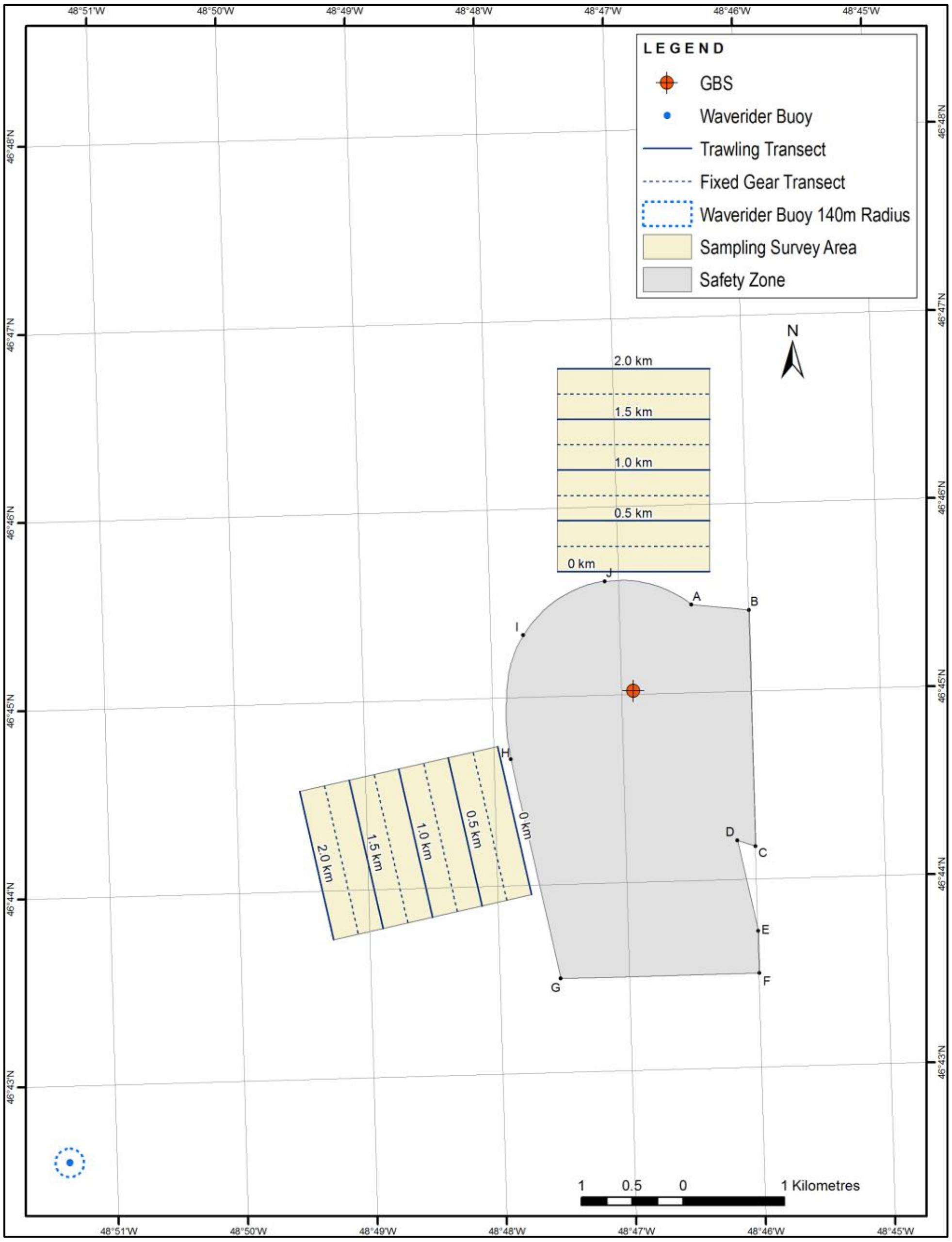

Figure 3. Layout of Juvenile Fish Sampling Survey Areas in Relation to the Safety Zone at the Hibernia Treatment Area.

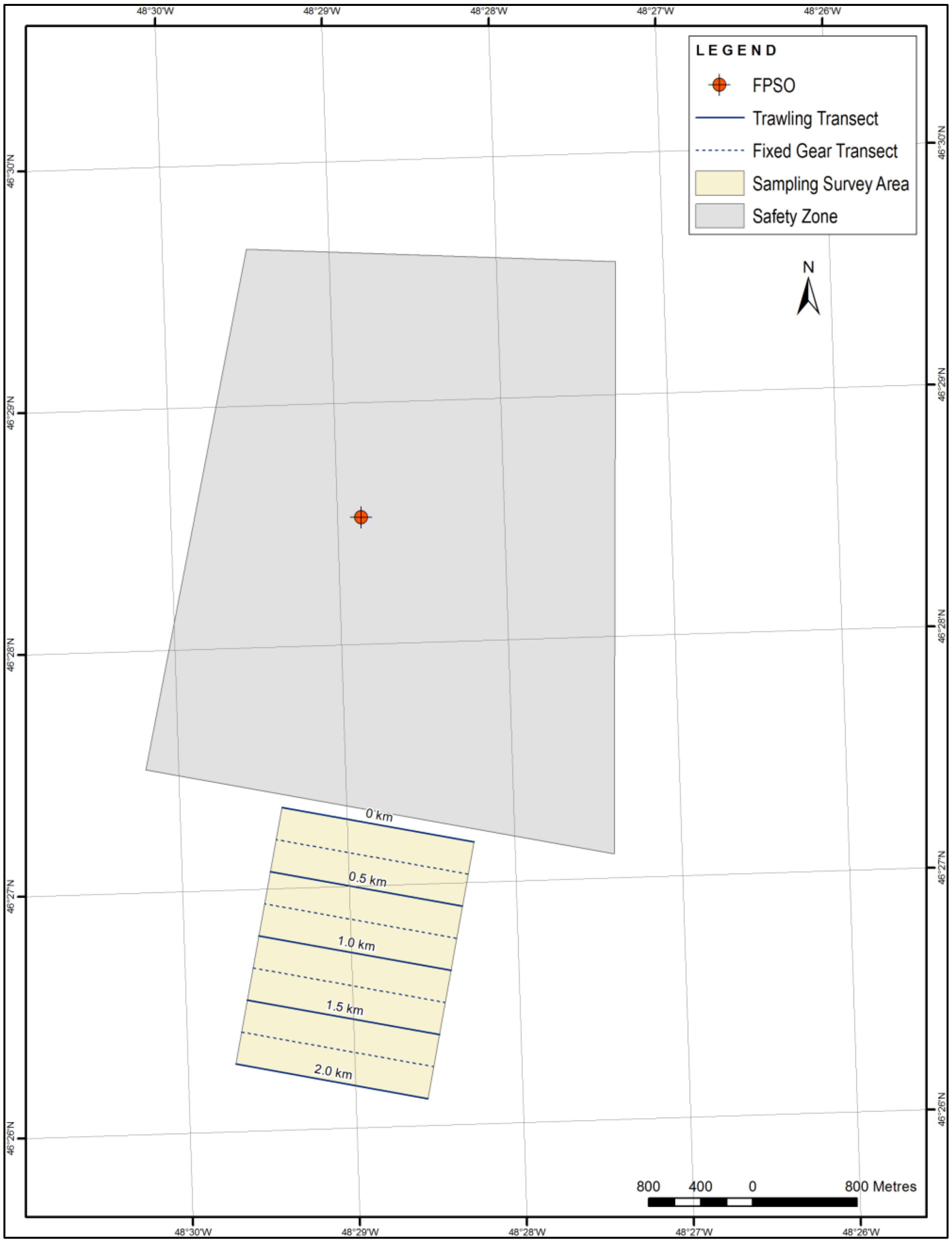

Figure 4. Layout of Juvenile Fish Sampling Survey Area in Relation to the Safety Zone at the Terra Nova Treatment Area.

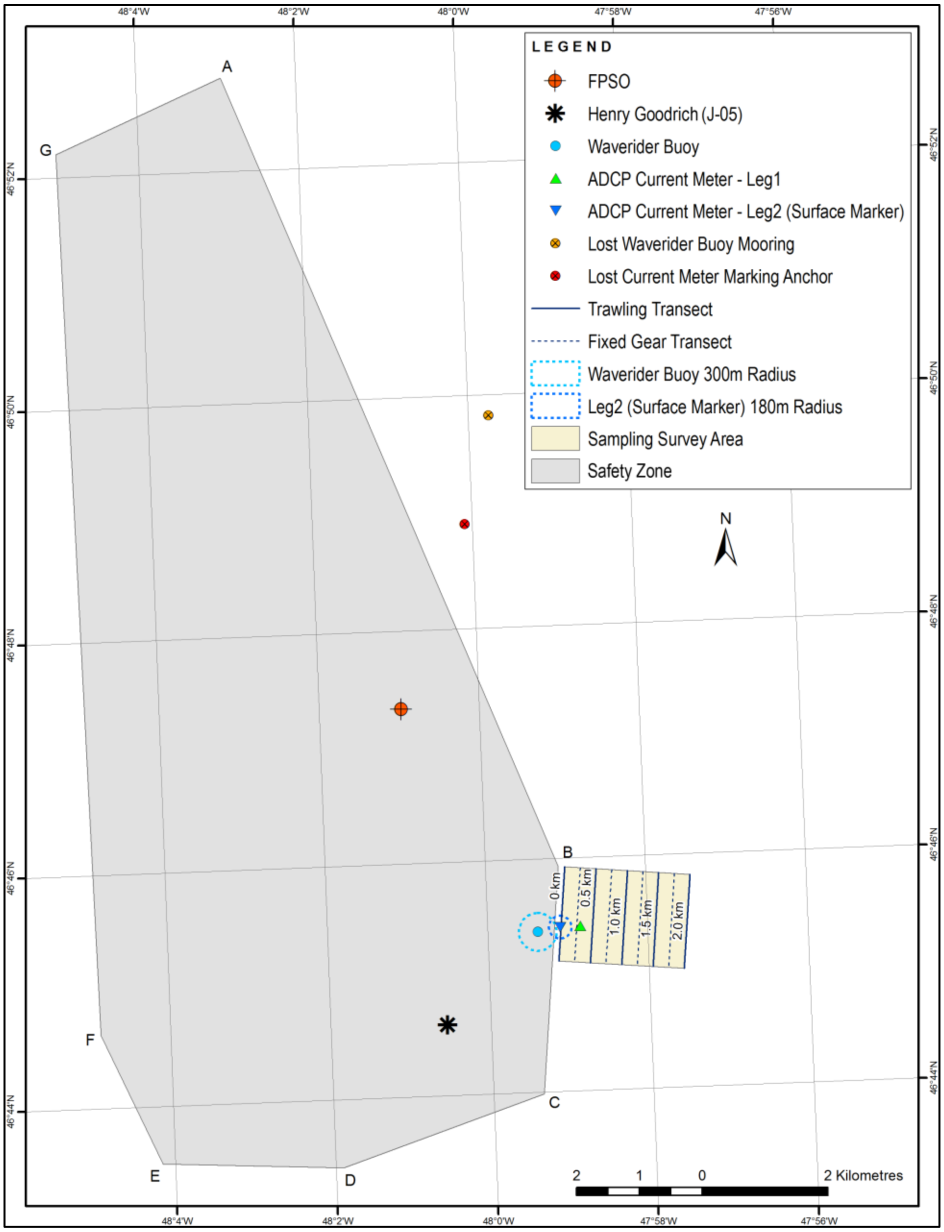

Figure 5. Layout of Juvenile Fish Sampling Survey Area in Relation to the Safety Zone at the White Rose Treatment Area.

The subcontractors on the study team included the following:

- Fisheries and Marine Institute of Memorial University of Newfoundland (St. John's, NL) – Philip Walsh (gear expert);
- Narwhal Environmental Consulting Services Inc. (St. John's, NL) – Narcissus Walsh (offshore study team supervisor);
- Oceans Ltd. (St. John's, NL) – Juan Pérez-Casanova (laboratory analysis); and
- FV *Joyful Sound* (Figure 6) (Port de Grave, NL) – Captain Matthew Petten and crew.

Figure 6. **FV *Joyful Sound.***

LGL marine biologist Andrew Murphy was also part of the study team that conducted the at-sea sampling.

Appendix 1 contains the Field Execution Plan (FEP) prepared prior to commencing the field work. In addition to the intended approach to sampling, the FEP also includes information related to working safely in the vicinities of the production platforms.

2.2 Task 2 – Mobilization and Study Implementation

2.2.1 Mobilization

Two days of mobilization at St. John’s harbour was required to prepare for the fieldwork component. The FV *Joyful Sound* with crew and study team sailed out of St. John’s Harbour on July 18, 2017.

2.2.2 Fieldwork

The principal tasks to be completed during the fieldwork component of the Study included:

- Collect a sufficient number of specimens of juvenile fishes at the three Treatment Areas (i.e., production fields) and at the Reference Area; and
- Conduct frequent CTD casts to collect water column temperature and salinity data throughout the water column at each sampling area.

2.2.2.1 Fishing Gear

The study team intended to use three types of fishing gear during the sampling: (1) a bottom trawl (i.e., Campelen 900); (2) a midwater trawl (i.e., IYGPT); and (3) a fixed fleet of baited pots.

Campelen 900 Bottom Trawl

The design of the Campelen 900 bottom trawl is based on that of the Campelen 1800 trawl used during the annual DFO multi-species surveys in the NL offshore. The Campelen 900 trawl is specifically designed to capture juvenile groundfishes. The trawl's design includes small footgear that help to lift and guide small species back into the net, a small mesh-lined cod end to prevent escapement of target animals, and a small headline opening (1.8–2.3 m) to eliminate the harvest of non-target species occurring further off bottom. The Campelen 900 trawl is also fished using specific procedures intended to prevent the capture of larger non-targeted individuals. Towing speed, tow duration, tow depth are all important factors when targeting specific animals and attempting to minimize by-catch.

The Campelen 900 has a 10 m footrope which is made with 9 mm chain, and a 15 m headline constructed with 10 mm combination wire. Wing lines are also constructed of 10 mm combination wire. The Campelen 900 trawl is characterized by all the same mesh sizes found in the regular Campelen 1800 trawl.

The study also used Notus Trawlmaster, a wireless trawl monitoring system that provides complete trawl geometry. This system provides trawl geometry data using small robust trawl sensors attached to all parts of the trawling system. The 'focus hydrophone' that receives all information at the vessel can be either hull mounted or portable. A portable one was employed during the study. The sensors on the trawl have a range of 2 km and a depth rating of 1,400 m.

This system allows the monitoring of all aspects of trawl performance during fishing operations. All the information was transmitted to the vessel wirelessly. This information was viewed in real time, providing an understanding of what is happening with the trawl during each tow. All information was recorded in a separate log file for each tow and is compatible with software programs such Microsoft Excel. For this study, door, headline, and wing end sensors were used to ensure that the trawl geometry was maintained.

International Young Gadoid Pelagic Trawl (IYGPT)

The IYGPT is a midwater survey trawl used during pelagic species surveys conducted by DFO, NL Region. It has also been used to collect juvenile stages of marine fishes occurring in the water column. This trawl, which has a 17.5 m headline and footrope, had a small mesh liner installed in the cod end in order to retain all specimens <15 cm in total length. The IYGPT uses high aspect ratio trawl doors weighing 500 kg. Chain weights (60 kg) were used on the wing ends to aid in opening the trawl vertically. The design features of this trawl include a 6–8 m vertical opening (headline to footrope). During this study, it was towed at speeds ranging between 2.8 and 3.5 knots. Variable tow speeds allowed the IYGPT to fish at different depths in the water column. The trawl is also fished using specific procedures that prevent the capture of larger non-targeted individuals. As with the Campelen 900 bottom trawl, the tow speed, tow duration and tow depth are all important factors when targeting specific species and minimizing bycatch of non-targeted species. The IYGPT used during the study was provided by DFO, NL Region.

Baited Pots (Fixed Gear)

The pots used for this study included four types, each with multiple entrances. All pots were designed to fish for juvenile stages of fishes and would not be considered useful for commercial fisheries. The pots are constructed of light materials, making them very manageable on deck. Three of the four pot types were collapsible. The pots, baited with squid, were set in strings of 25 oriented either vertically in the water column or horizontally across the seafloor. All sets were at least 12 hours in duration and pots were spaced at 20 m intervals for the horizontal seabed sets, and at 10 m intervals for the vertical sets in the water column. Figure 7 shows the four pot types.

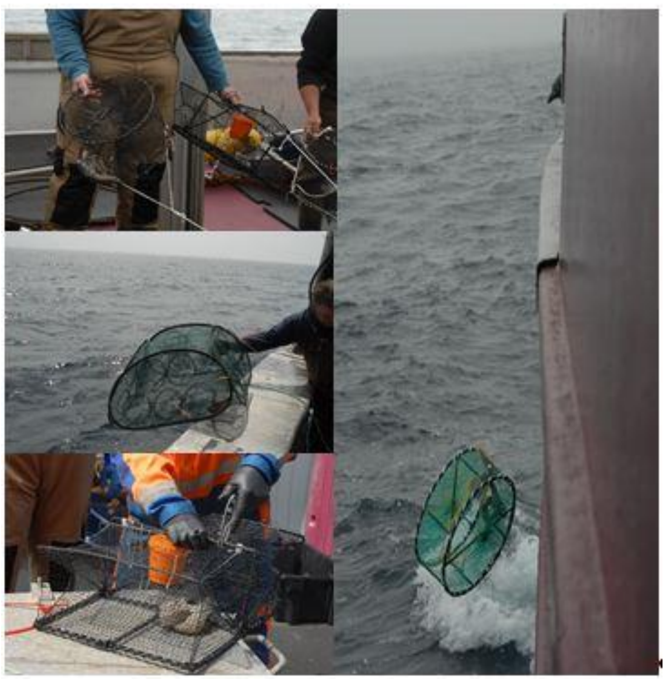

Figure 7. Baited pots used in the study.

2.2.2.2 Field Activities

The field component of the study was conducted during July 18–29, 2017. Table 2 provides a chronology of the principal fieldwork activities conducted during that period.

Table 2. Chronology of activities during the July 2017 fieldwork component of the study.

Date	Activities
July 18, 2017	Departure from St. John's; steaming towards Reference Area
July 19, 2017	Sampling commences at initially proposed Reference Area (changed to Reference Area Site A) • 4 midwater trawls Deployment and retrieval of 2 sets of fixed gear (baited pots) 2 CTD casts
July 20, 2017	Sampling continues at Reference Area Site A • 8 bottom trawls Deployment and retrieval of 2 sets of fixed gear (baited pots) 2 CTD casts
July 21, 2017	Sailed to Reference Area Site B. and continued sampling • 4 bottom trawls • 9 midwater trawls 2 CTD casts Move to the Terra Nova Treatment Area
July 22, 2017	Sampling commences at the Terra Nova Treatment Area • 11 midwater trawls • 1 bottom trawl 2 CTD casts
July 23, 2017	Sampling continues at the Terra Nova Treatment Area • 9 bottom trawls 1 CTD cast Move to the White Rose Treatment Area
July 24, 2017	Sampling commences at the White Rose Treatment Area • 7 bottom trawls 1 CTD cast Sampling completed at the White Rose Treatment Area Move to the Hibernia Treatment Area
July 25, 2017	Sampling commences at the Hibernia Treatment Area • 2 bottom trawls • 11 midwater trawls 2 CTD casts
July 26, 2017	Move to Reference Area Site C Sampling commences at Reference Area Site C • 3 midwater trawls 1 CTD cast
July 27, 2017	Sampling continues at Reference Area Sites C and B • 1 bottom trawl at Site C

Date	Activities
	• 4 bottom trawls at Site B 1 CTD cast Move back to the Terra Nova Treatment Area Sampling resumes at the Terra Nova Treatment Area • 3 bottom trawls 1 CTD cast
July 28, 2017	Sampling continues at the Terra Nova Treatment Area • 8 midwater trawls • 1 bottom trawl 1 CTD cast Move back to the Hibernia Treatment Area Sampling resumes the Hibernia Treatment Area • 8 midwater trawls 1 CTD cast Departed the Hibernia Treatment Area for steam back to St. John's
July 29, 2017	Arrival in St. John's

The following subsections describe the methodologies employed during the fieldwork component of the Study.

Fixed Gear

The fixed gear was deployed and retrieved only four times, all at the Reference Area Site A during the first two days of fieldwork. The soak time for each set was 12 hours, some set overnight. After four unsuccessful sets, it was decided to stop using the fixed gear and focus on trawling only.

Trawling

A total of 94 trawls were conducted during the at-sea field work; 40 bottom trawls and 54 midwater trawls. The study team made every effort to tow the midwater trawl at varying depths in the water column in order to sample it as completely as possible. Table 3 provides the temporal and spatial specifics of the trawling, as well as trawl type, tow duration, tow length, trawling depth range, and average water depth of each tow. See Appendix 2 for detailed data associated with each tow.

Table 3. Specifics of trawls conducted during the Study (MWT denotes IYGPT midwater trawl and BT denotes Campelen 900 bottom trawl).

Trawl No.	Date	Start Time (NST)	Trawl Type	Sampling Location	Tow Duration (min)	Tow Length (km)	Trawl Depth Range (m)	Average Bottom Depth (m)
1	July 19, 2017	14:30	MWT	Reference Area; Site A	20	1.9	73-94	118
2	July 19, 2017	17:45	MWT	Reference Area; Site A	15	1.5	107-115	119
3	July 19, 2017	19:30	MWT	Reference Area; Site A	15	1.4	99-108	120
4	July 19, 2017	20:00	MWT	Reference Area; Site A	20	1.6	86-94	121
5	July 20, 2017	8:40	BT	Reference Area; Site A	15	1.2	118-121	121
6	July 20, 2017	10:10	BT	Reference Area; Site A	15	1.3	116-119	119
7	July 20, 2017	11:10	BT	Reference Area; Site A	15	1.2	116-119	119
8	July 20, 2017	13:25	BT	Reference Area; Site A	20	1.7	116-119	119
9	July 20, 2017	14:45	BT	Reference Area; Site A	15	1.6	116-119	119
10	July 20, 2017	15:30	BT	Reference Area; Site A	20	1.7	118-121	121
11	July 20, 2017	16:25	BT	Reference Area; Site A	No data	No data	No data	119
12	July 20, 2017	17:30	BT	Reference Area; Site A	15	1.3	116-119	119
13	July 21, 2017	07:30	BT	Reference Area; Site B	20	1.8	107-110	110
14	July 21, 2017	08:25	BT	Reference Area; Site B	20	1.6	107-110	110
15	July 21, 2017	09:20	BT	Reference Area; Site B	20	1.9	107-110	110
16	July 21, 2017	10:05	BT	Reference Area; Site B	20	1.8	107-110	110
17	July 21, 2017	11:35	MWT	Reference Area; Site B	15	2.1	78-90	110
18	July 21, 2017	12:20	MWT	Reference Area; Site B	20	1.9	80-91	110
19	July 21, 2017	13:15	MWT	Reference Area; Site B	20	2.0	80-91	110
20	July 21, 2017	14:05	MWT	Reference Area; Site B	20	2.3	88-98	110
21	July 21, 2017	14:55	MWT	Reference Area; Site B	20	2.1	48-58	110
22	July 21, 2017	15:45	MWT	Reference Area; Site B	20	2.0	10-29	110
23	July 21, 2017	16:45	MWT	Reference Area; Site B	20	2.0	71-81	110
24	July 21, 2017	17:27	MWT	Reference Area; Site B	20	1.9	83-99	110
25	July 21, 2017	19:03	MWT	Reference Area; Site B	20	1.9	71-82	110
26	July 22, 2017	08:00	MWT	Terra Nova Treatment Area	10	1.1	75-83	93
27	July 22, 2017	08:38	MWT	Terra Nova Treatment Area	20	1.9	61-77	93
28	July 22, 2017	09:22	MWT	Terra Nova Treatment Area	20	1.7	16-29	93
29	July 22, 2017	10:05	MWT	Terra Nova Treatment Area	20	1.9	No data	93
30	July 22, 2017	11:11	MWT	Terra Nova Treatment Area	20	1.9	60-69	93
31	July 22, 2017	12:25	MWT	Terra Nova Treatment Area	20	1.9	52-63	93

Trawl No.	Date	Start Time (NST)	Trawl Type	Sampling Location	Tow Duration (min)	Tow Length (km)	Trawl Depth Range (m)	Average Bottom Depth (m)
32	July 22, 2017	13:25	MWT	Terra Nova Treatment Area	20	1.7	58-69	93
33	July 22, 2017	14:20	MWT	Terra Nova Treatment Area	20	1.7	57-69	93
34	July 22, 2017	15:02	MWT	Terra Nova Treatment Area	20	1.8	73-86	93
35	July 22, 2017	15:52	MWT	Terra Nova Treatment Area	20	1.5	No data	93
36	July 22, 2017	16:32	MWT	Terra Nova Treatment Area	15	1.6	No data	93
37	July 22, 2017	18:40	BT	Terra Nova Treatment Area	10	0.5	90-93	93
38	July 23, 2017	07:35	BT	Terra Nova Treatment Area	20	1.7	90-93	93
39	July 23, 2017	08:35	BT	Terra Nova Treatment Area	20	1.7	90-93	93
40	July 23, 2017	09:20	BT	Terra Nova Treatment Area	25	1.7	90-93	93
41	July 23, 2017	10:25	BT	Terra Nova Treatment Area	20	1.7	90-93	93
42	July 23, 2017	11:25	BT	Terra Nova Treatment Area	20	1.7	90-93	93
43	July 23, 2017	13:05	BT	Terra Nova Treatment Area	25	1.7	90-93	93
44	July 23, 2017	13:50	BT	Terra Nova Treatment Area	20	1.7	90-93	93
45	July 23, 2017	14:30	BT	Terra Nova Treatment Area	20	1.7	90-93	93
46	July 23, 2017	15:10	BT	Terra Nova Treatment Area	20	1.7	90-93	93
47	July 24, 2017	09:16	BT	White Rose Treatment Area	25	1.9	121-124	124
48	July 24, 2017	10:25	BT	White Rose Treatment Area	25	2.0	121-124	124
49	July 24, 2017	11:30	BT	White Rose Treatment Area	20	1.9	121-124	124
50	July 24, 2017	13:00	BT	White Rose Treatment Area	25	1.9	121-124	124
51	July 24, 2017	14:07	BT	White Rose Treatment Area	25	1.7	121-124	124
52	July 24, 2017	15:00	BT	White Rose Treatment Area	25	1.9	121-124	124
53	July 24, 2017	16:00	BT	White Rose Treatment Area	20	1.9	121-124	124
54	July 25, 2017	07:50	BT	Hibernia Treatment Area	25	1.7	76-79	79
55	July 25, 2017	09:15	BT	Hibernia Treatment Area	20	1.7	79-82	82
56	July 25, 2017	11:40	MWT	Hibernia Treatment Area	15	1.5	50-64	80
57	July 25, 2017	12:21	MWT	Hibernia Treatment Area	25	1.9	44-55	79
58	July 25, 2017	13:08	MWT	Hibernia Treatment Area	15	1.5	35-51	80
59	July 25, 2017	13:45	MWT	Hibernia Treatment Area	20	1.7	9-20	79
60	July 25, 2017	14:30	MWT	Hibernia Treatment Area	20	1.8	29-45	79
61	July 25, 2017	15:15	MWT	Hibernia Treatment Area	20	1.8	35-47	79
62	July 25, 2017	16:00	MWT	Hibernia Treatment Area	20	1.7	34-50	79
63	July 25, 2017	16:40	MWT	Hibernia Treatment Area	25	1.9	35-47	79
64	July 25, 2017	18:45	MWT	Hibernia Treatment Area	20	1.9	44-55	79
65	July 25, 2017	19:37	MWT	Hibernia Treatment Area	25	2.0	44-60	79

Trawl No.	Date	Start Time (NST)	Trawl Type	Sampling Location	Tow Duration (min)	Tow Length (km)	Trawl Depth Range (m)	Average Bottom Depth (m)
66	July 25, 2017	20:25	MWT	Hibernia Treatment Area	20	1.9	No data	79
67	July 26, 2017	20:10	MWT	Reference Area; Site C	20	2.2	99-120	134
68	July 26, 2017	21:00	MWT	Reference Area; Site C	22	2.2	97-116	132
69	July 26, 2017	21:50	MWT	Reference Area; Site C	25	2.3	114-126	134
70	July 27, 2017	07:52	BT	Reference Area; Site C	30	2.2	131-134	134
71	July 27, 2017	11:12	BT	Reference Area; Site C	26	1.7	107-110	110
72	July 27, 2017	12:40	BT	Reference Area; Site C	20	1.6	107-110	110
73	July 27, 2017	13:14	BT	Reference Area; Site C	25	1.9	107-110	110
74	July 27, 2017	14:15	BT	Reference Area; Site C	28	1.9	107-110	110
75	July 27, 2017	18:31	BT	Terra Nova Treatment Area	30	1.9	92-95	95
76	July 27, 2017	19:40	BT	Terra Nova Treatment Area	20	1.7	90-93	93
77	July 27, 2017	21:23	BT	Terra Nova Treatment Area	15	1.2	90-93	93
78	July 28, 2017	07:50	MWT	Terra Nova Treatment Area	20	1.9	50-61	95
79	July 28, 2017	08:30	MWT	Terra Nova Treatment Area	23	2.0	63-74	93
80	July 28, 2017	09:15	MWT	Terra Nova Treatment Area	21	1.9	50-61	95
81	July 28, 2017	10:10	MWT	Terra Nova Treatment Area	23	1.9	40-56	95
82	July 28, 2017	10:50	MWT	Terra Nova Treatment Area	25	2.6	No data	95
83	July 28, 2017	11:38	MWT	Terra Nova Treatment Area	30	2.8	50-66	95
84	July 28, 2017	12:42	MWT	Terra Nova Treatment Area	18	1.9	No data	95
85	July 28, 2017	13:25	MWT	Terra Nova Treatment Area	17	1.7	75-86	95
86	July 28, 2017	14:05	BT	Terra Nova Treatment Area	15	1.5	92-95	95
87	July 28, 2017	17:10	MWT	Hibernia Treatment Area	25	1.9	34-45	79
88	July 28, 2017	17:51	MWT	Hibernia Treatment Area	23	2.0	59-70	79
89	July 28, 2017	18:37	MWT	Hibernia Treatment Area	20	1.9	32-43	77
90	July 28, 2017	19:15	MWT	Hibernia Treatment Area	23	2.0	57-67	79
91	July 28, 2017	20:02	MWT	Hibernia Treatment Area	25	1.9	51-60	79
92	July 28, 2017	20:45	MWT	Hibernia Treatment Area	25	2.0	54-70	79
93	July 28, 2017	21:30	MWT	Hibernia Treatment Area	20	1.7	24-40	79
94	July 28, 2017	22:05	MWT	Hibernia Treatment Area	11	1.3	19-30	79

Figures 8–13 indicate the transect locations for each trawl type at the Treatment Areas and Reference Area Sites.

A total of 21 trawls were conducted at the Hibernia Treatment Area, 19 midwater trawls and 2 bottom trawls (Figure 8). Trawling depth with the IYGPT ranged between nine and 70 m, and the two trawls with the Campelen 900 were conducted at a depth range of 76–82 m.

A total of 33 trawls were conducted at the Terra Nova Treatment Area, 19 midwater trawls and 14 bottom trawls (Figure 9). Trawling depth with the IYGPT ranged between 16 and 86 m, and the trawls with the Campelen 900 were conducted at a depth range of 90–95 m.

A total of seven trawls were conducted at the White Rose Treatment Area, all bottom trawls (Figure 10). No midwater trawls were conducted because the sample quota, as per the DFO experimental licence, was reached with the bottom trawls. Trawling depth with the Campelen 900 bottom trawl ranged between 121 and 124 m.

A total of 12 trawls were conducted at the Reference Area Site A, 4 midwater trawls and 8 bottom trawls (Figure 11). Trawling depth with the IYGPT ranged between 73 and 115 m, and the trawls with the Campelen 900 were conducted at a depth range of 116–121 m.

A total of 17 trawls were conducted at the Reference Area Site B, 9 midwater trawls and 8 bottom trawls (Figure 12). Trawling depth with the IYGPT ranged between 10 and 99 m, and the trawls with the Campelen 900 were conducted at a depth range of 107–110 m.

A total of 4 trawls were conducted at the Reference Area Site C, 3 midwater trawls and 1 bottom trawls (Figure 13). Trawling depth with the IYGPT ranged between 97 and 126 m, while the single trawl with the Campelen 900 was conducted at a depth range of 131–134m.

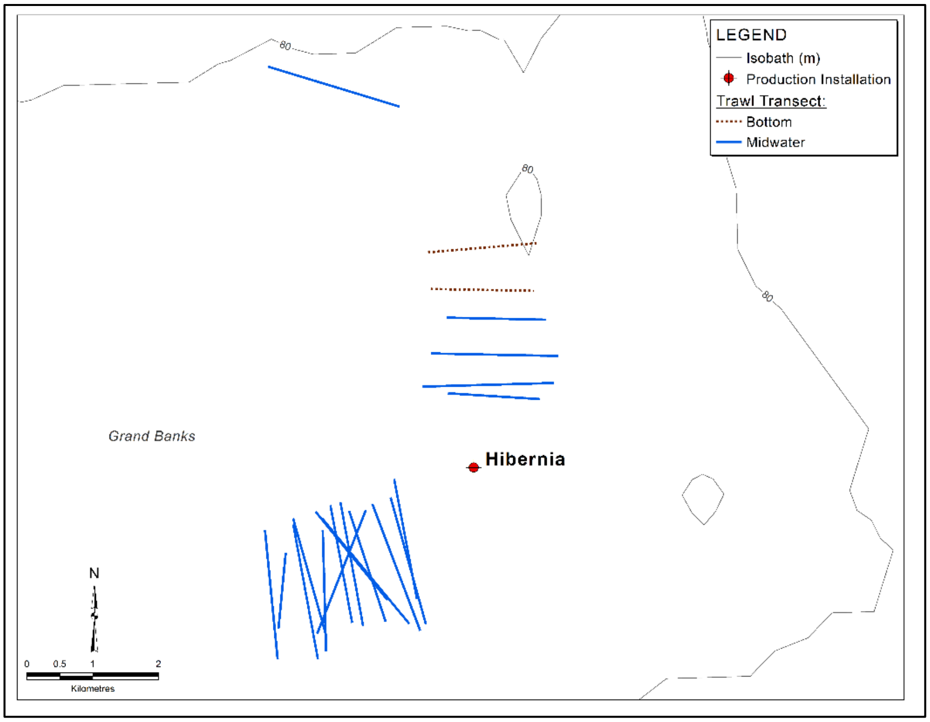

Figure 8. Locations of Campelen 900 bottom trawls (dotted red lines) and IYGPT midwater trawls (solid blue lines) at the Hibernia Treatment Area.

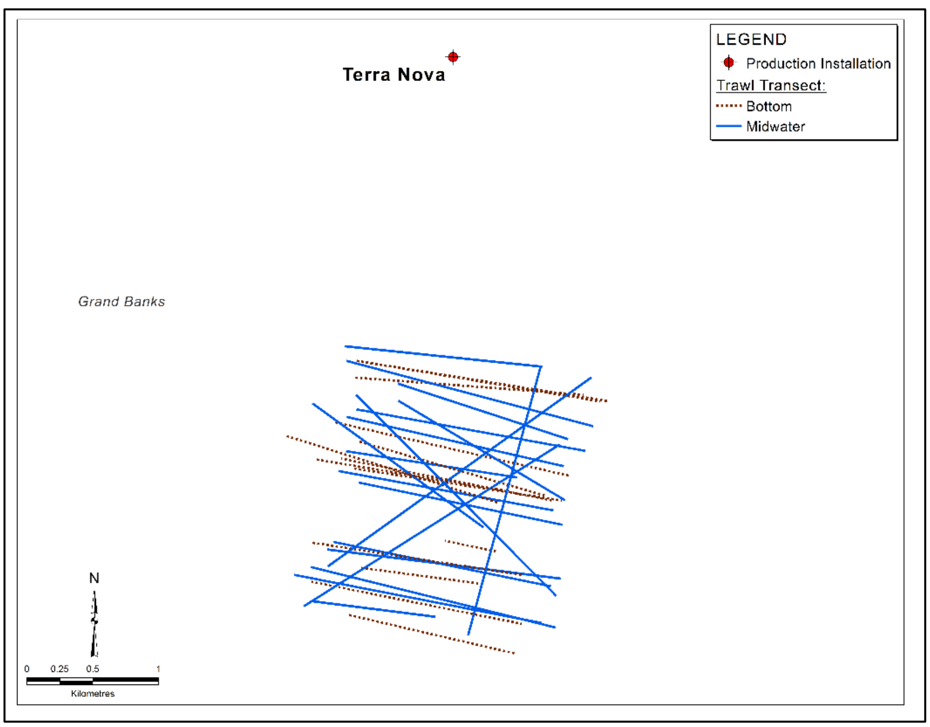

Figure 9. Locations of Campelen 900 bottom trawls (dotted red lines) and IYGPT midwater trawls (solid blue lines) at the Terra Nova Treatment Area.

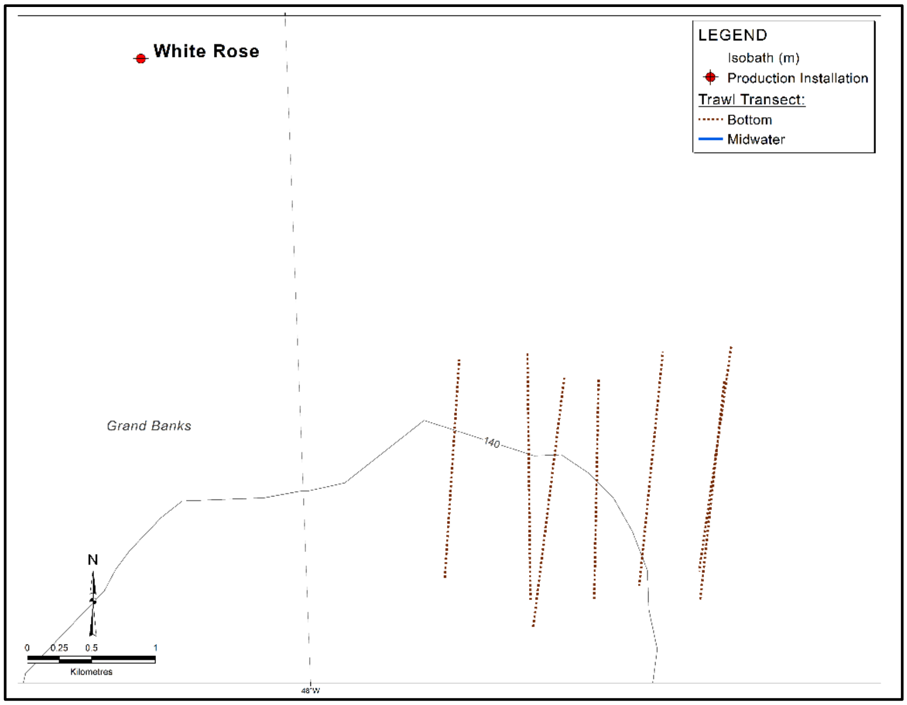

Figure 10. Locations of Campelen 900 bottom trawls (dotted red lines) and IYGPT midwater trawls (solid blue lines) at the White Rose Treatment Area.

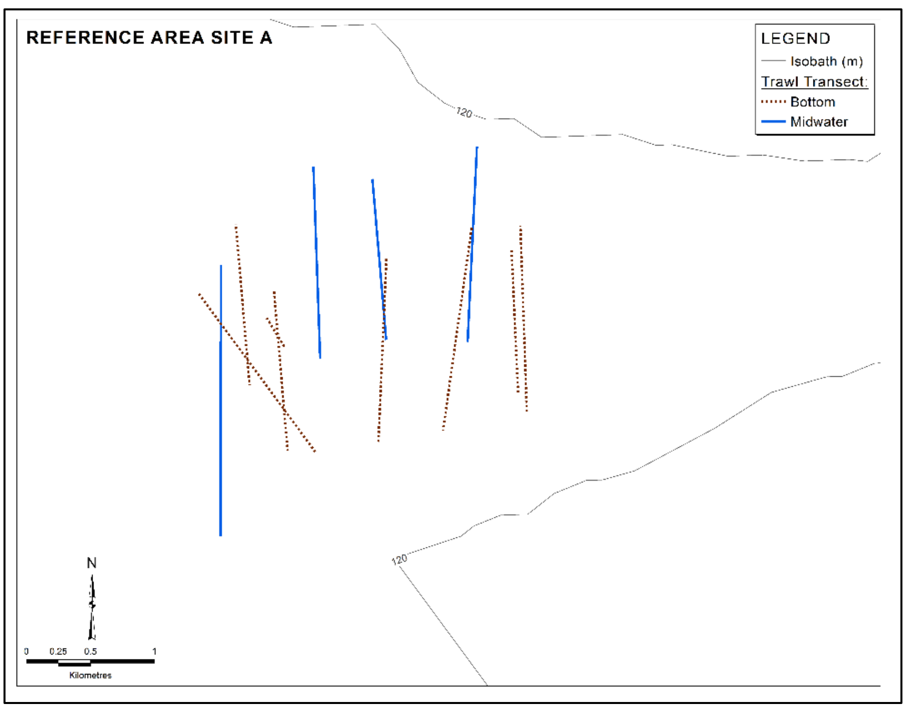

Figure 11. Locations of Campelen 900 bottom trawls (dotted red lines) and IYGPT midwater trawls (solid blue lines) at the Reference Area Site A.

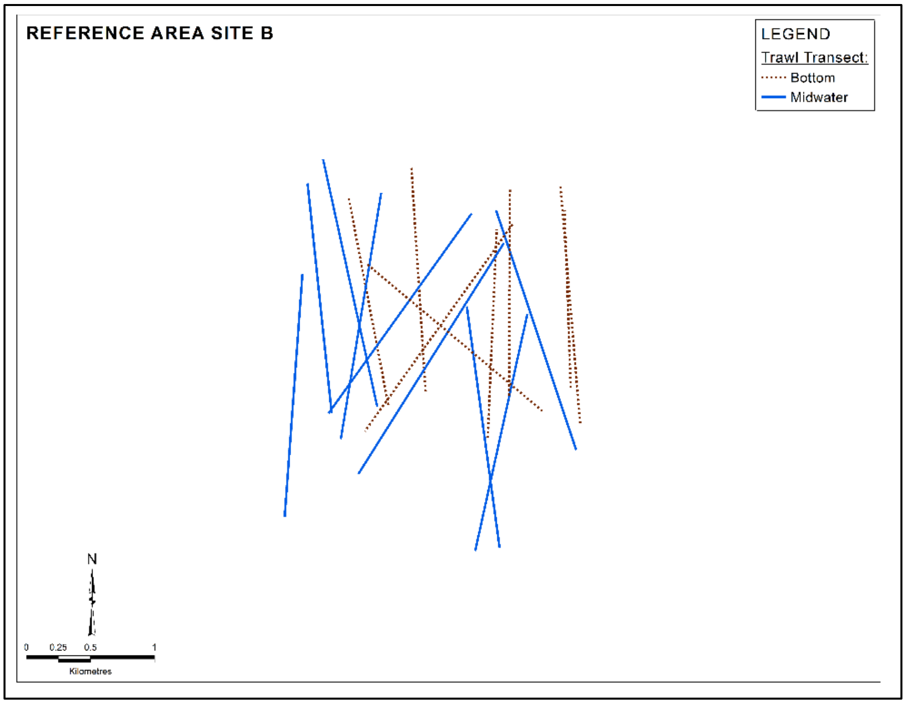

Figure 12. Locations of Campelen 900 bottom trawls (dotted red lines) and IYGPT midwater trawls (solid blue lines) at the Reference Area Site B.

Figure 13. Locations of Campelen 900 bottom trawls (dotted red lines) and IYGPT midwater trawls (solid blue lines) at the Reference Area Site C.

2.2.2.3 Juvenile Fish Collection

Upon recovery of the trawl, the total catch was placed in standard-sized fish pans and then processed on a stainless-steel sorting table. Photographs were taken of all fishes and invertebrates captured in the trawl to provide a qualitative measure of the catch. Target fish species that were considered to be ≤10 cm in total length were placed in a container containing fresh seawater. Specimens with total lengths >10 cm and ≤20 cm were also sometimes kept and processed in cases where a trawl did not catch juvenile fish in the preferred size range (i.e., 3–10 cm). Only the smallest individuals caught in each tow were kept. All non-target fishes and larger individuals of the target species were returned to the ocean as quickly as possible. The total lengths of all specimens were measured with fish boards, patted dry with clean shop towels, placed in pre-labeled Whirl-pak bags, and temporarily stored in a cooler containing dry ice pellets. The Whirl-pak bags containing the specimens were then transferred to large insulated boxes that contained large amounts of dry ice pellets. Towards the end of the field work period, Whirl-pak bags containing the specimens were transferred to a -80°C Eppendorf Innova® U101, Compact ULT freezer to facilitate delivery of the specimens to the laboratory at Oceans Ltd. A reference collection of 3–10 cm total length juvenile fishes was also produced. These specimens preserved in propanol were intended to aid personnel at Oceans Ltd. during the identification verification of the frozen specimens at their laboratory.

During the time between trawls at a sampling area, the back deck, sorting table, fish pans, and sampling equipment were rinsed with fresh seawater. During transit between sampling area s, each trawl was towed in an open position for at least 15 minutes in order to rinse the trawl and remove any fish or marine invertebrates that were trapped in the netting. All sampling equipment, including fish pans, fish measuring boards, and sorting table were cleaned with a mixture of Fisherbrand™ Versa-Clean™ Multi-Purpose Cleaner solution and water and scrubbed vigorously in order to remove any possible contaminants from the previous sampling area, and then rinsed with fresh seawater. Once a trawl was recovered after the 'cleaning' tow, it was carefully examined to verify that it was suitably clean for deployment at the next sampling area. Photographs were taken to verify the 'clean' condition of the trawl nets.

Conductivity-Temperature-Density (CTD) Casts

The Minos X CTD, an oceanographic instrument that allows one to change its sensor load in the field, was used to collect water temperature and salinity data in the water column. The Minos X is rated to 1,000 m and has various sampling rates. It also has a built in GPS receiver and Wi-Fi for quick downloads. The CTD was calibrated in accordance with the manufacturer's recommendations in advance of the survey.

The CTD was sent to the seabed from a hauler/power block that was set at a continuous deployment speed. The rope that was attached to the CTD was marked in 10 m intervals for verification of deployment speed. Once the CTD reached the targeted depth (i.e, the seabed), it was recovered, turned off and secured. At the end of each sampling day, the CTD was connected to a laptop and the water column profiles for that day were downloaded to the laptop and backed up to an external hard drive.

A total of 17 CTD casts were conducted, typically one in the morning and one in the evening. Table 4 presents spatial and temporal specifics of the CTD casts conducted in the field.

Table 4. Spatial and temporal specifics for CTD casts.

Cast No.	Date	Sampling Area	Time of Day	Latitude	Longitude
1	July 19, 2017	Reference Area Site A	15:45	46° 58.87'N	48° 16.52'W
2	July 19, 2017	Reference Area Site A	21:30	46° 59.13'N	48° 15.39'W
3	July 20, 2017	Reference Area Site A	13:00	46° 58.36'N	48° 14.99'W
4	July 20, 2017	Reference Area Site B	21:45	46° 46.49'N	48° 16.16'W
5	July 21, 2017	Reference Area Site B	11:00	46° 47.44'N	48° 17.81'W
6	July 21, 2017	Reference Area Site B	18:10	46° 47.27'N	48° 17.80'W
7	July 22, 2017	Terra Nova Treatment Area	7:20	46° 26.27'N	48° 28.71'W
8	July 22, 2017	Terra Nova Treatment Area	17:35	46° 27.15'N	48° 29.07'W
9	July 23, 2017	Terra Nova Treatment Area	7:25	46° 26.13'N	48° 28.67'W
10	July 24, 2017	White Rose Treatment Area	17:10	46° 45.80'N	47° 57.64'N
11	July 25, 2017	Hibernia Treatment Area	7:30	46° 46.61'N	48° 46.51'W
12	July 25, 2017	Hibernia Treatment Area	18:30	46° 43.84'N	48° 49.16'W
13	July 26, 2017	Reference Area Site C	22:35	47° 01.91'N	48° 10.92'W
14	July 27, 2017	Reference Area Site C	7:20	47° 02.19'N	48° 09.60'W
15	July 27, 2017	Terra Nova Treatment Area	22:40	46° 26.84'N	48° 28.44'W
16	July 28, 2017	Terra Nova Treatment Area	7:10	46° 28.32'N	48° 28.61'W
17	July 28, 2017	Hibernia Treatment Area	22:50	46° 44.75'N	48° 48.20'W

2.3 Task 3 – Data Analysis and Final Reporting

2.3.1 Laboratory Analysis

2.3.1.1 Sample Preparation

Once the frozen juvenile fish specimens were delivered to Oceans Ltd., the analytical laboratory, they were transferred to a -80°C freezing unit until further processing. During processing, the specimens were partially thawed, and measured for total length and weight. Note that the species identification of each fish specimen was confirmed by the laboratory. Each fish was dissected, the liver removed and used for S9 fraction preparation, and the gall bladders removed and stored individually at -80°C. Due to the small sizes of the fish, it was necessary to pool the livers of 3 similarly-sized fish for S9 preparation for American plaice, sand lance and capelin. For Atlantic cod, the livers of only two similarly-sized fish were pooled for S9 preparation. In a few cases for the larger fish, only two specimens of American plaice, capelin and sand lance were pooled. Pooling of specimens was conducted using four total length size classes: (1) 7.0–9.0 cm; (2) 9.5–12.0 cm; (3) 12.5–15.0; and (4) 15.5–19.0 cm. Note that pooling was done within each sampling area.

For the analysis of MFO enzyme activity, liver samples were homogenized in four volumes of 50 mM Tris buffer, pH 7.5, (1 g liver to 4 ml buffer) using at least ten passes of a glass Ten Broeck homogeniser. Homogenates were centrifuged at 9,000 *g* for 15 minutes at 4°C and the post-mitochondrial supernatant (S9 fraction) was then frozen in triplicate at -80°C until assaying. All liver samples were held and processed under the same storage and assay conditions. Assays were carried out within five weeks of storing the S9 fractions. Samples for MFO assay can be stored for several months before any measurable change in activity can be detected (Mathieu et al. 2011; Hodson et al. 1991a).

For PAH metabolite analysis in bile, gall bladders were thawed on ice and the bile extracted using disposable syringes with a stainless-steel needle. Bile was transferred to a new microcentrifuge tube and analyzed immediately.

2.3.1.2 Sample Analysis

MFO Activity

MFO induction was assessed in liver samples as EROD activity according to the fluorimetric method of Pohl and Fouts (1980) as modified by Porter et al. (1989).

The reaction mixture contained 50 mM Tris buffer, pH 7.5, 2 μM ethoxyresorufin (Sigma) dissolved in dimethyl sulfoxide, 0.15 mM NADPH and 4–5 μl of S9 fraction. After 15 min of incubation at 27°C, the reaction was stopped with 2 ml of methanol (HPLC grade) and samples were centrifuged (2,900 *g* for 5 minutes) to remove the protein precipitate. The fluorescence of 7-hydroxyresorufin formed in the supernatant was measured at an excitation wavelength of 550 nm and an emission wavelength of 580 nm using a Perkin-Elmer LS-45 fluorescence spectrophotometer. Blanks were performed as above with methanol added before the incubation. All the samples were run in duplicate. Protein concentration was determined using the Lowry protein method (Lowry et al. 1951) with bovine serum albumin as standard. The rate of enzyme activity expressed as 'pmol/min/mg protein' was obtained from the regression of fluorescence against standard concentrations of 7-hydroxyresorufin. Two external positive controls (a pool of liver homogenates with known activity) were run with each batch of samples to ensure consistency of measurements.

PAH Metabolites

PAH metabolites were assessed in fish bile by fixed wavelength fluorescence (FF) detection according to the method described by Aas et al. (2000b) and Aas and Klungosyr (1998). Excitation/emission wavelengths used for PAH metabolite detection includes:

- 290/335 nm for naphthalene-type metabolites;
- 256/380 nm for phenanthrene-type metabolites;

- 341/383 nm for pyrene type metabolites; and
- 380/430 nm benzo-a-pyrene-type (BaP) metabolites.

Results are expressed as mg/mg protein except for BaP metabolites which are expressed as relative fluorescence units (F.U.) per mg protein. Not all specimen gall bladders contained bile, as reflected by the sample numbers presented in Section 3.0.

2.3.1.3 Quality Assurance / Quality Control (QA/QC)

QA/QC procedures were used during all stages of laboratory analysis, including sample preparation and analysis. QA/QC procedures for MFO analysis followed the protocols recommended by Stagg et al. (1998) and Hodson et al. (1991b). All liver homogenates (i.e., S9 fractions) were prepared in triplicate and frozen at -80 °C. A stock solution of the enzyme substrate 7-ethoxyresorufin was made up to a consistent peak absorbance (i.e., dissolved in DMSO until the absorbance at 461.5 nm = 1.6–1.7). In preparing 7-hydroxyresorufin standards, the purity of the 7-hydroxyresorufin was taken into account by measuring its molar absorbance at 572 nm in 0.1 M phosphate buffer, pH 8.0. Ethoxy-resorufin and standard stock solutions were prepared in multiple small aliquots and stored in amber glass vials due to their light sensitivity. Aliquots of ethoxy-resorufin were stored at -20°C and standard stock solutions were stored at -80°C. An eight-point standard curve and two external positive controls (pool of liver homogenates aliquoted and stored at -80°C) were incorporated into each assay. All assays, including samples, blanks, standards and positive control were run in duplicate.

Protein contents were measured on the individual homogenates used for the MFO assays. A standard stock solution of bovine serum albumin was prepared in multiple aliquots and stored at -20°C. A seven-point standard curve and one blank (reaction mixture with distilled water instead of S9) were incorporated into each assay. All samples were run in triplicate.

PAH metabolite concentrations were determined based on modified protocols for analysis of PAH metabolites in bile samples using fixed fluorescence (Aas et al. 2000b; Aas and Klungsøyr 1998) A series of Ten-point standard curves prepared weekly and read on the same day from standards of 2-naphthol, 9-phenanthrol, and 1-hydroxypyrene were used to calculate the concentrations of metabolites in each sample. Only thoroughly washed glassware rinsed with HPLC-grade methanol was used during the assay. All results were standardized to bile protein content via the Lowry protein assay.

2.3.1.4 Laboratory Statistical Analyses on Specimens

All fish total length data were analyzed using a One-way ANOVA. When the residuals of the data deviated severely from a normal distribution but met the homogeneity of variances assumption, the data were analyzed using a Kruskal-Wallis ANOVA (non-parametric) on ranks. If the data did not meet the homogeneity of variances assumption, data transformation was applied. Results were considered statistically significant when $p \leq 0.05$. All laboratory statistical analyses were conducted using Minitab® 16.2.4 or SigmaPlot 13.

Analysis of Covariance (ANCOVA) was conducted by the analytical laboratory to investigate the possible effect of fish size on the EROD activity. The average total lengths (TL) of the pooled fish used for the S9 preparation were used for the ANCOVA.

2.3.2 Statistical Analyses on Effects

In addition to the statistical analyses conducted by the analytical laboratory, LGL conducted statistical analyses using a generalized linear model (GLM) to compare EROD activity and PAH metabolite levels observed in fish collected at the Treatment Areas with those observed in fish collected at the Reference Area. For each of the four species, responses included EROD and five PAH metabolites: (1) protein; (2) 2-Naphthol; (3) 9-Phenanthrol; (4) 1-OH Pyrene; and (5) and Benzo-a-Pyrene (BaP). Thus, there were a total of 24 responses that were tested with the GLM. All responses were assumed to follow a gamma distribution with a log-link function for shape versatility.

For EROD, model terms included the categorical variable *Site* (four levels = Hibernia, White Rose, Terra Nova Treatment Areas, and Reference Area), the covariate total length (*TL*) which was transformed to its natural logarithm before entering the model, and their interaction, *Site***TL*. Models for all PAH metabolites included only *Site* as an independent variable. Total length was not included as an independent variable because it shouldn't have an effect on PAH metabolite levels in the bile (J. Pérez-Casanova, Aquatic Toxicologist, Oceans Ltd., August 2018).

Instead of overall p-values for model terms, all nested combinations of terms were compared using the information-theoretic approach as recommended by Burnham and Anderson (2002). Weights were assigned to each model based on their Akaike Information Criterion (AIC) values. Of the suite of models investigated, Akaike weights sum to one (i.e., 100%) and indicate how probable one model is compared to all others considered. The weight of evidence for any one term (e.g., a *Site* effect) was given by the sum of weights for all models containing that variable. However, p-values were used for pairwise tests between the Reference Area *Site* and each Treatment Area *Site* and were Bonferroni adjusted to control for experiment-wise error rate across multiple tests (adjusted α=0.05).

All models were parameterized with the GLIMMIX procedure in the statistical software SAS 9.4 TS Level 1M5 (SAS Institute, Inc., 2016). Standard residual plots were used to assess overall goodness-of-fit for the global models. After an initial run of the global GLM, all records having Studentized residuals with absolute values >3 were deemed outliers and deleted, and subsequent nested models were based on these filtered datasets to maintain continuity. Zero values were also removed from the dataset prior to the nested modelling.

3.0 Results

3.1 Juvenile Fish Counts and Morphometrics

A total of 1,020 juvenile fish specimens were collected during the field work; 136 Atlantic cod, 269 American plaice, 287 capelin and 328 sand lance. Appendix 3 contains representative photographs of juvenile fishes collected during the field work, and Appendix 4 contains the more detailed data associated with the fish catches. Tables 5 and 6 provide count and total length statistics of the fish specimens.

Table 5. Number of each species collected by midwater and bottom trawl.

Trawl Type/Species	Sampling Area				Total
	Terra Nova	White Rose	Hibernia	Reference	
Bottom trawl					
Atlantic cod	4	50	1	49	**104**
American plaice	57	61	50	95	**263**
Capelin	5	50	0	57	**112**
Sand lance	33	50	50	67	**200**
Total	**99**	**211**	**101**	**268**	**679**
Midwater trawl					
Atlantic cod	2	0	4	26	**32**
American plaice	0	0	0	6	**6**
Capelin	49	0	104	22	**175**
Sand lance	78	0	47	3	**128**
Total	**129**	**0**	**155**	**57**	**341**

In the laboratory, total length was compared between the all sampling areas using a one-way ANOVA or a Kruskal-Wallis ANOVA on ranks. Results show statistical differences between sampling areas for all species except Atlantic cod. Table 7 presents the results of the statistical analysis of fish total length conducted by the analytical laboratory.

American plaice collected at the Terra Nova Treatment Area were significantly ($P < 0.001$) larger than those collected at the Hibernia and White Rose Treatment Areas, and the Reference Area (Table 7). American plaice collected at the Hibernia and White Rose Treatment Areas and the Reference Area were not significantly different in terms of total length.

Capelin collected at the White Rose Treatment Area were significantly larger than those collected at the other two Treatment Areas and Reference Area, and capelin collected at the Reference Area were significantly larger than those collected at the Hibernia and Terra Nova Treatment Areas. No significant difference in total length was observed between capelin collected at the Hibernia and Terra Nova Treatment Areas (Table 7).

Table 6. Total length (cm) statistics of juvenile fish specimens.

Species/Statistics	Sampling Area			
	Terra Nova	White Rose	Hibernia	Reference Area
Atlantic cod				
Sample Size	6	50	5	75
Mean TL	11.7	11.7	10.5	11.1
Standard Deviation	2.3	0.9	1.2	1.6
Minimum TL	10.0	9.5	9.0	6.0
Maximum TL	16.0	13.5	12.0	16.5
American plaice				
Sample Size	57	61	50	101
Mean TL	11.7	11.0	10.6	10.8
Standard Deviation	1.2	1.1	1.0	1.9
Minimum TL	9.0	7.0	8.0	7.0
Maximum TL	14.0	12.5	11.5	18.0
Capelin				
Sample Size	54	50	104	79
Mean TL	10.5	12.2	10.7	11.7
Standard Deviation	1.0	0.7	1.7	0.7
Minimum TL	7.5	10.0	5.5	10.0
Maximum TL	13.0	13.0	14.5	13.5
Sand lance				
Sample Size	111	50	97	70
Mean TL	10.2	13.7	10.7	14.3
Standard Deviation	2.3	0.4	3.2	1.4
Minimum TL	6.0	12.0	5.5	12.0
Maximum TL	14.0	14.0	14.0	19.0

Table 7. Results of statistical analysis of differences in total length of fishes collected at the various sampling areas.

Fish Species	Pairwise Comparisons	p-value for Site Effect
Atlantic cod	TN=WR=HIB=Reference Area	0.077
American plaice	TN>WR=HIB=Reference Area	<0.001
Capelin	WR>Reference Area>TN=HIB	<0.001
Sand lance	WR=Reference Area>TN=HIB	<0.001[a]

[a] indicates that p-value derived from analysis using Kruskal-Wallis ANOVA on ranks test; otherwise, parametric ANOVA was employed.

'=' denotes no significant difference; '>' denotes significantly greater.

Sand lance collected at the Hibernia and Terra Nova Treatment Areas were significantly ($P < 0.001$) smaller than sand lance collected at the White Rose Treatment Area and the Reference Area. No significant differences in total length were observed between sand lance collected at the Hibernia and Terra Nova Treatment Areas, nor between sand lance collected at the White Rose Treatment Area and the Reference Area.

Gross pathology was assessed visually in all fish during the necropsies for any external or internal abnormalities. There were no visible lesions on the skin, fins or internal organs (gonad, digestive tract, liver, body cavity, and spleen) of any fish.

3.2 MFO Activity

The differences in MFO activity (measured as EROD activity) were compared between sampling areas in pooled samples of livers of juvenile fishes. The pooling of samples was necessary due to the small size of the livers (see Section 2.0). The summary statistics regarding EROD are presented in Table 8. The EROD empirical data are presented in Appendix 5.

Table 8. EROD activity (pmol/min/mg of protein) in the liver tissue of juvenile fishes at the various sampling locations.

Species/Statistics	Sampling Area			
	Terra Nova	White Rose	Hibernia	Reference Area
Atlantic cod				
Sample Size	3	25	3	39
Mean EROD activity	0.770	0.739	0.658	0.789
Standard Deviation	0.291	0.331	0.364	0.365
Minimum EROD activity	0.467	0.106	0.412	0.000
Maximum EROD activity	1.048	1.616	1.076	1.569
American plaice				
Sample Size	18	21	17	34
Mean EROD activity	28.478	28.074	18.392	36.856
Standard Deviation	9.190	8.800	6.050	16.190
Minimum EROD activity	15.253	12.595	9.668	13.251
Maximum EROD activity	43.017	47.282	36.120	86.003
Capelin				
Sample Size	18	17	35	26
Mean EROD activity	1.559	1.334	1.091	1.485
Standard Deviation	0.537	0.558	0.479	0.615
Minimum EROD activity	0.061	0.363	0.204	0.365
Maximum EROD activity	2.377	2.363	1.800	2.607
Sand lance				
Sample Size	37	17	33	24
Mean EROD activity	0.337	0.166	0.409	0.236
Standard Deviation	0.309	0.194	0.322	0.244
Minimum EROD activity	0.000	0.000	0.000	0.000
Maximum EROD activity	1.288	0.850	0.979	0.885

3.2.1 Statistical Analysis

The results of the statistical analyses of EROD data conducted by both Oceans and LGL are presented separately.

3.2.1.1 Oceans

Results of ANCOVA analysis showed that there was a significant effect of fish size on the hepatic EROD activity ($p = <0.001$) for all species except American plaice ($p = 0.344$). The ANCOVA results also showed a significant effect of site ($p < 0.05$) on EROD activity for all species except Atlantic cod. The significant pairwise comparisons associated with American plaice, capelin and sand lance, as determined by the laboratory statistical analysis are as follow.

- American plaice collected at the Hibernia Treatment Area had significantly lower EROD levels (arithmetic mean = 18.392 pmol/min/mg of protein) than those collected at the Reference Area (arithmetic mean = 36.856 pmol/min/mg of protein), and those collected at the Terra Nova and White Rose Treatment Areas.
- Capelin collected at the Hibernia Treatment Area had significantly lower EROD levels (arithmetic mean = 1.091 pmol/min/mg of protein) than those collected at the Reference Area (arithmetic mean = 1.485 pmol/min/mg of protein), and those collected at the Terra Nova Treatment Area. The EROD levels in capelin collected at the White Rose Treatment Area did not differ significantly from those in capelin collected at the other three sampling areas.
- While sand lance collected at the Hibernia Treatment Area had significantly higher EROD levels (arithmetic mean = 0.409 pmol/min/mg of protein) than those collected at the White Rose Treatment Area (arithmetic mean = 0.166 pmol/min/mg of protein), none of the sand lance collected at the three Treatment Areas had EROD levels that differed significantly from those at the Reference Area.

3.2.1.2 LGL

Residual panels for the global model runs conducted by LGL indicated that goodness-of-fit was adequate for the EROD models, and that the gamma distribution was appropriate for this response (Figure 14). Across the four species, four records were deemed outliers and removed, and 14 EROD values equal to zero were also removed (Table 9).

There was no compelling evidence for the interaction term, *Site***TL*, in any of EROD models based on Akaike weights, which were <50% for all four species (Table 10). *Site* was found to be important for all but Atlantic cod (~5% chance), and *TL* was important for all species, although less so for Atlantic cod (85%). *TL* was included as a nuisance/extraneous variable to reduce noise.

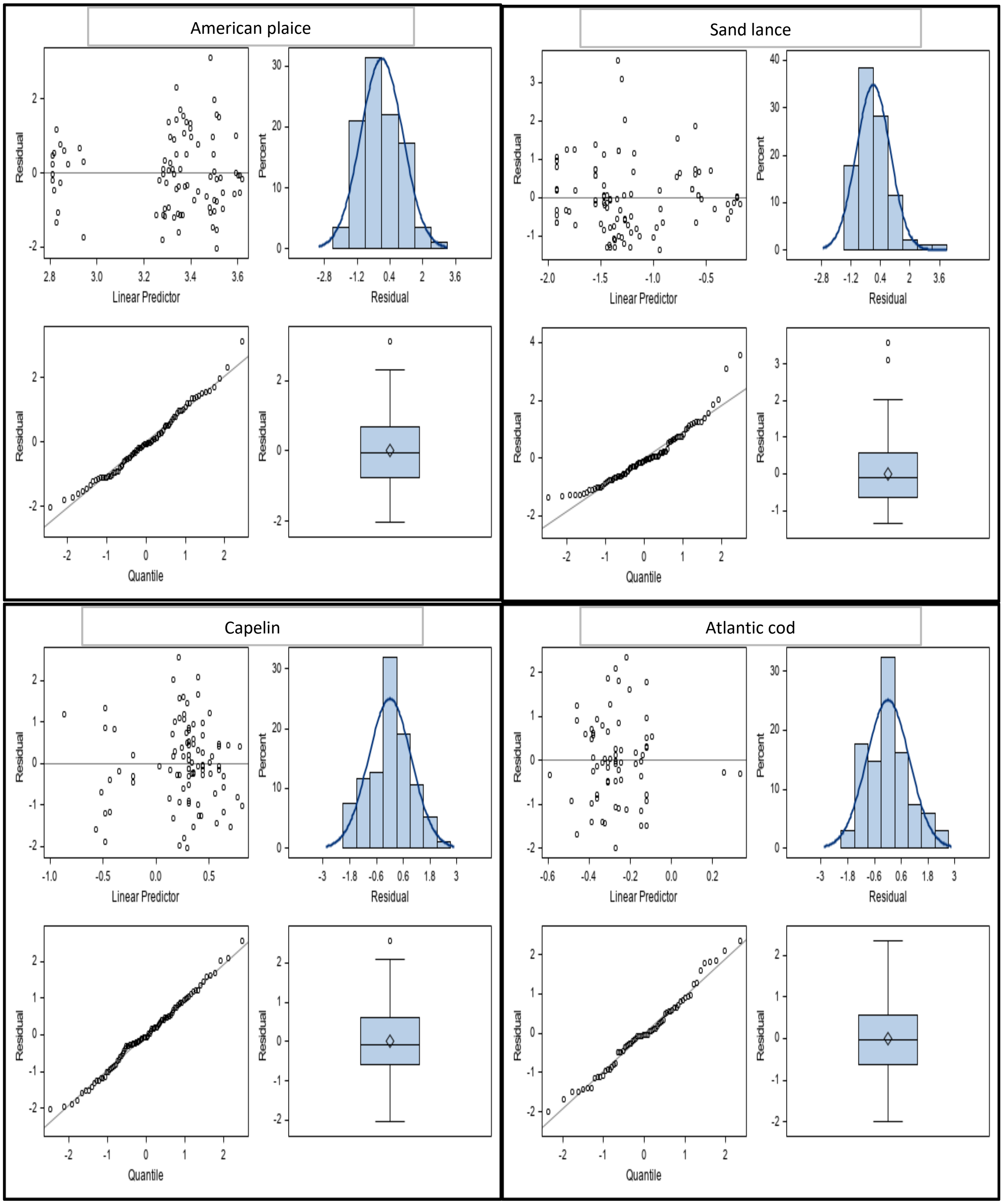

Figure 14. Studentized residual panel for the global GLM used to model EROD for the species tested.

Table 9. Outliers and Zeros Removed from Dataset Prior to Nested Modelling.

Variable	Fish Species			
	American Plaice	Sand Lance	Capelin	Atlantic Cod
Initial Sample Size				
EROD	91	124	96	69
Protein	52	55	129	51
2-Naphthol	52	55	129	51
9-Phenanthrol	52	55	129	51
1-OH Pyrene	52	55	129	51
Benzo-a-pyrene	52	55	129	51
Outliers and Zeros Removed				
EROD	4	2 (+ 13 zeros)	2	0 (+ 1 zero)
Protein	0	1	1	0
2-Naphthol	1	1	2	2
9-Phenanthrol	2	1	3	2
1-OH Pyrene	2	1	1	1
Benzo-a-pyrene	1	1	2	1
Final Sample Size				
EROD	87	109	94	68
Protein	52	54	128	51
2-Naphthol	51	54	127	49
9-Phenanthrol	50	54	126	49
1-OH Pyrene	50	54	128	50
Benzo-a-pyrene	51	54	127	50

Table 10. Akaike weights (reported as percentages) from GLMs of EROD. Weights are given for the null models (i.e., constant mean across all samples), the global models (Site|TL), and all nested model combinations. Term weights are given by the summation of weights for all models in which it occurs. The operator "|" indicates a model with an interaction of two or more terms and all the corresponding main effects.

Species	Model					Term	
	Site|TL	Site + TL	Site	TL	Null	Site	TL
Atlantic cod	0%	4%	1%	80%	14%	5%	85%
American plaice	10%	87%	3%	0%	0%	100%	97%
Capelin	30%	70%	0%	0%	0%	100%	100%
Sand lance	45%	47%	0%	8%	0%	92%	100%

For all species, EROD was highest at the Reference Area *Site*; although, the significance of pairwise tests between Treatment Area *Sites* and the Reference Area *Site* varied across species (Figure 15). Note that no significant differences in EROD between sampling areas were observed for Atlantic cod. The significant pairwise comparisons are as follow.

- American plaice collected at the Hibernia Treatment Area had significantly lower EROD levels (arithmetic mean = 18.392 pmol/min/mg of protein) than those collected at the Reference Area (arithmetic mean = 36.856 pmol/min/mg of protein).
- Capelin collected at the Hibernia Treatment Area had significantly lower EROD levels (arithmetic mean = 1.091 pmol/min/mg of protein) than those collected at the Reference Area (arithmetic mean = 1.485 pmol/min/mg of protein).
- Sand lance collected at the Terra Nova Treatment Area had significantly lower EROD levels (arithmetic mean = 0.337 pmol/min/mg of protein) than those collected at the Reference Area (arithmetic mean = 0.236 pmol/min/mg of protein)
- Sand lance collected at the White Rose Treatment Area had significantly lower EROD levels (arithmetic mean = 0.166 pmol/min/mg of protein) than those collected at the Reference Area (arithmetic mean = 0.236 pmol/min/mg of protein).

Note that the values presented in the above bullets are arithmetic means (see Table 8). The GLM results, however, are based on marginal means which are comparisons made while holding TL constant at its average observed value. This explains the GLM result of sand lance from the Terra Nova Treatment Area having significantly lower EROD levels than those from the Reference Area, despite the arithmetic means suggesting otherwise.

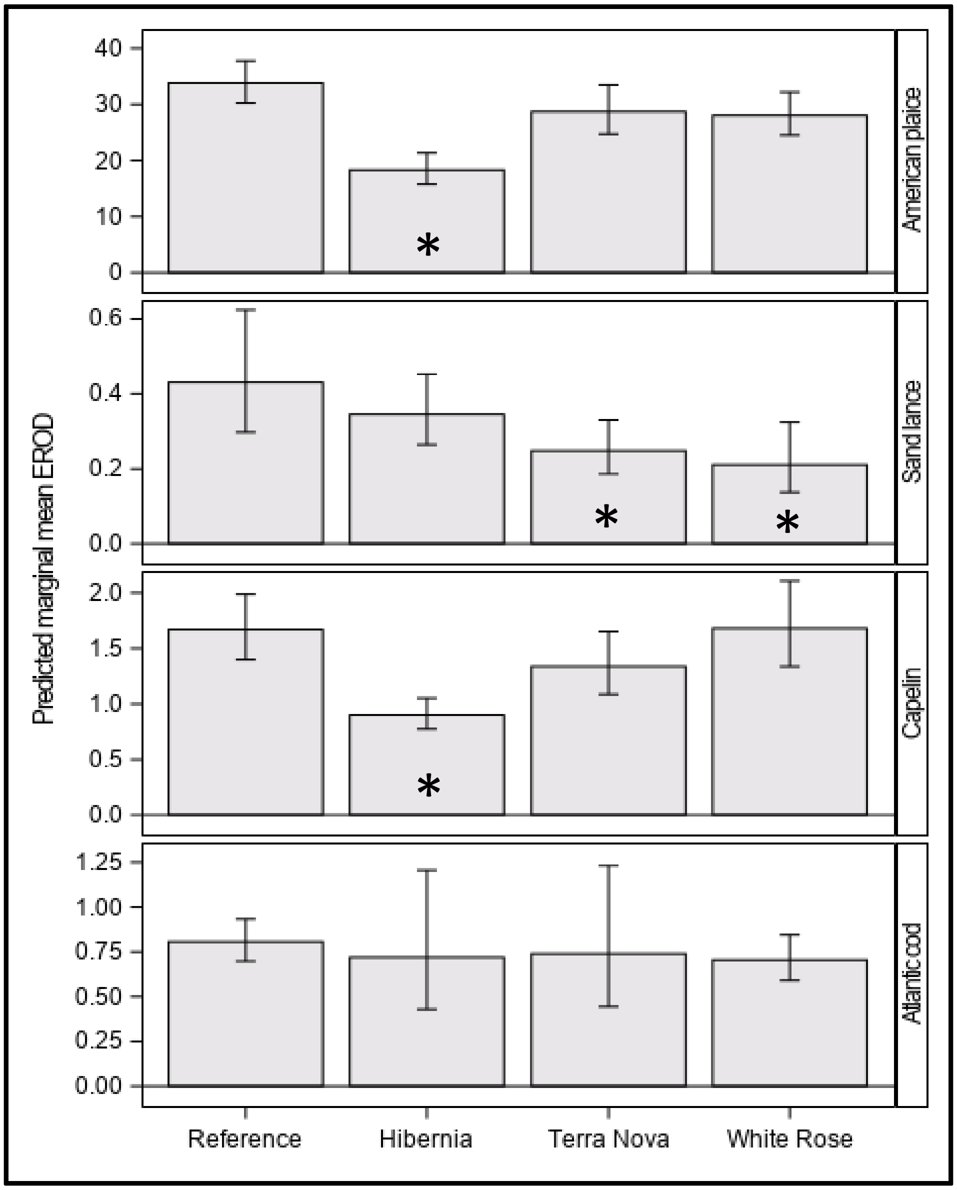

Figure 15. Predicted marginal mean EROD with 95% confidence limits (error bars) for the species tested as a function of the categorical variable *Site* when the effects of all other variables considered in the GLM were held constant. Asterisks indicate a significant difference (α=0.05) from the Reference Area *Site.*

3.3 PAH Metabolites

The summary statistics for PAH metabolite levels measured in the bile of juvenile fish are presented in Table 11. The results of fluorescence measurements were standardized to the total protein concentration of the bile samples. The PAH metabolite empirical data are presented in Appendix 6.

Table 11. Levels of biliary PAH metabolites (standardized to biliary protein content) in the bile of juvenile fishes at the various sampling locations (arithmetic mean ± standard deviation).

Species/Statistics	Sampling Area			
	Terra Nova	White Rose	Hibernia	Reference
Atlantic cod				
Sample Size	3	22	0	25
Protein (mg/ml)	43.70 ± 2.36	41.89 ± 1.61	-	40.41 ± 1.61
2-Naphthol (mg/mg protein)	0.04511 ± 0.01206	0.050871 ± 0.01240	-	0.04801 ± 0.01022
9-Phenanthrol (mg/mg protein)	0.00482 ± 0.00134	0.004601 ± 0.000173	-	0.004484 ± 0.000217
1-OH Pyrene (mg/mg protein)	0.000070 ± 0.000010	0.000054 ± 0.000003	-	0.000058 ± 0.000004
Benzo-a-pyrene (F.U./mg protein)	161.7 ± 31.4	147.8 ± 8.1	-	153.7 ± 9.2
American plaice				
Sample Size	3	13	4	32
Protein (mg/ml)	3.16 ± 5.48	3.07 ± 11.07	5.06 ± 10.12	2.51 ± 14.19
2-Naphthol (mg/mg protein)	0.07026 ± 0.00218	0.07814 ± 0.00674	0.07559 ± 0.00487	0.07093 ± 0.00192
9-Phenanthrol (mg/mg protein)	0.005770 ± 0.000181	0.007178 ± 0.000636	0.006539 ± 0.000186	0.006239 ± 0.000275
1-OH Pyrene (mg/mg protein)	0.000023 ± 0.000001	0.000046 ± 0.000010	0.000042 ± 0.000006	0.000043 ± 0.000007
Benzo-a-pyrene (F.U./mg protein)	70.0 ± 6.3	103.9 ± 11.0	107.9 ± 12.4	126.8 ± 21.6
Capelin				
Sample Size	18	26	34	51
Protein (mg/ml)	34.36 ± 3.38	30.37 ± 1.96	29.37 ± 2.22	25.91 ± 1.43
2-Naphthol (mg/mg protein)	0.04855 ± 0.00149	0.05558 ± 0.00311	0.05259 ± 0.00273	0.04868 ± 0.00158
9-Phenanthrol (mg/mg protein)	0.004282 ± 0.000199	0.004978 ± 0.000297	0.005098 ± 0.000370	0.004644 ± 0.000142
1-OH Pyrene (mg/mg protein)	0.000032 ± 0.000002	0.000040 ± 0.000003	0.000036 ± 0.000003	0.000040 ± 0.000002
Benzo-a-pyrene (F.U./mg protein)	110.4 ± 9.1	121.1 ± 8.2	134.8 ± 12.8	134.2 ± 6.4
Sand lance				
Sample Size	3	2	25	25
Protein (mg/ml)	46.72 ± 4.23	49.33 ± 2.82	34.91 ± 2.65	43.86 ± 1.89
2-Naphthol (mg/mg protein)	0.06320 ± 0.00699	0.06055 ± 0.00280	0.05693 ± 0.00308	0.05961 ± 0.00377
9-Phenanthrol (mg/mg protein)	0.005794 ± 0.000742	0.006118 ± 0.000324	0.005038 ± 0.000355	0.004737 ± 0.000323
1-OH Pyrene (mg/mg protein)	0.000034 ± 0.000004	0.000028 ± 0.000002	0.000040 ± 0.000003	0.000032 ± 0.000002
Benzo-a-pyrene (F.U./mg protein)	94.8 ± 8.4	90.6 ± 1.3	144.2 ± 10.2	108.7 ± 6.7

3.3.1 Statistical Analysis

The results of the statistical analyses of PAH metabolite data conducted by both Oceans and LGL are presented separately.

3.3.1.1 Oceans

Results of laboratory statistical analysis of bile metabolite levels showed some significant differences between sampling areas for sand lance only. The significant pairwise comparisons associated with sand lance are as follow.

- The protein levels in the bile of sand lance collected at the Hibernia Treatment Area (arithmetic mean = 34.91 mg/ml) were significantly lower than the protein levels in sand lance collected at the Reference Area (arithmetic mean = 43.86 mg/ml). Note that lower protein levels in the bile could be due to the fish having recently fed.
- The BaP levels in the bile of sand lance collected at the Hibernia Treatment Area (arithmetic mean = 144.2 F.U./mg protein) were significantly higher than BaP levels in sand lance collected at the Reference Area (arithmetic mean = 108.7 F.U./mg protein).

3.3.1.2 LGL

As for the LGL statistical analysis, global models for the PAH metabolite responses also yielded adequate model fits (Figures 16–20). Twenty outliers were removed across all species-response combinations (see Table 9).

Strong evidence (≥95% chance) for differences among *Sites* occurred only for protein in sand lance. Marginal evidence (≥80% chance) for differences among *Sites* occurred for protein in capelin, and for BaP in sand lance (Table 12).

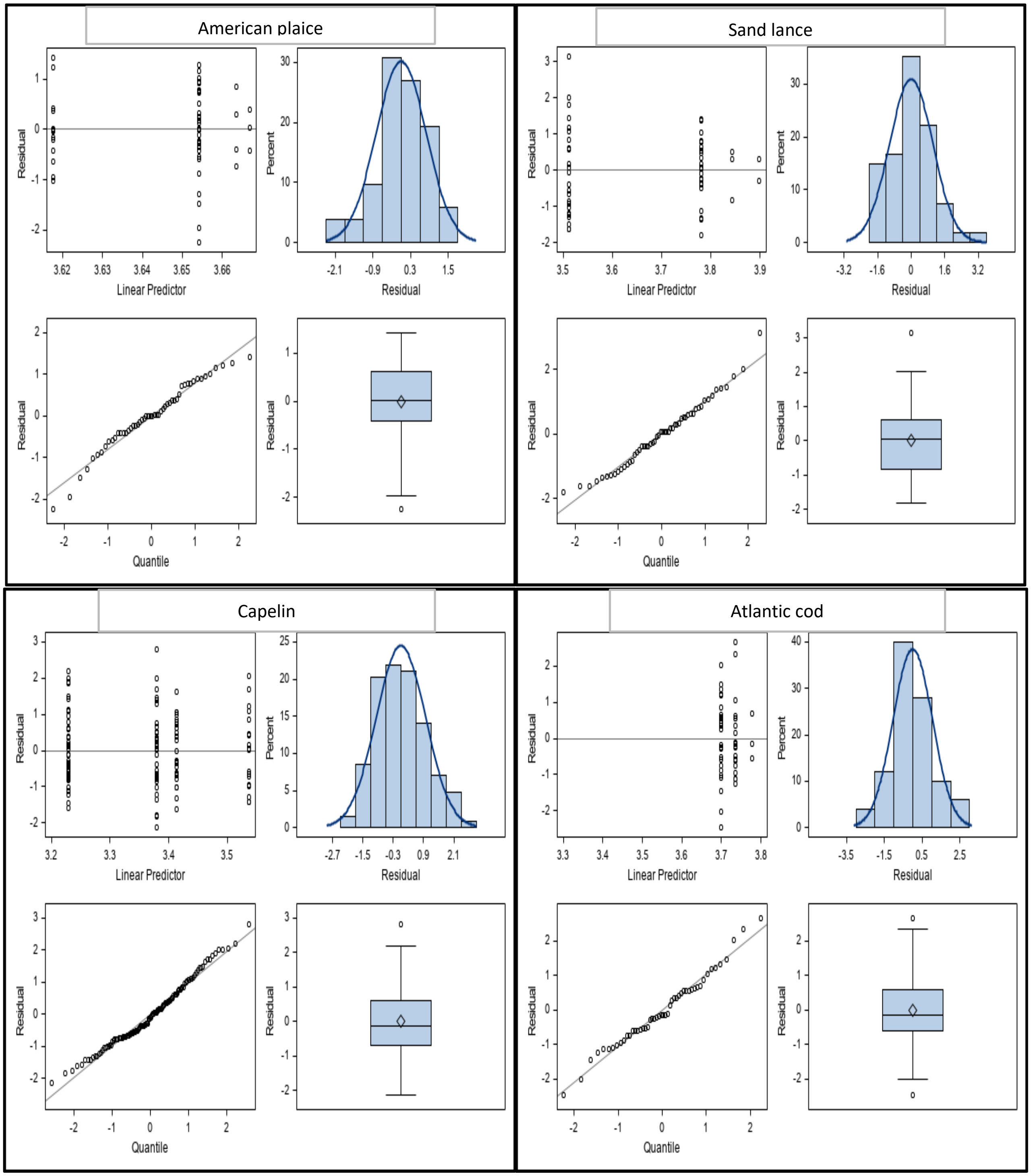

Figure 16. Studentized residual panel for the global GLM used to model the PAH metabolite, protein, for the species tested.

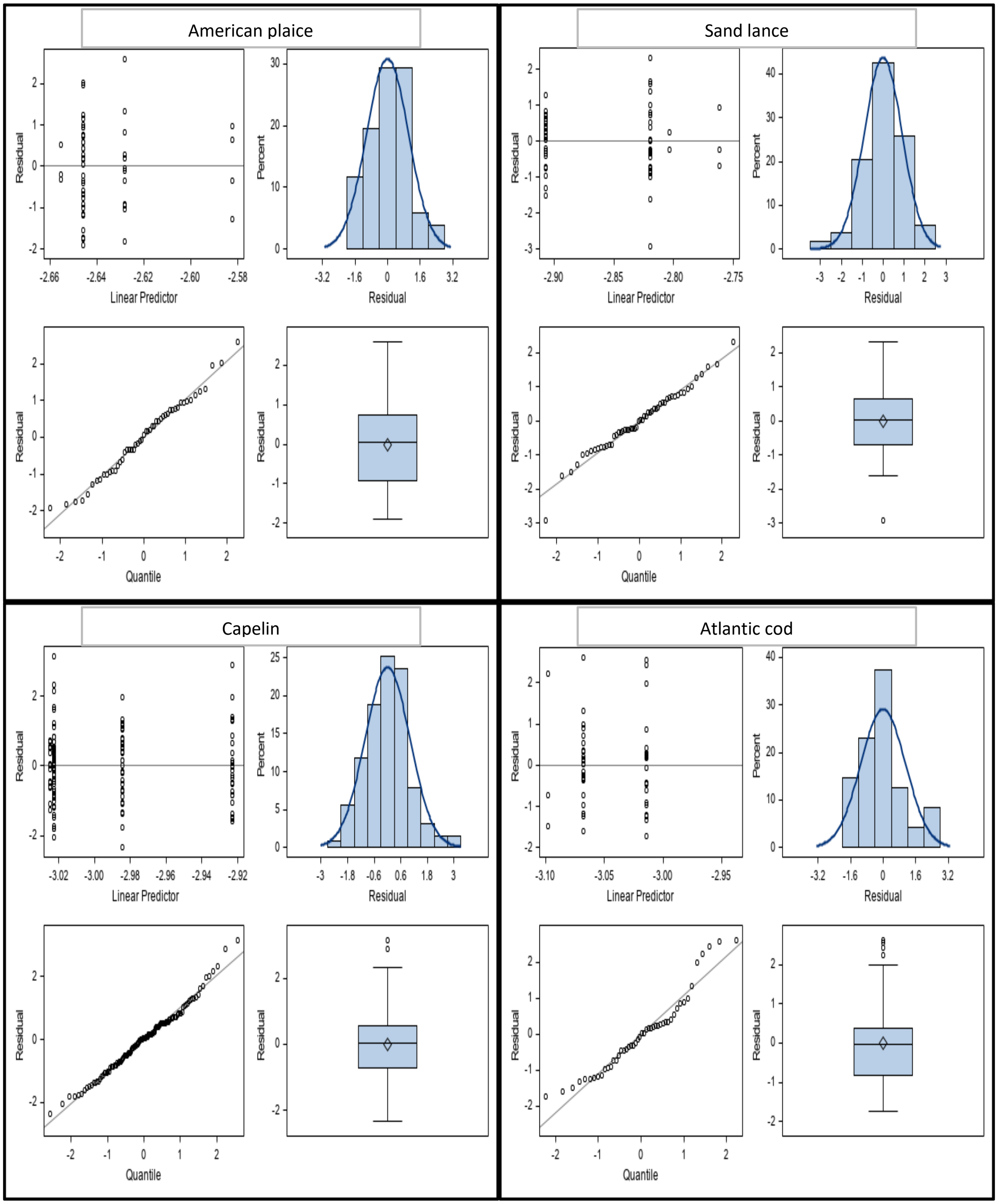

Figure 17. Studentized residual panel for the global GLM used to model the PAH metabolite, 2-Naphthol, for the species tested.

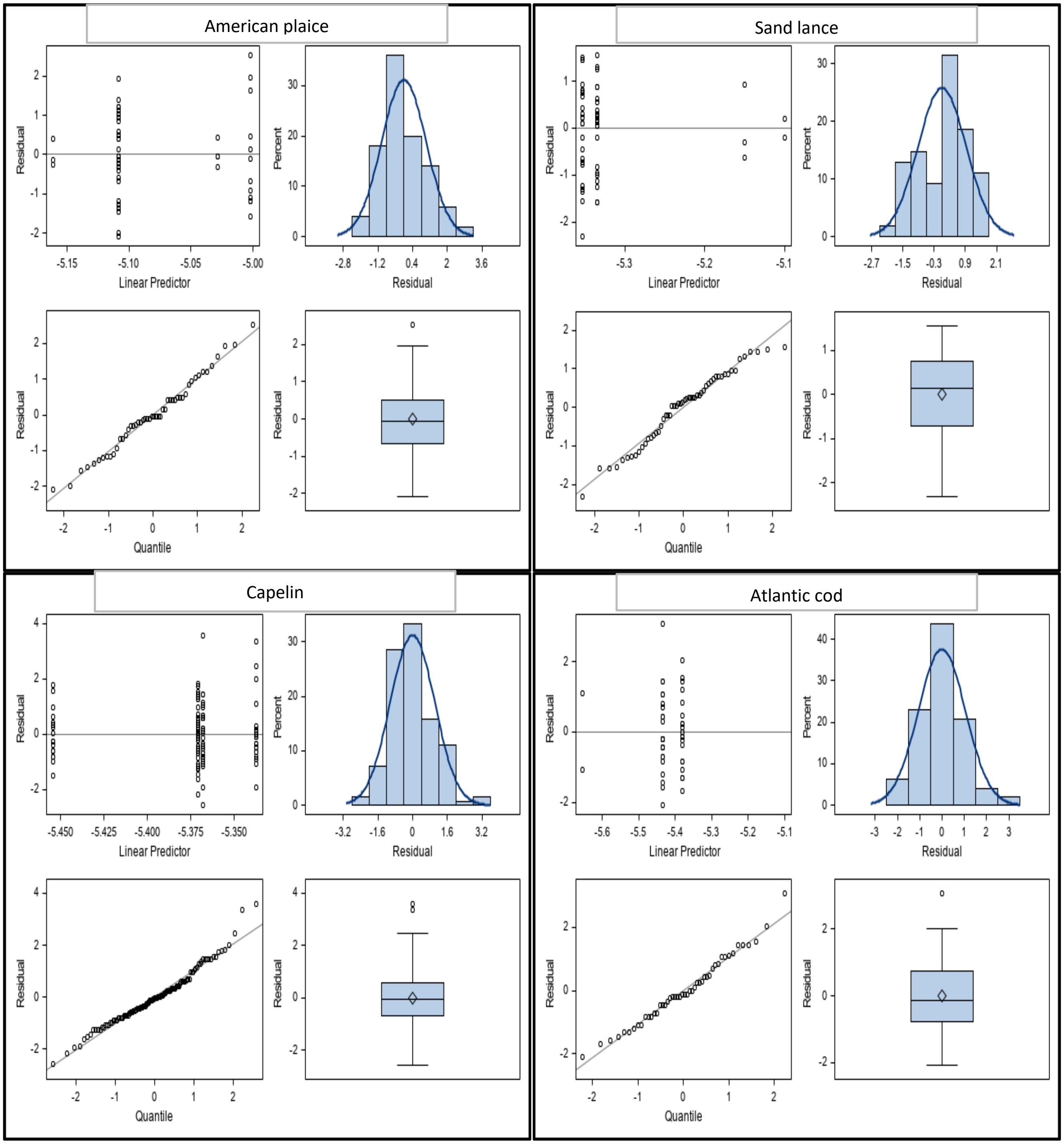

Figure 18. Studentized residual panel for the global GLM used to model the PAH metabolite, 9-Phenanthrol, for the species tested.

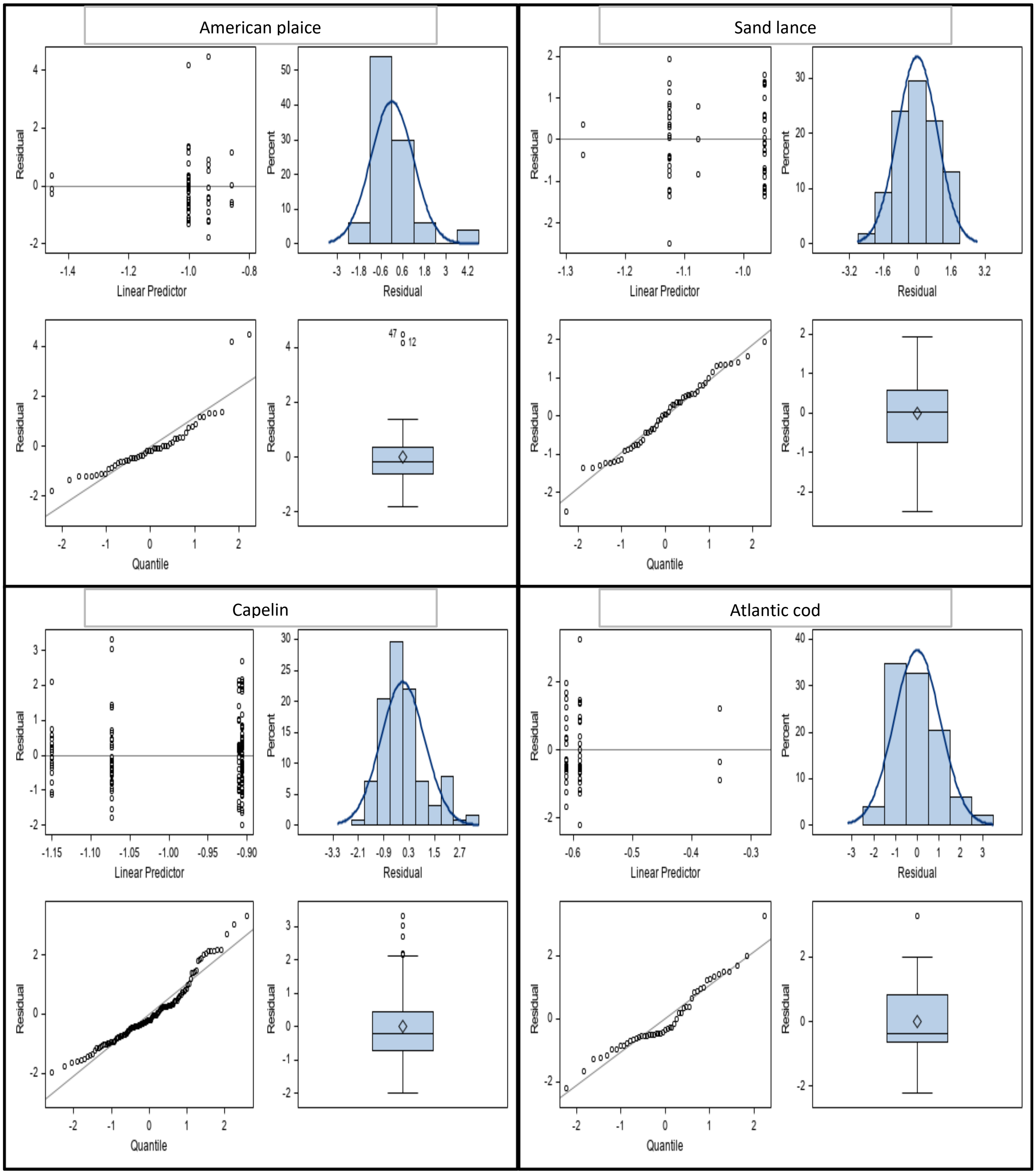

Figure 19. Studentized residual panel for the global GLM used to model the PAH metabolite, 1-OH Pyrene, for the species tested.

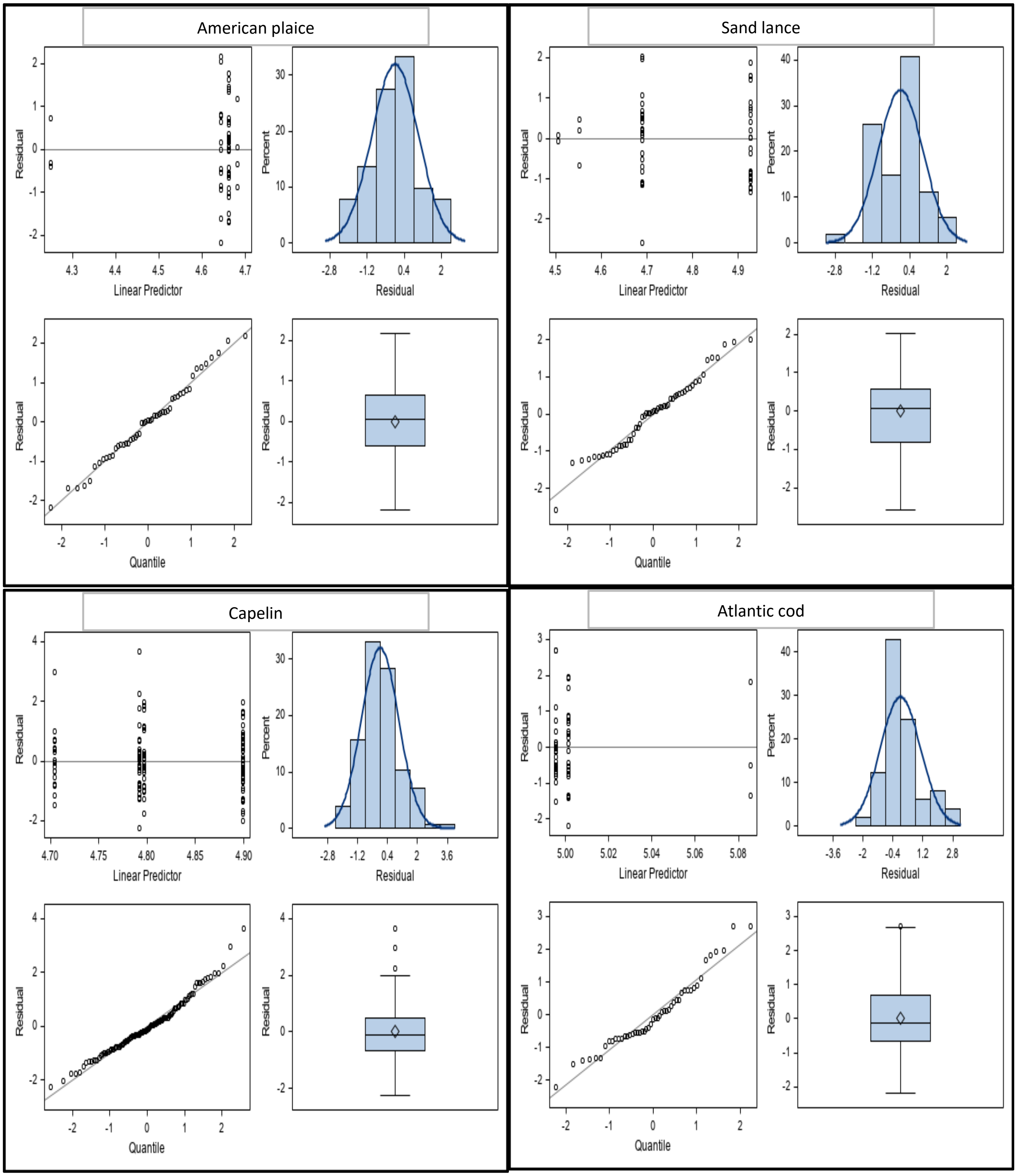

Figure 20. Studentized residual panel for the global GLM used to model the PAH metabolite, BaP, for the species tested.

Table 12. Akaike weights (reported as percentages) from GLMs of PAH metabolite responses. Weights are given for the null models (i.e., constant mean across all samples) and models containing the term *Site*.

Metabolite	Species	Model	
		Site	Null
Protein	Atlantic cod	25%	75%
	American plaice	3%	97%
	Capelin	80%	20%
	Sand lance	97%	3%
2-Naphthol	Atlantic cod	7%	93%
	American plaice	4%	96%
	Capelin	23%	77%
	Sand lance	6%	94%
9-Phenanthrol	Atlantic cod	42%	58%
	American plaice	14%	86%
	Capelin	14%	86%
	Sand lance	7%	93%
1-OH Pyrene	Atlantic cod	13%	87%
	American plaice	17%	83%
	Capelin	70%	30%
	Sand lance	16%	84%
BaP	Atlantic cod	3%	97%
	American plaice	21%	79%
	Capelin	28%	72%
	Sand lance	80%	20%

Reference Area *Site* levels of PAH metabolites were generally consistent with or greater than Treatment Area *Site* levels (Figures 21–25). The significant pairwise comparisons are as follow.

- Capelin collected at the Terra Nova Treatment Area had significantly higher protein levels (arithmetic mean = 34.36 mg/ml) than those collected at the Reference Area (arithmetic mean = 25.91 mg/ml) (Figure 21).
- Sand lance collected at the Hibernia Treatment Area had significantly lower protein levels (arithmetic mean = 34.91 mg/ml) than those collected at the Reference Area (arithmetic mean = 43.86 mg/ml) (Figure 21).
- Sand lance collected at the Hibernia Treatment Area had significantly higher BaP levels (arithmetic mean = 144.2 F.U./mg protein) than those collected at the Reference Area (arithmetic mean = 108.7 F.U./mg protein) (Figure 25).

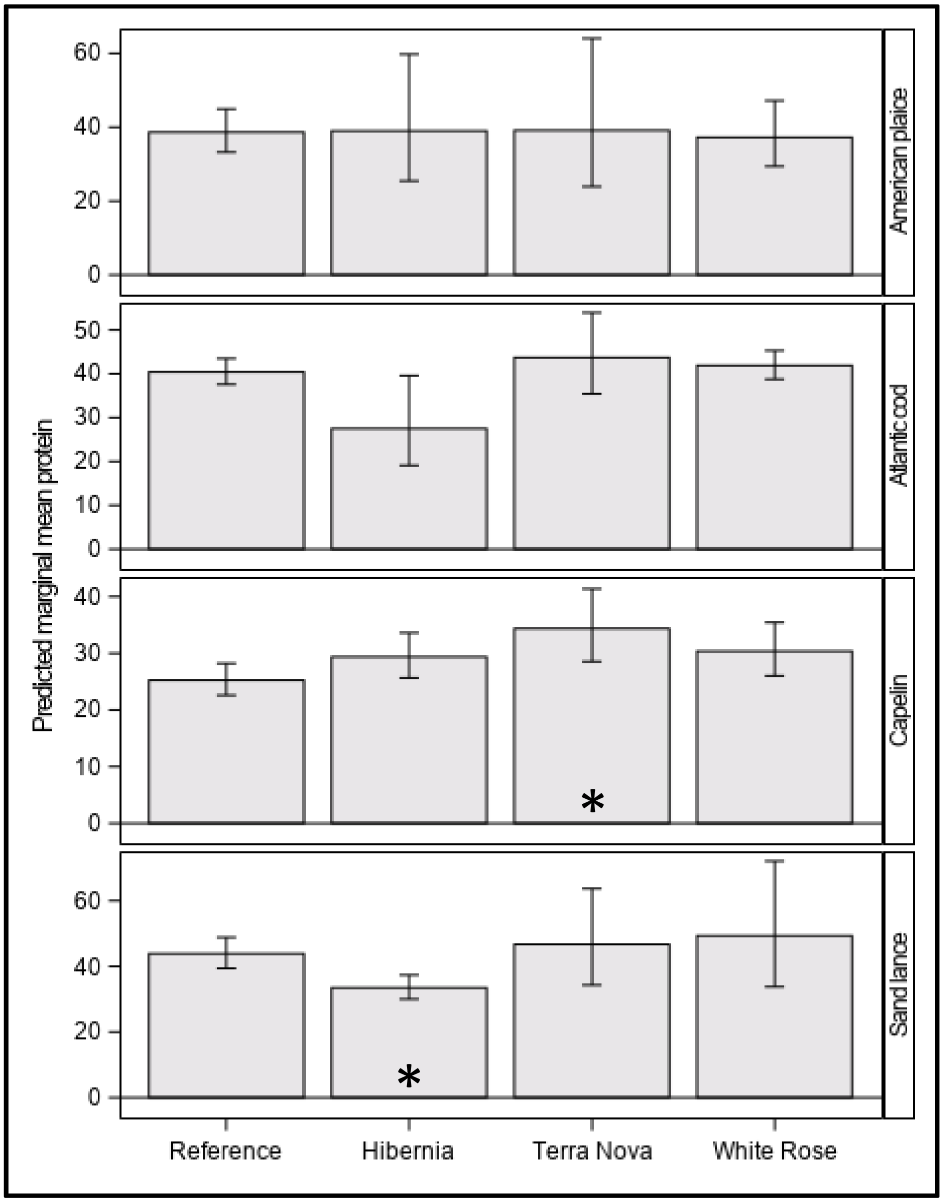

Figure 21. Predicted marginal mean protein with 95% confidence limits (error bars) for the species tested as a function of the categorical variable *Site*. Asterisks indicate a significant difference (α=0.05) from the Reference Area *Site*.

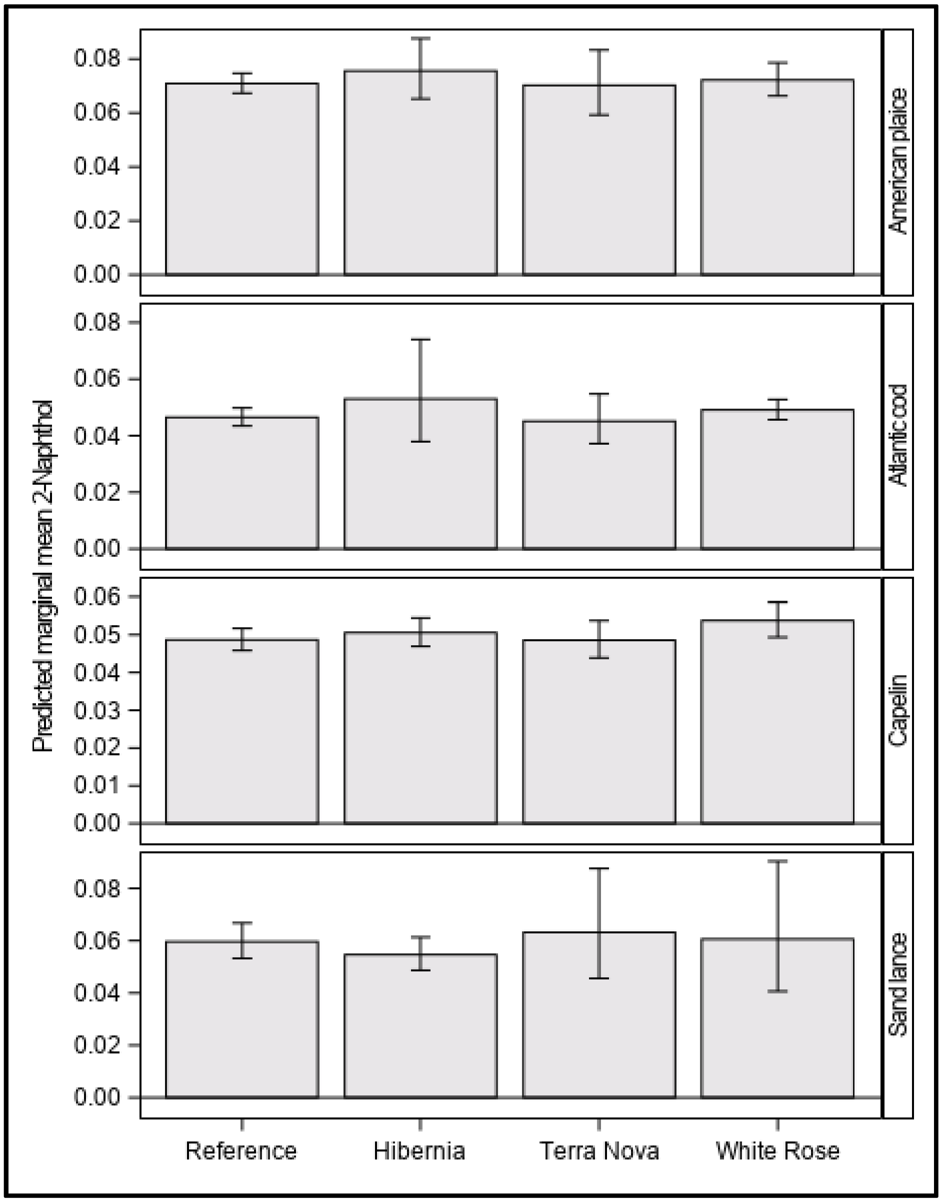

Figure 22. Predicted marginal mean 2-Naphthol with 95% confidence limits (error bars) for the species tested as a function of the categorical variable *Site.* Asterisks indicate a significant difference (α=0.05) from the Reference Area *Site.*

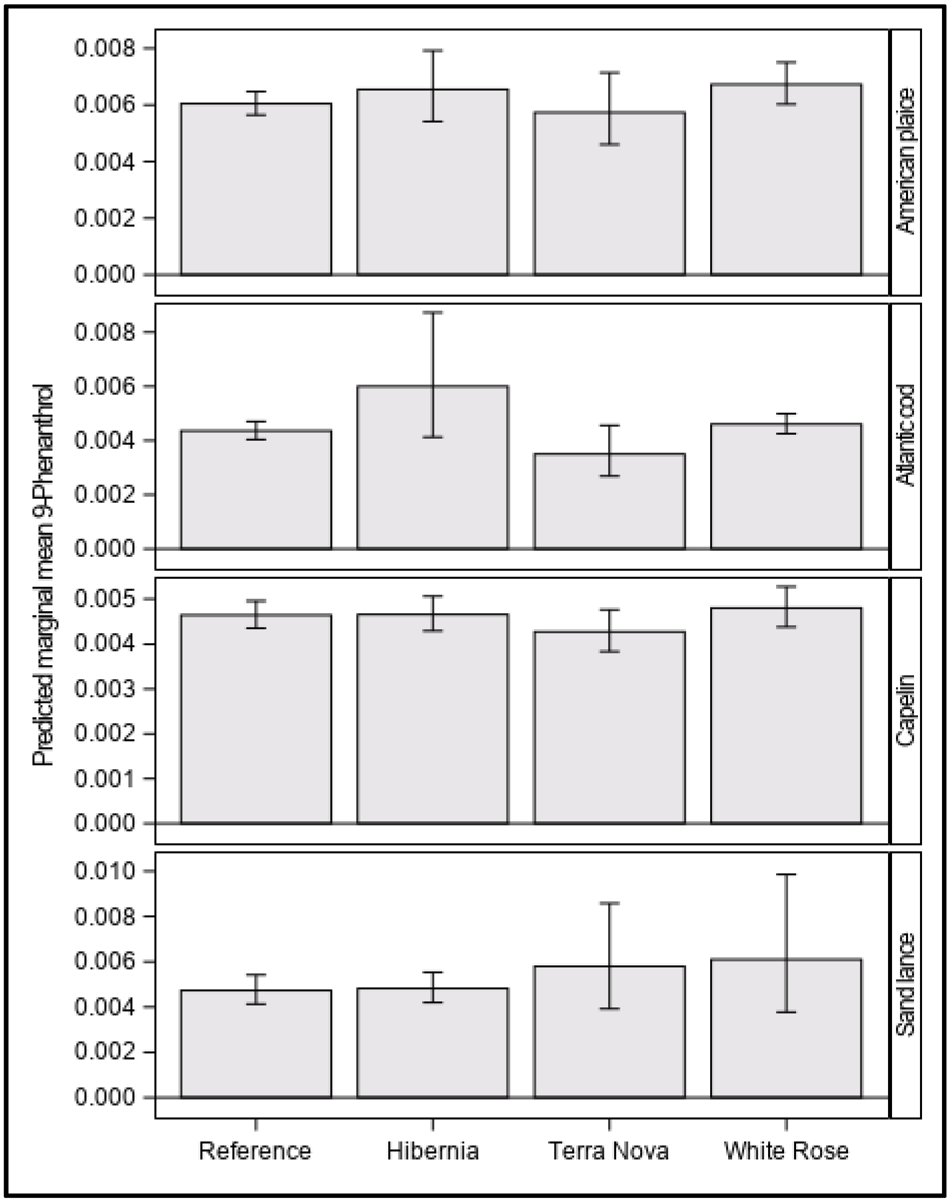

Figure 23. Predicted marginal mean 9-Phenanthrol with 95% confidence limits (error bars) for the species tested as a function of the categorical variable *Site.* Asterisks indicate a significant difference (α=0.05) from the Reference Area *Site.*

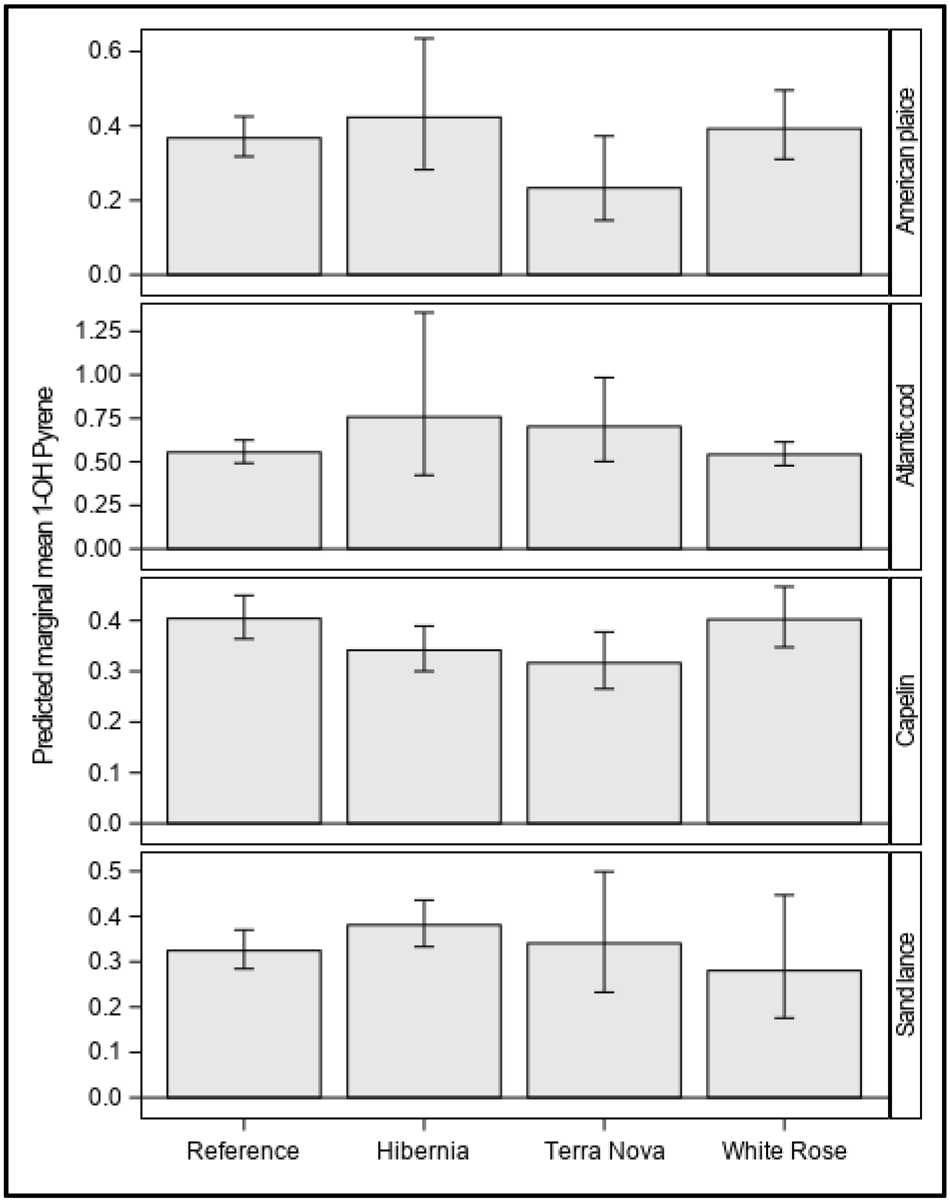

Figure 24. Predicted marginal mean 1-OH Pyrene with 95% confidence limits (error bars) for the species tested as a function of the categorical variable *Site.* Asterisks indicate a significant difference (α=0.05) from the Reference Area *Site.*

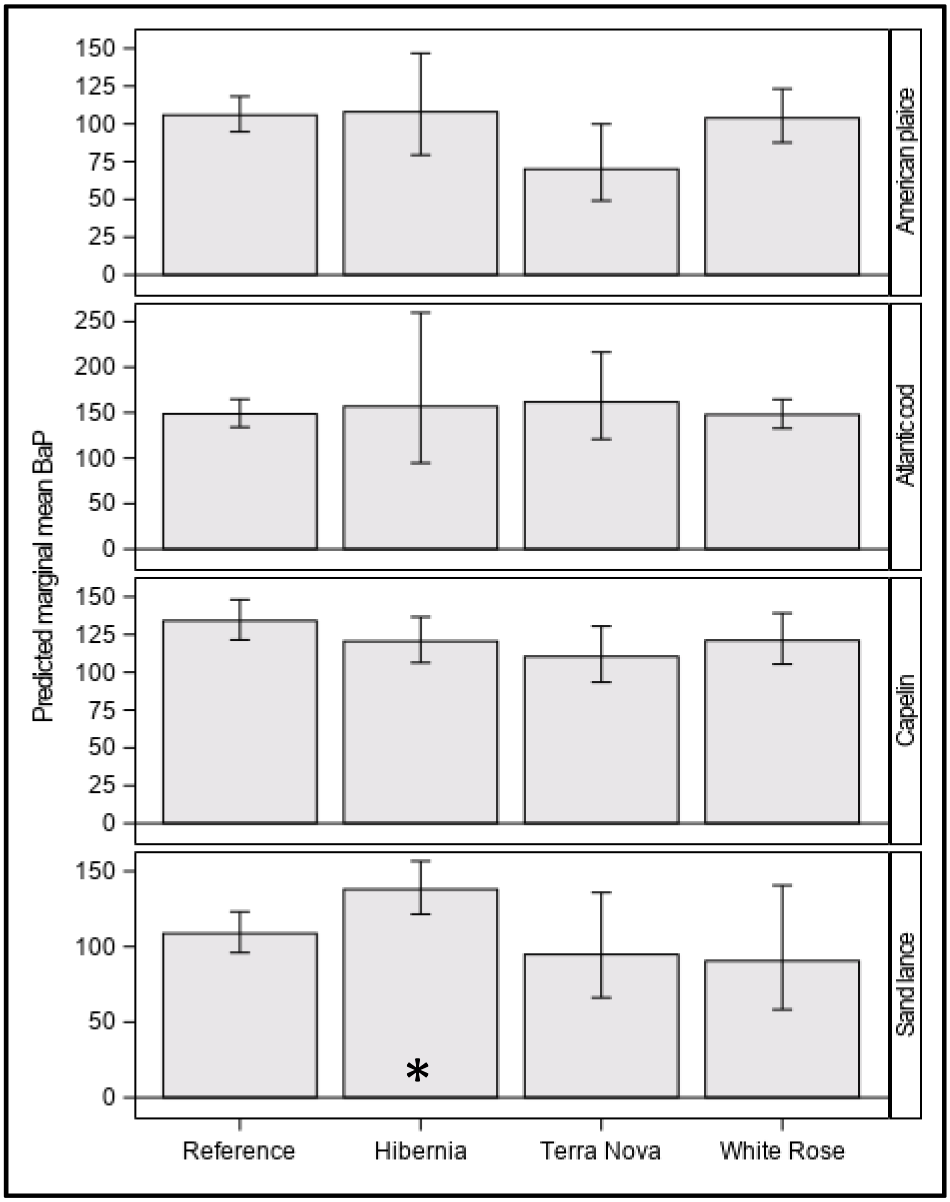

Figure 25. Predicted marginal mean BaP with 95% confidence limits (error bars) for the species tested as a function of the categorical variable *Site.* Asterisks indicate a significant difference (α=0.05) from the Reference Area *Site.*

3.4 Summary of EROD and Bile Metabolite Statistical Analyses

The statistically significant differences in EROD and bile metabolite levels between the Treatment Area fish and the Reference Area fish are indicated in Table 13. Results of both Oceans Ltd. and LGL statistical analyses are included.

Table 13. Summary of EROD and Bile Metabolite Statistical Analyses.

Species/ Source of Analysis	Variables					
	EROD	**Protein**	**2-Naphthol**	**9-Phenanthrol**	**1-OH Pyrene**	**BaP**
Atlantic cod						
Oceans						
LGL						
Sand lance						
Oceans		Hibernia **L**				Hibernia **H**
LGL	Terra Nova **L** White Rose **L**	Hibernia **L**				Hibernia **H**
Capelin						
Oceans	Hibernia **L**					
LGL	Hibernia **L**	Terra Nova **H**				
American plaice						
Oceans	Hibernia **L**					
LGL	Hibernia **L**					

'**L**' denotes that the level of the particular variable at the indicated Treatment Area is significantly lower than the level of that variable at the Reference Area

'**H**' denotes that the level of the particular variable at the indicated Treatment Area is significantly higher than the level of that variable at the Reference Area

Blank cells indicate no significant difference between Treatment Area and Reference Area

Note that the Oceans Ltd. and LGL statistical analysis results agreed with respect to significant differences for EROD in capelin and American plaice collected at the Hibernia Treatment Area, for protein in sand lance collected at the Hibernia Treatment Area, and for BaP in sand lance collected at the Hibernia Treatment Area.

Only the LGL statistical analysis found significant differences for EROD in sand lance collected at the Terra Nova and White Rose Treatment Areas, and for protein in capelin collected at the Terra Nova Treatment Area.

3.5 CTD

A total of 17 CTD casts were conducted; three at Hibernia, five at Terra Nova, one at White Rose, three at Reference Area Site A, three at Reference Area Site B, and two at Reference Area Site C. Summary information for the water temperature and salinity data at each sampling area is presented in Table 14 in chronological order. Appendix 7 presents the graphical representations of the 17 CTD casts.

Table 14. Specifics of CTD Casts and Water Column Profiles.

Date/Time of Day	Sampling Area	Minimum and Maximum Temperatures	Minimum and Maximum Salinity Levels/ Variability	Water Column Profile Description
July 19, 2017 15:45	Reference Area - Site A	Min: -1.0°C Max: 11.2°C	Min: 32.2 ppt Max: 33.1 ppt Most variability in salinity between 10-m and 40-m	Temperature constant @ 11.2°C from surface to 8-m Strong thermocline between 8-m and 35-m with temperature decreasing from 11.2°C to -0.5°C Gradual decrease in temperature between 35-m and 70-m from -0.5°C to -1.4°C Relatively constant temperature between 70-m and seabed (-1.2 to -1.4°C)
July 19, 2017 21:30	Reference Area - Site A	Min: -1.0°C Max: 10.7°C	Min: 32.2 ppt Max: 33.1 ppt Most variability in salinity between 10-m and 30-m	Temperature constant @ 10.7°C from surface to 8-m Strong thermocline between 8-m and 40-m with temperature decreasing from 10.7°C to 0.0°C Gradual decrease in temperature between 40-m and 55-m from 0.0°C to -1.2°C Relatively constant temperature between 55-m and seabed (-1.2 to -1.4°C)
July 20, 2017 13:00	Reference Area - Site A	Min: -1.4°C Max: 9.5°C	Min: 32.2 ppt Max: 33.1 ppt Most variability in salinity between 10-m and 40-m	Temperature constant @ 9.5°C from surface to 10-m Strong thermocline between 10-m and 22-m with temperature decreasing from 9.5°C to 4.5°C Temperature constant @ 4.5°C between 22-m and 30-m

Date/Time of Day	Sampling Area	Minimum and Maximum Temperatures	Minimum and Maximum Salinity Levels/ Variability	Water Column Profile Description
				Strong thermocline between 30-m and 42-m with temperature decreasing to -0.5°C Gradual decrease in temperature between 42-m and 52-m from -0.5°C to -1.3°C Relatively constant temperature between 52-m and seabed (-1.1 to -1.4°C)
July 20, 2017 21:45	Reference Area - Site B	Min: -1.2°C Max: 10.2°C	Min: 32.3 ppt Max: 33.1 ppt Most variability in salinity between 10-m and 40-m	Temperature constant @ 10.2°C from surface to 12-m Strong thermocline between 12-m and 20-m with temperature decreasing to 7.0°C Gradual decrease in temperature between 20-m and 70-m from -0.5°C to -1.2°C Relatively constant temperature between 57-m and seabed (-1.2 to -1.0°C)
July 21, 2017 11:00	Reference Area - Site B	Min: -1.2°C Max: 10.2°C	Min: 32.3 ppt Max: 33.1 ppt Most variability in salinity between 10-m and 60-m	Temperature constant @ 10.2°C from surface to 10-m Strong thermocline between 10-m and 13-m with temperature decreasing to 7.5°C Gradual decrease in temperature between 13-m and 55-m from 7.5°C to -0.75°C Slight decrease in temperature between 55-m and 87-m from -0.75°C to --1.0°C Relatively constant temperature between 87-m and seabed (-1.1 to -1.0°C)
July 21, 2017 18:10	Reference Area - Site B	Min: -1.2°C Max: 10.0°C	Min: 32.2 ppt Max: 33.1 ppt Most variability in salinity between 10-m and 60-m	Temperature constant @ 10.0°C from surface to 8-m Strong thermocline between 8-m and 12-m with temperature decreasing from 10.0°C to 6.5°C Gradual decrease in temperature between 12-m and 23-m from 6.5°C to 6.0°C

Date/Time of Day	Sampling Area	Minimum and Maximum Temperatures	Minimum and Maximum Salinity Levels/ Variability	Water Column Profile Description
				More gradual decrease in temperature between 23-m and 60-m from 6.0°C to --1.0°C Relatively constant temperature between 60-m and seabed (-1.2 to -1.0°C)
July 22, 2017 7:20	Terra Nova	Min: -1.0°C Max: 11.7°C	Min: 32.3 ppt Max: 32.9 ppt Most variability in salinity between 8-m and 35-m	Temperature constant @ 11.7°C from surface to 5-m Strong thermocline between 5-m and 10-m with temperature decreasing from 11.7°C to 8.0°C Gradual decrease in temperature between 10-m and 70-m from 8.0°C to -1.0°C Constant temperature between 70-m and seabed at -1.0°C
July 22, 2017 17:35	Terra Nova	Min: -1.0°C Max: 12.0°C	Min: 32.3 ppt Max: 32.9 ppt Most variability in salinity between 10-m and 30-m	Temperature constant @ 12.0°C from surface to 9-m Moderate thermocline between 9-m and 12-m with temperature decreasing from 12.0°C to 10.5°C Gradual decrease in temperature between 12-m and 70-m from 10.5°C to -1.0°C Constant temperature between 70-m and seabed at -1.0°C
July 23, 2017 7:25	Terra Nova	Min: -1.0°C Max: 11.8°C	Min: 32.3 ppt Max: 32.9 ppt Most variability in salinity between 10-m and 15-m	Temperature constant @ 11.8°C from surface to 10-m Strong thermocline between 10-m and 13-m with temperature decreasing from 11.8°C to 8.0°C Gradual decrease in temperature between 13-m and 70-m from 8.0°C to -1.0°C Constant temperature between 70-m and seabed at -1.0°C
July 24, 2017 17:10	White Rose	Min: -1.5°C Max: 11.0°C	Min: 32.1 ppt Max: 33.5 ppt Most variability in salinity between 20-m and 40-m	Gradual decrease in temperature between surface and 20-m from 11.0°C to 9.3°C

Date/Time of Day	Sampling Area	Minimum and Maximum Temperatures	Minimum and Maximum Salinity Levels/ Variability	Water Column Profile Description
				Strong thermocline between 20-m and 43-m with temperature decreasing from 9.3°C to -1.5°C Temperature constant between 43 -m and 73-m at -1.5°C Slight increase in temperature between 73-m and seabed from -1.5°C to -0.75°C
July 25, 2017 7:30	Hibernia	Min: -0.75°C Max: 11.4°C	Min: 32.3 ppt Max: 32.9 ppt Most variability in salinity between 10-m and 60-m	Temperature constant @ 11.4°C from surface to 10-m Strong thermocline between 10-m and 12-m with temperature decreasing from 11.4°C to 9.0°C Gradual decrease in temperature between 12-m and 30-m from 9.0°C to 3.5°C More rapid decrease in temperature between 30-m and 60-m from 3.5°C to 1.0°C Strong thermocline between 60-m and 63-m with temperature decreasing from 1.0°C to -0.5°C Constant temperature between 63-m and seabed at -0.5°C
July 25, 2017 18:30	Hibernia	Min: -0.5°C Max: 11.5°C	Min: 32.3 ppt Max: 32.8 ppt Most variability in salinity between 10-m and 60-m	Temperature constant @ 11.5°C from surface to 9-m Strong thermocline between 9-m and 11-m with temperature decreasing from 11.5°C to 8.7°C Gradual decrease in temperature between 11-m and 22-m from 8.7°C to 4.5°C More rapid decrease in temperature between 22-m and 57-m from 4.5°C to 0.5°C Moderate thermocline between 57-m and 60-m with temperature decreasing from 0.5°C to -0.5°C Constant temperature between 60-m and seabed at -0.5°C

Date/Time of Day	Sampling Area	Minimum and Maximum Temperatures	Minimum and Maximum Salinity Levels/ Variability	Water Column Profile Description
July 26, 2017 22:35	Reference Area - Site C	Min: -1.4°C Max: 11.9°C	Min: 31.8 ppt Max: 33.4 ppt Most variability in salinity between 10-m and 40-m	Temperature constant @ 11.9°C from surface to 10-m Strong thermocline between 10-m and 40-m with temperature decreasing from 11.9°C to -1.0°C Relatively constant temperature between 40-m and seabed (-1.5°C to -0.75°C)
July 27, 2017 7:20	Reference Area - Site C	Min: -1.4°C Max: 11.9°C	Min: 31.8 ppt Max: 33.4 ppt Most variability in salinity between 10-m and 40-m	Temperature constant @ 11.9°C from surface to 10-m Strong thermocline between 10-m and 40-m with temperature decreasing from 11.9°C to -1.0°C Relatively constant temperature between 40-m and seabed (-1.5°C to -0.75°C)
July 27, 2017 22:40	Terra Nova	Min: -1.0°C Max: 11.5°C	Min: 32.3 ppt Max: 32.9 ppt Most variability in salinity between 13-m and 70-m	Temperature constant @ 11.5°C from surface to 12-m Moderate thermocline between 12-m and 13-m with temperature decreasing from 11.5°C to 10.7°C Gradual decrease in temperature between 13-m and 16-m from 10.7°C to 10.4°C Less gradual decrease in temperature between 16-m and 70-m from 10.4°C to -1.0°C Relatively constant temperature between 70-m and seabed (-1.5°C to -0.75°C) Constant temperature between 70-m and seabed at -1.0°C
July 28, 2017 7:10	Terra Nova	Min: -1.0°C Max: 11.9°C	Min: 32.3 ppt Max: 32.8 ppt Most variability in salinity between 20-m and 50-m	Temperature constant @ 11.9°C from surface to 12-m Gradual decrease in temperature between 12-m and 70-m from 11.9°C to -1.0°C Constant temperature between 70-m and seabed at -1.0°C

Date/Time of Day	Sampling Area	Minimum and Maximum Temperatures	Minimum and Maximum Salinity Levels/ Variability	Water Column Profile Description
July 28, 2017 22:50	Hibernia	Min: -0.5°C Max: 12.5°C	Min: 32.3 ppt Max: 32.8 ppt Most variability in salinity between 15-m and 55-m	Temperature constant @ 12.5°C from surface to 5-m Moderate thermocline between 5-m and 7-m with temperature decreasing from 12.5°C to 11.7°C Relatively constant temperature between 7-m and 17-m at 11.7°C Strong thermocline between 17-m and 19-m with temperature decreasing from 11.7°C to 8.8°C Gradual decrease in temperature between 19-m and 32-m from 8.8°C to 4.0°C More rapid decrease in temperature between 32-m and 50-m from 4.0°C to 2.0°C Gradual decrease in temperature between 50-m and 55-m from 2.0°C to -0.5°C Constant temperature between 55-m and seabed at -0.5°C

4.0 Discussion

4.1 Fish Total Length

Information on fish biological characteristics and condition is valuable for interpreting results of biomarker studies (Adams 2002; Levine et al. 1995). Although a limited number of fish are being analyzed from a population perspective (Dutil et al. 1995), these types of data could also provide a level of information for assessing major effects on animal condition. Significant differences in total length of the juvenile fishes between sampling areas were observed for all species except Atlantic cod. A clear geographical pattern of species size was not identified. For example, significantly larger American plaice were collected at the Terra Nova Treatment Area, significantly larger capelin were collected at the White Rose Treatment Area, and the largest sand lance were collected at the Reference Area. It is possible that environmental conditions at each sampling area were different enough to favour particular species; however, this determination was outside the scope of this study. Additional variables, such as gear type and time of day of fish collection, were not included in the GLM analysis because sample sizes were too small to accommodate any more terms in the model.

Since EROD activity has been shown to be influenced by fish size (Whyte et al. 2000), the mean total lengths of the pooled fish for each S9 preparation were used for statistical analysis of EROD activity. EROD results are discussed in Section 4.2.

4.2 MFO Activity

The induction of EROD activity has been used extensively as a biomarker of exposure in both laboratory and field studies due to its high sensitivity to aromatic compounds (Mathieu et al. 2011; Whyte et al. 2000) Although EROD activity is most commonly measured as an indicator of exposure to planar halogenated hydrocarbons (PHHs) and PAHs, its sensitivity to a wide range of chemicals that share similar structure and toxic activity makes it suitable as a biomarker of exposure (Whyte et al. 2000).

Across all species tested, none of the sites exhibited higher EROD activity than the Reference Area (see Figure 15). However, EROD activity for sand lance was lower at the Terra Nova and White Rose Treatment Areas than at the Reference Area. Likewise, capelin and American plaice had lower EROD estimates at the Hibernia Treatment Area compared to the Reference Area.

For this study, it was necessary to pool samples of fish of the same species with similar total lengths in order to obtain sufficient amounts of liver tissue for the EROD assay. For American plaice, sand lance and capelin, the livers of three fish were pooled for S9 preparation. For Atlantic cod, the livers of two fish were pooled for S9 preparation.

EROD activity was lowest in American plaice, capelin and Atlantic cod collected at the Hibernia Treatment Area, although significant differences ($p < 0.05$) when compared to the Reference Area were only detected in American plaice and capelin. The reason for the differences in EROD activity between sampling areas is unclear. Since fish size has been observed to have an effect on EROD activity (Whyte et al. 2000) and there was high variability in the total length of the fish in this study, the possible effect of fish size on the EROD activity was examined by the analytical laboratory using Analysis of Covariance (ANCOVA). To perform the ANCOVAs, the average size of the grouped fish utilized for the S9 preparation was used. Results of the ANCOVAs showed that there was a significant effect of fish size on the hepatic EROD activity ($p = <0.001$) for all species, except American plaice. However, the results still showed a significant effect of sampling area ($p < 0.05$) on EROD activity with the same pattern of activity being observed for each species.

The statistical analysis using GLMs also found fish size (*TL*) and sampling area (*Site*) effect on EROD levels (see Table 8). The Akaike weights for the TL term ranged from 85% for Atlantic cod to 100% for both capelin and sand lance. For the *Site* term, the Akaike weights ranged from 97% to 100% for American plaice, capelin and sand lance. Sampling area had minimal effect on EROD levels found in Atlantic cod (Akaike weight of 5%).

Another possible effector on EROD level could be the depth at which the fish were captured at each Treatment Area. Produced water consists of water trapped with oil and gas in the reservoirs of the ocean subfloor together with water injected during the drilling process to maintain the reservoirs pressure (Pérez-Casanova et al. 2012; Utvik 1999). PAHs are found in produced water, and as mentioned above, EROD activity is commonly used to estimate exposure to PAHs. The depth of the produced water discharge locations at each production platform is variable. For example, at Hibernia, the discharge occurs at an approximate 40 m depth (Lee et al. 2011), while at White Rose, the produced water is discharged at a depth of 5 m (Neff et al. 2011). However, considering the relatively rapid dilution of produced water close to discharge, the considerable distance of fish sampling from the production platforms, and the mobility of the fishes, depth of capture as an effector of EROD level is highly speculative.

Lastly, the differences in composition and volume of the produced water being discharged at the production platforms could have an effect on EROD levels. Sturve et al. (2006) described that the alkylphenols (AP) in produced water significantly inhibit the induction of EROD in Atlantic cod. Olsvick et al. (2009) reported down-regulation of several cytochrome P450 genes, including CYP1A, in Atlantic cod exposed for six weeks to nonylphenol, an alkylphenol. While the specific compositions of produced water being discharged during this study's short period of sampling are unknown, alkylphenols have accounted for almost 50% of total phenols in Hibernia produced water in the past (Burridge et al. 2013). Pérez-Casanova et al. (2012) reported concentrations of total phenols and alkylphenol in Hibernia produced water of 14,934 μg/L and 9,894 μg/L, respectively. Thus, it is possible, yet speculative, that the EROD activity in American plaice, capelin and, to a lesser extent, Atlantic cod could have been suppressed by the produced water from the Hibernia platform.

Furthermore, it is noteworthy that the composition of produced water is highly variable (Pérez-Casanova et al. 2012; Neff et al. 2011), and therefore fish of the same species collected at different sampling areas in this study may have responded differently to the different produced water-types. For example, the total phenol concentrations in produced water from the White Rose and the Terra Nova platforms have been measured at 3.522 μg/L and 4.042 μg/L respectively (Courtenay et al. 2013), considerably lower than the 14,934 μg/L measured in produced water discharged from the Hibernia platform (Pérez-Casanova et al. 2012).

4.3 PAH Metabolites

Polycyclic aromatic hydrocarbons are ubiquitous pollutants that are produced by pyrogenic and petrogenic sources. Fish absorb PAHs through the gills and body surface but PAHs can also be absorbed through contaminated sediment and food consumed (Lee et al. 2011; Vuontisjärvi et al. 2004). Since PAHs are rapidly transformed into more hydrophilic metabolites that are subsequently excreted, fish exposed to these compounds show only trace amounts of PAH in their tissues (Tuvikene 1995). PAH metabolites are usually determined in fish bile where they are concentrated and stored prior to excretion. Biliary PAH metabolite analysis provides information about the actual exposure of fish to PAH compounds and reveals the state and suitability of the marine environment for fish. The protein concentration in the bile is used to standardize the levels of PAH metabolites (the fluorescence units in the case of BaP). This standardization can account for the differences in levels of PAH metabolites due to differences in the feeding status of the fish (Yang et al. 2003; Stein et al. 1992; Collier and Varanasi 1991).

In the current study, there were no significant differences in the concentration of biliary PAH metabolites between sampling areas for Atlantic cod and American plaice, based on the statistical analyses conducted by Oceans Ltd. and LGL.

While the Oceans statistical analysis indicated no significant differences in capelin PAH metabolite levels between sampling areas, the LGL analysis indicated that protein levels in capelin bile collected at the Terra Nova Treatment Area were significantly greater than those observed at the Reference Area. Again, this could be due to the capelin collected at the Reference Area having recently fed.

For sand lance, the statistical analyses conducted by Oceans Ltd. and LGL both concluded that when the levels of BaP were analyzed as F.U./ml, there was no significant difference observed (i.e., $p = 0.562$) between sites. However, when the results were normalized using protein concentration in the bile, the BaP levels in sand lance collected at the Hibernia Treatment Area were significantly greater than those observed in sand lance collected at the Reference Area. Protein concentration in bile is used to normalize the concentrations of biliary PAH metabolites because it helps to account for variation in the PAH metabolite concentration due to differences in the feeding status of the fish (Yang et al. 2003; Collier and Varanasi 1991). During periods when fish do not feed, bile concentrates in the gall bladder, and when the fish does feed, the bile is released into the intestine via the common bile duct. Upon release of the bile from the gall bladder, water enters the gall bladder relatively quickly, thus diluting the remaining bile and resulting in a lower protein concentration (Richardson et al. 2004). PAHs are ubiquitous pollutants in the marine environment that originate from petrochemical pollution and/or from incomplete combustion processes (Viñas et al. 2010; Beyer et al. 1997). When analyzing PAHs using fluorescence, the signal intensity ratios can provide information about the source of the PAH. When fish are exposed to a source of petrochemicals, the dominant fluorescence signal occurs at 290/335 nm, indicating a mixture of naphthalene metabolites (e.g., crude oil). On the other hand, strong fluorescence signals at 341/383 nm (i.e., pyrene) and 380/430 nm (i.e., BaP) indicate that the PAHs originated from a combustion source. While BaP is a minor component of raw crude oil, its levels increase substantially after combustion of the oil (Lee et al. 1972). Therefore, although the source of the BaP metabolites in the bile of sand lance collected at the Hibernia Treatment Area is unknown, their presence might indicate a combustion source. The source of background levels of all PAH equivalents in the bile of oceanic fish in general could be mostly related to ship traffic (J. Payne, DFO Scientific Investigator, pers. comm., April 2018). Furthermore, the elevated BaP level reported for sand lance at the Hibernia Treatment Area may just be a spurious result as there was only an 80% chance that sites varied with respect to this response (see Table 12).

4.4 Specifics of Produced Water Discharges

After the field work was completed, specifics related to produced water discharges during the time of field sampling were requested from the Operators of Hibernia, Terra Nova and White Rose. Information provided by the Operators is indicated below in Table 15.

Table 15. Produced Water Specifics.

Production Site	Dates of Provided Data	Range of Daily Volumes of Discharged Produced Water (m^3)	Range of Daily Oil:Water Ratios (mg/L)	Depth of Produced Water Discharge (m)
Hibernia	July 24–25, 28	15,964–17,648	10.0–11.8	+40
Terra Nova	July 21–23, 2–28	13,516–16,504	17.4–22.0	15
White Rose	July 23–24	8,990–10,729	14.2–14.4	11

Sources: HMDC, Suncor and Husky (2018).

Cursory examination of these produced water data did not provide any more basis for further explanation related to the observed EROD and bile metabolite levels, and the differences in these levels between the Treat Areas and the Reference Area.

4.5 Water Temperature and Salinity Profiles

Despite some of the differences in the water temperature and salinity data observed between sampling areas, they cannot be conclusively regarded as potential reasons for differences in fish catches and observed bioindicator levels between sampling areas.

5.0 Conclusions

All sampled species except for Atlantic cod showed significant differences in total length between the sampling areas. American plaice collected at the Terra Nova Treatment Area were significantly larger than plaice collected at the other three sampling areas. Capelin collected at the White Rose Treatment Area were significantly larger than those sampled at the other three sampling areas while those collected at the Reference Area were significantly larger than capelin caught at the Terra Nova and Hibernia Treatment Areas. Sand lance collected at the White Rose Treatment Area and the Reference Area were significantly larger than sand lance sampled at the Terra Nova and Hibernia Treatment Areas.

Laboratory analysis and subsequent statistical analyses indicated significant differences of EROD activity between sampling areas for all species except Atlantic cod. It was determined that both fish total length and sampling area had significant effect on the observed EROD levels. The primary findings of the Study with respect to observed EROD levels are as follow:

- American plaice collected at the Hibernia Treatment Area had significantly lower EROD levels than those collected at the Reference Area;
- Capelin collected at the Hibernia Treatment Area had significantly lower EROD levels than those collected at the Reference Area; and
- Sand lance collected at the Terra Nova and White Rose Treatment Areas had significantly lower EROD levels than those collected at the Reference Area.

While the cause of these differences is inconclusive, it is possibly due to differences in fish size and/or differences in the volumes and compositions of produced water discharged from each production platform as discussed in Section 4.0 of this report. Some data related to the volumes and oil-to-water ratios of the produced water discharged from the three production platforms during fish sampling were provided by the production site Operators after sampling was completed. However, the within and between sample site variation in those data (see Table 15) did not provide any persuasive argument for the observed differences in EROD and bile metabolite levels.

Laboratory analysis and subsequent statistical analyses indicate significant differences in bile metabolite levels in sand lance only. The primary findings of the Study with respect to observed bile metabolite levels are as follow:

- Sand lance collected at the Hibernia Treatment Area had significantly lower protein levels than those collected at the Reference Area;
- Capelin collected at the Terra Nova Treatment Area had significantly higher levels of protein than those collected at the Reference Area; and
- Sand lance collected at the Hibernia Treatment Area had significantly higher BaP levels than those collected at the Reference Area.

The difference between BaP concentration measured in sand lance collected at the Hibernia Treatment Area and that measured in sand lance collected at the Reference Area is likely due to the difference in biliary protein concentration measured in the same fish since PAH metabolites were standardized to the biliary protein concentration.

Despite some differences between sampling areas in terms of water temperature and salinity and the locations of their respective clines, they cannot be conclusively regarded as potential reasons for differences in fish catches and observed bioindicator levels between sampling areas.

In summary, neither of the two health bioindicators (i.e., MFO activity and PAH metabolite levels) provided a clear signal that could be attributed to exposure to hydrocarbon-containing discharges from the production platforms.

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Appendix 1

Field Execution Plan

Field Execution Plan for ESRF

Juvenile Fish Sampling Program

Introduction

During the latter part of July 2017, LGL Limited and its sub-contractors will be conducting a field program that involves the collection of juveniles of four finfish species using three methodologies; bottom trawling with a Campelen 900 trawl, pelagic trawling with an IYGPT trawl, and fishing with fixed gear, namely baited pots. The fixed gear will consist of 25 baited pots deployed along the seafloor, and 25 baited pots on a vertical line extending up into the water column. The collected juveniles will subsequently be analyzed in a laboratory back on shore to determine whether or not the juvenile fishes have been exposed to hydrocarbons, specifically produced water being discharged at each production platform. Juvenile fishes will be collected at each of the three production areas and at a reference station (WR-R1) located about 28 km northwest of White Rose (see Figure 1). Mobilization will commence on July 16. The tentative date for sailing is 18 July 2017. The 14-day field program will consist of 2 days of transit, one day each way, and three days of effort at each of the four sampling areas.

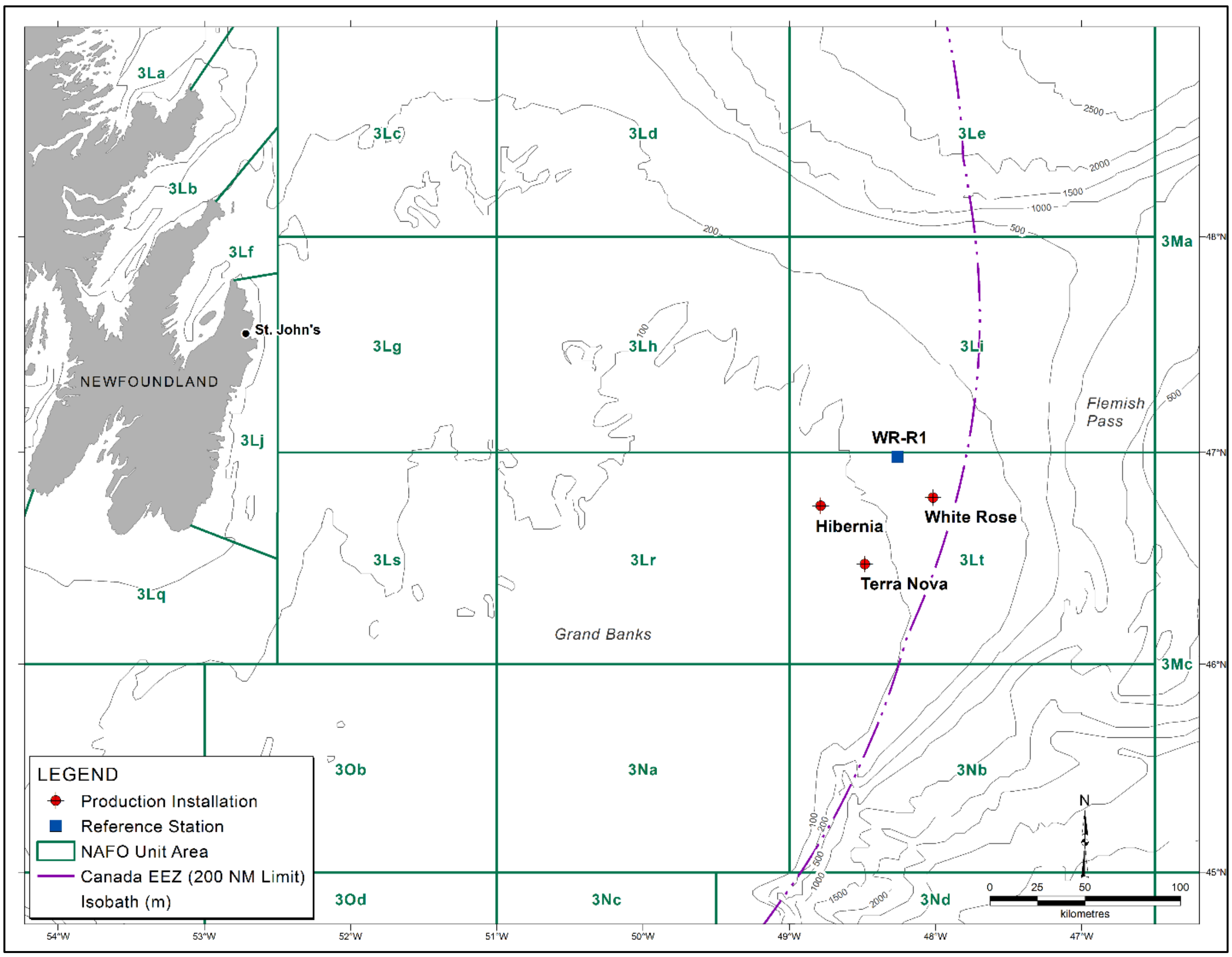


Figure 1. Locations of the Offshore Newfoundland and Labrador Juvenile Fish Sampling Areas – Hibernia, Terra Nova, White Rose and Reference Site (WR-R1).

The primary objectives of the field program are as follow:

- Collect 50 juvenile specimens of Atlantic cod, American plaice, capelin and sand lance at each of the four sampling areas. Specimens will be frozen in dry ice after morphometric data has been collected from each specimen;

- Produce a reference collection of juvenile fishes to help with the final identification of the frozen specimens back on shore. The reference collection samples will be fixed in propanol aboard the sampling vessel; and

- Collect physical and chemical data from the water column by conducting frequent CTD casts.

The field program will be conducted from the 65-foot fishing vessel *FV Joyful Sound*. The study team going to sea will consist of three biologists plus the vessel captain Matthew Petten and his 3-person crew. The three biologists are Andrew Murphy (LGL Limited), Narcissus Walsh (Narwhal Environmental) and Phil Walsh (Marine Institute). Narcissus will serve as field leader. John Christian of LGL Limited will serve as Project Manager and he will be engaged with the at-sea team throughout the 14-day field program.

Fisheries and Oceans Canada-issued experimental fishing license and Species at Risk permit have been obtained by LGL.

The *FV Joyful Sound* will have satellite phone capability enabling daily update reports to be sent to John Christian at LGL Limited.

All activities at sea will be geo-referenced using the GPS systems installed on the fishing vessel. All sampling activities will occur outside of the areas defined by Suncor, Husky and HMDC as 'no entry' areas. For the purposes of this juvenile fish sampling program, all three of the defined areas are being referred to as "exclusion zones'.

The specific sampling design at each of the four sampling areas is provided in Figure 2 (i.e., sampling survey area). Five parallel trawling transects will be established 0.5 km apart. Both the bottom trawling and the pelagic trawling will be conducted along these transects. Tows are anticipated to be 10-15 minutes in duration along each transect. The fixed gear (i.e., a single fleet of baited pots) will be deployed along the same orientation between the trawling transects (i.e., 250 m from any trawling transect). The soak time (i.e., the period of time between deployment and retrieval; fishing time) for the initial deployment of the baited pots will be ~ 8 hours. Soak times will be adjusted depending on catch success. The fixed gear will be moved for subsequent deployment after each retrieval. The fixed gear will be deployed before any trawling commences. The tracks of the trawl tows and the fixed locations of the fleet of pots will be geo-referenced.

Based on water current information and Operator-defined limitations on vessel approach to the drilling platforms, sampling transects will be established to the south of the Terra Nova FPSO, to the southeast of the White Rose FPSO, and to the north and southwest of the Hibernia GBS. Water current data suggest that in the upper water column at Hibernia in July, water currents tend to move in a southerly direction but that water currents below the thermocline and halocline show more northerly movement than the water currents above the clines. Therefore, it is best to establish the sampling survey area on both the southwestern and northern sides of the GBS.

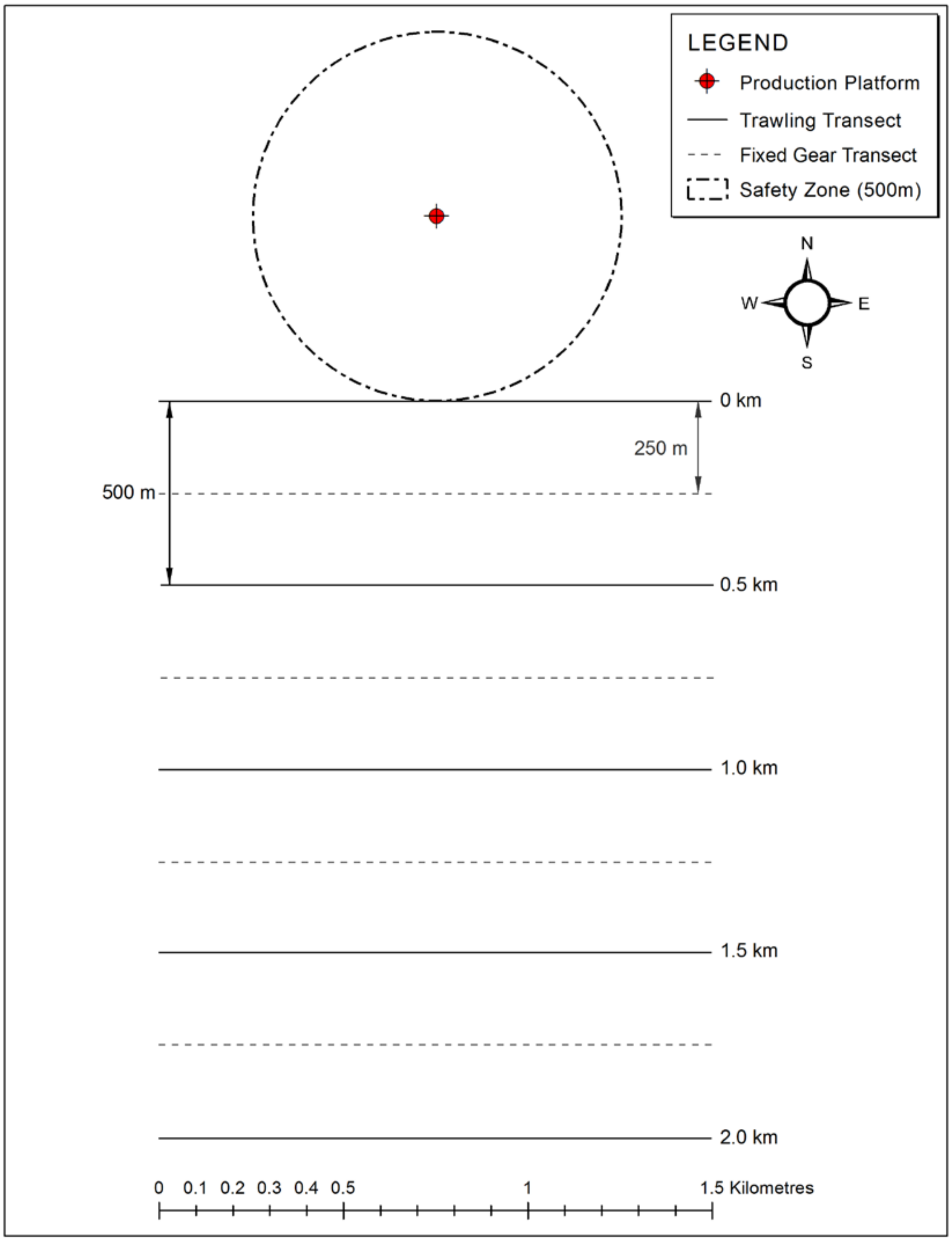


Figure 2. Schematic Showing Proposed Sampling Configuration.

The following three subsections provide information on where the juvenile fish sampling will occur at each of the three production areas, and, where applicable, the locations of other infrastructure in the vicinity of the production areas. Also included in each subsection is SIMOPS information.

Terra Nova

Survey Sampling Area

As already indicated, juvenile fish sampling at the Terra Nova production area will be conducted due south of the FPSO. Table 1 presents the coordinates of the Operator-defined exclusion zone and the end points of each of the trawl and fixed gear transects. Figure 3 indicates the location of the sampling survey area in relation to the exclusion zone. The sampling survey area's point that is closest to the FPSO is 2.3 km (1.25 nm) to the south-southwest (see Figure 3).

Table 1. Coordinates for Terra Nova Exclusion Zone and End Points of Juvenile Fish Sampling Survey Trawl and Fixed Gear Transects.

Point	Latitude	Longitude
Exclusion Zone		
NW Corner	46° 29.65'N	48° 29.50'W
NE Corner	46° 29.55'N	48° 29.50'W
SE Corner	46° 27.10'N	48° 29.50'W
SW Corner	46° 27.51'N	48° 30.20'W
Sampling Survey Area		
NW Corner	46° 27.34'N	48° 29.39'W
NE Corner	46° 27.17'N	48° 28.25'W
SE Corner	46° 26.11'N	48° 28.57'W
SW Corner	46° 26.28'N	48° 29.72'W
Trawling Transects		
West [0 km]	46° 27.34'N	48° 29.39'W
East [0 km]	46° 27.17'N	48° 28.25'W
West [0.5 km]	46° 27.07'N	48° 29.47'W
East [0.5 km]	46° 26.90'N	48° 28.33'W
West [1.0 km]	46° 26.81'N	48° 29.56'W

East [1.0 km]	46° 26.64’N	48° 28.41’W
West [1.5 km]	46° 26.54’N	48° 29.64’W
East [1.5 km]	46° 26.38’N	48° 28.49’W
West [2.0 km]	46° 26.28’N	48° 29.72’W
East [2.0 km]	46° 26.11’N	48° 28.57’W
Fixed Gear Transects		
West [0.25 km]	46° 27.20’N	48° 29.44’W
East [0.25 km]	46° 27.04’N	48° 28.29’W
West [0.75 km]	46° 26.94’N	48° 29.51’W
East [0.75 km]	46° 26.77’N	48° 28.37’W
West [1.25 km]	46° 26.68’N	48° 29.60’W
East [1.25 km]	46° 26.51’N	48° 28.45’W
West [1.75 km]	46° 26.41’N	48° 29.68’W
East [1.75 km]	46° 26.24’N	48° 28.53’W

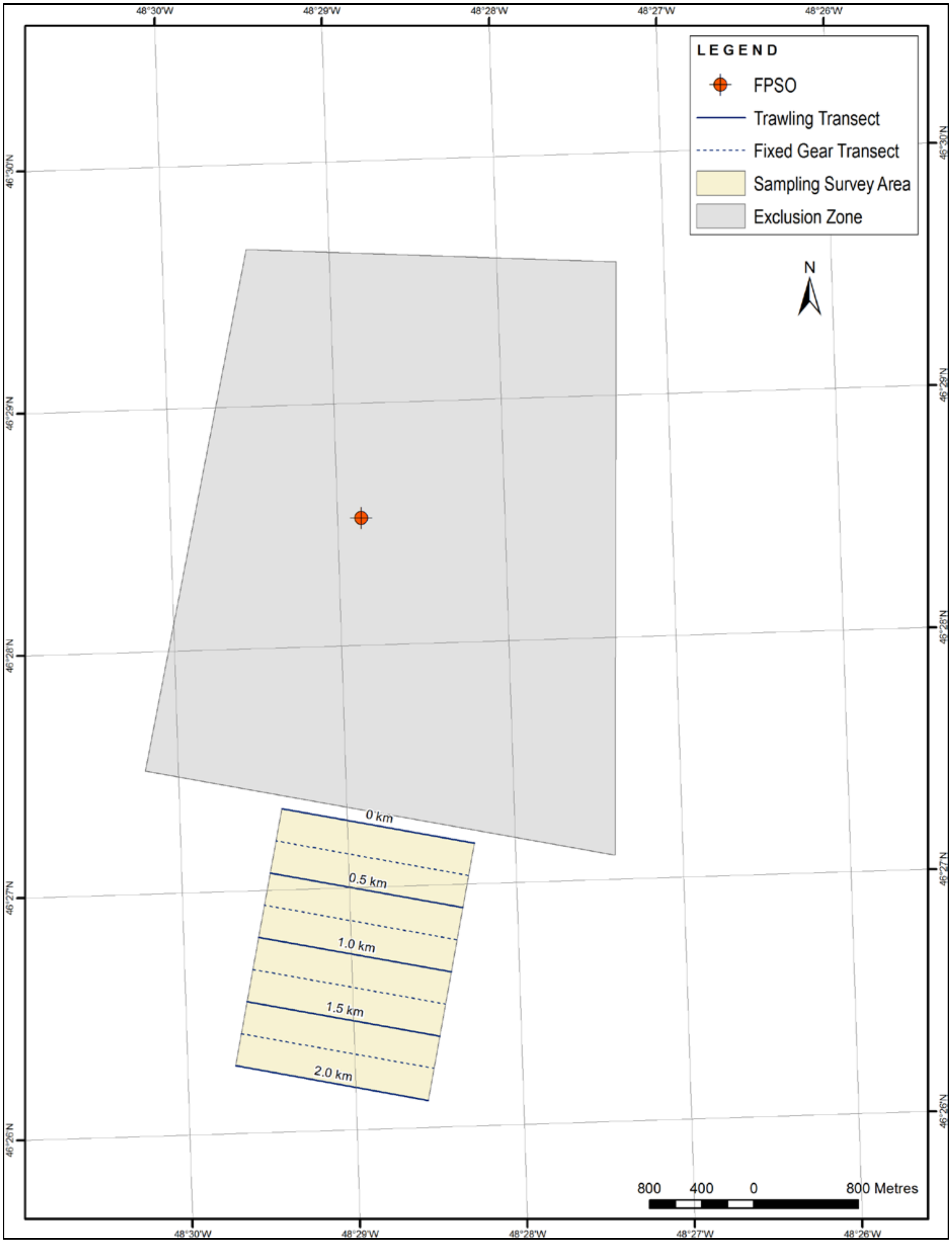


Figure 3. Layout of Juvenile Fish Sampling Survey Area in Relation to the Operator-defined Exclusion Zone at Terra Nova.

SIMOPS Information

The Terra Nova **call in points** for the Joyful Sound are at 10 nm from the FPSO (i.e., Precautionary Zone) and at 3 nm from the FPSO (i.e., Traffic Zone). The Terra Nova FPSO Central Control Room will coordinate via VHF radio on Channel 10.

Note that any marine traffic must notify the Hebron platform when crossing Hebron's 10 nm Precautionary Zone.

Vessel/project information related to emergency preparedness is as follows:

- Vessel Name: FV Joyful Sound
- AIS ID: Joyful Sound
- MMSI #: 316011040
- Bridge satellite (voice) telephone number: 613-980-2569
- Vessel operator onshore 24hr number: 709-786-4613 (Dwight Petten)
- LGL onshore 24hr number: 709-699-1992

Suncor has also provided LGL with the 'Joyful Sound Emergency Response Call Out Procedure' flowchart which will be kept on the bridge of the vessel.

Two internal Terra Nova documents will be available to the crew of the Joyful Sound during the juvenile fish sampling. They are as follow:

- Suncor. 2017. Simultaneous Operations Manual – FPSO Production, MODU Operations and Special Vessel Operations. Document Number TN-PE-PT04-X00-002. 16 p. + appendices.

- Suncor. 2017. Terra Nova Field Marine Traffic Management Plan. Document Number TN-PE-MR04-X00-005. 26 p, + appendices.

White Rose

Survey Sampling Area

As already indicated, juvenile fish sampling at the White Rose production area will be conducted southeast of the FPSO. Table 2 presents the coordinates of the Operator-defined exclusion zone and the end points of each of the trawl and fixed gear transects. Figure 4 indicates the location of the sampling survey area in relation to the exclusion zone.

Table 2. Coordinates for White Rose Exclusion Zone, End Points of Juvenile Fish Sampling Survey Trawl and Fix Gear Transects, and Other Husky Infrastructure

Point	Latitude	Longitude
Exclusion Zone		
A	46° 52.80’N	48° 02.95’W
B	46° 45.93’N	47° 59.09’W
C	46° 43.99’N	48° 59.38’W
D	46° 43.42’N	48° 01.91’W
E	46° 43.51’N	48° 04.19’W
F	46° 44.63’N	48° 04.88’W
G	46° 52.20’N	48° 05.04’W
Oceanographic Equipment		
Waverider Buoy	46° 45.378’N	47° 59.382’W
ADCP Current Meter*	46° 45.414’N	47° 58.846’W
Surface Marker for ADCP Mooring	46° 45.412’N	47° 59.099’W
Lost Moorings		
Waverider Buoy Mooring**	46° 49.824’N	47° 59.753’W
Current Meter Marker Anchor***	46° 48.900’N	48° 00.100’W
Sampling Survey Area		
NW Corner	46° 45.93’N	47° 59.02’W
NE Corner	46° 45.82’N	47° 57.46’W
SE Corner	46° 45.02’N	47° 57.57’W
SW Corner	46° 45.13’N	47° 59.13’W
Trawling Transects		

North [0 km]	46° 45.93’N	47° 59.02’W
South [0 km]	46° 45.13’N	47° 59.13’W
North [0.5 km]	46° 45.90’N	47° 58.63’W
South [0.5 km]	46° 45.10’N	47° 58.74’W
North [1.0 km]	46° 45.88’N	47° 58.24’W
South [1.0 km]	46° 45.08’N	47° 58.35’W
North [1.5 km]	46° 45.85’N	47° 57.85’W
South [1.5 km]	46° 45.04’N	47° 57.96’W
North [2.0 km]	46° 45.82’N	47° 57.46’W
South [2.0 km]	46° 45.02’N	47° 57.57’W
Fixed Gear Transects		
North [0.25 km]	46° 45.92’N	47° 58.82’W
South [0.25 km]	46° 45.11’N	47° 58.94’W
North [0.75 km]	46° 45.89’N	47° 58.43’W
South [0.75 km]	46° 45.08’N	47° 58.55’W
North [1.25 km]	46° 45.86’N	47° 58.04’W
South [1.25 km]	46° 45.06’N	47° 58.16’W
North [1.75 km]	46° 45.83’N	47° 57.65’W
South [1.75 km]	46° 45.03’N	47° 57.77’W

*ADCP is ~117 m below surface

**Possible floating rope @ 40 m below surface down to anchor

***Possible floating rope @ 60 m below surface down to anchor

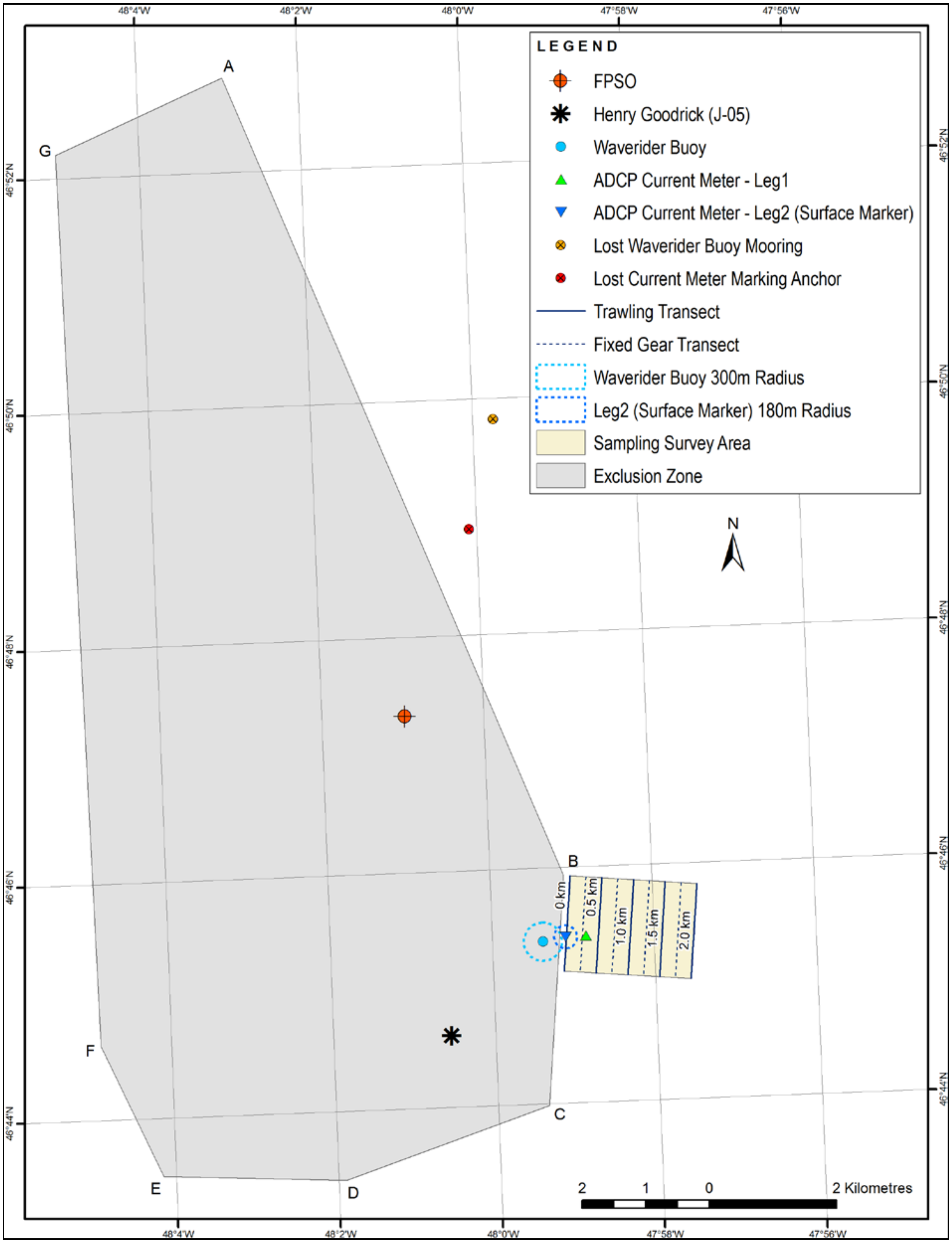


Figure 4. Layout of Juvenile Fish Sampling Survey Area in Relation to the Operator-defined Exclusion Zone at White Rose.

SIMOPS Information

Once within 10 nm of the Husky-defined ‘exclusion zone’, the Joyful Sound will contact the Sea Rose FPSO via VHF Channel 74, or secondarily on Channel 69/72. Traffic control should also be contacted once the vessel is within 3 nm of the Husky-defined ‘exclusion zone’ Contact with the Sea Rose should also be made when the Joyful Sound is leaving the area.

Vessel/project information related to emergency preparedness is as follows:

- Vessel Name: FV Joyful Sound
- AIS ID: Joyful Sound
- MMSI #: 316011040
- Bridge satellite (voice) telephone number: 613-980-2569
- Vessel operator onshore 24hr number: 709-786-4613 (Dwight Petten)
- LGL onshore 24hr number: 709-699-1992

The ADCP mooring and the surface buoy indicated in Figure 4 will be re-located to some position inside the exclusion zone prior to the onset of juvenile fish sampling at the White Rose area.

LGL will coordinate with PGS who will be conducting a short 3D seismic survey in the area. LGL would like to complete its sampling prior to the onset of 3D surveying.

Hibernia

As already indicated, juvenile fish sampling at the Hibernia production area will be conducted north and west-southwest of the GBS. Table 3 presents the coordinates of the Operator-defined exclusion zone and the end points of each of the trawl and fixed gear transects. Figure 5 indicates the location of the sampling survey area in relation to the exclusion zone.

Table 3. Table 2. Coordinates for Hibernia Exclusion Zone, End Points of Juvenile Fish Sampling Survey Trawl and Fixed Gear Transects, and Other HMDC Infrastructure.

Point	Latitude	Longitude
Exclusion Zone (portion used for this study)		
A	46° 45.47’N	48° 46.44’W
B	46° 45.43’N	48° 46.00’W
C	46° 44.18’N	48° 46.00’W
D	46° 44.21’N	48° 46.14’W
E	46° 43.72’N	48° 46.00’W
F	46° 43.50’N	48° 46.00’W
G	46° 43.50’N	48° 47.54’W
H	46° 44.67’N	48° 47.88’W
I	46° 45.33’N	48° 47.75’W
J	46° 45.61’N	48° 47.11’W
Oceanographic Equipment		
Waverider Buoy*	46° 42.593’N	48° 51.372’W
Sampling Survey Area #1 (North of GBS)		
NW Corner	46° 46.74’N	48° 47.43’W
NE Corner	46° 46.72’N	48° 46.25’W
SE Corner	46° 45.64’N	48° 46.30’W
SW Corner	46° 45.66’N	48° 47.47’W
Trawling Transects (Area #1)		
West [0 km]	46° 45.66’N	48° 47.47’W
East [0 km]	46° 45.64’N	48° 46.30’W
West [0.5 km]	46° 45.93’N	48° 47.46’W

East [0.5 km]	46° 45.91’N	48° 46.29’W
West [1.0 km]	46° 46.20’N	48° 47.45’W
East [1.0 km]	46° 46.18’N	48° 46.28’W
West [1.5 km]	46° 46.47’N	48° 47.44’W
East [1.5 km]	46° 46.45’N	48° 46.26’W
West [2.0 km]	46° 46.74’N	48° 47.43’W
East [2.0 km]	46° 46.72’N	48° 46.25’W
Fixed Gear Transects (Area #1)		
West [0.25 km]	46° 45.80’N	48° 47.47’W
East [0.25 km]	46° 45.78’N	48° 46.29’W
West [0.75 km]	46° 46.07’N	48° 47.46’W
East [0.75 km]	46° 46.05’N	48° 46.28’W
West [1.25 km]	46° 46.34’N	48° 47.45’W
East [1.25 km]	46° 46.132’N	48° 46.27’W
West [1.75 km]	46° 46.61’N	48° 47.44’W
East [1.75 km]	46° 46.59’N	48° 46.26’W
Sampling Survey Area #2 (West-Southwest of GBS)		
NW Corner	46° 44.53’N	48° 49.52’W
NE Corner	46° 44.74’N	48° 47.97’W
SE Corner	46° 43.95’N	48° 47.75’W
SW Corner	46° 43.74’N	48° 49.29’W
Trawling Transects (Area #2)		
North [0 km]	46° 44.74’N	48° 47.97’W
South [0 km]	46° 43.95’N	48° 47.75’W
North [0.5 km]	46° 44.69’N	48° 48.36’W
South [0.5 km]	46° 43.90’N	48° 48.13’W
North [1.0 km]	46° 44.64’N	48° 48.75’W
South [1.0 km]	46° 43.85’N	48° 48.52’W
North [1.5 km]	46° 44.59’N	48° 49.13’W

South [1.5 km]	46° 43.79'N	48° 48.90'W
North [2.0 km]	46° 44.53'N	48° 49.52'W
South [2.0 km]	46° 43.74'N	48° 49.29'W
Fixed Gear Transects (Area #2)		
North [0.25 km]	46° 44.72'N	48° 48.17'W
South [0.25 km]	46° 43.92'N	48° 47.94'W
North [0.75 km]	46° 44.67'N	48° 48.55'W
South [0.75 km]	46° 43.87'N	48° 48.32'W
North [1.25 km]	46° 44.61'N	48° 48.94'W
South [1.25 km]	46° 43.82'N	48° 48.71'W
North [1.75 km]	46° 44.56'N	48° 48.32'W
South [1.75 km]	46° 43.77'N	48° 49.09'W

*Waverider location is 7.23 km (3.91 nm) southwest of the Hibernia GBS at a bearing of 231.6°

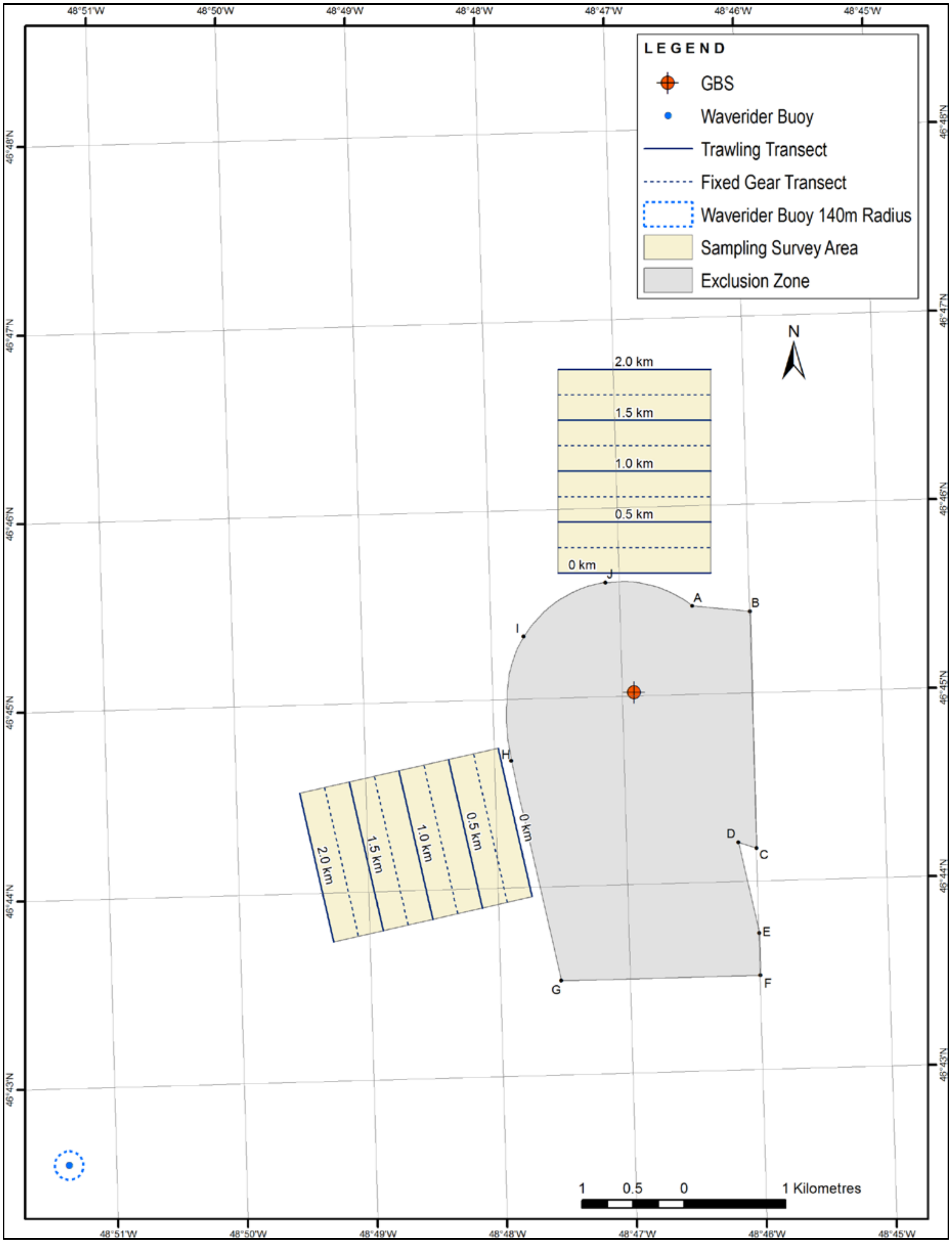


Figure 5. Layout of Juvenile Fish Sampling Survey Areas in Relation to the Operator-defined Exclusion Zone at Hibernia.

SIMOPS Information

The FV Joyful Sound will not enter the Hibernia safety zone which consists of an area within a line drawn at a distance of 500 m from the outer edge of the GBS, the subsea crude loading system, the 7-km southern subsea flowline and the southern extension excavated drill centre (EDC). If a drilling rig is present at the EDC, an additional 50 m collision avoidance zone extends beyond each of the eight rig anchors which are located 1-2 km from the rig itself.

ODAS buoys are located outside of the safety zone.

Supply vessels and crude tankers are regularly moving through the area.

Hibernia uses a 3-nm (5.5 km) marine communications zone around the GBS. Vessels approaching within 3 nm of the GBS are encouraged to contact the rig radio operator on VHF Channel 16. See Table 4 for further communications details.

Mariners are advised to consult with the latest marine chart and the Hibernia radio operator for specific locations and other details.

30 knot wind velocity is the limit for working/sampling when vessel is in an area upwind from the GBS

The Captain of the Joyful Sound will contact the stand-by supply vessel to discuss response should the sampling vessel lose power. Discussion will include tow procedure, identification of what equipment is to be used for towing, and verification of tow speed.

A waverider buoy is deployed ~ 3.9 nm SW of the GBS. It has a drift radius of 140 m.

Vessel/project information related to emergency preparedness is as follows:

- Vessel Name: FV Joyful Sound
- AIS ID: Joyful Sound
- MMSI #: 316011040
- Bridge satellite (voice) telephone number: 613-980-2569
- Vessel operator onshore 24hr number: 709-786-4613 (Dwight Petten)
- LGL onshore 24hr number: 709-699-1992

Table 4. Hibernia Field Communications Information.

Location	E-mail	Voice	Mobile	VHS Radio
Offshore Installation Manager	OIM@exxonmobil.com	709-778-7435	011-8703-31609920	16
Radio Room		709-778-7433	011-8703-31609920	9 & 16
Central Control Room		709-778-7434	011-8703-31609920	71

Chronology of Juvenile Fish Study Field Activities

July 16-17, 2017

- Mobilization at St. John's Harbour

July 18, 2017

- Depart St. John's Harbor and sail to the Reference Station (~ 350 km)

July 19, 2017 (Reference Station)

- Deploy the fixed gear between Transects '0 km' and '0.5 km'.
- Commence bottom trawling with the Campelen 900 trawl, starting at the '2.0 km' transect and continuing until all five transects have been sampled. Process juvenile fishes after each trawl.
- After completion of the five trawling transects and processing of the catches, retrieve the fixed gear to get an initial sense of its effectiveness, and redeploy fixed gear between Transects '0.5 km' and '1.0 km'. Process juvenile fishes prior to redeployment of fixed gear.
- Continue with the bottom trawling.
- Conduct at least two CTD casts per day – one at the 0.25 km fixed gear transect, and the other at the 1.75 km fixed gear transect.

July 20, 2017 (Reference Station)

- Retrieve the fixed gear and redeploy between transects '1.0 km' and '1.5' km'.
- Commence pelagic trawling with the IYGPT trawl, starting at the '2.0 km' transect and continuing until all five transects have been sampled.
- After completion of the five trawling transects and processing of the catches, retrieve the fixed gear, and then redeploy it between Transects '1.5 km' and '2.0 km'.
- Continue with the pelagic trawling.
- Conduct at least two CTD casts per day – one at the 0.25 km fixed gear transect, and the other at the 1.75 km fixed gear transect.

July 21, 2017 (Reference Station)

- Retrieve the fixed gear and redeploy it between Transects '0 km' and '0.5 km'.

- Commence trawling with either the Campelen 900 or the IYGPT, whichever one provided the best juvenile fish catch results during the previous two days. As before, start at the ‘2.0 km’ transect and continue until all five transects have been sampled.

- After completion of the five trawling transects and processing of the catches, retrieve the fixed gear.

- If time allows, continue with the trawling.

- Sail to the Terra Nova production area (~60 km).

July 22, 2017 (Terra Nova)

- Deploy the fixed gear between Transects ‘0 km’ and ‘0.5 km’.

- Commence bottom trawling with the Campelen 900 trawl, starting at the ‘2.0 km’ transect and continuing until all five transects have been sampled.

- After completion of the five trawling transects and processing of the catches, retrieve the fixed gear and redeploy fixed gear between Transects ‘0.5 km’ and ‘1.0 km’.

- Continue with the bottom trawling.

- Conduct at least two CTD casts per day – one at the 0.25 km fixed gear transect, and the other at the 1.75 km fixed gear transect.

July 23, 2017 (Terra Nova)

- Retrieve the fixed gear and redeploy between transects ‘1.0 km’ and ‘1.5’ km’.

- Commence pelagic trawling with the IYGPT trawl, starting at the ‘2.0 km’ transect and continuing until all five transects have been sampled.

- After completion of the five trawling transects and processing of the catches, retrieve the fixed gear, and then redeploy it between Transects ‘1.5 km’ and ‘2.0 km’.

- Continue with the pelagic trawling.

- Conduct at least two CTD casts per day – one at the 0.25 km fixed gear transect, and the other at the 1.75 km fixed gear transect.

July 24, 2017 (Terra Nova)

- Retrieve the fixed gear and redeploy it between Transects ‘0 km’ and ‘0.5 km’.

- Commence trawling with either the Campelen 900 or the IYGPT, whichever one provided the best juvenile fish catch results during the previous two days. As before, start at the ‘2.0 km’ transect and continue until all five transects have been sampled.

- After completion of the five trawling transects and processing of the catches, retrieve the fixed gear.
- If time allows, continue with the trawling.
- Sail to the White Rose production area (~50 km).

July 25, 2017 (White Rose)

- Deploy the fixed gear between Transects ‘0 km’ and ‘0.5 km’.
- Commence bottom trawling with the Campelen 900 trawl, starting at the ‘2.0 km’ transect and continuing until all five transects have been sampled.
- After completion of the five trawling transects and processing of the catches, retrieve the fixed gear and redeploy fixed gear between Transects ‘0.5 km’ and ‘1.0 km’.
- Continue with the bottom trawling.
- Conduct at least two CTD casts per day – one at the 0.25 km fixed gear transect, and the other at the 1.75 km fixed gear transect.

July 26, 2017 (White Rose)

- Retrieve the fixed gear and redeploy between transects ‘1.0 km’ and ‘1.5’ km’.
- Commence pelagic trawling with the IYGPT trawl, starting at the ‘2.0 km’ transect and continuing until all five transects have been sampled.
- After completion of the five trawling transects and processing of the catches, retrieve the fixed gear, and then redeploy it between Transects ‘1.5 km’ and ‘2.0 km’.
- Continue with the pelagic trawling.
- Conduct at least two CTD casts per day – one at the 0.25 km fixed gear transect, and the other at the 1.75 km fixed gear transect.

July 27, 2017 (White Rose)

- Retrieve the fixed gear and redeploy it between Transects ‘0 km’ and ‘0.5 km’.
- Commence trawling with either the Campelen 900 or the IYGPT, whichever one provided the best juvenile fish catch results during the previous two days. As before, start at the ‘2.0 km’ transect and continue until all five transects have been sampled.
- After completion of the five trawling transects and processing of the catches, retrieve the fixed gear.

- If time allows, continue with the trawling.
- Sail to the Hibernia production area (~60 km).

July 28, 2017 (Hibernia)

- Deploy the fixed gear between Transects '0 km' and '0.5 km' of the sampling survey area to the southwest of the GBS (SSA1)
- Commence bottom trawling with the Campelen 900 trawl, starting at the '2.0 km' transect and continuing until all five transects have been sampled.
- After completion of the five trawling transects and processing of the catches, retrieve the fixed gear and redeploy fixed gear between Transects '0.5 km' and '1.0 km' of SSA1.
- Commence bottom trawling with the Campelen 900 trawl at sampling survey area to the north of the GBS (SSA2), starting at the '2.0 km' transect and continuing until all five transects have been sampled.
- Conduct at least two CTD casts per day within each survey sampling area – one at the 0.25 km fixed gear transect, and the other at the 1.75 km fixed gear transect.

July 29, 2017 (Hibernia)

- Commence pelagic trawling with the IYGPT trawl in SSA1, starting at the '2.0 km' transect and continuing until all five transects have been sampled.
- Retrieve the fixed gear in SSA1 and redeploy in SSA2 between Transects '0 km' and '0.5 km'.
- Commence pelagic trawling with the IYGPT trawl in SSA2, starting at the '2.0 km' transect and continuing until all five transects have been sampled.
- Retrieve the fixed gear in SSA2 and redeploy between Transects '0.5 km' and '1.0 km'.
- If time allows, continue with the pelagic trawling.
- Conduct at least two CTD casts per day within each survey sampling area – one at the 0.25 km fixed gear transect, and the other at the 1.75 km fixed gear transect.

July 30, 2017 (Hibernia)

- Retrieve the fixed gear in SSA2 and redeploy between Transects '1.0 km' and '1.5 km' of the SSA2.

- Commence trawling with either the Campelen 900 or the IYGPT, whichever one provided the best juvenile fish catch results during the previous two days. Start at the ‘2.0 km’ transect of SSA2 and continue until all five transects have been sampled.
- Retrieve the fixed gear in SSA2 and redeploy between Transects ‘1.0 km’ and ‘1.5 km’ of the SSA1.
- Continue trawling in SSA1, starting at the ‘2.0 km’ transect.
- Retrieve the fixed gear in SSA1.
- If time allows, continue with the trawling.
- Commence transit to St. John’s (~315 km).

July 31, 2007

- Arrive at St. John’s

August 1, 2017

- Demobilization

Appendix 2

Specifics of Bottom and Midwater Trawls

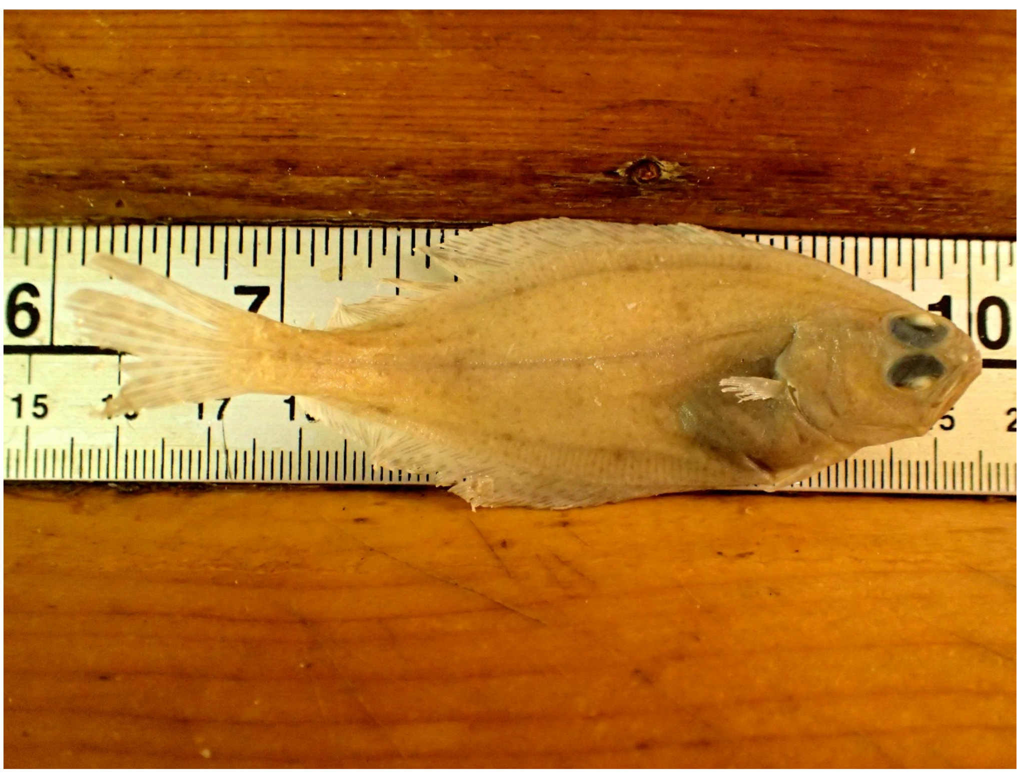
Date	Time	Tow #	Trawl Type	Survey Location	Latitude Start °	Latitude Start '	Longitude Start °	Longitude Start '	Latitude End °	Latitude End '	Longitude End °	Longitude End '	Tow Duration (min)	Length of Tow (km)	Length of Tow (nm)	Tow Speed (Kts)	Vessel Bearing	Average Depth (m)	Average Depth (fathom)	Wind Speed (Kts)	Wind Direction	Current Speed (Kts)	Current Direction	Sea State
07/19/17	14:30	1	MWT	REF	46	59.01	48	16.75	46	57.87	48	16.81	20	1.9	1.00	3.0 to 3.6	S	118	64.5	10	S	0.5	N	1
07/19/17	17:45	2	MWT	REF	46	58.60	48	16.16	46	59.41	48	16.16	15	1.5	0.80	2.9 to 3.0	N	119	65.0	10	S	0.8	N	1
07/19/17	19:30	3	MWT	REF	46	59.35	48	15.80	46	58.67	48	15.75	15	1.4	0.75	2.9 to 3.0	S	120	65.5	15	S	0.8	N	1
07/19/17	20:00	4	MWT	REF	46	58.65	48	15.25	46	59.47	48	15.15	20	1.6	0.84	3.0 to 3.1	N	121	66.0	15	S	0.8	E	1
07/20/17	08:40	5	BT	REF	46	59.03	48	14.96	46	58.43	48	14.95	15	1.2	0.65	2.0	S	121	66.0	na	na	na	na	na
07/20/17	10:10	6	BT	REF	46	58.90	48	16.90	46	58.21	48	16.21	15	1.3	0.70	2.0 to 2.2	na	119	65.0	15	na	na	na	na
07/20/17	11:10	7	BT	REF	46	59.18	48	16.65	46	58.50	48	16.60	15	1.2	0.65	2.4	S	119	65.0	na	na	na	na	na
07/20/17	13:25	8	BT	REF	46	58.28	48	15.42	46	59.13	48	15.20	20	1.7	0.90	2.3	N	119	65.0	15	S	1	E	1
07/20/17	14:45	9	BT	REF	46	59.02	48	15.73	46	58.24	48	15.82	15	1.6	0.85	2.5 to 2.6	S	119	65.0	na	na	na	na	na
07/20/17	15:30	10	BT	REF	46	58.34	48	14.90	46	59.13	48	14.90	20	1.7	0.90	2.3 to 2.4	N	121	66.0	15	S	0.8	NE	1
07/20/17	16:25	11	BT	REF	46	58.78	48	16.48	na	na	na	na	na	na	na	na	S	119	65.0	na	na	na	na	na
07/20/17	17:30	12	BT	REF	46	58.90	48	16.43	46	58.22	48	16.38	15	1.3	0.70	2.5	NW	119	65.0	15	S	1	ENE	1
07/21/17	07:30	13	BT	REF	46	47.70	48	17.11	46	46.75	48	17.07	20	1.8	0.98	2.2	S	110	60.0	10	Variable	1	NE	2
07/21/17	08:25	14	BT	REF	46	46.75	48	16.18	46	47.50	48	16.18	20	1.6	0.85	2.3	N	110	60.0	na	na	na	na	na
07/21/17	09:20	15	BT	REF	46	47.43	48	16.60	46	46.55	48	16.70	20	1.9	1.00	2.3	S	110	60.0	10	Variable	0.5	E	1
07/21/17	10:05	16	BT	REF	46	46.70	48	17.30	46	47.58	48	17.50	20	1.8	0.95	2.2	N	110	60.0	10	Variable	0.8	E	1
07/21/17	11:35	17	MWT	REF	46	47.11	48	16.80	46	46.09	48	16.65	15	2.1	1.13	3.1	S	110	60.0	na	na	na	na	na
07/21/17	12:20	18	MWT	REF	46	46.49	48	16.16	46	47.51	48	16.60	20	1.9	1.00	3.0 to 3.1	N	110	60.0	na	na	na	na	na
07/21/17	13:15	19	MWT	REF	46	47.27	48	17.80	46	46.25	48	17.96	20	2.0	1.10	3.1	S	110	60.0	na	na	na	na	na
07/21/17	14:05	20	MWT	REF	46	46.42	48	17.50	46	47.37	48	16.56	20	2.3	1.22	3.1	NE	110	60.0	10	Variable	na	na	1
07/21/17	14:55	21	MWT	REF	46	47.60	48	17.30	46	46.57	48	17.60	20	2.1	1.15	3.0	S	110	60.0	na	na	na	na	na
07/21/17	15:45	22	MWT	REF	46	46.68	48	17.67	46	47.50	48	16.75	20	2.0	1.10	2.9	NE	110	60.0	na	na	na	na	na
07/21/17	16:45	23	MWT	REF	46	47.07	48	16.43	46	46.08	48	16.80	20	2.0	1.10	2.9 to 3.0	S	110	60.0	na	na	na	na	na
07/21/17	17:27	24	MWT	REF	46	46.70	48	17.37	46	47.75	48	17.65	20	1.9	1.00	3.1 to 3.2	N	110	60.0	na	na	na	na	na
07/21/17	19:03	25	MWT	REF	46	47.65	48	17.75	46	46.68	48	17.65	20	1.9	1.00	3.1	S	110	60.0	na	na	na	na	na
07/22/17	08:00	26	MWT	TN	46	26.24	48	29.07	46	26.32	48	29.80	10	1.1	0.60	2.9 to 3.0	W	93	51.0	10	Variable	0.4	E	1
07/22/17	08:38	27	MWT	TN	46	26.56	48	29.66	46	26.35	48	28.38	20	1.9	1.00	3.0	E	93	51.0	10	Variable	na	na	2
07/22/17	09:22	28	MWT	TN	46	26.66	48	28.35	46	26.85	48	29.62	20	1.7	0.90	3.0	W	93	51.0	na	na	na	na	na
07/22/17	10:05	29	MWT	TN	46	27.10	48	29.50	46	26.90	48	28.15	20	1.9	1.00	3.0	E	93	51.0	10	Variable	na	na	2
07/22/17	11:11	30	MWT	TN	46	27.25	48	28.39	46	27.36	48	29.56	20	1.9	1.00	3.0	W	93	51.0	na	na	na	na	na
07/22/17	12:25	31	MWT	TN	46	26.43	48	29.90	46	26.20	48	28.44	20	1.9	1.00	3.0	E	93	51.0	10	Variable	na	na	1
07/22/17	13:25	32	MWT	TN	46	26.38	48	28.32	46	26.53	48	29.70	20	1.7	0.90	3.0	W	93	51.0	na	na	na	na	na
07/22/17	14:20	33	MWT	TN	46	26.80	48	29.50	46	26.60	48	28.30	20	1.7	0.90	3.0	E	93	51.0	na	na	na	na	na
07/22/17	15:02	34	MWT	TN	46	26.84	48	28.28	46	27.07	48	29.56	20	1.8	0.95	3.0	W	93	51.0	10	Variable	na	na	1
07/22/17	15:52	35	MWT	TN	46	27.20	48	29.25	46	26.95	48	28.25	20	1.5	0.80	3.0	E	93	51.0	na	na	na	na	na
07/22/17	16:32	36	MWT	TN	46	26.80	48	28.56	46	26.93	48	29.57	15	1.6	0.85	3.0	W	93	51.0	10	Variable	na	na	1
07/22/17	18:40	37	BT	TN	46	26.50	48	28.70	46	26.55	48	29.00	10	0.5	0.25	2.5	W	93	51.0	na	na	na	na	na
07/23/17	07:35	38	BT	TN	46	26.20	48	28.56	46	26.40	48	29.80	20	1.7	0.90	2.2	W	93	51.0	20	SW	0.5	E	2
07/23/17	08:35	39	BT	TN	46	26.86	48	29.54	46	26.70	48	28.30	20	1.7	0.90	2.4	E	93	51.0	na	na	na	na	na
07/23/17	09:20	40	BT	TN	46	27.10	48	28.05	46	27.30	48	29.50	25	1.7	0.90	2.2	W	93	51.0	20	SW	0.6	E	2
07/23/17	10:25	41	BT	TN	46	27.05	48	29.63	46	26.80	48	28.25	20	1.7	0.90	2.4	E	93	51.0	na	na	na	na	na
07/23/17	11:25	42	BT	TN	46	26.70	48	28.35	46	26.90	48	29.60	20	1.7	0.90	2.2	W	93	51.0	20	SW	0.5	E	2
07/23/17	13:05	43	BT	TN	46	27.13	48	28.15	46	27.23	48	29.50	25	1.7	0.90	2.1	W	93	51.0	na	na	na	na	na
07/23/17	13:50	44	BT	TN	46	26.97	48	29.50	46	26.72	48	28.39	20	1.7	0.90	2.3	na	93	51.0	20	SW	0.5	E	2
07/23/17	14:30	45	BT	TN	46	26.40	48	28.55	46	26.56	48	29.79	20	1.7	0.90	2.3	W	93	51.0	20	SW	0.5	E	2
07/23/17	15:10	46	BT	TN	46	26.26	48	29.59	46	26.08	48	28.61	20	1.7	0.90	2.4	E	93	51.0	20	W	0.5	E	2
07/24/17	09:16	47	BT	WR	46	46.01	47	57.35	46	45.07	47	57.60	25	1.9	1.00	2.4	S	124	68.0	15	S	na	na	2
07/24/17	10:25	48	BT	WR	46	45.02	47	57.97	46	46.00	47	57.77	25	2.0	1.10	2.3	N	124	68.0	10	S	0.5	NE	2
07/24/17	11:30	49	BT	WR	46	46.00	47	59.02	46	45.08	47	59.16	20	1.9	1.00	2.2 to 2.3	S	124	68.0	na	na	na	na	na
07/24/17	13:00	50	BT	WR	46	44.86	47	58.63	46	45.91	47	58.38	25	1.9	1.00	2.3	N	124	68.0	10	S	0.5	E	2
07/24/17	14:07	51	BT	WR	46	45.90	47	58.17	46	44.96	47	58.25	25	1.7	0.90	2.3	S	124	68.0	15	S	1	E	2
07/24/17	15:00	52	BT	WR	46	44.98	47	58.64	46	46.02	47	58.60	25	1.9	1.00	2.2	na	124	68.0	10	S	0.5	E	1
07/24/17	16:00	53	BT	WR	46	45.87	47	57.40	46	44.95	47	57.60	20	1.9	1.00	2.3	S	124	68.0	10	S	0.6	E	2
07/25/17	07:50	54	BT	HIB	46	46.85	48	46.15	46	46.80	48	47.45	25	1.7	0.90	2.2	na	79	43.0	10	Variable	0.8	N	2
07/25/17	09:15	55	BT	HIB	46	46.50	48	47.46	46	46.46	48	46.20	20	1.7	0.90	2.2	E	82	45.0	10	Variable	0.5	NE	2
07/25/17	11:40	56	MWT	HIB	46	46.26	48	47.25	46	46.22	48	46.06	15	1.5	0.80	2.9	E	80	44.0	na	na	na	na	na

Date	Time	Tow #	Trawl Type	Survey Location	Latitude Start °	Latitude Start '	Longitude Start °	Longitude Start '	Latitude End °	Latitude End '	Longitude End °	Longitude End '	Tow Duration (min)	Length of Tow (km)	Length of Tow (nm)	Tow Speed (Kts)	Vessel Bearing	Average Depth (m)	Average Depth (fathom)	Wind Speed (Kts)	Wind Direction	Current Speed (Kts)	Current Direction	Sea State
07/25/17	12:21	57	MWT	HIB	46	45.92	48	45.93	46	45.97	48	47.45	25	1.9	1.00	2.8	W	79	43.0	10	Variable	0.2	N	2
07/25/17	13:08	58	MWT	HIB	46	45.64	48	47.26	46	45.57	48	46.16	15	1.5	0.80	3.0	E	80	44.0	na	na	na	na	na
07/25/17	13:45	59	MWT	HIB	46	45.70	48	45.99	46	45.70	48	47.56	20	1.7	0.90	2.9	W	79	43.0	na	na	na	na	na
07/25/17	14:30	60	MWT	HIB	46	44.95	48	47.93	46	43.96	48	47.70	20	1.8	0.95	2.9	S	79	43.0	10	Variable	0.5	NE	2
07/25/17	15:15	61	MWT	HIB	46	43.78	48	48.08	46	44.70	48	48.48	20	1.8	0.95	2.8	N	79	43.0	na	na	na	na	na
07/25/17	16:00	62	MWT	HIB	46	44.75	48	48.70	46	43.78	48	48.48	20	1.7	0.90	2.9	S	79	43.0	10	Variable	0.5	NE	2
07/25/17	16:40	63	MWT	HIB	46	43.49	48	48.90	46	44.60	48	49.15	25	1.9	1.00	2.9	N	79	43.0	na	na	na	na	na
07/25/17	18:45	64	MWT	HIB	46	43.50	48	49.38	46	44.56	48	49.49	20	1.9	1.00	3.0	N	79	43.0	15	SE	0.8	NW	2
07/25/17	19:37	65	MWT	HIB	46	48.36	48	49.30	46	48.00	48	47.74	25	2.0	1.10	3.0	SE	79	43.0	15	SE	0.5	NW	2
07/25/17	20:25	66	MWT	HIB	46	43.96	48	48.05	46	44.70	48	48.88	20	1.9	1.00	3.0	NW	79	43.0	15	SE	0.5	NW	2
07/26/17	20:10	67	MWT	REF	47	03.08	48	11.60	47	01.85	48	11.50	20	2.2	1.20	3.1	S	134	73.0	10	Variable	na	na	1
07/26/17	21:00	68	MWT	REF	47	01.70	48	10.97	47	03.03	48	11.00	22	2.2	1.20	3.1	N	132	72.0	na	na	na	na	na
07/26/17	21:50	69	MWT	REF	47	03.03	48	10.70	47	01.75	48	10.70	25	2.3	1.24	2.9	na	134	73.0	10	Variable	na	na	1
07/27/17	07:52	70	BT	REF	47	01.80	48	10.10	47	03.00	48	10.10	30	2.2	1.20	2.3	N	134	73.0	15	Variable	0.3	E	2
07/27/17	11:12	71	BT	REF	46	47.60	48	16.20	46	46.60	48	16.13	26	1.7	0.90	2.2	S	110	60.0	15	Variable	1	E	1
07/27/17	12:40	72	BT	REF	46	46.72	48	16.56	46	47.60	48	16.51	20	1.6	0.85	3.2	N	110	60.0	na	na	na	na	na
07/27/17	13:14	73	BT	REF	46	47.45	48	16.50	46	46.60	48	17.45	25	1.9	1.00	2.3	SW	110	60.0	na	na	na	na	na
07/27/17	14:15	74	BT	REF	46	46.66	48	16.36	46	47.30	48	17.40	28	1.9	1.00	2.3	NW	110	60.0	na	na	na	na	na
07/27/17	18:31	75	BT	TN	46	27.10	48	28.00	46	27.30	48	29.50	30	1.9	1.00	2.1	W	95	52.0	na	na	na	na	na
07/27/17	19:40	76	BT	TN	46	27.00	48	29.92	46	26.70	48	28.68	20	1.7	0.90	2.2	E	93	51.0	15	W	na	na	2
07/27/17	21:23	77	BT	TN	46	26.37	48	28.80	46	26.45	48	29.50	15	1.2	0.65	2.3	W	93	51.0	na	na	na	na	na
07/28/17	07:50	78	MWT	TN	46	26.46	48	29.80	46	26.18	48	28.36	20	1.9	1.00	3.0	E	95	52.0	na	na	na	na	na
07/28/17	08:30	79	MWT	TN	46	26.31	48	28.35	46	27.16	48	29.50	23	2.0	1.10	3.1	NW	93	51.0	15	SW	na	na	1
07/28/17	09:15	80	MWT	TN	46	27.30	48	29.55	46	27.00	48	28.10	21	1.9	1.00	3.0	E	95	52.0	15	SW	na	na	1
07/28/17	10:10	81	MWT	TN	46	26.93	48	28.30	46	26.30	48	29.85	23	1.9	1.00	3.1	SW	95	52.0	na	na	na	na	na
07/28/17	10:50	82	MWT	TN	46	26.46	48	29.70	46	27.20	48	28.10	25	2.6	1.40	3.1	NE	95	52.0	na	na	na	na	na
07/28/17	11:38	83	MWT	TN	46	27.25	48	28.40	46	26.16	48	28.88	30	2.8	1.50	3.1	WSW	95	52.0	na	na	na	na	na
07/28/17	12:42	84	MWT	TN	46	26.60	48	28.77	46	27.13	48	29.76	18	1.9	1.00	2.8	na	95	52.0	na	na	na	na	na
07/28/17	13:25	85	MWT	TN	46	27.13	48	29.25	46	26.70	48	28.28	17	1.7	0.90	2.9	E	95	52.0	na	na	na	na	na
07/28/17	14:05	86	BT	TN	46	26.75	48	28.65	46	26.90	48	29.75	15	1.5	0.80	2.8	W	95	52.0	na	na	na	na	na
07/28/17	17:10	87	MWT	HIB	46	43.75	48	47.60	46	44.80	48	47.98	25	1.9	1.00	3.0	na	79	43.0	10	Variable	na	na	1
07/28/17	17:51	88	MWT	HIB	46	44.70	48	48.28	46	43.70	48	48.90	23	2.0	1.10	3.0	SW	79	43.0	na	na	na	na	na
07/28/17	18:37	89	MWT	HIB	46	43.75	48	48.35	46	44.77	48	48.58	20	1.9	1.00	3.0	N	77	42.0	na	na	na	na	na
07/28/17	19:15	90	MWT	HIB	46	44.75	48	48.20	46	43.70	48	47.67	23	2.0	1.10	3.0	S	79	43.0	10	Variable	na	na	1
07/28/17	20:02	91	MWT	HIB	46	43.76	48	47.80	46	44.64	48	48.80	25	1.9	1.00	3.0	N	79	43.0	na	na	na	na	na
07/28/17	20:45	92	MWT	HIB	46	44.55	48	48.80	46	43.55	48	48.80	25	2.0	1.10	2.9	S	79	43.0	na	na	na	na	na
07/28/17	21:30	93	MWT	HIB	46	43.70	48	48.80	46	44.65	48	49.15	20	1.7	0.90	3.2	N	79	43.0	na	na	na	na	na
07/28/17	22:05	94	MWT	HIB	46	44.37	48	49.25	46	43.75	48	49.36	11	1.3	0.70	3.5	S	79	43.0	na	na	na	na	na

Appendix 3

Representative Photos
of Juvenile Fish Specimens

Juvenile Atlantic cod



Juvenile American plaice

Juvenile Capelin

Juvenile Sand Lance

Appendix 4

Field Specific Data for Collected Juvenile Fish Specimens

Sampling Station	Date	Trawl Type	Tow #	Species	Specimen No.	Total Length (cm)
Reference	07/19/17	MWT	1	Atlantic Cod	RF-AC-01	8.0
Reference	07/19/17	MWT	1	Atlantic Cod	RF-AC-02	11.0
Reference	07/19/17	MWT	1	Atlantic Cod	RF-AC-03	9.0
Reference	07/19/17	MWT	2	Atlantic Cod	RF-AC-04	10.5
Reference	07/19/17	MWT	3	Atlantic Cod	RF-AC-05	10.5
Reference	07/19/17	MWT	3	Atlantic Cod	RF-AC-06	9.0
Reference	07/19/17	MWT	3	Atlantic Cod	RF-AC-07	12.0
Reference	07/19/17	MWT	4	Atlantic Cod	RF-AC-08	11.0
Reference	07/20/17	BT	5	Atlantic Cod	RF-AC-09	12.5
Reference	07/20/17	BT	5	Atlantic Cod	RF-AC-10	12.5
Reference	07/20/17	BT	5	Atlantic Cod	RF-AC-11	12.0
Reference	07/20/17	BT	5	Atlantic Cod	RF-AC-12	11.0
Reference	07/20/17	BT	6	Atlantic Cod	RF-AC-13	10.5
Reference	07/20/17	BT	7	Atlantic Cod	RF-AC-14	11.0
Reference	07/20/17	BT	7	Atlantic Cod	RF-AC-15	13.0
Reference	07/20/17	BT	7	Atlantic Cod	RF-AC-16	12.5
Reference	07/20/17	BT	7	Atlantic Cod	RF-AC-17	11.0
Reference	07/20/17	BT	8	Atlantic Cod	RF-AC-18	12.5
Reference	07/20/17	BT	8	Atlantic Cod	RF-AC-19	9.5
Reference	07/20/17	BT	8	Atlantic Cod	RF-AC-20	11.0
Reference	07/20/17	BT	10	Atlantic Cod	RF-AC-21	12.0
Reference	07/20/17	BT	12	Atlantic Cod	RF-AC-22	16.0
Reference	07/20/17	BT	12	Atlantic Cod	RF-AC-23	15.5
Reference	07/21/17	BT	13	Atlantic Cod	RF-AC-24	12.5
Reference	07/21/17	BT	16	Atlantic Cod	RF-AC-25	16.5
Reference	07/21/17	BT	16	Atlantic Cod	RF-AC-26	9.5
Reference	07/21/17	MWT	17	Atlantic Cod	RF-AC-27	9.5
Reference	07/21/17	MWT	17	Atlantic Cod	RF-AC-28	10.5
Reference	07/21/17	MWT	17	Atlantic Cod	RF-AC-29	10.5
Reference	07/21/17	MWT	17	Atlantic Cod	RF-AC-30	9.0
Reference	07/21/17	MWT	18	Atlantic Cod	RF-AC-31	10.0
Reference	07/21/17	MWT	19	Atlantic Cod	RF-AC-32	11.5
Reference	07/21/17	MWT	19	Atlantic Cod	RF-AC-33	9.0
Reference	07/21/17	MWT	20	Atlantic Cod	RF-AC-34	10.5
Reference	07/21/17	MWT	23	Atlantic Cod	RF-AC-35	10.0
Reference	07/21/17	MWT	23	Atlantic Cod	RF-AC-36	12.0
Reference	07/21/17	MWT	25	Atlantic Cod	RF-AC-37	10.5
Reference	07/21/17	MWT	25	Atlantic Cod	RF-AC-38	6.0
Reference	07/26/17	MWT	67	Atlantic Cod	RF-AC-39	10.0
Reference	07/26/17	MWT	67	Atlantic Cod	RF-AC-40	10.0
Reference	07/26/17	MWT	67	Atlantic Cod	RF-AC-41	9.5
Reference	07/26/17	MWT	69	Atlantic Cod	RF-AC-42	11.0
Reference	07/26/17	MWT	69	Atlantic Cod	RF-AC-43	10.0
Reference	07/26/17	MWT	69	Atlantic Cod	RF-AC-44	10.0
Reference	07/27/17	BT	70	Atlantic Cod	RF-AC-45	12.5
Reference	07/27/17	BT	70	Atlantic Cod	RF-AC-46	12.5
Reference	07/27/17	BT	70	Atlantic Cod	RF-AC-47	12.0
Reference	07/27/17	BT	70	Atlantic Cod	RF-AC-48	12.0
Reference	07/27/17	BT	70	Atlantic Cod	RF-AC-49	12.0
Reference	07/27/17	BT	70	Atlantic Cod	RF-AC-50	11.0
Reference	07/27/17	BT	70	Atlantic Cod	RF-AC-51	12.5
Reference	07/27/17	BT	70	Atlantic Cod	RF-AC-52	12.0
Reference	07/27/17	BT	70	Atlantic Cod	RF-AC-53	11.0
Reference	07/27/17	BT	70	Atlantic Cod	RF-AC-54	11.0
Reference	07/27/17	BT	70	Atlantic Cod	RF-AC-55	11.0
Reference	07/27/17	BT	70	Atlantic Cod	RF-AC-56	11.5
Reference	07/27/17	BT	70	Atlantic Cod	RF-AC-57	10.0

Sampling Station	Date	Trawl Type	Tow #	Species	Specimen No.	Total Length (cm)
Reference	07/27/17	BT	70	Atlantic Cod	RF-AC-58	11.5
Reference	07/27/17	BT	70	Atlantic Cod	RF-AC-59	12.0
Reference	07/27/17	BT	70	Atlantic Cod	RF-AC-60	12.0
Reference	07/27/17	BT	70	Atlantic Cod	RF-AC-61	12.0
Reference	07/27/17	BT	70	Atlantic Cod	RF-AC-62	12.0
Reference	07/27/17	BT	70	Atlantic Cod	RF-AC-63	11.0
Reference	07/27/17	BT	70	Atlantic Cod	RF-AC-64	10.0
Reference	07/27/17	BT	70	Atlantic Cod	RF-AC-65	12.5
Reference	07/27/17	BT	70	Atlantic Cod	RF-AC-66	12.0
Reference	07/27/17	BT	70	Atlantic Cod	RF-AC-67	12.0
Reference	07/27/17	BT	70	Atlantic Cod	RF-AC-68	10.5
Reference	07/27/17	BT	70	Atlantic Cod	RF-AC-69	11.0
Reference	07/27/17	BT	70	Atlantic Cod	RF-AC-70	10.5
Reference	07/27/17	BT	70	Atlantic Cod	RF-AC-71	11.5
Reference	07/27/17	BT	70	Atlantic Cod	RF-AC-72	12.0
Reference	07/27/17	BT	70	Atlantic Cod	RF-AC-73	9.5
Reference	07/27/17	BT	70	Atlantic Cod	RF-AC-74	11.0
Reference	07/27/17	BT	70	Atlantic Cod	RF-AC-75	10.5
Reference	07/19/17	MWT	1	American Plaice	RF-AP-01	16.5
Reference	07/19/17	MWT	1	American Plaice	RF-AP-02	16.0
Reference	07/19/17	MWT	1	American Plaice	RF-AP-03	14.0
Reference	07/19/17	MWT	2	American Plaice	RF-AP-04	17.0
Reference	07/19/17	MWT	2	American Plaice	RF-AP-05	14.5
Reference	07/19/17	MWT	2	American Plaice	RF-AP-06	18.0
Reference	07/20/17	BT	5	American Plaice	RF-AP-07	12.5
Reference	07/20/17	BT	5	American Plaice	RF-AP-08	12.5
Reference	07/20/17	BT	5	American Plaice	RF-AP-09	12.5
Reference	07/20/17	BT	5	American Plaice	RF-AP-10	13.0
Reference	07/20/17	BT	5	American Plaice	RF-AP-11	12.0
Reference	07/20/17	BT	5	American Plaice	RF-AP-12	11.0
Reference	07/20/17	BT	5	American Plaice	RF-AP-13	11.5
Reference	07/20/17	BT	5	American Plaice	RF-AP-14	13.0
Reference	07/20/17	BT	5	American Plaice	RF-AP-15	11.0
Reference	07/20/17	BT	5	American Plaice	RF-AP-16	13.0
Reference	07/20/17	BT	5	American Plaice	RF-AP-17	13.5
Reference	07/20/17	BT	5	American Plaice	RF-AP-18	11.0
Reference	07/20/17	BT	5	American Plaice	RF-AP-19	13.0
Reference	07/20/17	BT	5	American Plaice	RF-AP-20	11.5
Reference	07/20/17	BT	5	American Plaice	RF-AP-21	12.5
Reference	07/20/17	BT	5	American Plaice	RF-AP-22	12.5
Reference	07/20/17	BT	5	American Plaice	RF-AP-23	13.5
Reference	07/20/17	BT	5	American Plaice	RF-AP-24	10.5
Reference	07/20/17	BT	5	American Plaice	RF-AP-25	13.0
Reference	07/20/17	BT	5	American Plaice	RF-AP-26	11.5
Reference	07/20/17	BT	5	American Plaice	RF-AP-27	11.0
Reference	07/20/17	BT	5	American Plaice	RF-AP-28	7.5
Reference	07/20/17	BT	5	American Plaice	RF-AP-29	11.5
Reference	07/20/17	BT	5	American Plaice	RF-AP-30	10.5
Reference	07/20/17	BT	5	American Plaice	RF-AP-31	9.0
Reference	07/20/17	BT	5	American Plaice	RF-AP-32	11.5
Reference	07/20/17	BT	5	American Plaice	RF-AP-33	11.5
Reference	07/20/17	BT	5	American Plaice	RF-AP-34	9.5
Reference	07/20/17	BT	5	American Plaice	RF-AP-35	11.5
Reference	07/20/17	BT	5	American Plaice	RF-AP-36	10.0
Reference	07/20/17	BT	5	American Plaice	RF-AP-37	11.5
Reference	07/20/17	BT	5	American Plaice	RF-AP-38	10.5
Reference	07/20/17	BT	5	American Plaice	RF-AP-39	9.0

Sampling Station	Date	Trawl Type	Tow #	Species	Specimen No.	Total Length (cm)
Reference	07/20/17	BT	5	American Plaice	RF-AP-40	11.5
Reference	07/20/17	BT	5	American Plaice	RF-AP-41	9.0
Reference	07/20/17	BT	5	American Plaice	RF-AP-42	11.0
Reference	07/20/17	BT	5	American Plaice	RF-AP-43	11.5
Reference	07/20/17	BT	5	American Plaice	RF-AP-44	11.0
Reference	07/20/17	BT	5	American Plaice	RF-AP-45	9.5
Reference	07/20/17	BT	5	American Plaice	RF-AP-46	9.5
Reference	07/20/17	BT	5	American Plaice	RF-AP-47	9.0
Reference	07/20/17	BT	5	American Plaice	RF-AP-48	8.5
Reference	07/20/17	BT	6	American Plaice	RF-AP-49	11.0
Reference	07/20/17	BT	6	American Plaice	RF-AP-50	11.0
Reference	07/20/17	BT	7	American Plaice	RF-AP-51	11.0
Reference	07/20/17	BT	7	American Plaice	RF-AP-52	11.0
Reference	07/20/17	BT	7	American Plaice	RF-AP-53	11.0
Reference	07/20/17	BT	7	American Plaice	RF-AP-54	10.0
Reference	07/20/17	BT	7	American Plaice	RF-AP-55	11.0
Reference	07/20/17	BT	7	American Plaice	RF-AP-56	9.0
Reference	07/20/17	BT	7	American Plaice	RF-AP-57	11.0
Reference	07/20/17	BT	7	American Plaice	RF-AP-58	10.0
Reference	07/20/17	BT	7	American Plaice	RF-AP-59	11.0
Reference	07/20/17	BT	7	American Plaice	RF-AP-60	11.0
Reference	07/20/17	BT	7	American Plaice	RF-AP-61	10.5
Reference	07/20/17	BT	7	American Plaice	RF-AP-62	10.0
Reference	07/20/17	BT	7	American Plaice	RF-AP-63	10.0
Reference	07/20/17	BT	7	American Plaice	RF-AP-64	10.0
Reference	07/20/17	BT	7	American Plaice	RF-AP-65	10.0
Reference	07/20/17	BT	7	American Plaice	RF-AP-66	10.0
Reference	07/20/17	BT	8	American Plaice	RF-AP-67	10.0
Reference	07/20/17	BT	8	American Plaice	RF-AP-68	10.5
Reference	07/20/17	BT	8	American Plaice	RF-AP-69	10.5
Reference	07/20/17	BT	8	American Plaice	RF-AP-70	11.0
Reference	07/20/17	BT	8	American Plaice	RF-AP-71	11.0
Reference	07/20/17	BT	8	American Plaice	RF-AP-72	10.5
Reference	07/20/17	BT	8	American Plaice	RF-AP-73	11.0
Reference	07/20/17	BT	8	American Plaice	RF-AP-74	11.0
Reference	07/20/17	BT	8	American Plaice	RF-AP-75	11.0
Reference	07/20/17	BT	8	American Plaice	RF-AP-76	10.5
Reference	07/20/17	BT	8	American Plaice	RF-AP-77	8.0
Reference	07/20/17	BT	8	American Plaice	RF-AP-78	11.0
Reference	07/20/17	BT	8	American Plaice	RF-AP-79	9.5
Reference	07/20/17	BT	8	American Plaice	RF-AP-80	10.5
Reference	07/27/17	BT	70	American Plaice	RF-AP-81	8.5
Reference	07/27/17	BT	70	American Plaice	RF-AP-82	9.5
Reference	07/27/17	BT	70	American Plaice	RF-AP-83	9.0
Reference	07/27/17	BT	70	American Plaice	RF-AP-84	9.0
Reference	07/27/17	BT	70	American Plaice	RF-AP-85	9.0
Reference	07/27/17	BT	70	American Plaice	RF-AP-86	10.0
Reference	07/27/17	BT	70	American Plaice	RF-AP-87	9.5
Reference	07/27/17	BT	70	American Plaice	RF-AP-88	8.5
Reference	07/27/17	BT	70	American Plaice	RF-AP-89	9.5
Reference	07/27/17	BT	71	American Plaice	RF-AP-90	8.5
Reference	07/27/17	BT	71	American Plaice	RF-AP-91	10.0
Reference	07/27/17	BT	71	American Plaice	RF-AP-92	9.0
Reference	07/27/17	BT	71	American Plaice	RF-AP-93	9.0
Reference	07/27/17	BT	71	American Plaice	RF-AP-94	10.0
Reference	07/27/17	BT	71	American Plaice	RF-AP-95	9.0
Reference	07/27/17	BT	71	American Plaice	RF-AP-96	8.5

Sampling Station	Date	Trawl Type	Tow #	Species	Specimen No.	Total Length (cm)
Reference	07/27/17	BT	71	American Plaice	RF-AP-97	9.0
Reference	07/27/17	BT	71	American Plaice	RF-AP-98	10.0
Reference	07/27/17	BT	71	American Plaice	RF-AP-99	9.0
Reference	07/27/17	BT	71	American Plaice	RF-AP-100	9.0
Reference	07/27/17	BT	74	American Plaice	RF-AP-101	7.0
Reference	07/19/17	MWT	3	Capelin	RF-C-01	12.0
Reference	07/19/17	MWT	3	Capelin	RF-C-02	12.5
Reference	07/19/17	MWT	4	Capelin	RF-C-03	10.0
Reference	07/19/17	MWT	4	Capelin	RF-C-04	11.0
Reference	07/19/17	MWT	4	Capelin	RF-C-05	12.0
Reference	07/19/17	MWT	4	Capelin	RF-C-06	11.5
Reference	07/19/17	MWT	4	Capelin	RF-C-07	12.0
Reference	07/19/17	MWT	4	Capelin	RF-C-08	12.0
Reference	07/19/17	MWT	4	Capelin	RF-C-09	11.5
Reference	07/19/17	MWT	4	Capelin	RF-C-10	11.5
Reference	07/19/17	MWT	4	Capelin	RF-C-11	11.5
Reference	07/19/17	MWT	4	Capelin	RF-C-12	11.5
Reference	07/19/17	MWT	4	Capelin	RF-C-13	12.0
Reference	07/19/17	MWT	4	Capelin	RF-C-14	12.0
Reference	07/19/17	MWT	4	Capelin	RF-C-15	13.0
Reference	07/19/17	MWT	4	Capelin	RF-C-16	11.5
Reference	07/19/17	MWT	4	Capelin	RF-C-17	12.0
Reference	07/19/17	MWT	4	Capelin	RF-C-18	11.5
Reference	07/19/17	MWT	4	Capelin	RF-C-19	12.0
Reference	07/19/17	MWT	4	Capelin	RF-C-20	12.5
Reference	07/19/17	MWT	4	Capelin	RF-C-21	12.5
Reference	07/20/17	BT	5	Capelin	RF-C-22	13.0
Reference	07/20/17	BT	5	Capelin	RF-C-23	12.0
Reference	07/20/17	BT	5	Capelin	RF-C-24	12.0
Reference	07/20/17	BT	5	Capelin	RF-C-25	13.0
Reference	07/20/17	BT	5	Capelin	RF-C-26	12.5
Reference	07/20/17	BT	5	Capelin	RF-C-27	12.0
Reference	07/20/17	BT	5	Capelin	RF-C-28	12.0
Reference	07/20/17	BT	5	Capelin	RF-C-29	12.5
Reference	07/20/17	BT	5	Capelin	RF-C-30	12.0
Reference	07/20/17	BT	5	Capelin	RF-C-31	13.5
Reference	07/20/17	BT	5	Capelin	RF-C-32	12.0
Reference	07/20/17	BT	5	Capelin	RF-C-33	13.0
Reference	07/20/17	BT	5	Capelin	RF-C-34	12.0
Reference	07/20/17	BT	5	Capelin	RF-C-35	12.0
Reference	07/20/17	BT	5	Capelin	RF-C-36	12.0
Reference	07/20/17	BT	5	Capelin	RF-C-37	12.0
Reference	07/20/17	BT	5	Capelin	RF-C-38	12.0
Reference	07/20/17	BT	5	Capelin	RF-C-39	13.0
Reference	07/20/17	BT	5	Capelin	RF-C-40	11.5
Reference	07/20/17	BT	5	Capelin	RF-C-41	12.5
Reference	07/20/17	BT	6	Capelin	RF-C-42	12.0
Reference	07/20/17	BT	6	Capelin	RF-C-43	12.0
Reference	07/20/17	BT	6	Capelin	RF-C-44	11.5
Reference	07/20/17	BT	6	Capelin	RF-C-45	12.5
Reference	07/20/17	BT	6	Capelin	RF-C-46	12.0
Reference	07/20/17	BT	6	Capelin	RF-C-47	12.0
Reference	07/20/17	BT	6	Capelin	RF-C-48	12.0
Reference	07/20/17	BT	6	Capelin	RF-C-49	11.5
Reference	07/20/17	BT	6	Capelin	RF-C-50	11.5
Reference	07/20/17	BT	8	Capelin	RF-C-51	11.5
Reference	07/20/17	BT	8	Capelin	RF-C-52	12.0

Sampling Station	Date	Trawl Type	Tow #	Species	Specimen No.	Total Length (cm)
Reference	07/20/17	BT	8	Capelin	RF-C-53	11.0
Reference	07/20/17	BT	8	Capelin	RF-C-54	11.0
Reference	07/20/17	BT	8	Capelin	RF-C-55	12.0
Reference	07/20/17	BT	8	Capelin	RF-C-56	11.0
Reference	07/20/17	BT	8	Capelin	RF-C-57	11.0
Reference	07/20/17	BT	8	Capelin	RF-C-58	11.0
Reference	07/20/17	BT	8	Capelin	RF-C-59	11.0
Reference	07/20/17	BT	8	Capelin	RF-C-60	11.0
Reference	07/20/17	BT	8	Capelin	RF-C-61	11.0
Reference	07/20/17	BT	8	Capelin	RF-C-62	11.5
Reference	07/20/17	BT	8	Capelin	RF-C-63	12.0
Reference	07/20/17	BT	8	Capelin	RF-C-64	12.0
Reference	07/26/17	MWT	67	Capelin	RF-C-65	10.0
Reference	07/27/17	BT	70	Capelin	RF-C-66	10.5
Reference	07/27/17	BT	70	Capelin	RF-C-67	11.0
Reference	07/27/17	BT	70	Capelin	RF-C-68	11.0
Reference	07/27/17	BT	70	Capelin	RF-C-69	10.0
Reference	07/27/17	BT	70	Capelin	RF-C-70	11.0
Reference	07/27/17	BT	70	Capelin	RF-C-71	10.5
Reference	07/27/17	BT	70	Capelin	RF-C-72	11.0
Reference	07/27/17	BT	70	Capelin	RF-C-73	11.0
Reference	07/27/17	BT	70	Capelin	RF-C-74	11.0
Reference	07/27/17	BT	70	Capelin	RF-C-75	11.0
Reference	07/27/17	BT	70	Capelin	RF-C-76	10.5
Reference	07/27/17	BT	70	Capelin	RF-C-77	11.0
Reference	07/27/17	BT	70	Capelin	RF-C-78	11.0
Reference	07/27/17	BT	70	Capelin	RF-C-79	10.5
Reference	07/19/17	MWT	1	Sandlance	RF-SL-01	15.0
Reference	07/19/17	MWT	1	Sandlance	RF-SL-02	14.5
Reference	07/19/17	MWT	2	Sandlance	RF-SL-04	16.0
Reference	07/20/17	BT	6	Sandlance	RF-SL-05	19.0
Reference	07/20/17	BT	6	Sandlance	RF-SL-06	15.0
Reference	07/20/17	BT	6	Sandlance	RF-SL-07	15.5
Reference	07/20/17	BT	6	Sandlance	RF-SL-08	17.0
Reference	07/20/17	BT	6	Sandlance	RF-SL-09	17.0
Reference	07/20/17	BT	6	Sandlance	RF-SL-10	15.0
Reference	07/20/17	BT	6	Sandlance	RF-SL-11	17.0
Reference	07/20/17	BT	6	Sandlance	RF-SL-12	16.0
Reference	07/20/17	BT	6	Sandlance	RF-SL-13	18.0
Reference	07/20/17	BT	7	Sandlance	RF-SL-14	14.0
Reference	07/20/17	BT	7	Sandlance	RF-SL-15	13.5
Reference	07/20/17	BT	7	Sandlance	RF-SL-16	14.0
Reference	07/20/17	BT	7	Sandlance	RF-SL-17	14.0
Reference	07/20/17	BT	7	Sandlance	RF-SL-18	15.0
Reference	07/20/17	BT	7	Sandlance	RF-SL-19	14.5
Reference	07/20/17	BT	7	Sandlance	RF-SL-20	15.0
Reference	07/20/17	BT	7	Sandlance	RF-SL-21	14.5
Reference	07/20/17	BT	7	Sandlance	RF-SL-22	14.0
Reference	07/20/17	BT	7	Sandlance	RF-SL-23	15.0
Reference	07/20/17	BT	7	Sandlance	RF-SL-24	15.0
Reference	07/20/17	BT	7	Sandlance	RF-SL-25	14.0
Reference	07/20/17	BT	7	Sandlance	RF-SL-26	13.5
Reference	07/20/17	BT	7	Sandlance	RF-SL-27	15.0
Reference	07/20/17	BT	7	Sandlance	RF-SL-28	14.5
Reference	07/20/17	BT	7	Sandlance	RF-SL-29	15.0
Reference	07/20/17	BT	7	Sandlance	RF-SL-30	14.0
Reference	07/20/17	BT	7	Sandlance	RF-SL-31	13.0

Sampling Station	Date	Trawl Type	Tow #	Species	Specimen No.	Total Length (cm)
Reference	07/20/17	BT	7	Sandlance	RF-SL-32	13.0
Reference	07/20/17	BT	7	Sandlance	RF-SL-33	14.0
Reference	07/20/17	BT	7	Sandlance	RF-SL-34	14.5
Reference	07/20/17	BT	8	Sandlance	RF-SL-35	15.0
Reference	07/20/17	BT	8	Sandlance	RF-SL-36	15.0
Reference	07/20/17	BT	8	Sandlance	RF-SL-37	15.0
Reference	07/20/17	BT	8	Sandlance	RF-SL-38	14.5
Reference	07/20/17	BT	8	Sandlance	RF-SL-39	14.5
Reference	07/20/17	BT	8	Sandlance	RF-SL-40	15.0
Reference	07/20/17	BT	8	Sandlance	RF-SL-41	13.5
Reference	07/20/17	BT	8	Sandlance	RF-SL-42	15.0
Reference	07/20/17	BT	8	Sandlance	RF-SL-43	14.0
Reference	07/20/17	BT	8	Sandlance	RF-SL-44	15.0
Reference	07/20/17	BT	8	Sandlance	RF-SL-45	15.0
Reference	07/20/17	BT	8	Sandlance	RF-SL-46	15.0
Reference	07/20/17	BT	8	Sandlance	RF-SL-47	14.0
Reference	07/20/17	BT	8	Sandlance	RF-SL-48	15.0
Reference	07/20/17	BT	8	Sandlance	RF-SL-49	15.0
Reference	07/20/17	BT	8	Sandlance	RF-SL-50	15.0
Reference	07/20/17	BT	8	Sandlance	RF-SL-51	15.0
Reference	07/27/17	BT	71	Sandlance	RF-SL-52	12.0
Reference	07/27/17	BT	73	Sandlance	RF-SL-53	13.0
Reference	07/27/17	BT	73	Sandlance	RF-SL-54	13.5
Reference	07/27/17	BT	73	Sandlance	RF-SL-55	12.0
Reference	07/27/17	BT	73	Sandlance	RF-SL-56	13.0
Reference	07/27/17	BT	73	Sandlance	RF-SL-57	12.0
Reference	07/27/17	BT	73	Sandlance	RF-SL-58	13.0
Reference	07/27/17	BT	73	Sandlance	RF-SL-59	13.0
Reference	07/27/17	BT	73	Sandlance	RF-SL-60	12.5
Reference	07/27/17	BT	73	Sandlance	RF-SL-61	12.5
Reference	07/27/17	BT	73	Sandlance	RF-SL-62	12.5
Reference	07/27/17	BT	73	Sandlance	RF-SL-63	13.0
Reference	07/27/17	BT	73	Sandlance	RF-SL-64	12.5
Reference	07/27/17	BT	73	Sandlance	RF-SL-65	13.0
Reference	07/27/17	BT	73	Sandlance	RF-SL-66	12.5
Reference	07/27/17	BT	74	Sandlance	RF-SL-67	13.0
Reference	07/27/17	BT	74	Sandlance	RF-SL-68	12.5
Reference	07/27/17	BT	74	Sandlance	RF-SL-69	13.0
Reference	07/27/17	BT	74	Sandlance	RF-SL-70	13.0
Reference	07/27/17	BT	74	Sandlance	RF-SL-71	13.0
Terra Nova	07/22/17	MWT	33	Atlantic Cod	TN-AC-01	10.0
Terra Nova	07/23/17	BT	44	Atlantic Cod	TN-AC-02	10.0
Terra Nova	07/23/17	BT	44	Atlantic Cod	TN-AC-03	11.5
Terra Nova	07/27/17	BT	76	Atlantic Cod	TN-AC-04	16.0
Terra Nova	07/28/17	MWT	79	Atlantic Cod	TN-AC-05	12.0
Terra Nova	07/28/17	BT	86	Atlantic Cod	TN-AC-06	10.5
Terra Nova	07/23/17	BT	38	American Plaice	TN-AP-01	11.0
Terra Nova	07/23/17	BT	38	American Plaice	TN-AP-02	11.0
Terra Nova	07/23/17	BT	38	American Plaice	TN-AP-03	12.0
Terra Nova	07/23/17	BT	38	American Plaice	TN-AP-04	11.5
Terra Nova	07/23/17	BT	38	American Plaice	TN-AP-05	12.0
Terra Nova	07/23/17	BT	39	American Plaice	TN-AP-06	12.5
Terra Nova	07/23/17	BT	40	American Plaice	TN-AP-07	12.0
Terra Nova	07/23/17	BT	40	American Plaice	TN-AP-08	13.0
Terra Nova	07/23/17	BT	40	American Plaice	TN-AP-09	11.0
Terra Nova	07/23/17	BT	40	American Plaice	TN-AP-10	9.0
Terra Nova	07/23/17	BT	40	American Plaice	TN-AP-11	13.0

Sampling Station	Date	Trawl Type	Tow #	Species	Specimen No.	Total Length (cm)
Terra Nova	07/23/17	BT	40	American Plaice	TN-AP-12	11.0
Terra Nova	07/23/17	BT	40	American Plaice	TN-AP-13	13.0
Terra Nova	07/23/17	BT	40	American Plaice	TN-AP-14	12.0
Terra Nova	07/23/17	BT	40	American Plaice	TN-AP-15	12.0
Terra Nova	07/23/17	BT	41	American Plaice	TN-AP-16	12.0
Terra Nova	07/23/17	BT	41	American Plaice	TN-AP-17	9.5
Terra Nova	07/23/17	BT	41	American Plaice	TN-AP-18	12.0
Terra Nova	07/23/17	BT	41	American Plaice	TN-AP-19	9.0
Terra Nova	07/23/17	BT	41	American Plaice	TN-AP-20	13.0
Terra Nova	07/23/17	BT	41	American Plaice	TN-AP-21	12.0
Terra Nova	07/23/17	BT	41	American Plaice	TN-AP-22	11.0
Terra Nova	07/23/17	BT	41	American Plaice	TN-AP-23	13.0
Terra Nova	07/23/17	BT	41	American Plaice	TN-AP-24	10.0
Terra Nova	07/23/17	BT	41	American Plaice	TN-AP-25	13.0
Terra Nova	07/23/17	BT	41	American Plaice	TN-AP-26	11.0
Terra Nova	07/23/17	BT	41	American Plaice	TN-AP-27	11.0
Terra Nova	07/23/17	BT	41	American Plaice	TN-AP-28	13.0
Terra Nova	07/23/17	BT	42	American Plaice	TN-AP-29	11.5
Terra Nova	07/23/17	BT	42	American Plaice	TN-AP-30	12.5
Terra Nova	07/23/17	BT	42	American Plaice	TN-AP-31	12.5
Terra Nova	07/23/17	BT	42	American Plaice	TN-AP-32	13.0
Terra Nova	07/23/17	BT	42	American Plaice	TN-AP-33	13.0
Terra Nova	07/23/17	BT	42	American Plaice	TN-AP-34	13.0
Terra Nova	07/23/17	BT	42	American Plaice	TN-AP-35	11.0
Terra Nova	07/23/17	BT	44	American Plaice	TN-AP-36	12.5
Terra Nova	07/23/17	BT	44	American Plaice	TN-AP-37	11.5
Terra Nova	07/23/17	BT	44	American Plaice	TN-AP-38	11.0
Terra Nova	07/23/17	BT	44	American Plaice	TN-AP-39	13.0
Terra Nova	07/23/17	BT	44	American Plaice	TN-AP-40	13.0
Terra Nova	07/23/17	BT	44	American Plaice	TN-AP-41	13.0
Terra Nova	07/23/17	BT	45	American Plaice	TN-AP-42	11.0
Terra Nova	07/23/17	BT	45	American Plaice	TN-AP-43	10.0
Terra Nova	07/23/17	BT	45	American Plaice	TN-AP-44	11.5
Terra Nova	07/23/17	BT	45	American Plaice	TN-AP-45	13.0
Terra Nova	07/23/17	BT	46	American Plaice	TN-AP-46	13.0
Terra Nova	07/23/17	BT	46	American Plaice	TN-AP-47	12.0
Terra Nova	07/23/17	BT	46	American Plaice	TN-AP-48	11.5
Terra Nova	07/23/17	BT	46	American Plaice	TN-AP-49	14.0
Terra Nova	07/23/17	BT	46	American Plaice	TN-AP-50	13.5
Terra Nova	07/27/17	BT	75	American Plaice	TN-AP-51	11.5
Terra Nova	07/27/17	BT	77	American Plaice	TN-AP-52	10.5
Terra Nova	07/27/17	BT	77	American Plaice	TN-AP-53	10.0
Terra Nova	07/27/17	BT	77	American Plaice	TN-AP-54	11.0
Terra Nova	07/27/17	BT	77	American Plaice	TN-AP-55	10.0
Terra Nova	07/27/17	BT	77	American Plaice	TN-AP-56	10.0
Terra Nova	07/27/17	BT	77	American Plaice	TN-AP-57	11.0
Terra Nova	07/22/17	MWT	33	Capelin	TN-C-01	13.0
Terra Nova	07/28/17	MWT	78	Capelin	TN-C-02	10.0
Terra Nova	07/28/17	MWT	78	Capelin	TN-C-03	10.5
Terra Nova	07/28/17	MWT	79	Capelin	TN-C-04	10.0
Terra Nova	07/28/17	MWT	79	Capelin	TN-C-05	10.5
Terra Nova	07/28/17	MWT	79	Capelin	TN-C-06	12.5
Terra Nova	07/28/17	MWT	79	Capelin	TN-C-07	10.5
Terra Nova	07/28/17	MWT	80	Capelin	TN-C-08	9.5
Terra Nova	07/28/17	MWT	80	Capelin	TN-C-09	11.0
Terra Nova	07/28/17	MWT	80	Capelin	TN-C-10	11.0
Terra Nova	07/28/17	MWT	80	Capelin	TN-C-11	10.0

Sampling Station	Date	Trawl Type	Tow #	Species	Specimen No.	Total Length (cm)
Terra Nova	07/28/17	MWT	80	Capelin	TN-C-12	9.5
Terra Nova	07/28/17	MWT	80	Capelin	TN-C-13	10.0
Terra Nova	07/28/17	MWT	80	Capelin	TN-C-14	12.5
Terra Nova	07/28/17	MWT	80	Capelin	TN-C-15	11.0
Terra Nova	07/28/17	MWT	80	Capelin	TN-C-16	9.5
Terra Nova	07/28/17	MWT	81	Capelin	TN-C-17	10.5
Terra Nova	07/28/17	MWT	81	Capelin	TN-C-18	10.5
Terra Nova	07/28/17	MWT	81	Capelin	TN-C-19	10.5
Terra Nova	07/28/17	MWT	81	Capelin	TN-C-20	10.5
Terra Nova	07/28/17	MWT	81	Capelin	TN-C-21	10.0
Terra Nova	07/28/17	MWT	81	Capelin	TN-C-22	10.5
Terra Nova	07/28/17	MWT	81	Capelin	TN-C-23	11.5
Terra Nova	07/28/17	MWT	81	Capelin	TN-C-24	10.5
Terra Nova	07/28/17	MWT	81	Capelin	TN-C-25	10.0
Terra Nova	07/28/17	MWT	81	Capelin	TN-C-26	10.0
Terra Nova	07/28/17	MWT	81	Capelin	TN-C-27	10.5
Terra Nova	07/28/17	MWT	82	Capelin	TN-C-28	10.5
Terra Nova	07/28/17	MWT	82	Capelin	TN-C-29	11.0
Terra Nova	07/28/17	MWT	82	Capelin	TN-C-30	10.5
Terra Nova	07/28/17	MWT	82	Capelin	TN-C-31	9.5
Terra Nova	07/28/17	MWT	82	Capelin	TN-C-32	9.5
Terra Nova	07/28/17	MWT	83	Capelin	TN-C-33	10.5
Terra Nova	07/28/17	MWT	83	Capelin	TN-C-34	10.5
Terra Nova	07/28/17	MWT	83	Capelin	TN-C-35	10.5
Terra Nova	07/28/17	MWT	83	Capelin	TN-C-36	10.0
Terra Nova	07/28/17	MWT	83	Capelin	TN-C-37	11.0
Terra Nova	07/28/17	MWT	83	Capelin	TN-C-38	9.5
Terra Nova	07/28/17	MWT	83	Capelin	TN-C-39	7.5
Terra Nova	07/28/17	MWT	83	Capelin	TN-C-40	11.0
Terra Nova	07/28/17	MWT	83	Capelin	TN-C-41	11.5
Terra Nova	07/28/17	MWT	83	Capelin	TN-C-42	9.5
Terra Nova	07/28/17	MWT	83	Capelin	TN-C-43	12.5
Terra Nova	07/28/17	MWT	83	Capelin	TN-C-44	12.0
Terra Nova	07/28/17	MWT	83	Capelin	TN-C-45	12.5
Terra Nova	07/28/17	MWT	83	Capelin	TN-C-46	10.0
Terra Nova	07/28/17	MWT	84	Capelin	TN-C-47	11.0
Terra Nova	07/28/17	MWT	84	Capelin	TN-C-48	11.0
Terra Nova	07/28/17	MWT	85	Capelin	TN-C-49	12.0
Terra Nova	07/28/17	BT	86	Capelin	TN-C-50	9.5
Terra Nova	07/28/17	BT	86	Capelin	TN-C-51	9.0
Terra Nova	07/28/17	BT	86	Capelin	TN-C-52	9.5
Terra Nova	07/28/17	BT	86	Capelin	TN-C-53	9.0
Terra Nova	07/28/17	BT	86	Capelin	TN-C-54	10.0
Terra Nova	07/22/17	MWT	26	Sandlance	TN-SL-01	12.5
Terra Nova	07/22/17	MWT	26	Sandlance	TN-SL-02	14.0
Terra Nova	07/22/17	MWT	26	Sandlance	TN-SL-03	14.0
Terra Nova	07/22/17	MWT	26	Sandlance	TN-SL-04	14.0
Terra Nova	07/22/17	MWT	27	Sandlance	TN-SL-05	6.5
Terra Nova	07/22/17	MWT	27	Sandlance	TN-SL-06	8.0
Terra Nova	07/22/17	MWT	27	Sandlance	TN-SL-07	7.5
Terra Nova	07/22/17	MWT	27	Sandlance	TN-SL-08	7.5
Terra Nova	07/22/17	MWT	27	Sandlance	TN-SL-09	7.5
Terra Nova	07/22/17	MWT	28	Sandlance	TN-SL-10	8.0
Terra Nova	07/22/17	MWT	28	Sandlance	TN-SL-11	7.0
Terra Nova	07/22/17	MWT	28	Sandlance	TN-SL-12	12.0
Terra Nova	07/22/17	MWT	28	Sandlance	TN-SL-13	12.5
Terra Nova	07/22/17	MWT	28	Sandlance	TN-SL-14	12.0

Sampling Station	Date	Trawl Type	Tow #	Species	Specimen No.	Total Length (cm)
Terra Nova	07/22/17	MWT	29	Sandlance	TN-SL-15	12.0
Terra Nova	07/22/17	MWT	30	Sandlance	TN-SL-16	12.0
Terra Nova	07/22/17	MWT	30	Sandlance	TN-SL-17	12.0
Terra Nova	07/22/17	MWT	30	Sandlance	TN-SL-18	12.0
Terra Nova	07/22/17	MWT	30	Sandlance	TN-SL-19	12.0
Terra Nova	07/22/17	MWT	30	Sandlance	TN-SL-20	7.0
Terra Nova	07/22/17	MWT	30	Sandlance	TN-SL-21	12.0
Terra Nova	07/22/17	MWT	30	Sandlance	TN-SL-22	12.0
Terra Nova	07/22/17	MWT	30	Sandlance	TN-SL-23	12.0
Terra Nova	07/22/17	MWT	30	Sandlance	TN-SL-24	11.5
Terra Nova	07/22/17	MWT	30	Sandlance	TN-SL-25	11.5
Terra Nova	07/22/17	MWT	30	Sandlance	TN-SL-26	11.5
Terra Nova	07/22/17	MWT	30	Sandlance	TN-SL-27	12.0
Terra Nova	07/22/17	MWT	30	Sandlance	TN-SL-28	12.0
Terra Nova	07/22/17	MWT	31	Sandlance	TN-SL-29	11.5
Terra Nova	07/22/17	MWT	31	Sandlance	TN-SL-30	12.0
Terra Nova	07/22/17	MWT	31	Sandlance	TN-SL-31	7.5
Terra Nova	07/22/17	MWT	31	Sandlance	TN-SL-32	8.0
Terra Nova	07/22/17	MWT	31	Sandlance	TN-SL-33	12.5
Terra Nova	07/22/17	MWT	31	Sandlance	TN-SL-34	11.0
Terra Nova	07/22/17	MWT	31	Sandlance	TN-SL-35	12.0
Terra Nova	07/22/17	MWT	31	Sandlance	TN-SL-36	12.0
Terra Nova	07/22/17	MWT	31	Sandlance	TN-SL-37	11.5
Terra Nova	07/22/17	MWT	31	Sandlance	TN-SL-38	11.5
Terra Nova	07/22/17	MWT	32	Sandlance	TN-SL-39	11.5
Terra Nova	07/22/17	MWT	32	Sandlance	TN-SL-40	11.5
Terra Nova	07/22/17	MWT	33	Sandlance	TN-SL-41	12.0
Terra Nova	07/22/17	MWT	33	Sandlance	TN-SL-42	12.5
Terra Nova	07/22/17	MWT	35	Sandlance	TN-SL-43	12.0
Terra Nova	07/22/17	MWT	35	Sandlance	TN-SL-44	12.0
Terra Nova	07/22/17	MWT	35	Sandlance	TN-SL-45	12.0
Terra Nova	07/22/17	MWT	35	Sandlance	TN-SL-46	12.0
Terra Nova	07/22/17	MWT	36	Sandlance	TN-SL-47	12.0
Terra Nova	07/22/17	BT	37	Sandlance	TN-SL-48	12.0
Terra Nova	07/22/17	BT	37	Sandlance	TN-SL-49	12.0
Terra Nova	07/22/17	BT	37	Sandlance	TN-SL-50	11.0
Terra Nova	07/22/17	BT	37	Sandlance	TN-SL-51	11.5
Terra Nova	07/22/17	BT	37	Sandlance	TN-SL-52	12.0
Terra Nova	07/22/17	BT	37	Sandlance	TN-SL-53	11.0
Terra Nova	07/22/17	BT	37	Sandlance	TN-SL-54	11.0
Terra Nova	07/22/17	BT	37	Sandlance	TN-SL-55	11.0
Terra Nova	07/22/17	BT	37	Sandlance	TN-SL-56	12.0
Terra Nova	07/22/17	BT	37	Sandlance	TN-SL-57	12.0
Terra Nova	07/22/17	BT	37	Sandlance	TN-SL-58	11.5
Terra Nova	07/22/17	BT	37	Sandlance	TN-SL-59	12.0
Terra Nova	07/22/17	BT	37	Sandlance	TN-SL-60	12.0
Terra Nova	07/27/17	BT	75	Sandlance	TN-SL-61	11.5
Terra Nova	07/27/17	BT	75	Sandlance	TN-SL-62	11.0
Terra Nova	07/27/17	BT	75	Sandlance	TN-SL-63	12.0
Terra Nova	07/27/17	BT	75	Sandlance	TN-SL-64	12.0
Terra Nova	07/27/17	BT	75	Sandlance	TN-SL-65	12.0
Terra Nova	07/27/17	BT	75	Sandlance	TN-SL-66	11.5
Terra Nova	07/27/17	BT	75	Sandlance	TN-SL-67	11.5
Terra Nova	07/27/17	BT	75	Sandlance	TN-SL-68	10.5
Terra Nova	07/27/17	BT	75	Sandlance	TN-SL-69	11.0
Terra Nova	07/27/17	BT	75	Sandlance	TN-SL-70	11.5
Terra Nova	07/27/17	BT	76	Sandlance	TN-SL-71	11.5

Sampling Station	Date	Trawl Type	Tow #	Species	Specimen No.	Total Length (cm)
Terra Nova	07/27/17	BT	76	Sandlance	TN-SL-72	11.5
Terra Nova	07/27/17	BT	76	Sandlance	TN-SL-73	11.5
Terra Nova	07/27/17	BT	77	Sandlance	TN-SL-74	11.5
Terra Nova	07/27/17	BT	77	Sandlance	TN-SL-75	11.5
Terra Nova	07/28/17	MWT	78	Sandlance	TN-SL-76	12.0
Terra Nova	07/28/17	MWT	78	Sandlance	TN-SL-77	11.0
Terra Nova	07/28/17	MWT	78	Sandlance	TN-SL-78	12.0
Terra Nova	07/28/17	MWT	78	Sandlance	TN-SL-79	11.0
Terra Nova	07/28/17	MWT	78	Sandlance	TN-SL-80	11.0
Terra Nova	07/28/17	MWT	78	Sandlance	TN-SL-81	12.0
Terra Nova	07/28/17	MWT	81	Sandlance	TN-SL-82	8.0
Terra Nova	07/28/17	MWT	81	Sandlance	TN-SL-83	11.5
Terra Nova	07/28/17	MWT	82	Sandlance	TN-SL-84	7.0
Terra Nova	07/28/17	MWT	82	Sandlance	TN-SL-85	7.0
Terra Nova	07/28/17	MWT	82	Sandlance	TN-SL-86	6.5
Terra Nova	07/28/17	MWT	82	Sandlance	TN-SL-87	8.0
Terra Nova	07/28/17	MWT	82	Sandlance	TN-SL-88	8.5
Terra Nova	07/28/17	MWT	82	Sandlance	TN-SL-89	7.5
Terra Nova	07/28/17	MWT	82	Sandlance	TN-SL-90	7.5
Terra Nova	07/28/17	MWT	82	Sandlance	TN-SL-91	6.0
Terra Nova	07/28/17	MWT	83	Sandlance	TN-SL-92	7.5
Terra Nova	07/28/17	MWT	83	Sandlance	TN-SL-93	8.0
Terra Nova	07/28/17	MWT	83	Sandlance	TN-SL-94	6.5
Terra Nova	07/28/17	MWT	83	Sandlance	TN-SL-95	7.0
Terra Nova	07/28/17	MWT	83	Sandlance	TN-SL-96	7.5
Terra Nova	07/28/17	MWT	83	Sandlance	TN-SL-97	6.5
Terra Nova	07/28/17	MWT	83	Sandlance	TN-SL-98	7.0
Terra Nova	07/28/17	MWT	83	Sandlance	TN-SL-99	7.0
Terra Nova	07/28/17	MWT	83	Sandlance	TN-SL-100	6.0
Terra Nova	07/28/17	MWT	83	Sandlance	TN-SL-101	7.0
Terra Nova	07/28/17	MWT	83	Sandlance	TN-SL-102	7.5
Terra Nova	07/28/17	MWT	83	Sandlance	TN-SL-103	7.5
Terra Nova	07/28/17	MWT	83	Sandlance	TN-SL-104	7.0
Terra Nova	07/28/17	MWT	83	Sandlance	TN-SL-105	8.0
Terra Nova	07/28/17	MWT	84	Sandlance	TN-SL-106	8.5
Terra Nova	07/28/17	BT	86	Sandlance	TN-SL-107	6.0
Terra Nova	07/28/17	BT	86	Sandlance	TN-SL-108	7.5
Terra Nova	07/28/17	BT	86	Sandlance	TN-SL-109	6.5
Terra Nova	07/28/17	BT	86	Sandlance	TN-SL-110	6.5
Terra Nova	07/28/17	BT	86	Sandlance	TN-SL-111	8.5
White Rose	07/24/17	BT	47	Atlantic Cod	WR-AC-01	12.5
White Rose	07/24/17	BT	47	Atlantic Cod	WR-AC-02	10.0
White Rose	07/24/17	BT	47	Atlantic Cod	WR-AC-03	12.0
White Rose	07/24/17	BT	47	Atlantic Cod	WR-AC-04	13.5
White Rose	07/24/17	BT	47	Atlantic Cod	WR-AC-05	11.0
White Rose	07/24/17	BT	47	Atlantic Cod	WR-AC-06	12.5
White Rose	07/24/17	BT	47	Atlantic Cod	WR-AC-07	11.0
White Rose	07/24/17	BT	47	Atlantic Cod	WR-AC-08	13.0
White Rose	07/24/17	BT	47	Atlantic Cod	WR-AC-09	11.5
White Rose	07/24/17	BT	48	Atlantic Cod	WR-AC-10	12.0
White Rose	07/24/17	BT	48	Atlantic Cod	WR-AC-11	12.0
White Rose	07/24/17	BT	48	Atlantic Cod	WR-AC-12	11.0
White Rose	07/24/17	BT	49	Atlantic Cod	WR-AC-13	11.5
White Rose	07/24/17	BT	49	Atlantic Cod	WR-AC-14	11.5
White Rose	07/24/17	BT	49	Atlantic Cod	WR-AC-15	13.0
White Rose	07/24/17	BT	49	Atlantic Cod	WR-AC-16	11.0
White Rose	07/24/17	BT	49	Atlantic Cod	WR-AC-17	13.0

Sampling Station	Date	Trawl Type	Tow #	Species	Specimen No.	Total Length (cm)
White Rose	07/24/17	BT	49	Atlantic Cod	WR-AC-18	12.0
White Rose	07/24/17	BT	49	Atlantic Cod	WR-AC-19	12.0
White Rose	07/24/17	BT	50	Atlantic Cod	WR-AC-20	10.5
White Rose	07/24/17	BT	50	Atlantic Cod	WR-AC-21	12.0
White Rose	07/24/17	BT	50	Atlantic Cod	WR-AC-22	12.0
White Rose	07/24/17	BT	50	Atlantic Cod	WR-AC-23	11.0
White Rose	07/24/17	BT	50	Atlantic Cod	WR-AC-24	12.5
White Rose	07/24/17	BT	50	Atlantic Cod	WR-AC-25	12.0
White Rose	07/24/17	BT	50	Atlantic Cod	WR-AC-26	11.0
White Rose	07/24/17	BT	50	Atlantic Cod	WR-AC-27	11.5
White Rose	07/24/17	BT	50	Atlantic Cod	WR-AC-28	12.0
White Rose	07/24/17	BT	50	Atlantic Cod	WR-AC-29	12.0
White Rose	07/24/17	BT	50	Atlantic Cod	WR-AC-30	11.5
White Rose	07/24/17	BT	50	Atlantic Cod	WR-AC-31	12.5
White Rose	07/24/17	BT	50	Atlantic Cod	WR-AC-32	11.0
White Rose	07/24/17	BT	50	Atlantic Cod	WR-AC-33	13.5
White Rose	07/24/17	BT	51	Atlantic Cod	WR-AC-34	11.5
White Rose	07/24/17	BT	51	Atlantic Cod	WR-AC-35	12.0
White Rose	07/24/17	BT	51	Atlantic Cod	WR-AC-36	10.5
White Rose	07/24/17	BT	51	Atlantic Cod	WR-AC-37	11.5
White Rose	07/24/17	BT	51	Atlantic Cod	WR-AC-38	12.0
White Rose	07/24/17	BT	51	Atlantic Cod	WR-AC-39	12.5
White Rose	07/24/17	BT	51	Atlantic Cod	WR-AC-40	9.5
White Rose	07/24/17	BT	51	Atlantic Cod	WR-AC-41	11.5
White Rose	07/24/17	BT	51	Atlantic Cod	WR-AC-42	12.5
White Rose	07/24/17	BT	51	Atlantic Cod	WR-AC-43	12.0
White Rose	07/24/17	BT	52	Atlantic Cod	WR-AC-44	11.0
White Rose	07/24/17	BT	52	Atlantic Cod	WR-AC-45	11.0
White Rose	07/24/17	BT	52	Atlantic Cod	WR-AC-46	12.0
White Rose	07/24/17	BT	53	Atlantic Cod	WR-AC-47	11.0
White Rose	07/24/17	BT	53	Atlantic Cod	WR-AC-48	12.0
White Rose	07/24/17	BT	53	Atlantic Cod	WR-AC-49	11.5
White Rose	07/24/17	BT	53	Atlantic Cod	WR-AC-50	10.0
White Rose	07/24/17	BT	47	American Plaice	WR-AP-01	12.5
White Rose	07/24/17	BT	47	American Plaice	WR-AP-02	11.5
White Rose	07/24/17	BT	47	American Plaice	WR-AP-03	11.5
White Rose	07/24/17	BT	47	American Plaice	WR-AP-04	12.5
White Rose	07/24/17	BT	47	American Plaice	WR-AP-05	12.0
White Rose	07/24/17	BT	47	American Plaice	WR-AP-06	11.5
White Rose	07/24/17	BT	47	American Plaice	WR-AP-07	10.0
White Rose	07/24/17	BT	47	American Plaice	WR-AP-08	12.0
White Rose	07/24/17	BT	47	American Plaice	WR-AP-09	11.0
White Rose	07/24/17	BT	47	American Plaice	WR-AP-10	12.0
White Rose	07/24/17	BT	47	American Plaice	WR-AP-11	12.0
White Rose	07/24/17	BT	47	American Plaice	WR-AP-12	12.0
White Rose	07/24/17	BT	47	American Plaice	WR-AP-13	11.0
White Rose	07/24/17	BT	47	American Plaice	WR-AP-14	10.5
White Rose	07/24/17	BT	47	American Plaice	WR-AP-15	12.0
White Rose	07/24/17	BT	47	American Plaice	WR-AP-16	10.0
White Rose	07/24/17	BT	47	American Plaice	WR-AP-17	11.0
White Rose	07/24/17	BT	47	American Plaice	WR-AP-18	10.0
White Rose	07/24/17	BT	47	American Plaice	WR-AP-19	12.0
White Rose	07/24/17	BT	47	American Plaice	WR-AP-20	12.0
White Rose	07/24/17	BT	47	American Plaice	WR-AP-21	9.0
White Rose	07/24/17	BT	47	American Plaice	WR-AP-22	11.0
White Rose	07/24/17	BT	47	American Plaice	WR-AP-23	10.0
White Rose	07/24/17	BT	47	American Plaice	WR-AP-24	9.0

Sampling Station	Date	Trawl Type	Tow #	Species	Specimen No.	Total Length (cm)
White Rose	07/24/17	BT	47	American Plaice	WR-AP-25	11.0
White Rose	07/24/17	BT	47	American Plaice	WR-AP-26	11.5
White Rose	07/24/17	BT	47	American Plaice	WR-AP-27	12.0
White Rose	07/24/17	BT	47	American Plaice	WR-AP-28	11.0
White Rose	07/24/17	BT	47	American Plaice	WR-AP-29	11.0
White Rose	07/24/17	BT	47	American Plaice	WR-AP-30	12.0
White Rose	07/24/17	BT	48	American Plaice	WR-AP-31	11.0
White Rose	07/24/17	BT	48	American Plaice	WR-AP-32	12.0
White Rose	07/24/17	BT	48	American Plaice	WR-AP-33	11.0
White Rose	07/24/17	BT	48	American Plaice	WR-AP-34	11.0
White Rose	07/24/17	BT	48	American Plaice	WR-AP-35	12.0
White Rose	07/24/17	BT	48	American Plaice	WR-AP-36	11.0
White Rose	07/24/17	BT	48	American Plaice	WR-AP-37	12.0
White Rose	07/24/17	BT	48	American Plaice	WR-AP-38	11.0
White Rose	07/24/17	BT	48	American Plaice	WR-AP-39	11.0
White Rose	07/24/17	BT	48	American Plaice	WR-AP-40	12.5
White Rose	07/24/17	BT	48	American Plaice	WR-AP-41	10.0
White Rose	07/24/17	BT	48	American Plaice	WR-AP-42	11.0
White Rose	07/24/17	BT	48	American Plaice	WR-AP-43	11.0
White Rose	07/24/17	BT	48	American Plaice	WR-AP-44	12.0
White Rose	07/24/17	BT	48	American Plaice	WR-AP-45	11.0
White Rose	07/24/17	BT	48	American Plaice	WR-AP-46	12.0
White Rose	07/24/17	BT	48	American Plaice	WR-AP-47	10.5
White Rose	07/24/17	BT	48	American Plaice	WR-AP-48	12.0
White Rose	07/24/17	BT	49	American Plaice	WR-AP-49	9.5
White Rose	07/24/17	BT	49	American Plaice	WR-AP-50	10.0
White Rose	07/24/17	BT	49	American Plaice	WR-AP-51	11.0
White Rose	07/24/17	BT	49	American Plaice	WR-AP-52	10.5
White Rose	07/24/17	BT	49	American Plaice	WR-AP-53	9.0
White Rose	07/24/17	BT	49	American Plaice	WR-AP-54	10.0
White Rose	07/24/17	BT	49	American Plaice	WR-AP-55	11.0
White Rose	07/24/17	BT	49	American Plaice	WR-AP-56	9.0
White Rose	07/24/17	BT	49	American Plaice	WR-AP-57	10.0
White Rose	07/24/17	BT	49	American Plaice	WR-AP-58	11.0
White Rose	07/24/17	BT	49	American Plaice	WR-AP-59	10.5
White Rose	07/24/17	BT	50	American Plaice	WR-AP-60	10.5
White Rose	07/24/18	BT	51	American Plaice	WR-AP-61	7.0
White Rose	07/24/17	BT	47	Capelin	WR-C-01	12.0
White Rose	07/24/17	BT	47	Capelin	WR-C-02	12.0
White Rose	07/24/17	BT	47	Capelin	WR-C-03	12.0
White Rose	07/24/17	BT	47	Capelin	WR-C-04	11.0
White Rose	07/24/17	BT	47	Capelin	WR-C-05	11.0
White Rose	07/24/17	BT	47	Capelin	WR-C-06	11.5
White Rose	07/24/17	BT	47	Capelin	WR-C-07	12.0
White Rose	07/24/17	BT	47	Capelin	WR-C-08	11.0
White Rose	07/24/17	BT	47	Capelin	WR-C-09	12.5
White Rose	07/24/17	BT	47	Capelin	WR-C-10	12.5
White Rose	07/24/17	BT	48	Capelin	WR-C-11	12.0
White Rose	07/24/17	BT	48	Capelin	WR-C-12	12.0
White Rose	07/24/17	BT	48	Capelin	WR-C-13	12.0
White Rose	07/24/17	BT	48	Capelin	WR-C-14	12.0
White Rose	07/24/17	BT	48	Capelin	WR-C-15	12.0
White Rose	07/24/17	BT	48	Capelin	WR-C-16	12.0
White Rose	07/24/17	BT	49	Capelin	WR-C-17	10.0
White Rose	07/24/17	BT	49	Capelin	WR-C-18	12.0
White Rose	07/24/17	BT	49	Capelin	WR-C-19	12.0
White Rose	07/24/17	BT	49	Capelin	WR-C-20	12.0

Sampling Station	Date	Trawl Type	Tow #	Species	Specimen No.	Total Length (cm)
White Rose	07/24/17	BT	49	Capelin	WR-C-21	11.0
White Rose	07/24/17	BT	49	Capelin	WR-C-22	12.5
White Rose	07/24/17	BT	49	Capelin	WR-C-23	13.0
White Rose	07/24/17	BT	49	Capelin	WR-C-24	12.5
White Rose	07/24/17	BT	49	Capelin	WR-C-25	12.0
White Rose	07/24/17	BT	49	Capelin	WR-C-26	13.0
White Rose	07/24/17	BT	49	Capelin	WR-C-27	12.5
White Rose	07/24/17	BT	49	Capelin	WR-C-28	12.5
White Rose	07/24/17	BT	49	Capelin	WR-C-29	12.0
White Rose	07/24/17	BT	50	Capelin	WR-C-30	11.5
White Rose	07/24/17	BT	50	Capelin	WR-C-31	12.0
White Rose	07/24/17	BT	50	Capelin	WR-C-32	13.0
White Rose	07/24/17	BT	50	Capelin	WR-C-33	12.5
White Rose	07/24/17	BT	50	Capelin	WR-C-34	13.0
White Rose	07/24/17	BT	50	Capelin	WR-C-35	12.5
White Rose	07/24/17	BT	50	Capelin	WR-C-36	13.0
White Rose	07/24/17	BT	50	Capelin	WR-C-37	13.0
White Rose	07/24/17	BT	50	Capelin	WR-C-38	12.0
White Rose	07/24/17	BT	50	Capelin	WR-C-39	12.0
White Rose	07/24/17	BT	50	Capelin	WR-C-40	12.5
White Rose	07/24/17	BT	50	Capelin	WR-C-41	12.0
White Rose	07/24/17	BT	50	Capelin	WR-C-42	13.0
White Rose	07/24/17	BT	50	Capelin	WR-C-43	13.0
White Rose	07/24/17	BT	50	Capelin	WR-C-44	13.0
White Rose	07/24/17	BT	50	Capelin	WR-C-45	13.0
White Rose	07/24/17	BT	50	Capelin	WR-C-46	13.0
White Rose	07/24/17	BT	50	Capelin	WR-C-47	12.5
White Rose	07/24/17	BT	50	Capelin	WR-C-48	12.5
White Rose	07/24/17	BT	50	Capelin	WR-C-49	11.0
White Rose	07/24/17	BT	50	Capelin	WR-C-50	12.0
White Rose	07/24/17	BT	48	Sandlance	WR-SL-01	14.0
White Rose	07/24/17	BT	48	Sandlance	WR-SL-02	14.0
White Rose	07/24/17	BT	48	Sandlance	WR-SL-03	14.0
White Rose	07/24/17	BT	48	Sandlance	WR-SL-04	14.0
White Rose	07/24/17	BT	49	Sandlance	WR-SL-05	13.5
White Rose	07/24/17	BT	49	Sandlance	WR-SL-06	14.0
White Rose	07/24/17	BT	49	Sandlance	WR-SL-07	13.5
White Rose	07/24/17	BT	49	Sandlance	WR-SL-08	13.5
White Rose	07/24/17	BT	49	Sandlance	WR-SL-09	13.5
White Rose	07/24/17	BT	49	Sandlance	WR-SL-10	13.5
White Rose	07/24/17	BT	49	Sandlance	WR-SL-11	13.0
White Rose	07/24/17	BT	49	Sandlance	WR-SL-12	14.0
White Rose	07/24/17	BT	49	Sandlance	WR-SL-13	14.0
White Rose	07/24/17	BT	49	Sandlance	WR-SL-14	13.5
White Rose	07/24/17	BT	49	Sandlance	WR-SL-15	13.0
White Rose	07/24/17	BT	49	Sandlance	WR-SL-16	13.0
White Rose	07/24/17	BT	49	Sandlance	WR-SL-17	13.0
White Rose	07/24/17	BT	50	Sandlance	WR-SL-18	14.0
White Rose	07/24/17	BT	50	Sandlance	WR-SL-19	14.0
White Rose	07/24/17	BT	50	Sandlance	WR-SL-20	13.5
White Rose	07/24/17	BT	50	Sandlance	WR-SL-21	14.0
White Rose	07/24/17	BT	50	Sandlance	WR-SL-22	14.0
White Rose	07/24/17	BT	50	Sandlance	WR-SL-23	14.0
White Rose	07/24/17	BT	52	Sandlance	WR-SL-24	14.0
White Rose	07/24/17	BT	52	Sandlance	WR-SL-25	14.0
White Rose	07/24/17	BT	52	Sandlance	WR-SL-26	13.5
White Rose	07/24/17	BT	52	Sandlance	WR-SL-27	14.0

Sampling Station	Date	Trawl Type	Tow #	Species	Specimen No.	Total Length (cm)
White Rose	07/24/17	BT	52	Sandlance	WR-SL-28	13.5
White Rose	07/24/17	BT	52	Sandlance	WR-SL-29	14.0
White Rose	07/24/17	BT	52	Sandlance	WR-SL-30	14.0
White Rose	07/24/17	BT	52	Sandlance	WR-SL-31	14.0
White Rose	07/24/17	BT	53	Sandlance	WR-SL-32	14.0
White Rose	07/24/17	BT	53	Sandlance	WR-SL-33	14.0
White Rose	07/24/17	BT	53	Sandlance	WR-SL-34	13.5
White Rose	07/24/17	BT	53	Sandlance	WR-SL-35	14.0
White Rose	07/24/17	BT	53	Sandlance	WR-SL-36	14.0
White Rose	07/24/17	BT	53	Sandlance	WR-SL-37	14.0
White Rose	07/24/17	BT	53	Sandlance	WR-SL-38	12.5
White Rose	07/24/17	BT	53	Sandlance	WR-SL-39	14.0
White Rose	07/24/17	BT	53	Sandlance	WR-SL-40	14.0
White Rose	07/24/17	BT	53	Sandlance	WR-SL-41	14.0
White Rose	07/24/17	BT	53	Sandlance	WR-SL-42	13.5
White Rose	07/24/17	BT	53	Sandlance	WR-SL-43	14.0
White Rose	07/24/17	BT	53	Sandlance	WR-SL-44	14.0
White Rose	07/24/17	BT	53	Sandlance	WR-SL-45	14.0
White Rose	07/24/17	BT	53	Sandlance	WR-SL-46	12.0
White Rose	07/24/17	BT	53	Sandlance	WR-SL-47	14.0
White Rose	07/24/17	BT	53	Sandlance	WR-SL-48	14.0
White Rose	07/24/17	BT	53	Sandlance	WR-SL-49	13.5
White Rose	07/24/17	BT	53	Sandlance	WR-SL-50	13.5
Hibernia	07/25/17	BT	55	Atlantic Cod	H-AC-01	10.0
Hibernia	07/25/17	MWT	56	Atlantic Cod	H-AC-02	9.0
Hibernia	07/25/17	MWT	57	Atlantic Cod	H-AC-03	11.5
Hibernia	07/25/17	MWT	58	Atlantic Cod	H-AC-04	10.0
Hibernia	07/25/17	MWT	58	Atlantic Cod	H-AC-05	12.0
Hibernia	07/25/17	BT	54	American Plaice	H-AP-01	9.0
Hibernia	07/25/17	BT	54	American Plaice	H-AP-02	9.5
Hibernia	07/25/17	BT	54	American Plaice	H-AP-03	9.5
Hibernia	07/25/17	BT	54	American Plaice	H-AP-04	11.5
Hibernia	07/25/17	BT	54	American Plaice	H-AP-05	11.0
Hibernia	07/25/17	BT	54	American Plaice	H-AP-06	11.5
Hibernia	07/25/17	BT	54	American Plaice	H-AP-07	11.0
Hibernia	07/25/17	BT	54	American Plaice	H-AP-08	11.0
Hibernia	07/25/17	BT	54	American Plaice	H-AP-09	8.0
Hibernia	07/25/17	BT	54	American Plaice	H-AP-10	8.5
Hibernia	07/25/17	BT	54	American Plaice	H-AP-11	11.5
Hibernia	07/25/17	BT	54	American Plaice	H-AP-12	11.5
Hibernia	07/25/17	BT	54	American Plaice	H-AP-13	10.0
Hibernia	07/25/17	BT	54	American Plaice	H-AP-14	11.5
Hibernia	07/25/17	BT	54	American Plaice	H-AP-15	11.0
Hibernia	07/25/17	BT	54	American Plaice	H-AP-16	11.0
Hibernia	07/25/17	BT	54	American Plaice	H-AP-17	11.0
Hibernia	07/25/17	BT	54	American Plaice	H-AP-18	11.0
Hibernia	07/25/17	BT	54	American Plaice	H-AP-19	10.0
Hibernia	07/25/17	BT	54	American Plaice	H-AP-20	11.5
Hibernia	07/25/17	BT	54	American Plaice	H-AP-21	11.0
Hibernia	07/25/17	BT	54	American Plaice	H-AP-22	11.0
Hibernia	07/25/17	BT	55	American Plaice	H-AP-23	11.5
Hibernia	07/25/17	BT	55	American Plaice	H-AP-24	8.5
Hibernia	07/25/17	BT	55	American Plaice	H-AP-25	11.0
Hibernia	07/25/17	BT	55	American Plaice	H-AP-26	11.5
Hibernia	07/25/17	BT	55	American Plaice	H-AP-27	11.5
Hibernia	07/25/17	BT	55	American Plaice	H-AP-28	11.0
Hibernia	07/25/17	BT	55	American Plaice	H-AP-29	11.5

Sampling Station	Date	Trawl Type	Tow #	Species	Specimen No.	Total Length (cm)
Hibernia	07/25/17	BT	55	American Plaice	H-AP-30	9.0
Hibernia	07/25/17	BT	55	American Plaice	H-AP-31	9.0
Hibernia	07/25/17	BT	55	American Plaice	H-AP-32	11.0
Hibernia	07/25/17	BT	55	American Plaice	H-AP-33	11.0
Hibernia	07/25/17	BT	55	American Plaice	H-AP-34	11.0
Hibernia	07/25/17	BT	55	American Plaice	H-AP-35	10.5
Hibernia	07/25/17	BT	55	American Plaice	H-AP-36	11.0
Hibernia	07/25/17	BT	55	American Plaice	H-AP-37	10.0
Hibernia	07/25/17	BT	55	American Plaice	H-AP-38	11.5
Hibernia	07/25/17	BT	55	American Plaice	H-AP-39	10.5
Hibernia	07/25/17	BT	55	American Plaice	H-AP-40	11.0
Hibernia	07/25/17	BT	55	American Plaice	H-AP-41	9.0
Hibernia	07/25/17	BT	55	American Plaice	H-AP-42	9.0
Hibernia	07/25/17	BT	55	American Plaice	H-AP-43	11.5
Hibernia	07/25/17	BT	55	American Plaice	H-AP-44	11.0
Hibernia	07/25/17	BT	55	American Plaice	H-AP-45	11.5
Hibernia	07/25/17	BT	55	American Plaice	H-AP-46	11.0
Hibernia	07/25/17	BT	55	American Plaice	H-AP-47	11.0
Hibernia	07/25/17	BT	55	American Plaice	H-AP-48	11.0
Hibernia	07/25/17	BT	55	American Plaice	H-AP-49	11.0
Hibernia	07/25/17	BT	55	American Plaice	H-AP-50	9.5
Hibernia	07/25/17	MWT	56	Capelin	H-C-01	12.0
Hibernia	07/25/17	MWT	57	Capelin	H-C-02	10.5
Hibernia	07/25/17	MWT	57	Capelin	H-C-03	14.5
Hibernia	07/25/17	MWT	57	Capelin	H-C-04	13.0
Hibernia	07/25/17	MWT	58	Capelin	H-C-05	5.5
Hibernia	07/25/17	MWT	58	Capelin	H-C-06	9.5
Hibernia	07/25/17	MWT	58	Capelin	H-C-07	11.0
Hibernia	07/25/17	MWT	58	Capelin	H-C-08	13.0
Hibernia	07/25/17	MWT	58	Capelin	H-C-09	13.5
Hibernia	07/25/17	MWT	60	Capelin	H-C-10	12.5
Hibernia	07/25/17	MWT	60	Capelin	H-C-11	12.0
Hibernia	07/25/17	MWT	60	Capelin	H-C-12	12.5
Hibernia	07/25/17	MWT	60	Capelin	H-C-13	10.5
Hibernia	07/25/17	MWT	60	Capelin	H-C-14	6.5
Hibernia	07/25/17	MWT	60	Capelin	H-C-15	11.0
Hibernia	07/25/17	MWT	60	Capelin	H-C-16	6.5
Hibernia	07/25/17	MWT	60	Capelin	H-C-17	12.0
Hibernia	07/25/17	MWT	60	Capelin	H-C-18	12.5
Hibernia	07/25/17	MWT	60	Capelin	H-C-19	12.0
Hibernia	07/25/17	MWT	60	Capelin	H-C-20	12.0
Hibernia	07/25/17	MWT	60	Capelin	H-C-21	12.5
Hibernia	07/25/17	MWT	60	Capelin	H-C-22	14.0
Hibernia	07/25/17	MWT	61	Capelin	H-C-23	13.0
Hibernia	07/25/17	MWT	61	Capelin	H-C-24	12.0
Hibernia	07/25/17	MWT	61	Capelin	H-C-25	11.0
Hibernia	07/25/17	MWT	62	Capelin	H-C-26	12.5
Hibernia	07/25/17	MWT	62	Capelin	H-C-27	10.5
Hibernia	07/25/17	MWT	62	Capelin	H-C-28	10.0
Hibernia	07/25/17	MWT	62	Capelin	H-C-29	10.5
Hibernia	07/25/17	MWT	62	Capelin	H-C-30	10.0
Hibernia	07/25/17	MWT	63	Capelin	H-C-31	12.5
Hibernia	07/25/17	MWT	63	Capelin	H-C-32	12.5
Hibernia	07/25/17	MWT	63	Capelin	H-C-33	12.5
Hibernia	07/25/17	MWT	63	Capelin	H-C-34	9.0
Hibernia	07/25/17	MWT	64	Capelin	H-C-35	14.0
Hibernia	07/25/17	MWT	64	Capelin	H-C-36	13.0

Sampling Station	Date	Trawl Type	Tow #	Species	Specimen No.	Total Length (cm)
Hibernia	07/25/17	MWT	64	Capelin	H-C-37	12.5
Hibernia	07/25/17	MWT	64	Capelin	H-C-38	11.0
Hibernia	07/25/17	MWT	65	Capelin	H-C-39	13.0
Hibernia	07/25/17	MWT	65	Capelin	H-C-40	13.0
Hibernia	07/25/17	MWT	65	Capelin	H-C-41	13.0
Hibernia	07/25/17	MWT	65	Capelin	H-C-42	10.0
Hibernia	07/25/17	MWT	65	Capelin	H-C-43	9.5
Hibernia	07/25/17	MWT	65	Capelin	H-C-44	13.5
Hibernia	07/25/17	MWT	66	Capelin	H-C-45	13.0
Hibernia	07/25/17	MWT	66	Capelin	H-C-46	12.0
Hibernia	07/25/17	MWT	66	Capelin	H-C-47	12.0
Hibernia	07/25/17	MWT	66	Capelin	H-C-48	11.5
Hibernia	07/25/17	MWT	66	Capelin	H-C-49	11.5
Hibernia	07/25/17	MWT	66	Capelin	H-C-50	13.0
Hibernia	07/25/17	MWT	66	Capelin	H-C-51	10.0
Hibernia	07/25/17	MWT	66	Capelin	H-C-52	10.0
Hibernia	07/25/17	MWT	66	Capelin	H-C-53	13.5
Hibernia	07/25/17	MWT	66	Capelin	H-C-54	9.0
Hibernia	07/25/17	MWT	66	Capelin	H-C-55	13.0
Hibernia	07/25/17	MWT	66	Capelin	H-C-56	10.0
Hibernia	07/25/17	MWT	66	Capelin	H-C-57	11.0
Hibernia	07/25/17	MWT	66	Capelin	H-C-58	9.0
Hibernia	07/25/17	MWT	66	Capelin	H-C-59	10.0
Hibernia	07/25/17	MWT	66	Capelin	H-C-60	9.5
Hibernia	07/25/17	MWT	66	Capelin	H-C-61	10.0
Hibernia	07/25/17	MWT	66	Capelin	H-C-62	10.0
Hibernia	07/25/17	MWT	66	Capelin	H-C-63	10.0
Hibernia	07/25/17	MWT	66	Capelin	H-C-64	10.5
Hibernia	07/25/17	MWT	66	Capelin	H-C-65	10.5
Hibernia	07/28/17	MWT	87	Capelin	H-C-66	10.0
Hibernia	07/28/17	MWT	87	Capelin	H-C-67	10.0
Hibernia	07/28/17	MWT	87	Capelin	H-C-68	10.0
Hibernia	07/28/17	MWT	87	Capelin	H-C-69	8.5
Hibernia	07/28/17	MWT	87	Capelin	H-C-70	9.5
Hibernia	07/28/17	MWT	87	Capelin	H-C-71	9.5
Hibernia	07/28/17	MWT	87	Capelin	H-C-72	9.5
Hibernia	07/28/17	MWT	87	Capelin	H-C-73	9.5
Hibernia	07/28/17	MWT	87	Capelin	H-C-74	9.0
Hibernia	07/28/17	MWT	87	Capelin	H-C-75	9.0
Hibernia	07/28/17	MWT	87	Capelin	H-C-76	9.5
Hibernia	07/28/17	MWT	87	Capelin	H-C-77	10.0
Hibernia	07/28/17	MWT	87	Capelin	H-C-78	10.0
Hibernia	07/28/17	MWT	88	Capelin	H-C-79	10.5
Hibernia	07/28/17	MWT	88	Capelin	H-C-80	8.5
Hibernia	07/28/17	MWT	88	Capelin	H-C-81	10.0
Hibernia	07/28/17	MWT	88	Capelin	H-C-82	10.0
Hibernia	07/28/17	MWT	88	Capelin	H-C-83	9.5
Hibernia	07/28/17	MWT	88	Capelin	H-C-84	9.0
Hibernia	07/28/17	MWT	88	Capelin	H-C-85	10.0
Hibernia	07/28/17	MWT	88	Capelin	H-C-86	9.5
Hibernia	07/28/17	MWT	88	Capelin	H-C-87	9.5
Hibernia	07/28/17	MWT	89	Capelin	H-C-88	10.0
Hibernia	07/28/17	MWT	90	Capelin	H-C-89	9.0
Hibernia	07/28/17	MWT	90	Capelin	H-C-90	10.5
Hibernia	07/28/17	MWT	90	Capelin	H-C-91	9.5
Hibernia	07/28/17	MWT	91	Capelin	H-C-92	9.5
Hibernia	07/28/17	MWT	91	Capelin	H-C-93	10.0

Sampling Station	Date	Trawl Type	Tow #	Species	Specimen No.	Total Length (cm)
Hibernia	07/28/17	MWT	91	Capelin	H-C-94	9.5
Hibernia	07/28/17	MWT	91	Capelin	H-C-95	9.5
Hibernia	07/28/17	MWT	91	Capelin	H-C-96	9.5
Hibernia	07/28/17	MWT	91	Capelin	H-C-97	9.0
Hibernia	07/28/17	MWT	91	Capelin	H-C-98	9.5
Hibernia	07/28/17	MWT	91	Capelin	H-C-99	9.0
Hibernia	07/28/17	MWT	91	Capelin	H-C-100	10.0
Hibernia	07/28/17	MWT	91	Capelin	H-C-101	9.0
Hibernia	07/28/17	MWT	91	Capelin	H-C-102	9.5
Hibernia	07/28/17	MWT	91	Capelin	H-C-103	9.5
Hibernia	07/28/17	MWT	91	Capelin	H-C-104	10.0
Hibernia	07/25/17	BT	54	Sandlance	H-SL-01	13.5
Hibernia	07/25/17	BT	54	Sandlance	H-SL-02	13.5
Hibernia	07/25/17	BT	54	Sandlance	H-SL-03	13.5
Hibernia	07/25/17	BT	54	Sandlance	H-SL-04	14.0
Hibernia	07/25/17	BT	54	Sandlance	H-SL-05	14.0
Hibernia	07/25/17	BT	54	Sandlance	H-SL-06	14.0
Hibernia	07/25/17	BT	54	Sandlance	H-SL-07	14.0
Hibernia	07/25/17	BT	54	Sandlance	H-SL-08	12.0
Hibernia	07/25/17	BT	54	Sandlance	H-SL-09	14.0
Hibernia	07/25/17	BT	54	Sandlance	H-SL-10	11.5
Hibernia	07/25/17	BT	54	Sandlance	H-SL-11	14.0
Hibernia	07/25/17	BT	54	Sandlance	H-SL-12	12.5
Hibernia	07/25/17	BT	54	Sandlance	H-SL-13	14.0
Hibernia	07/25/17	BT	54	Sandlance	H-SL-14	12.0
Hibernia	07/25/17	BT	54	Sandlance	H-SL-15	13.0
Hibernia	07/25/17	BT	54	Sandlance	H-SL-16	14.0
Hibernia	07/25/17	BT	54	Sandlance	H-SL-17	13.5
Hibernia	07/25/17	BT	54	Sandlance	H-SL-18	14.0
Hibernia	07/25/17	BT	54	Sandlance	H-SL-19	13.0
Hibernia	07/25/17	BT	54	Sandlance	H-SL-20	13.0
Hibernia	07/25/17	BT	54	Sandlance	H-SL-21	14.0
Hibernia	07/25/17	BT	54	Sandlance	H-SL-22	13.5
Hibernia	07/25/17	BT	54	Sandlance	H-SL-23	13.5
Hibernia	07/25/17	BT	54	Sandlance	H-SL-24	14.0
Hibernia	07/25/17	BT	54	Sandlance	H-SL-25	14.0
Hibernia	07/25/17	BT	54	Sandlance	H-SL-26	13.5
Hibernia	07/25/17	BT	54	Sandlance	H-SL-27	13.5
Hibernia	07/25/17	BT	54	Sandlance	H-SL-28	14.0
Hibernia	07/25/17	BT	54	Sandlance	H-SL-29	13.0
Hibernia	07/25/17	BT	54	Sandlance	H-SL-30	14.0
Hibernia	07/25/17	BT	54	Sandlance	H-SL-31	14.0
Hibernia	07/25/17	BT	55	Sandlance	H-SL-32	14.0
Hibernia	07/25/17	BT	55	Sandlance	H-SL-33	13.5
Hibernia	07/25/17	BT	55	Sandlance	H-SL-34	13.0
Hibernia	07/25/17	BT	55	Sandlance	H-SL-35	12.0
Hibernia	07/25/17	BT	55	Sandlance	H-SL-36	13.0
Hibernia	07/25/17	BT	55	Sandlance	H-SL-37	14.0
Hibernia	07/25/17	BT	55	Sandlance	H-SL-38	13.0
Hibernia	07/25/17	BT	55	Sandlance	H-SL-39	13.0
Hibernia	07/25/17	BT	55	Sandlance	H-SL-40	12.0
Hibernia	07/25/17	BT	55	Sandlance	H-SL-41	14.0
Hibernia	07/25/17	BT	55	Sandlance	H-SL-42	14.0
Hibernia	07/25/17	BT	55	Sandlance	H-SL-43	14.0
Hibernia	07/25/17	BT	55	Sandlance	H-SL-44	13.5
Hibernia	07/25/17	BT	55	Sandlance	H-SL-45	14.0
Hibernia	07/25/17	BT	55	Sandlance	H-SL-46	14.0

Sampling Station	Date	Trawl Type	Tow #	Species	Specimen No.	Total Length (cm)
Hibernia	07/25/17	BT	55	Sandlance	H-SL-47	13.0
Hibernia	07/25/17	BT	55	Sandlance	H-SL-48	14.0
Hibernia	07/25/17	BT	55	Sandlance	H-SL-49	14.0
Hibernia	07/25/17	BT	55	Sandlance	H-SL-50	13.5
Hibernia	07/25/17	MWT	62	Sandlance	H-SL-51	11.0
Hibernia	07/25/17	MWT	62	Sandlance	H-SL-52	7.0
Hibernia	07/25/17	MWT	62	Sandlance	H-SL-53	11.0
Hibernia	07/25/17	MWT	62	Sandlance	H-SL-54	11.0
Hibernia	07/25/17	MWT	62	Sandlance	H-SL-55	12.0
Hibernia	07/25/17	MWT	62	Sandlance	H-SL-56	11.0
Hibernia	07/25/17	MWT	62	Sandlance	H-SL-57	12.0
Hibernia	07/25/17	MWT	62	Sandlance	H-SL-58	11.5
Hibernia	07/25/17	MWT	62	Sandlance	H-SL-59	12.0
Hibernia	07/25/17	MWT	62	Sandlance	H-SL-60	11.0
Hibernia	07/28/17	MWT	87	Sandlance	H-SL-61	6.0
Hibernia	07/28/17	MWT	87	Sandlance	H-SL-62	5.5
Hibernia	07/28/17	MWT	87	Sandlance	H-SL-63	6.0
Hibernia	07/28/17	MWT	87	Sandlance	H-SL-64	6.0
Hibernia	07/28/17	MWT	87	Sandlance	H-SL-65	6.0
Hibernia	07/28/17	MWT	87	Sandlance	H-SL-66	10.0
Hibernia	07/28/17	MWT	88	Sandlance	H-SL-67	6.5
Hibernia	07/28/17	MWT	88	Sandlance	H-SL-68	7.5
Hibernia	07/28/17	MWT	88	Sandlance	H-SL-69	7.0
Hibernia	07/28/17	MWT	90	Sandlance	H-SL-70	7.0
Hibernia	07/28/17	MWT	90	Sandlance	H-SL-71	7.0
Hibernia	07/28/17	MWT	90	Sandlance	H-SL-72	8.0
Hibernia	07/28/17	MWT	90	Sandlance	H-SL-73	8.0
Hibernia	07/28/17	MWT	90	Sandlance	H-SL-74	7.0
Hibernia	07/28/17	MWT	90	Sandlance	H-SL-75	6.5
Hibernia	07/28/17	MWT	90	Sandlance	H-SL-76	7.0
Hibernia	07/28/17	MWT	90	Sandlance	H-SL-77	7.0
Hibernia	07/28/17	MWT	90	Sandlance	H-SL-78	7.5
Hibernia	07/28/17	MWT	90	Sandlance	H-SL-79	6.5
Hibernia	07/28/17	MWT	90	Sandlance	H-SL-80	7.0
Hibernia	07/28/17	MWT	90	Sandlance	H-SL-81	7.0
Hibernia	07/28/17	MWT	90	Sandlance	H-SL-82	6.5
Hibernia	07/28/17	MWT	93	Sandlance	H-SL-83	7.5
Hibernia	07/28/17	MWT	94	Sandlance	H-SL-84	6.5
Hibernia	07/28/17	MWT	94	Sandlance	H-SL-85	7.0
Hibernia	07/28/17	MWT	94	Sandlance	H-SL-86	6.5
Hibernia	07/28/17	MWT	94	Sandlance	H-SL-87	7.0
Hibernia	07/28/17	MWT	94	Sandlance	H-SL-88	6.5
Hibernia	07/28/17	MWT	94	Sandlance	H-SL-89	6.5
Hibernia	07/28/17	MWT	94	Sandlance	H-SL-90	7.0
Hibernia	07/28/17	MWT	94	Sandlance	H-SL-91	6.5
Hibernia	07/28/17	MWT	94	Sandlance	H-SL-92	6.5
Hibernia	07/28/17	MWT	94	Sandlance	H-SL-93	6.5
Hibernia	07/28/17	MWT	94	Sandlance	H-SL-94	6.5
Hibernia	07/28/17	MWT	94	Sandlance	H-SL-95	7.0
Hibernia	07/28/17	MWT	94	Sandlance	H-SL-96	6.5
Hibernia	07/28/17	MWT	94	Sandlance	H-SL-97	10.0

Appendix 5

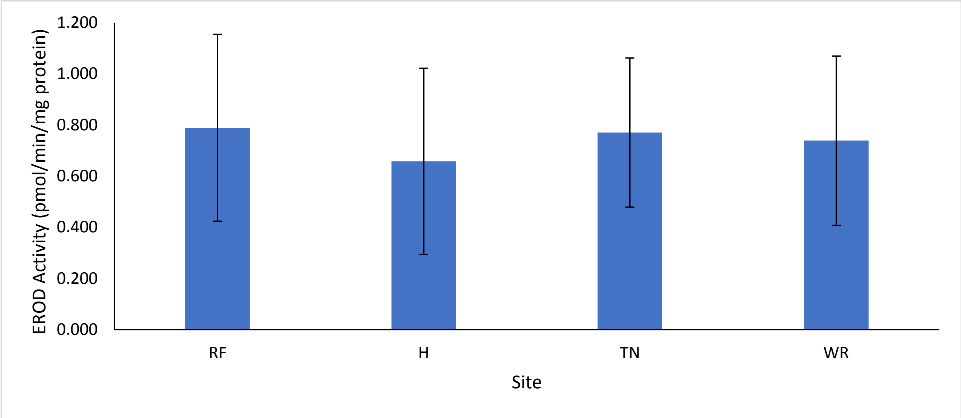
Laboratory Empirical Data Associated with MFO Activity Assays

Atlantic Cod

Sample ID	Site	EROD (pmol/ml/min)	Protein (mg/ml)	EROD activity (pmol/min/mg)
4	H	5.731	13.906	0.412
8	H	14.041	13.055	1.076
64	H	6.366	13.104	0.486
2	RF	15.110	20.770	0.728
6	RF	22.604	14.402	1.569
10	RF	11.074	12.238	0.905
11	RF	8.653	14.714	0.588
13	RF	18.970	15.069	1.259
15	RF	7.056	16.446	0.429
17	RF	6.868	21.825	0.315
18	RF	13.355	16.418	0.813
24	RF	12.431	12.485	0.996
25	RF	15.755	15.633	1.008
26	RF	17.612	15.611	1.128
27	RF	9.378	17.741	0.529
28	RF	13.656	16.083	0.849
29	RF	15.369	14.520	1.058
30	RF	10.840	15.152	0.715
31	RF	5.399	13.622	0.396
32	RF	6.185	13.454	0.460
33	RF	14.743	15.673	0.941
34	RF	9.153	15.822	0.578
35	RF	19.525	14.737	1.325
36	RF	3.866	14.353	0.269
39	RF	17.255	14.901	1.158
48	RF	13.973	14.368	0.973
49	RF	23.781	17.215	1.381
50	RF	11.772	16.901	0.697
51	RF	7.608	17.471	0.435
52	RF	0.000	2.526	0.000
53	RF	9.540	14.012	0.681
54	RF	3.753	13.353	0.281
55	RF	8.848	15.223	0.581
56	RF	9.764	13.845	0.705
57	RF	6.593	10.107	0.652
58	RF	14.007	14.606	0.959
59	RF	9.803	11.976	0.819
60	RF	12.729	14.447	0.881
62	RF	25.405	20.510	1.239
65	RF	21.450	15.457	1.388
67	RF	4.812	15.693	0.307
3	TN	6.208	13.300	0.467
7	TN	11.218	14.074	0.797
61	TN	25.707	24.540	1.048
1HW	WR	5.013	17.994	0.279
1	WR	14.398	19.129	0.753
5	WR	13.041	14.237	0.916
9	WR	9.810	13.077	0.750
12	WR	10.619	14.350	0.740
14	WR	22.945	14.199	1.616

Summary Table

Site	Site Mean EROD Activity (pmol/min/mg protein)	Site Standard Deviation
RF	0.789	0.365
H	0.658	0.364
TN	0.770	0.291
WR	0.739	0.331



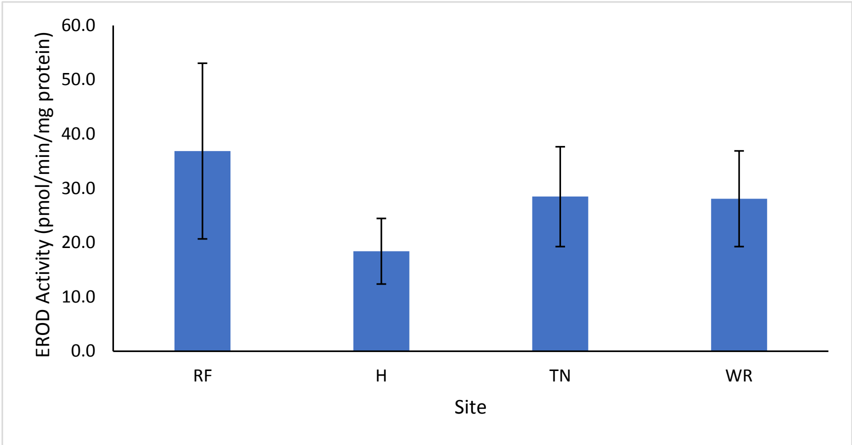
Sample ID	Site	EROD (pmol/ml/min)	Protein (mg/ml)	EROD activity (pmol/min/mg)
16	WR	13.529	16.958	0.798
19	WR	6.843	16.460	0.416
20	WR	6.832	16.770	0.407
21	WR	19.268	13.251	1.454
22	WR	11.205	15.261	0.734
23	WR	9.493	15.733	0.603
37	WR	8.875	12.590	0.705
38	WR	7.129	11.685	0.610
40	WR	2.543	14.204	0.179
41	WR	12.196	13.980	0.872
42	WR	12.188	12.645	0.964
43	WR	11.711	13.791	0.849
44	WR	12.653	14.469	0.874
45	WR	11.547	18.260	0.632
46	WR	9.584	12.569	0.762
47	WR	1.364	12.817	0.106
63	WR	13.158	15.545	0.846
66	WR	10.891	12.650	0.861
68	WR	12.548	16.735	0.750

American Plaice

Sample ID	Site	EROD (pmol/ml/min)	Protein (mg/ml)	EROD activity (pmol/min/mg)
3	H	284.706	17.341	16.418
6	H	207.254	17.535	11.819
15	H	851.699	23.580	36.120
19	H	347.495	21.983	15.807
23	H	201.011	19.439	10.341
27	H	449.822	21.312	21.107
31	H	353.646	18.187	19.445
35	H	462.176	20.367	22.693
39	H	354.535	17.252	20.550
43	H	275.386	17.509	15.728
47	H	182.959	18.924	9.668
51	H	284.618	19.724	14.430
55	H	344.490	16.747	20.570
59	H	346.891	18.417	18.836
63	H	338.788	19.030	17.803
88	H	353.880	15.810	22.383
10	H	348.351	18.380	18.952
4	RF	748.131	15.520	48.205
8	RF	589.274	22.081	26.687
12	RF	798.156	19.159	41.659
13	RF	441.610	16.845	26.216
17	RF	824.563	21.476	38.394
21	RF	573.729	17.513	32.761
25	RF	290.118	15.808	18.353
29	RF	453.186	17.602	25.747
30	RF	636.406	19.222	33.109
33	RF	1256.771	20.042	62.705
37	RF	868.707	17.681	49.132
41	RF	587.748	20.201	29.095
45	RF	344.128	14.039	24.512
49	RF	463.331	17.884	25.908
53	RF	330.984	17.618	18.787
57	RF	464.581	20.727	22.414
61	RF	533.420	16.666	32.007
65	RF	571.418	16.138	35.409
68	RF	473.784	12.999	36.449
71	RF	488.767	13.438	36.371
73	RF	487.169	15.571	31.286
74	RF	701.958	14.923	47.038
75	RF	645.318	17.962	35.927
76	RF	497.846	16.604	29.983
77	RF	1048.731	19.941	52.592
78	RF	612.391	18.252	33.552
79	RF	873.269	20.579	42.435
80	RF	906.028	18.537	48.878
81	RF	478.261	20.781	23.014
82	RF	698.784	21.941	31.848
83	RF	464.329	17.685	26.256
84	RF	225.293	17.002	13.251

Summary Table

Site	Site Mean	Site Standard Deviation
RF	36.856	16.188
H	18.392	6.046
TN	28.478	9.192
WR	28.074	8.805



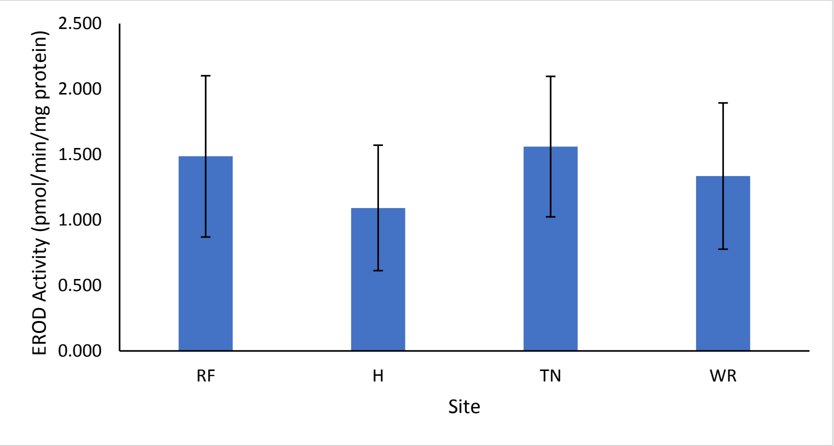
Sample ID	Site	EROD (pmol/ml/min)	Protein (mg/ml)	EROD activity (pmol/min/mg)
85	RF	2364.845	27.518	85.939
87	RF	2336.336	27.166	86.003
91	RF	688.470	18.094	38.050
1	TN	374.829	19.410	19.311
5	TN	493.899	18.016	27.415
9	TN	579.644	21.880	26.492
14	TN	390.641	22.034	17.729
18	TN	391.047	21.721	18.004
22	TN	549.621	18.564	29.606
26	TN	439.468	17.765	24.738
34	TN	827.424	20.453	40.454
38	TN	625.742	18.590	33.660
42	TN	746.088	17.344	43.017
46	TN	434.399	18.144	23.942
50	TN	339.862	17.457	19.469
54	TN	472.963	18.533	25.520
58	TN	284.266	18.636	15.253
62	TN	1046.250	25.137	41.622
66	TN	879.196	21.256	41.362
69	TN	719.722	18.762	38.360
90	TN	430.612	16.159	26.649
2	WR	311.277	17.799	17.488
7	WR	388.151	19.497	19.908
11	WR	219.775	17.449	12.595
16	WR	713.562	22.053	32.357
20	WR	998.869	21.126	47.282
24	WR	667.960	18.915	35.314
28	WR	540.880	19.032	28.420
32	WR	317.374	16.574	19.149
36	WR	746.415	18.656	40.010
40	WR	388.717	15.758	24.668
44	WR	452.234	16.248	27.833
48	WR	607.016	20.495	29.618
52	WR	255.543	13.305	19.207
56	WR	482.516	12.754	37.832
60	WR	313.867	17.390	18.049
64	WR	491.156	19.704	24.927
67	WR	728.565	20.650	35.281
70	WR	444.885	15.006	29.647
72	WR	776.747	20.369	38.134
86	WR	430.284	15.492	27.775
89	WR	266.758	11.089	24.057

Capelin

Sample ID	Site	EROD (pmol/ml/min)	Protein (mg/ml)	EROD activity (pmol/min/mg)
2	H	17.063	18.678	0.914
7	H	8.480	12.580	0.674
11	H	10.386	15.813	0.657
15	H	6.160	17.365	0.355
23	H	7.982	17.716	0.451
24	H	11.381	20.446	0.557
25	H	16.746	19.004	0.881
26	H	3.762	18.484	0.204
27	H	14.720	16.988	0.866
28	H	11.632	16.226	0.717
41	H	12.313	7.593	1.622
42	H	6.853	4.723	1.451
43	H	7.301	4.398	1.660
44	H	19.810	11.316	1.751
45	H	15.934	10.905	1.461
46	H	5.967	15.821	0.377
47	H	14.820	18.323	0.809
76	H	18.416	10.583	1.740
77	H	13.062	9.919	1.317
78	H	10.660	7.053	1.511
79	H	8.310	5.256	1.581
80	H	11.561	8.868	1.304
81	H	13.413	7.775	1.725
82	H	11.061	10.223	1.082
83	H	10.469	8.034	1.303
84	H	9.371	7.243	1.294
85	H	5.071	6.109	0.830
86	H	5.737	4.722	1.215
87	H	10.732	7.664	1.400
88	H	9.322	8.300	1.123
89	H	12.633	8.278	1.526
90	H	25.914	9.395	1.800
91	H	12.365	21.010	0.589
94	H	3.465	13.729	0.252
95	H	8.976	7.481	1.200
4	RF	28.051	15.102	1.857
8	RF	18.247	20.508	0.890
12	RF	24.660	17.071	1.445
16	RF	36.711	18.671	1.966
35	RF	18.371	10.791	1.702
36	RF	7.683	16.746	0.459
37	RF	20.779	12.429	1.672
38	RF	25.231	19.188	1.315
39	RF	27.581	19.733	1.398
40	RF	28.885	17.644	1.637
55	RF	5.675	15.548	0.365
56	RF	15.159	16.010	0.947
57	RF	47.515	19.930	2.384
58	RF	10.853	16.946	0.640

Summary Table

Site	Site Mean	Site Standard Deviation
RF	1.485	0.615
H	1.091	0.479
TN	1.559	0.537
WR	1.334	0.558



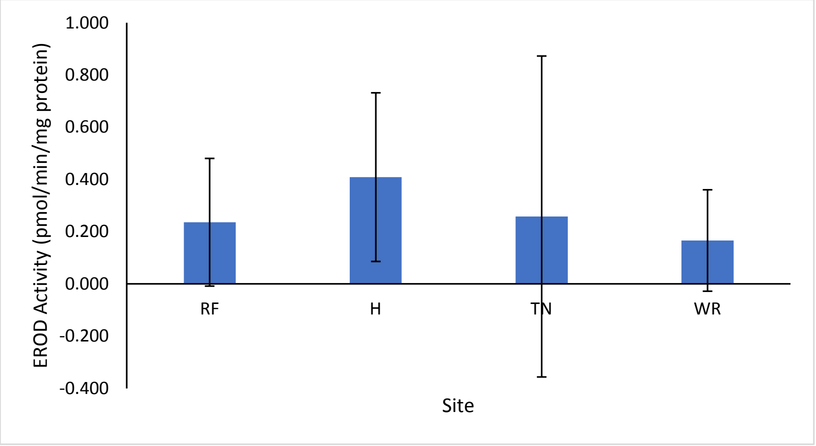
Sample ID	Site	EROD (pmol/ml/min)	Protein (mg/ml)	EROD activity (pmol/min/mg)
59	RF	38.113	14.622	2.607
60	RF	24.879	13.825	1.800
61	RF	28.350	15.850	1.789
68	RF	35.248	18.399	1.916
69	RF	33.897	16.074	2.109
70	RF	16.131	18.751	0.860
71	RF	15.735	17.005	0.925
72	RF	25.870	17.711	1.461
73	RF	29.240	15.113	1.935
74	RF	40.798	16.210	2.517
75	RF	10.903	11.989	0.909
RFC-1	RF	18.352	16.503	1.112
1	TN	16.078	10.411	1.544
5	TN	24.368	11.746	2.075
9	TN	18.303	10.389	1.762
13	TN	17.602	8.292	2.123
17	TN	23.180	13.764	1.684
18	TN	12.027	7.161	1.680
19	TN	16.940	9.956	1.701
20	TN	23.512	9.890	2.377
21	TN	6.385	4.452	1.434
22	TN	19.289	8.400	2.296
48	TN	9.635	6.394	1.507
49	TN	6.561	5.909	1.110
50	TN	11.058	10.024	1.103
51	TN	16.605	16.594	1.001
52	TN	24.279	14.408	1.685
53	TN	15.799	10.851	1.456
54	TN	23.340	15.860	1.472
92	TN	0.672	11.059	0.061
3	WR	34.849	17.130	2.034
6	WR	35.462	15.005	2.363
10	WR	31.431	25.066	1.254
14	WR	11.070	17.590	0.629
29	WR	6.169	17.015	0.363
30	WR	15.887	12.148	1.308
31	WR	16.271	19.266	0.845
32	WR	31.662	19.959	1.586
33	WR	13.221	16.642	0.794
34	WR	37.066	18.287	2.027
62	WR	27.801	19.640	1.416
63	WR	42.387	20.755	2.042
64	WR	17.914	17.658	1.014
65	WR	27.896	20.464	1.363
66	WR	23.380	18.172	1.287
67	WR	25.121	16.453	1.527
93	WR	10.102	12.244	0.825

Sand Lance

Sample ID	Site	EROD (pmol/ml/min)	Protein (mg/ml)	EROD activity (pmol/min/mg)
40	H	0.000	18.014	0.000
41	H	5.154	17.086	0.302
42	H	0.706	18.557	0.038
43	H	0.264	18.797	0.014
44	H	0.976	20.409	0.048
45	H	0.163	8.829	0.018
46	H	14.991	15.841	0.946
47	H	8.339	18.352	0.454
48	H	2.065	16.536	0.125
49	H	4.788	16.410	0.292
50	H	0.665	12.461	0.053
51	H	13.809	14.456	0.955
52	H	2.004	22.632	0.089
53	H	4.755	14.623	0.325
54	H	6.358	19.575	0.325
55	H	10.111	23.693	0.427
56	H	3.178	16.927	0.188
57	H	4.503	22.409	0.201
58	H	5.542	18.491	0.300
92	H	3.142	3.804	0.826
93	H	2.699	4.657	0.579
94	H	1.603	3.631	0.442
95	H	2.857	3.868	0.739
96	H	3.068	4.698	0.653
97	H	0.000	2.847	0.000
98	H	4.171	5.189	0.804
99	H	2.020	2.852	0.708
100	H	3.742	4.431	0.845
101	H	1.763	2.139	0.824
102	H	1.608	1.643	0.979
103	H	3.470	11.961	0.290
105	H	2.381	11.998	0.198
108	H	1.660	3.235	0.513
1	RF	19.696	22.250	0.885
2	RF	3.496	20.415	0.171
3	RF	1.279	18.297	0.070
4	RF	4.902	15.303	0.320
5	RF	8.868	19.892	0.446
6	RF	2.984	17.842	0.167
7	RF	0.000	20.296	0.000
8	RF	0.147	24.565	0.006
9	RF	0.000	15.378	0.000
10	RF	1.868	20.210	0.092
11	RF	0.000	19.874	0.000
12	RF	4.294	19.776	0.217
13	RF	7.002	21.246	0.330
62	RF	15.726	22.728	0.692
63	RF	3.939	24.689	0.160

Summary Table

Site	Site Mean	Site Standard Deviation
RF	0.236	0.244
H	0.409	0.322
TN	0.258	0.614
WR	0.166	0.194



Sample ID	Site	EROD (pmol/ml/min)	Protein (mg/ml)	EROD activity (pmol/min/mg)
64	RF	2.238	21.597	0.104
65	RF	3.116	16.033	0.194
66	RF	11.091	22.094	0.502
67	RF	0.611	22.443	0.027
68	RF	1.500	20.861	0.072
69	RF	9.428	18.924	0.498
106	RF	2.279	16.383	0.139
107	RF	0.000	25.516	0.000
1 HWR	RF	12.188	21.594	0.564
14	TN	0.000	12.651	0.000
15	TN	4.012	14.041	0.286
16	TN	0.865	14.996	0.058
17	TN	1.897	7.944	0.239
18	TN	1.919	1.989	0.965
19	TN	0.882	0.685	1.288
20	TN	3.437	4.321	0.795
21	TN	1.436	2.310	0.622
22	TN	2.154	3.652	0.590
23	TN	0.472	-0.163	0.000
24	TN	2.687	4.713	0.570
25	TN	2.433	2.890	0.842
26	TN	2.290	3.910	0.586
70	TN	3.714	16.113	0.230
71	TN	1.387	12.771	0.109
72	TN	0.904	10.105	0.089
73	TN	2.840	11.982	0.237
74	TN	2.440	15.549	0.157
75	TN	3.017	12.062	0.250
76	TN	3.697	14.659	0.252
77	TN	3.208	15.311	0.210
78	TN	2.163	19.526	0.111
79	TN	2.388	12.436	0.192
80	TN	6.573	15.599	0.421
81	TN	2.795	12.962	0.216
82	TN	3.444	14.209	0.242
83	TN	0.255	17.702	0.014
84	TN	2.712	13.367	0.203
85	TN	0.333	20.782	0.016
86	TN	0.000	13.421	0.000
87	TN	2.364	20.550	0.115
88	TN	5.666	18.585	0.305
89	TN	2.339	3.667	0.638
90	TN	1.412	4.610	0.306
91	TN	3.187	4.612	0.691
109	TN	2.722	4.438	0.613
110	TN	0.000	14.078	0.000
27	WR	4.573	19.720	0.232

Sample ID	Site	EROD (pmol/ml/min)	Protein (mg/ml)	EROD activity (pmol/min/mg)
28	WR	2.043	20.839	0.098
29	WR	5.359	21.524	0.249
30	WR	2.686	23.578	0.114
31	WR	1.410	17.652	0.080
32	WR	1.386	17.879	0.078
33	WR	3.435	20.161	0.170
34	WR	0.000	17.544	0.000
35	WR	1.164	13.251	0.088
36	WR	15.358	18.076	0.850
37	WR	2.086	16.664	0.125
38	WR	3.836	19.252	0.199
39	WR	2.659	21.764	0.122
59	WR	4.607	17.954	0.257
60	WR	0.000	19.146	0.000
61	WR	3.492	20.871	0.167
104	WR	0.000	21.479	0.000

Appendix 6

Laboratory Empirical Data Associated with PAH Metabolite Assays

Atlantic Cod

Sample ID	Bile Protein	2-Naphthol	9-Phenanthrol	1-OH Pyrene	Benzo-α-Pyrene
	mg/ml	mg/mg protein	mg/mg protein	mg/mg protein	Flu/mg protein
H-AC-05	27.49389025	0.052992674	0.005958622	7.58034E-05	156.806134
RF-AC-08	33.07576094	0.083962641	0.006839918	7.68642E-05	176.2051097
RF-AC-11	49.06341873	0.043709018	0.003794582	5.54327E-05	128.5507951
RF-AC-14	43.8911828	0.044033025	0.003449119	5.08517E-05	158.2513598
RF-AC-15	36.11598334	0.046709839	0.004174146	4.70657E-05	132.6347395
RF-AC-20	54.99006996	0.044081434	0.003170898	4.70392E-05	98.72567754
RF-AC-32	32.53993326	0.053304979	0.005468734	7.0862E-05	179.1066392
RF-AC-33	38.36907675	0.046650993	0.004687364	7.89729E-05	220.5616482
RF-AC-34	43.32322581	0.034400067	0.003100128	4.02594E-05	119.7837907
RF-AC-35	50.03698925	0.045445962	0.004003072	4.66736E-05	129.2407088
RF-AC-43	35.10064516	0.06629343	0.005231956	0.000113698	275.2173151
RF-AC-44	22.72834905	0.044663405	0.004591962	4.22718E-05	175.6335972
RF-AC-47	44.42254042	0.048137361	0.00516875	3.52702E-05	122.2111987
RF-AC-49	30.05956989	0.047392842	0.004748615	5.31064E-05	162.014004
RF-AC-50	42.31177373	0.048968281	0.004205738	6.88194E-05	209.4436654
RF-AC-53	45.20649966	0.053968653	0.005023146	0.000106918	218.99101
RF-AC-56	49.24916574	0.056648241	0.005501299	4.56195E-05	124.8237798
RF-AC-57	36.69668246	0.037698638	0.003993181	6.92799E-05	180.5746455
RF-AC-58	44.66073415	0.049148876	0.004159212	4.468E-05	128.7099498
RF-AC-61	39.18328042	0.037584079	0.003809724	4.82853E-05	99.83912592
RF-AC-63	51.05280975	0.037087668	0.002680316	3.73487E-05	96.95663245
RF-AC-65	25.95190352	0.047704081	0.004931517	7.77444E-05	164.5849222
RF-AC-66	42.90273076	0.05200868	0.004172379	6.167E-05	145.149368
RF-AC-69	46.59786714	0.039149505	0.004049655	2.06183E-05	68.53295135
RF-AC-72	34.03705328	0.050585757	0.00740867	5.86256E-05	152.4638508
RF-AC-75	38.67718285	0.041004787	0.003734193	4.77706E-05	173.3923509
TN-AC-02	40.19955506	0.035950776	0.003047305	5.58892E-05	144.9796665
TN-AC-04	42.71523915	0.058769455	0.007448476	9.06618E-05	222.4178312
TN-AC-05	48.18349206	0.040619337	0.003968899	6.44209E-05	117.642856
WR-AC-07	40.78442714	0.048529539	0.004275355	6.41482E-05	152.6882855
WR-AC-08	34.82803115	0.044198931	0.004619092	7.38458E-05	245.2789825
WR-AC-09	43.03337041	0.041822508	0.003895137	3.95001E-05	129.8668064
WR-AC-10	61.63957672	0.051355383	0.004638324	4.72403E-05	125.6370033
WR-AC-11	39.97612903	0.045548448	0.004683529	4.62184E-05	133.8072197
WR-AC-14	37.37213952	0.069533699	0.005590964	8.46392E-05	245.6718302
WR-AC-19	37.66772487	0.045462595	0.00475225	4.98356E-05	144.1268867
WR-AC-21	36.34751151	0.056032064	0.005255506	4.67659E-05	120.8073865
WR-AC-23	44.52747497	0.039218708	0.003930167	4.74694E-05	123.7161809
WR-AC-28	49.78960231	0.039437083	0.003197196	4.42337E-05	137.9003207
WR-AC-30	40.75677419	0.041511523	0.005018026	5.91144E-05	150.8330123
WR-AC-37	59.23222749	0.038473702	0.003474184	2.84481E-05	93.0029037
WR-AC-40	33.58242492	0.087938302	0.005794963	4.6215E-05	118.8675836
WR-AC-41	46.4744086	0.052401319	0.005870586	4.54808E-05	142.5836417
WR-AC-42	41.08298109	0.050373239	0.00454195	7.73539E-05	174.8984829
WR-AC-43	37.51354839	0.068513379	0.004766161	4.21601E-05	121.3087681
WR-AC-44	46.03848721	0.045558307	0.003732481	4.94431E-05	126.5923022
WR-AC-46	33.64605117	0.051348518	0.004518166	7.99545E-05	163.7270633
WR-AC-47	40.33096774	0.035274305	0.003518337	5.71731E-05	152.4254776
WR-AC-48	32.72102336	0.064909861	0.006295478	6.86629E-05	187.8751454
WR-AC-49	46.04860215	0.050851796	0.004468836	3.49877E-05	112.6944135
WR-AC-50	38.21735261	0.050814068	0.004385989	5.99483E-05	146.2321694

American Plaice

Sample ID	Bile Protein	2-Naphthol	9-Phenanthrol	1-OH Pyrene	Benzo-α-Pyrene
	mg/ml	mg/mg protein	mg/mg protein	mg/mg protein	Flu/mg protein
H-AP-02	43.18325434	0.072191525	0.006156881	3.42287E-05	97.98644101
H-AP-14	51.07763485	0.084950064	0.006493203	3.29898E-05	82.84199958
H-AP-19	33.2985782	0.081766073	0.007047425	5.94819E-05	141.4593975
H-AP-44	28.43322134	0.063435889	0.006458819	4.26279E-05	109.5075402
RF-AP-09	50.35930281	0.078351929	0.006008045	2.99382E-05	87.19437377
RF-AP-100	6.989920202	0.07549	0.007269522	3.3834E-05	148.4829601
RF-AP-11	30.03065985	0.064797189	0.006171419	3.83915E-05	87.73129649
RF-AP-12	17.90385917	0.080747707	0.007572257	4.78836E-05	129.3173592
RF-AP-13	34.05087758	0.090962667	0.007424238	4.08042E-05	124.2662071
RF-AP-14	53.82203955	0.080454423	0.00598191	3.89972E-05	114.2183959
RF-AP-20	46.88927867	0.083585568	0.005787167	3.53061E-05	114.07927
RF-AP-23	38.80267485	0.076802781	0.008199523	9.75178E-05	150.1988744
RF-AP-25	55.13247312	0.07283158	0.00577089	3.37807E-05	105.7111672
RF-AP-30	50.55209953	0.053228611	0.003807962	3.1286E-05	107.3928079
RF-AP-31	38.33503666	0.052973507	0.004532026	1.92788E-05	72.89162696
RF-AP-32	24.41290323	0.06158885	0.00597651	2.84567E-05	114.4600937
RF-AP-34	2.365392692	0.058879548	0.012211762	0.000237458	776.3008608
RF-AP-38	34.88186874	0.062983624	0.005409839	2.54248E-05	84.68518936
RF-AP-39	36.97711046	0.081085246	0.007235852	5.67624E-05	161.9324084
RF-AP-44	43.90521327	0.05917595	0.005325697	3.70324E-05	110.922392
RF-AP-45	42.4992224	0.078465239	0.006613178	3.68664E-05	125.8633542
RF-AP-46	57.13992327	0.051365779	0.003719477	1.96598E-05	51.69726333
RF-AP-48	40.63868201	0.091614868	0.007414018	3.41896E-05	111.9800671
RF-AP-51	41.5898782	0.067493407	0.005591765	2.70104E-05	86.38341075
RF-AP-54	34.64237715	0.078820814	0.007041849	3.58408E-05	112.9259823
RF-AP-55	28.98530029	0.063987198	0.005695672	1.73383E-05	52.33368057
RF-AP-57	14.63935906	0.066863306	0.006538751	4.13969E-05	158.1544504
RF-AP-72	38.92703003	0.068658547	0.006461751	5.61974E-05	92.29256711
RF-AP-76	51.05483871	0.076957935	0.006727368	5.61656E-05	104.7715518
RF-AP-80	59.39755284	0.072506051	0.00592446	4.18068E-05	116.9381402
RF-AP-84	33.16400672	0.060523513	0.00441854	2.36219E-05	77.03506729
RF-AP-90	53.26602151	0.055221166	0.004706441	2.05346E-05	58.45475295
RF-AP-91	51.17502646	0.071506668	0.0045609	2.0796E-05	70.20368685
RF-AP-94	38.694877	0.08261842	0.007088998	5.38606E-05	152.6805556
RF-AP-98	31.98516129	0.073854587	0.006552377	2.95758E-05	107.3310537
RF-AP-99	53.25409492	0.075345244	0.005919012	2.99762E-05	88.45135413
TN-AP-01	39.60586536	0.074564244	0.006127409	2.61243E-05	82.64752116
TN-AP-14	33.43501444	0.067527889	0.005643942	2.122E-05	64.47149359
TN-AP-47	44.35483871	0.068681507	0.005537911	2.26607E-05	62.99883559
WR-AP-01	42.93058954	0.053916851	0.005328732	1.20506E-05	37.19363507
WR-AP-03	34.77002934	0.075146461	0.006603647	3.31585E-05	89.54988497
WR-AP-05	37.16946661	0.062550819	0.005264082	2.06787E-05	75.17738204
WR-AP-18	21.82153037	0.080476391	0.007275633	4.74153E-05	128.0525767
WR-AP-23	30.9047619	0.098540684	0.009790109	5.02192E-05	103.3332459
WR-AP-25	23.00045137	0.14939812	0.012668719	5.26967E-05	170.0846825
WR-AP-29	36.48803024	0.062764755	0.005633979	3.80788E-05	129.0943024
WR-AP-31	55.87074527	0.068709332	0.005422922	2.59267E-05	87.16674984
WR-AP-36	33.99827957	0.074342446	0.009060544	0.000106951	166.7273665
WR-AP-37	37.31104199	0.071001345	0.005882668	3.24849E-05	109.1285239
WR-AP-41	27.73182796	0.085588662	0.006911088	2.9848E-05	77.73037257
WR-AP-52	58.82962963	0.061769128	0.004784606	2.13564E-05	54.28368973
WR-AP-59	43.3946503	0.071602527	0.008692309	0.000128754	123.2662239

Capelin

Sample ID	Bile Protein	2-Naphthol	9-Phenanthrol	1-OH Pyrene	Benzo-α-Pyrene
	mg/ml	mg/mg protein	mg/mg protein	mg/mg protein	Flu/mg protein
H-C-02	4.841663167	0.056315714	0.011453077	7.63222E-05	412.2407492
H-C-03	52.41814596	0.04128589	0.003455195	4.00417E-05	123.3697957
H-C-07	21.6378198	0.036171687	0.004073088	4.2353E-05	151.2780227
H-C-08	45.9969305	0.025267884	0.002608221	1.47821E-05	67.69260675
H-C-10	44.37606838	0.065112338	0.005891609	2.93116E-05	80.95975293
H-C-102	38.12064516	0.048743166	0.003401542	2.44279E-05	87.96188563
H-C-104	33.40507937	0.038917649	0.00386278	2.1239E-05	112.3287258
H-C-11	30.88625592	0.062906943	0.00527003	5.26421E-05	136.9985865
H-C-13	29.55333333	0.062159953	0.005714616	3.95118E-05	129.67022
H-C-17	20.26753465	0.035689501	0.003869929	3.71942E-05	122.1142235
H-C-19	32.60845384	0.057178305	0.004939968	5.1675E-05	129.76308
H-C-20	20.7657243	0.058897755	0.005391486	3.70137E-05	103.8059298
H-C-21	61.6442328	0.057182744	0.003598192	2.20598E-05	66.05157938
H-C-25	21.96275132	0.059304917	0.005289637	5.18215E-05	196.2964737
H-C-28	25.09764805	0.071769063	0.006216697	3.35697E-05	111.337253
H-C-30	21.01643655	0.043028005	0.004283806	2.39125E-05	87.37239437
H-C-39	45.34129032	0.048270565	0.005761538	1.85818E-05	73.95386867
H-C-43	8.214624238	0.119874106	0.012859114	8.81686E-05	311.0052773
H-C-48	8.962674961	0.052089319	0.008515927	7.25639E-05	276.1401329
H-C-57	15.48148148	0.054768627	0.005284212	2.67332E-05	108.295961
H-C-63	27.9621164	0.063969747	0.005425275	3.77956E-05	134.1940626
H-C-65	30.10397689	0.056608326	0.00416029	2.7987E-05	87.5176304
H-C-72	48.93348165	0.048284757	0.001921718	1.14784E-05	24.47319239
H-C-77	35.25913978	0.050904801	0.004096188	2.72488E-05	113.2149487
H-C-81	33.27257455	0.054725271	0.004892062	3.24296E-05	127.1730085
H-C-82	30.03863923	0.04607084	0.004274625	3.10003E-05	148.8378043
H-C-86	34.81525312	0.061780077	0.004729797	2.46243E-05	80.26088972
H-C-88	36.73481646	0.042892586	0.003834066	2.93732E-05	115.1870027
H-C-91	17.59510567	0.031438846	0.003738727	2.85623E-05	131.5865804
H-C-93	33.11089196	0.039159753	0.003769744	2.85703E-05	84.3922657
H-C-95	31.4549763	0.045040951	0.004491035	2.96044E-05	124.3690165
H-C-97	19.67829371	0.052258912	0.005292983	3.15477E-05	133.8850188
H-C-98	13.67496112	0.057557021	0.006228971	4.32354E-05	216.0136057
H-C-99	23.20978865	0.042511474	0.004751071	2.86581E-05	171.9904374
RF-C-03	20.02960941	0.039247357	0.004526442	2.95184E-05	171.396306
RF-C-04	20.67594826	0.060386845	0.005975761	3.43148E-05	173.7611009
RF-C-05	31.39133378	0.05605212	0.004802389	3.06062E-05	119.5345832
RF-C-07	10.93732194	0.044209469	0.004607315	2.83801E-05	109.4928464
RF-C-08	27.38067061	0.051331207	0.003857933	3.40097E-05	102.0538624
RF-C-10	24.19526882	0.065547924	0.006265554	4.70399E-05	191.382853
RF-C-12	19.98857143	0.04097171	0.003428172	2.58817E-05	119.8243221
RF-C-13	44.1201176	0.056031134	0.003660607	3.01517E-05	103.1439304
RF-C-14	19.71434928	0.046218158	0.004138944	4.34862E-05	149.8389634
RF-C-16	20.16084656	0.048210791	0.004674765	2.27279E-05	106.9203772
RF-C-18	36.22666667	0.052442165	0.004173033	4.52898E-05	134.4333256
RF-C-19	15.03968428	0.041671728	0.004640345	5.20886E-05	180.4868977
RF-C-20	26.52561949	0.061379299	0.006199977	2.45184E-05	69.22576809
RF-C-22	28.79333772	0.073134013	0.005330898	4.51748E-05	174.6843591
RF-C-23	36.46657901	0.049515154	0.00437107	3.72905E-05	102.8983278
RF-C-24	13.11668126	0.040116694	0.005111686	8.11361E-05	213.0343138

Sample ID	Bile Protein mg/ml	2-Naphthol mg/mg protein	9-Phenanthrol mg/mg protein	1-OH Pyrene mg/mg protein	Benzo-α-Pyrene Flu/mg protein
RF-C-25	9.446803853	0.051236756	0.006517169	6.88452E-05	228.1835585
RF-C-26	26.80471006	0.057300711	0.004955534	5.29378E-05	175.7301906
RF-C-27	22.54662872	0.066534552	0.00615326	7.08024E-05	166.4262115
RF-C-29	19.32171817	0.05025379	0.005030558	3.97799E-05	136.3558199
RF-C-31	16.94979171	0.050602831	0.005075243	7.23801E-05	211.9598632
RF-C-32	19.6278764	0.050519287	0.004855413	7.22942E-05	174.9043551
RF-C-33	36.12184966	0.033343237	0.003128642	3.60096E-05	108.3007793
RF-C-34	33.1832128	0.047291264	0.004612955	4.09803E-05	117.8916729
RF-C-37	17.53714286	0.054640554	0.005374149	5.81562E-05	154.7838197
RF-C-39	26.92380952	0.081636564	0.00657815	4.94096E-05	157.1610214
RF-C-40	31.1935979	0.036252938	0.003474231	2.46402E-05	99.81702457
RF-C-41	25.71168603	0.050791377	0.004510172	3.39178E-05	121.0987146
RF-C-42	21.46651835	0.029789647	0.00331001	4.47566E-05	137.6086057
RF-C-43	18.25136971	0.034070081	0.00332704	5.34508E-05	161.8496423
RF-C-44	19.36605732	0.071105839	0.006183981	7.32716E-05	210.2492453
RF-C-45	18.33333333	0.054086526	0.005704286	6.77242E-05	204.6736364
RF-C-46	58.47111111	0.045667361	0.00288476	1.64315E-05	53.25111954
RF-C-48	14.15752055	0.046000256	0.006106012	2.81892E-05	140.9802545
RF-C-49	17.77887355	0.029927805	0.004482792	4.07378E-05	211.0566786
RF-C-50	21.18518519	0.05356492	0.004886639	3.349E-05	124.3618453
RF-C-51	40.07026455	0.038086122	0.00419896	1.91817E-05	49.81077299
RF-C-52	47.0695401	0.044674962	0.003269971	2.3552E-05	86.5039031
RF-C-53	21.88182416	0.030613751	0.003256823	3.64767E-05	113.1054814
RF-C-54	39.51808606	0.057530335	0.004732479	2.58083E-05	90.91218452
RF-C-56	17.56673241	0.048211509	0.004416903	4.3754E-05	149.9783034
RF-C-59	28.97655052	0.027179924	0.002270225	3.36669E-05	107.4542025
RF-C-60	21.50339689	0.036717084	0.003892642	3.50565E-05	115.0959668
RF-C-61	24.16740741	0.04009648	0.003917214	3.54735E-05	128.8368287
RF-C-62	23.95748411	0.054039596	0.004972425	3.70182E-05	116.6359196
RF-C-63	21.81375661	0.053325335	0.005171117	4.81098E-05	135.4181085
RF-C-67	43.57571773	0.039726429	0.005065976	1.05153E-05	38.47514171
RF-C-76	45.17345653	0.050349689	0.00410267	2.61765E-05	72.46128251
RF-C-77	18.02835979	0.043359221	0.004034818	4.42734E-05	128.4243167
RF-C-78	34.77870968	0.048703284	0.00598363	1.57251E-05	71.16291197
RF-C-79	24.03565787	0.049089542	0.004622912	3.62829E-05	119.5781884
TN-C-04	21.33223756	0.053885333	0.005979708	3.25662E-05	108.5343148
TN-C-05	57.02074074	0.048635023	0.00369767	1.84048E-05	65.80675648
TN-C-10	26.74749722	0.0490628	0.004910955	4.03409E-05	137.3030432
TN-C-12	34.78328433	0.054294058	0.004303767	2.76216E-05	80.33465629
TN-C-15	21.56465608	0.042252513	0.003891361	3.70132E-05	136.9823682
TN-C-16	61.53298269	0.048838258	0.003738331	1.92171E-05	53.19629332
TN-C-18	48.80470391	0.053757798	0.004622566	3.81605E-05	80.15670939
TN-C-23	17.16655709	0.035766011	0.003475876	3.44415E-05	125.5700434
TN-C-27	25.52036959	0.052459611	0.004453104	2.89593E-05	122.0065453
TN-C-28	40.24172693	0.043590485	0.003321801	2.2773E-05	97.21313587
TN-C-33	15.64910053	0.044122758	0.004742576	2.83359E-05	147.9497037
TN-C-35	40.13935484	0.04746462	0.004013137	3.09325E-05	97.46106991
TN-C-41	45.72286166	0.042515728	0.003467731	3.55603E-05	127.4661706
TN-C-45	36.47343915	0.037593246	0.002849911	2.91784E-05	89.745488
TN-C-47	34.92419152	0.055675767	0.00463656	2.58172E-05	102.8706858

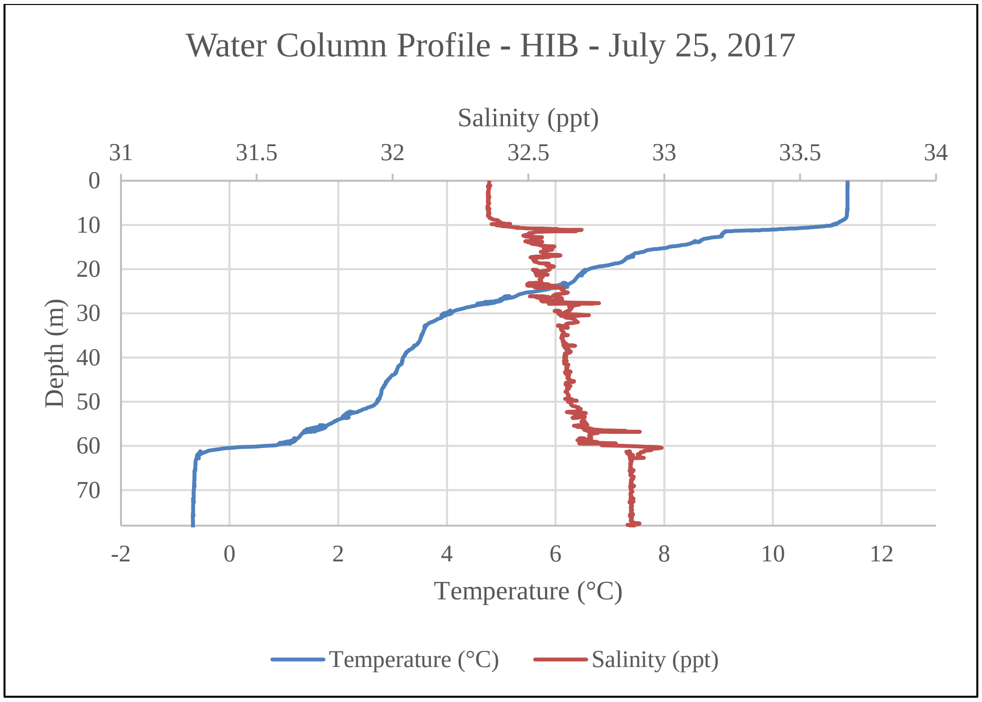
Sample ID	Bile Protein	2-Naphthol	9-Phenanthrol	1-OH Pyrene	Benzo-α-Pyrene
	mg/ml	mg/mg protein	mg/mg protein	mg/mg protein	Flu/mg protein
TN-C-48	25.00372562	0.05589713	0.005211284	3.074E-05	111.7554733
TN-C-49	15.27670753	0.053961911	0.005769093	5.61182E-05	224.7212665
TN-C-54	50.66150538	0.054207492	0.003991182	3.35525E-05	78.79477075
WR-C-01	49.69403612	0.076539021	0.005023524	4.22367E-05	107.6405762
WR-C-02	22.16874863	0.055656877	0.004755431	3.73381E-05	126.0469519
WR-C-03	27.1589418	0.044329009	0.004300886	1.85043E-05	67.61148489
WR-C-04	11.30133684	0.054675165	0.006977547	5.4932E-05	204.8677798
WR-C-05	40.29958361	0.069824745	0.004300632	4.25464E-05	104.9979435
WR-C-07	21.08643647	0.08667734	0.009289098	4.41614E-05	128.7304264
WR-C-11	26.14097786	0.048062535	0.004718403	5.54128E-05	167.9756548
WR-C-13	37.54615216	0.035526534	0.002723562	2.5589E-05	85.05503701
WR-C-14	38.8869165	0.063785901	0.004700852	3.95308E-05	112.9183866
WR-C-16	18.2103879	0.038347775	0.003878704	4.38309E-05	170.9821968
WR-C-17	43.0429542	0.068724033	0.007499532	1.71701E-05	46.37067525
WR-C-18	34.77635447	0.045533744	0.003843848	2.97522E-05	107.8994638
WR-C-22	39.65110673	0.052241781	0.00434438	2.013E-05	78.52623507
WR-C-23	26.78250384	0.054619969	0.004786449	4.30476E-05	128.1807364
WR-C-24	42.74161736	0.047798876	0.004109179	2.52451E-05	84.0556758
WR-C-27	30.07365079	0.0499634	0.004423889	3.93196E-05	130.0814622
WR-C-32	22.58846744	0.036364483	0.004051016	3.14094E-05	116.6360104
WR-C-33	22.87203791	0.101137075	0.008462503	6.78563E-05	198.9644455
WR-C-36	26.62116402	0.06878546	0.006035162	4.4419E-05	122.9595593
WR-C-39	37.57742724	0.061193115	0.004769281	7.04096E-05	133.8501892
WR-C-41	33.60058799	0.05819005	0.00491333	2.90337E-05	78.410197
WR-C-43	36.31857049	0.053578715	0.004365662	3.41866E-05	112.1106608
WR-C-46	14.91790718	0.050854781	0.005116367	6.14313E-05	165.9049239
WR-C-48	42.11483673	0.044062119	0.003759809	2.98325E-05	77.7238344
WR-C-49	25.05904762	0.036791091	0.0035759	2.65432E-05	95.57893252
WR-C-50	18.42252904	0.041872496	0.004692406	7.22103E-05	195.0153274

Sand Lance

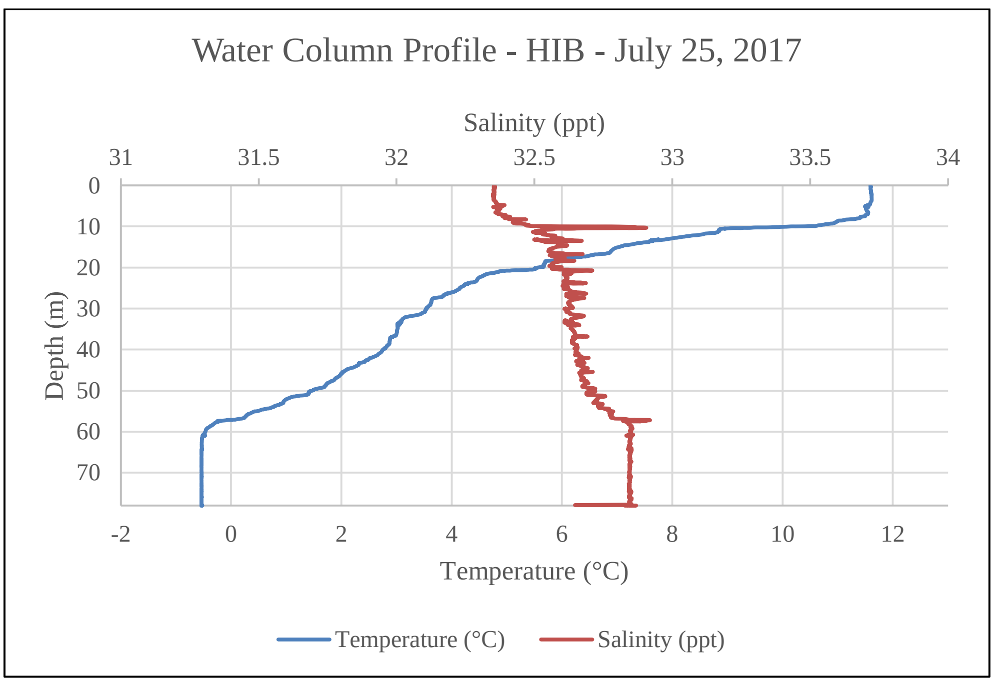
Sample ID	Bile Protein	2-Naphthol	9-Phenanthrol	1-OH Pyrene	Benzo-α-Pyrene
	mg/ml	mg/mg protein	mg/mg protein	mg/mg protein	Flu/mg protein
H-SL-03	22.61830704	0.050713023	0.005173613	3.85565E-05	127.0714214
H-SL-04	43.81075269	0.065034648	0.00524574	3.67749E-05	103.8722702
H-SL-05	40.84315907	0.049828538	0.003019935	2.35234E-05	97.7363601
H-SL-07	51.0616093	0.056702372	0.005797405	2.8658E-05	101.6305652
H-SL-11	25.27089947	0.054976267	0.005106129	5.03018E-05	167.4405539
H-SL-12	28.60415792	0.058153526	0.005380897	5.52917E-05	198.1685192
H-SL-16	25.83225806	0.050497356	0.004856413	3.71926E-05	154.5301108
H-SL-19	38.86959261	0.062224649	0.00445885	4.52525E-05	162.2641522
H-SL-20	38.62341702	0.056361667	0.003340887	2.98504E-05	82.68272484
H-SL-21	46.17781188	0.043774784	0.002319484	2.1446E-05	122.7525382
H-SL-23	19.22002225	0.064297788	0.006889168	5.46022E-05	216.0005913
H-SL-25	27.66985114	0.062811081	0.006781788	5.5022E-05	170.2357119
H-SL-29	19.37102234	0.111947802	0.010296737	9.69074E-05	292.6249073
H-SL-30	20.53283683	0.073800431	0.007270183	4.53521E-05	174.9721951
H-SL-31	49.18596254	0.031904958	0.002323374	2.43416E-05	102.2597807
H-SL-34	42.90268829	0.051551512	0.004889896	2.23941E-05	93.04455877
H-SL-38	60.98580645	0.035123941	0.002834955	2.39945E-05	87.71048531
H-SL-41	34.000877	0.059913646	0.005655431	5.43407E-05	201.9360303
H-SL-42	35.06754055	0.040303062	0.003535355	3.41417E-05	138.8768987
H-SL-43	22.12704746	0.065535593	0.006231826	5.74488E-05	202.0552048
H-SL-46	23.06688172	0.043157524	0.003153488	3.52435E-05	138.4447799
H-SL-47	24.49492214	0.067108467	0.005044087	4.40507E-05	146.6702164
H-SL-48	33.05788204	0.04836063	0.005261868	2.90632E-05	96.60296318
H-SL-49	29.98387097	0.060171586	0.006152921	4.09163E-05	138.4589793
H-SL-55	69.33175355	0.058934072	0.004926561	2.70755E-05	86.36436043
RF-SL-01	44.52435951	0.071812375	0.005085898	3.81774E-05	121.931724
RF-SL-02	51.18190025	0.085850134	0.006203968	4.6496E-05	143.5082616
RF-SL-04	44.68129032	0.011458405	0.001141959	6.28541E-06	23.22860497
RF-SL-05	49.99320324	0.04613318	0.003546876	2.77922E-05	71.86327938
RF-SL-07	59.9995615	0.045656459	0.002305243	2.34035E-05	70.52340548
RF-SL-08	39.3150411	0.04497968	0.003636068	3.79724E-05	107.6273428
RF-SL-11	44.49682087	0.054653062	0.004923201	2.79033E-05	91.50538974
RF-SL-13	28.58113293	0.082170281	0.007015556	4.44759E-05	136.8743667
RF-SL-18	52.75978495	0.068280593	0.005163219	3.558E-05	116.5180455
RF-SL-19	38.31548387	0.055752318	0.005436804	3.27907E-05	127.1045224
RF-SL-20	46.04516553	0.033335707	0.002573436	1.82977E-05	71.08947395
RF-SL-24	28.14032011	0.055208445	0.004915139	4.14958E-05	173.0638194
RF-SL-25	42.85136636	0.047882451	0.00278492	2.58704E-05	113.6503148
RF-SL-29	40.9370752	0.047030853	0.003976139	3.35793E-05	115.0643221
RF-SL-33	44.53590928	0.075867937	0.005946211	3.61761E-05	111.1442113
RF-SL-36	31.07783381	0.07163982	0.006004178	3.56711E-05	128.4472311
RF-SL-38	41.327779	0.059472798	0.006009858	2.46782E-05	96.59027896
RF-SL-42	47.7856032	0.052215496	0.003697498	3.80464E-05	115.2809378
RF-SL-45	39.43234837	0.072852775	0.00578543	3.93588E-05	125.5291332
RF-SL-46	49.19277614	0.043205292	0.002665938	1.95307E-05	86.01615391
RF-SL-48	53.19521553	0.066219008	0.004359946	3.61224E-05	111.0617799
RF-SL-50	55.92868251	0.086674523	0.005990324	4.0964E-05	131.3284204
RF-SL-51	39.58786936	0.097663855	0.007094195	5.26457E-05	175.4537305
RF-SL-53	59.55601842	0.060151151	0.00513692	2.82934E-05	81.77294933
RF-SL-59	23.16085314	0.054119736	0.007027871	1.97839E-05	72.38860782
TN-SL-27	51.94365591	0.076632397	0.007253591	4.15457E-05	99.9047934
TN-SL-42	49.87203791	0.059883828	0.004828031	2.63778E-05	78.44123945
TN-SL-81	38.34860215	0.053095435	0.005300154	3.43041E-05	106.1759414
WR-SL-23	52.14473118	0.057753464	0.005794244	3.03305E-05	91.86420054
WR-SL-32	46.51323693	0.063354142	0.006441374	2.57403E-05	89.25493997

Appendix 7

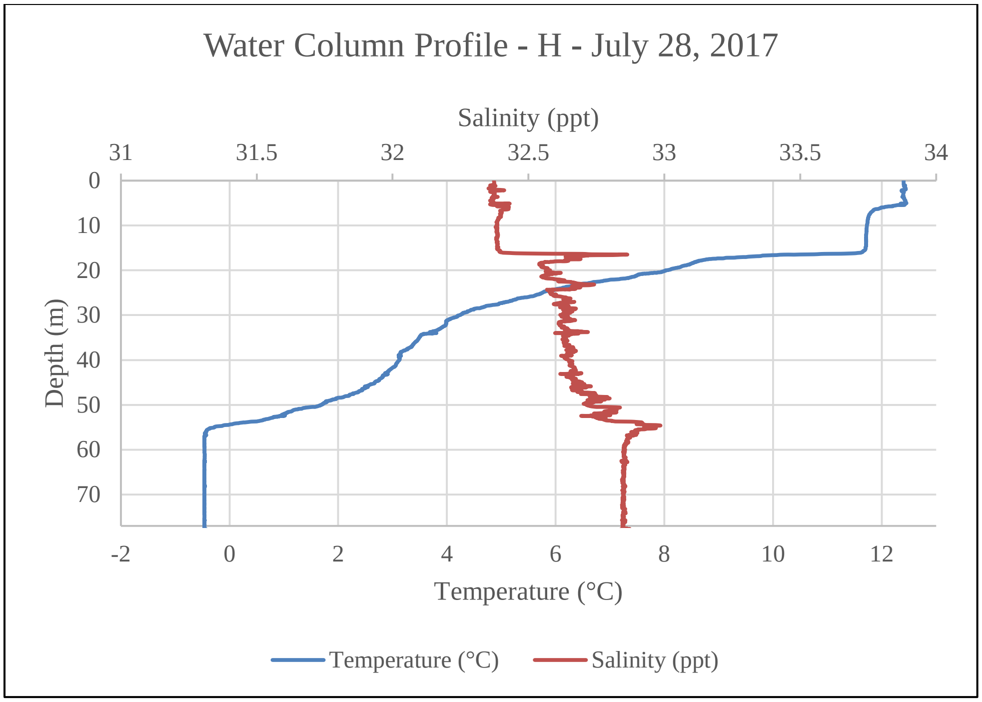
Water Temperature and Salinity Profiles



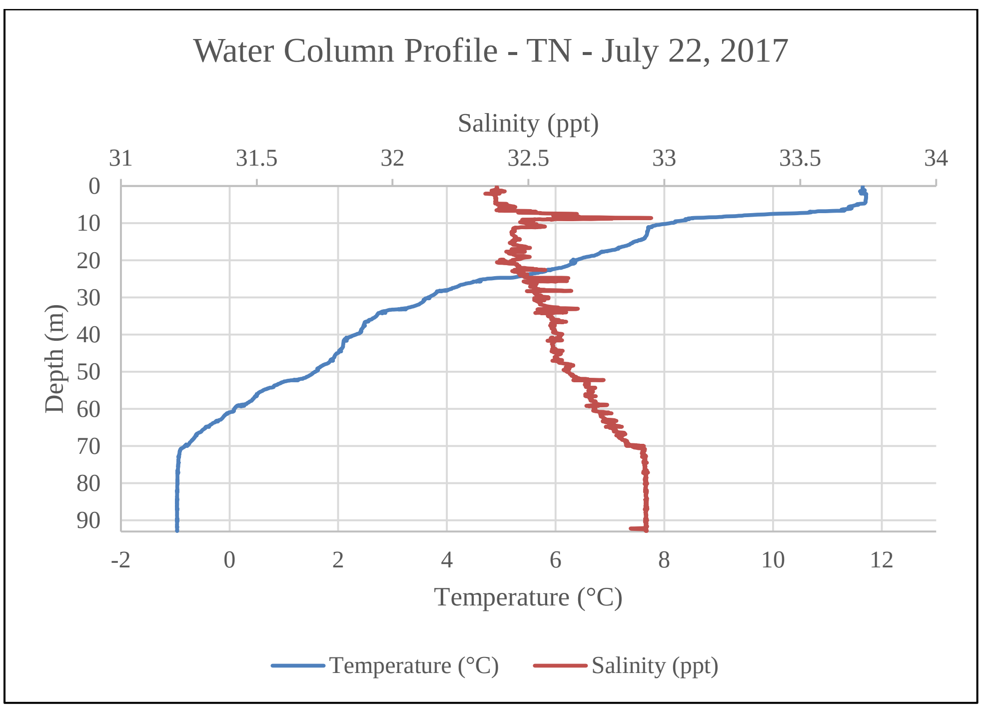
CTD water column profile at Hibernia, on July 25, 2017 @ 7:30.



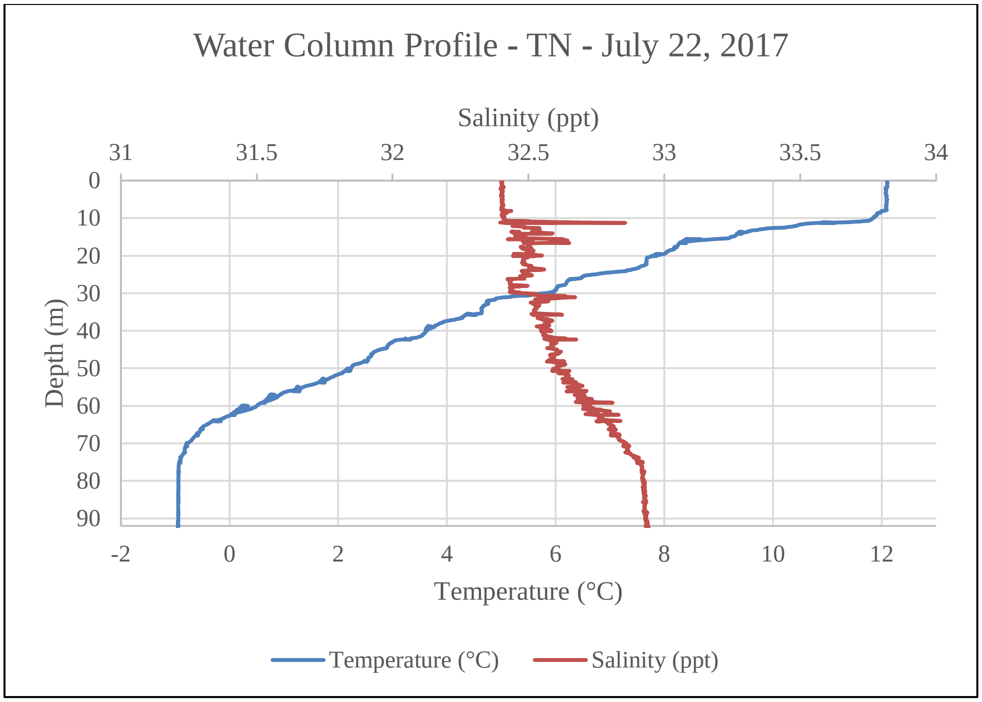
CTD water column profile at Hibernia on July 25, 2017 @ 18:30.



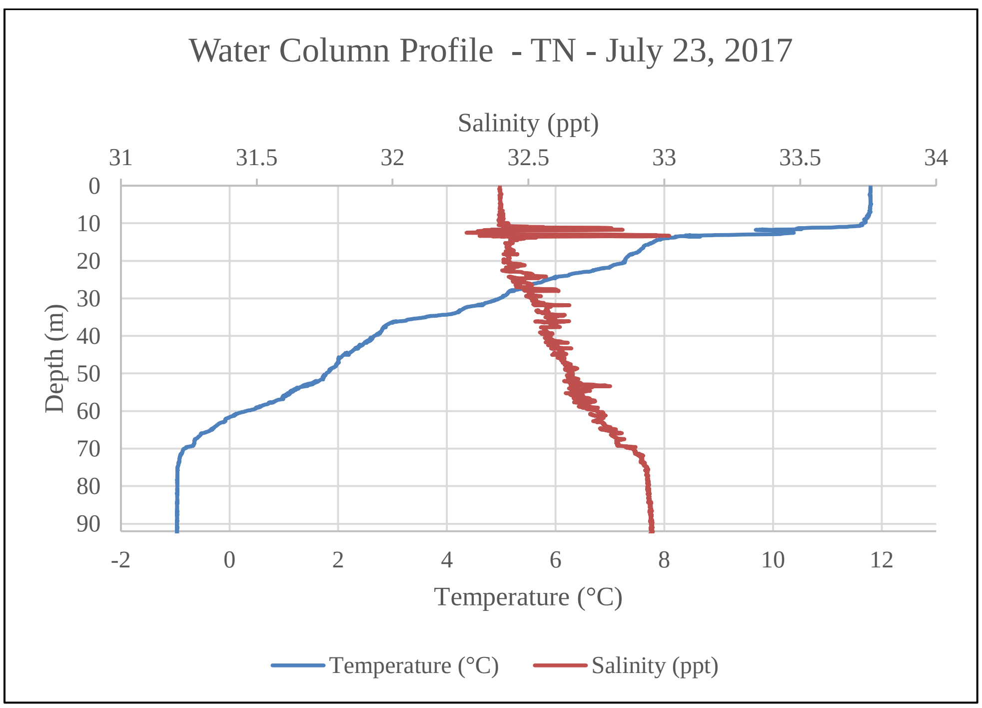
CTD water column profile at Hibernia on July 28, 2017 @ 22:50.



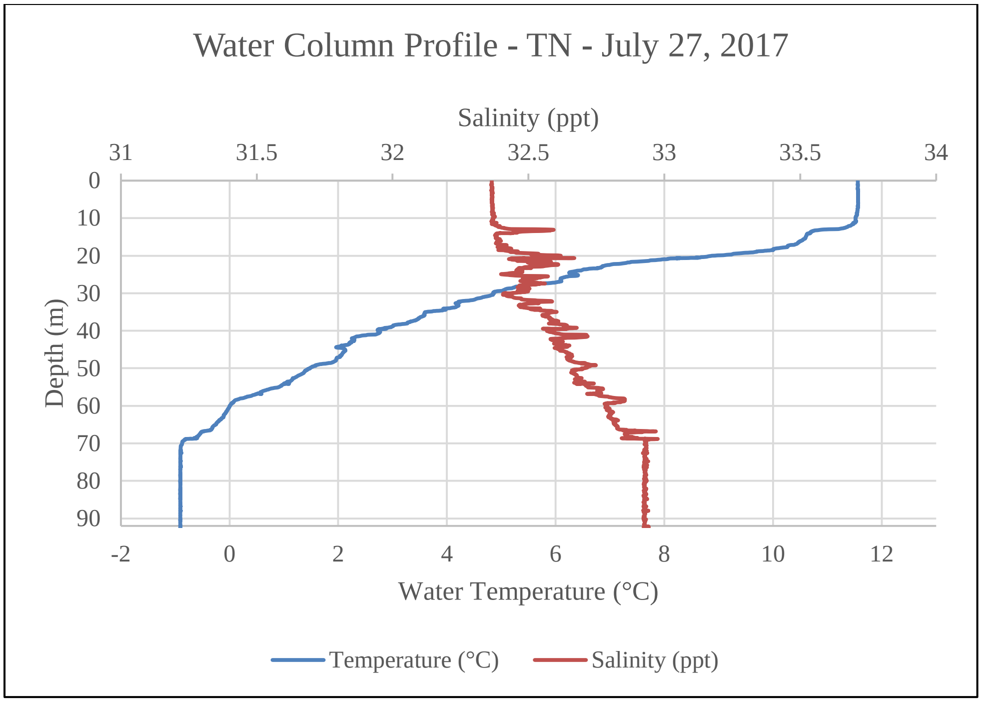
CTD water column profile at Terra Nova on July 22, 2017 @ 7:20.



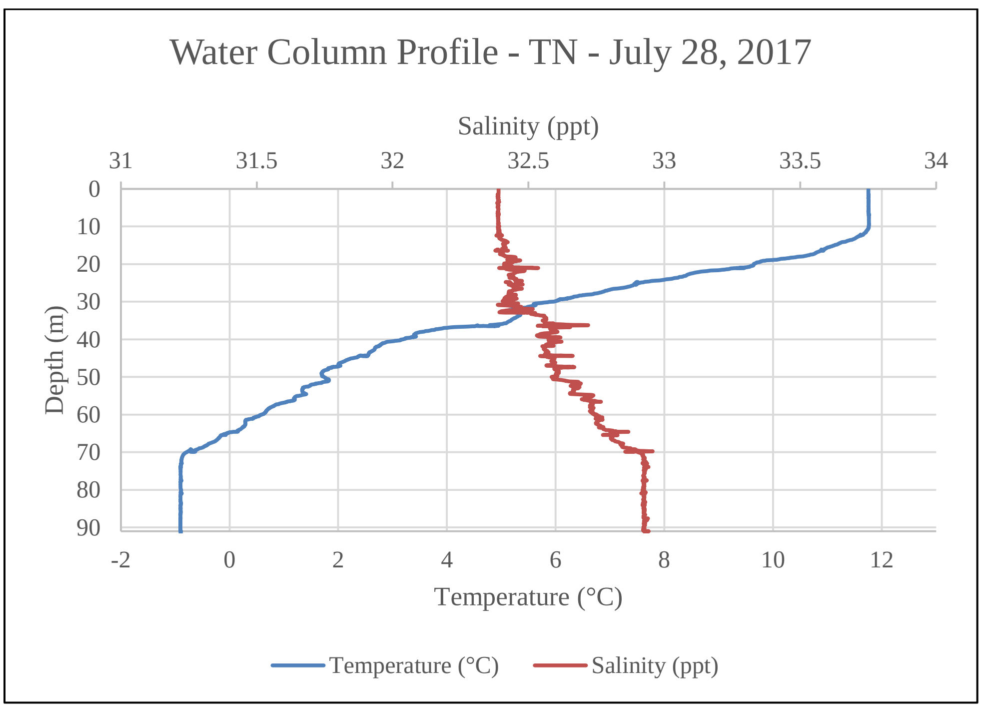
CTD water column profile at Terra Nova on July 22, 2017 @ 17:35.



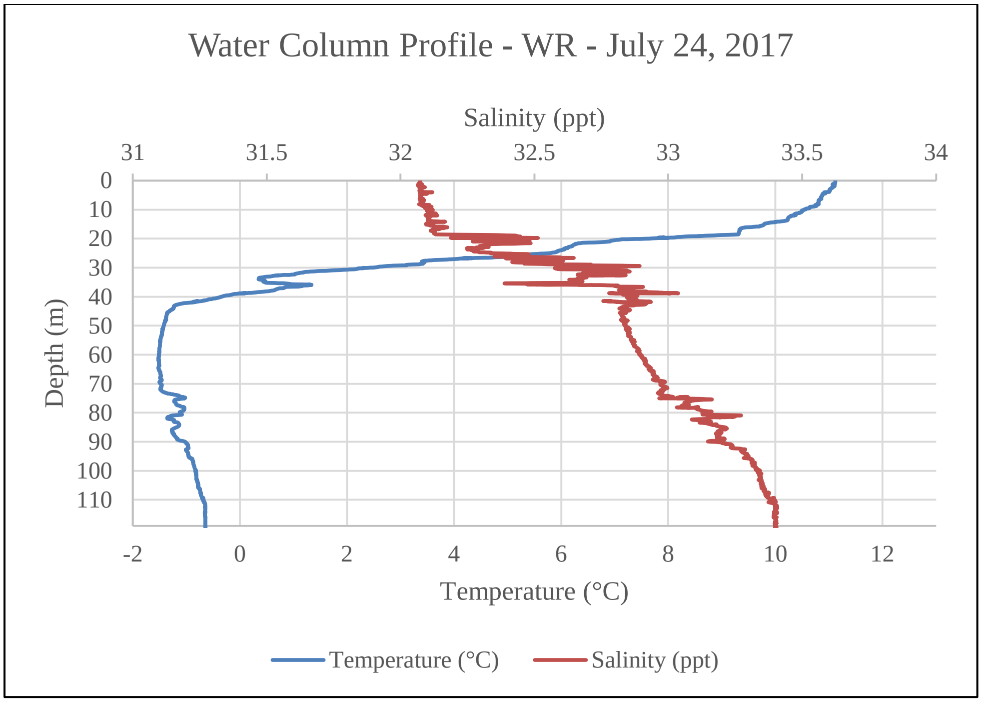
CTD water column profile at Terra Nova on July 23, 2017 @ 7:25.



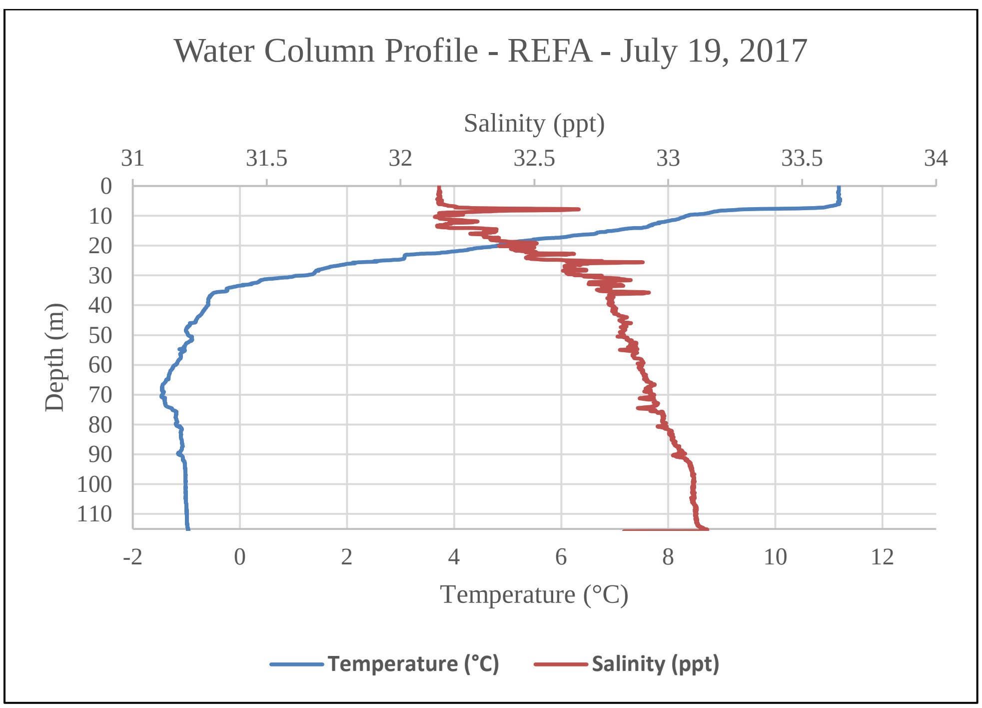
CTD water column profile at Terra Nova on July 27, 2017 @ 22:40.



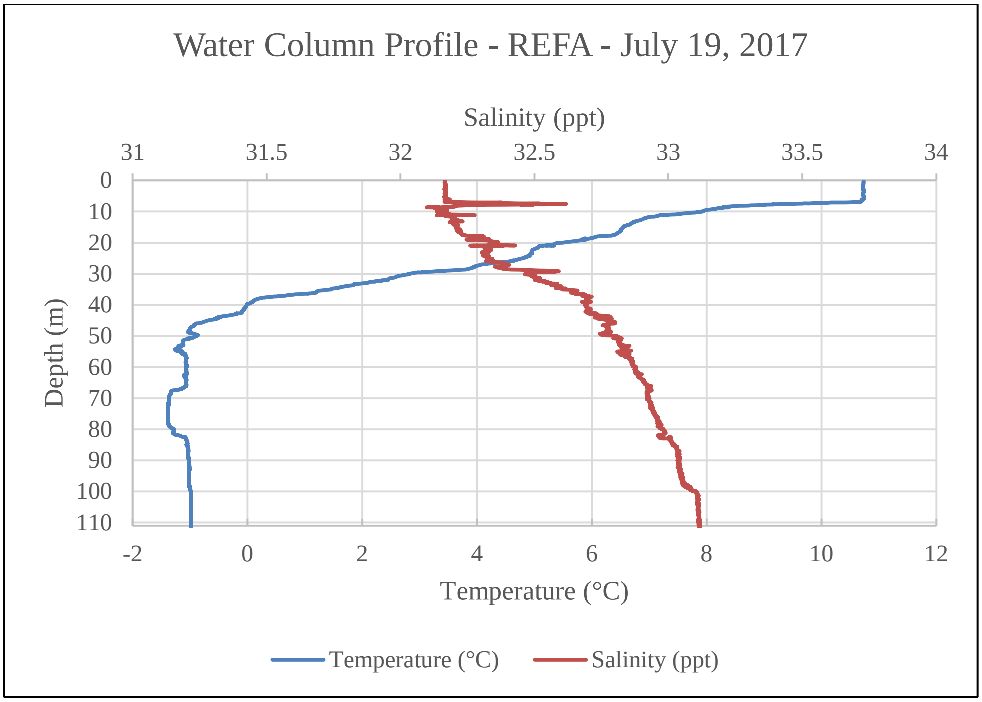
CTD water column profile at Terra Nova on July 28, 2017 @ 7:10.



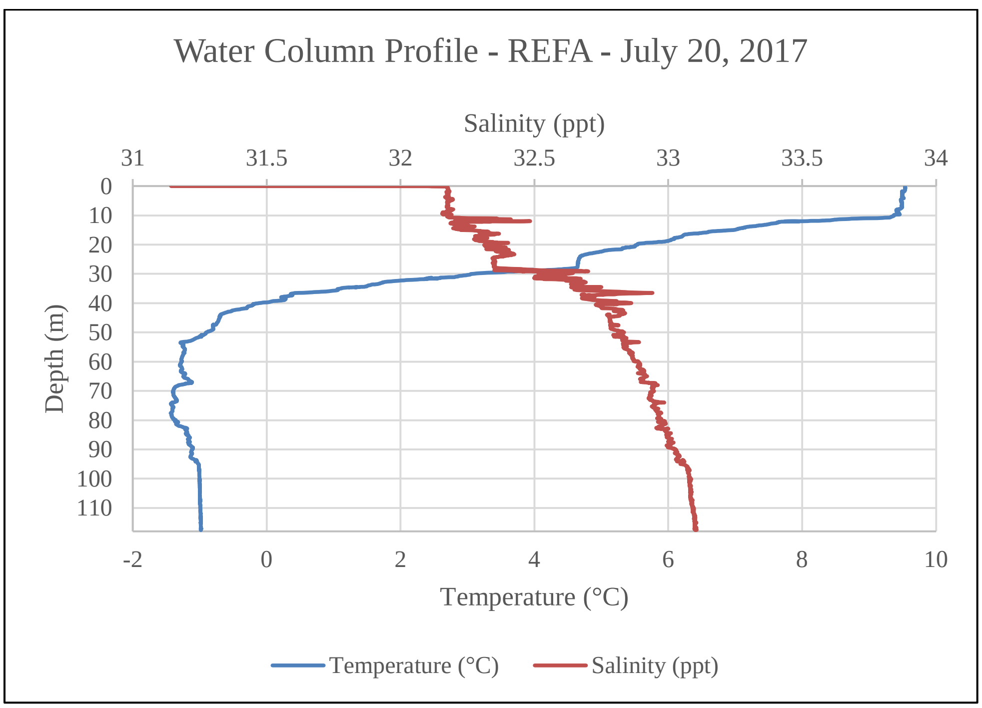
CTD water column profile at White Rose on July 24, 2017 @ 17:10.



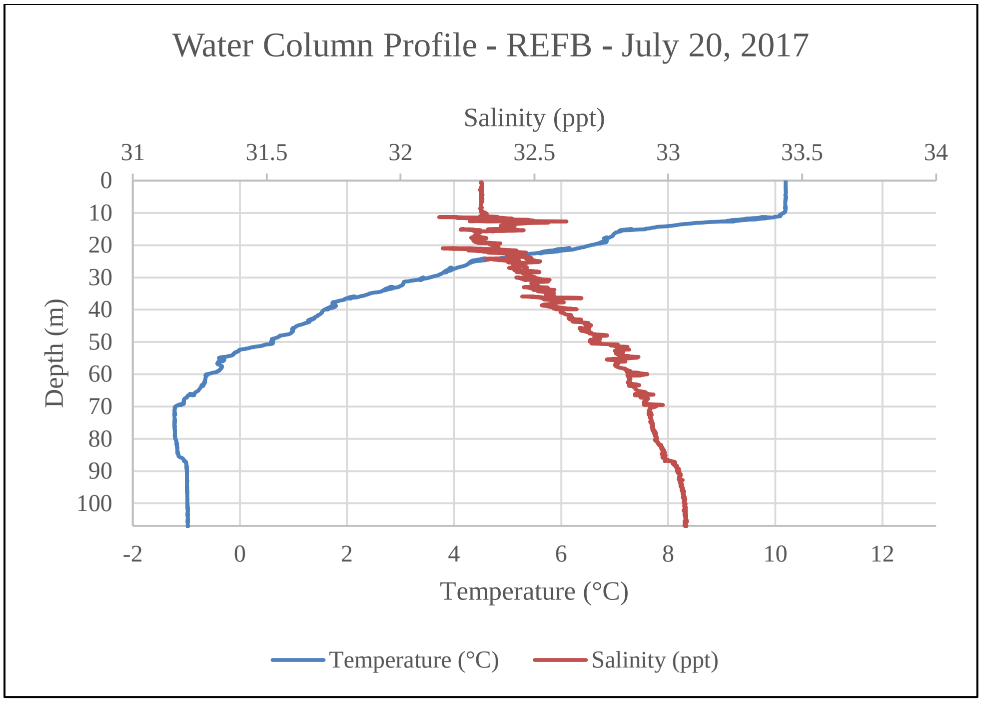
CTD water column profile at Reference Area Site A on July 19, 2017 @ 15:45.



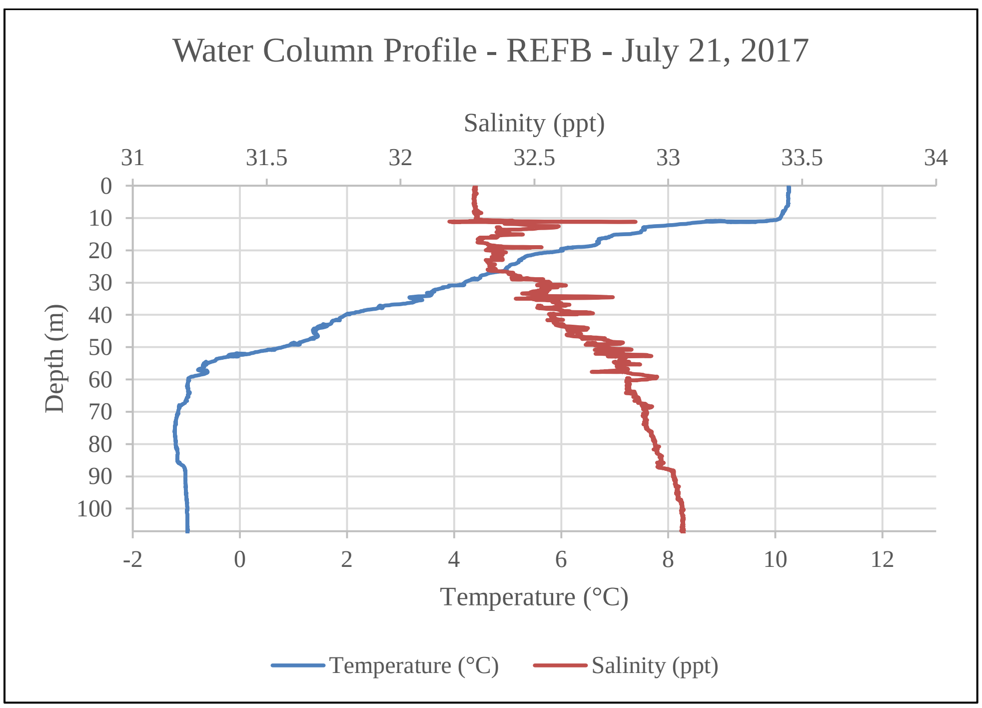
CTD water column profile at Reference Area Site A on July 19, 2017 @ 21:30.



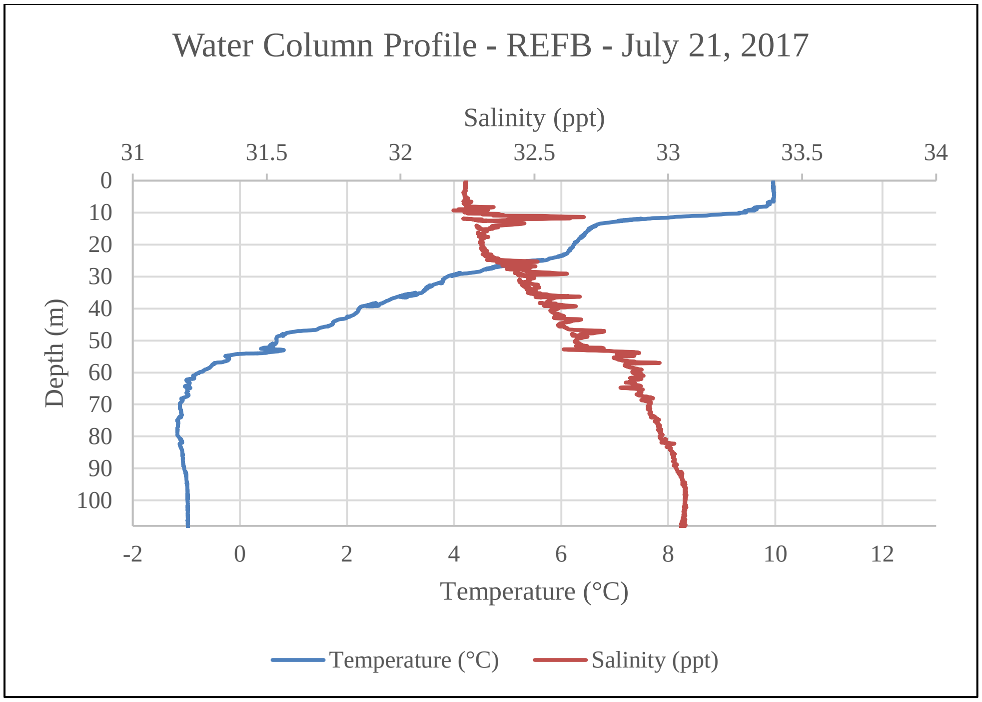
CTD water column profile at Reference Area Site A on July 20, 2017 @ 13:00.



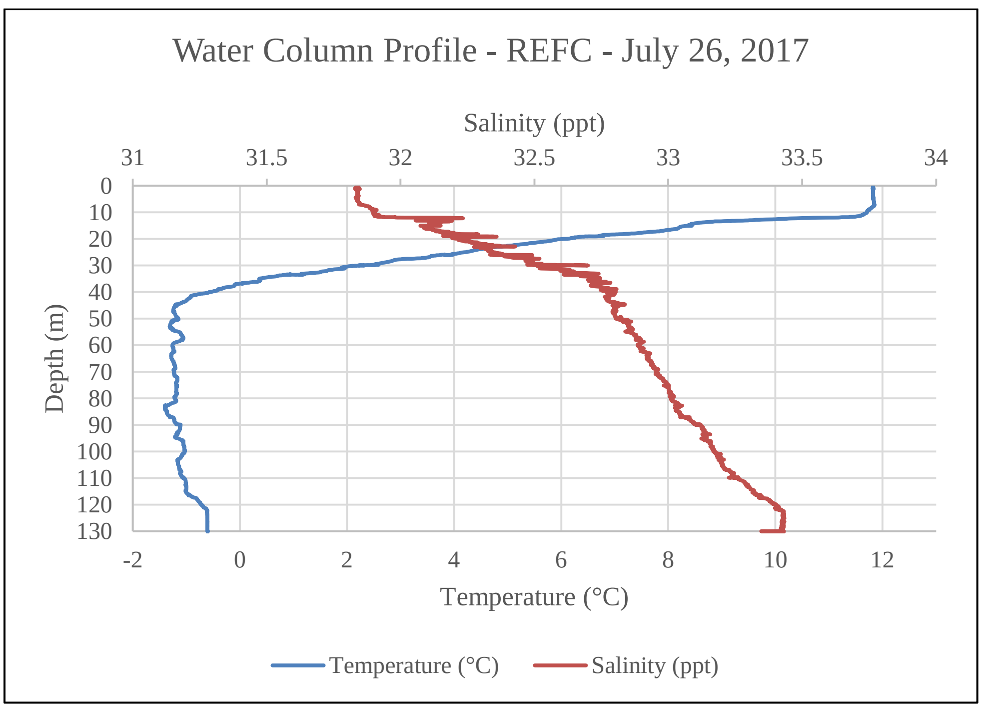
CTD water column profile at Reference Area Site B on July 20, 2017 @ 21:45.



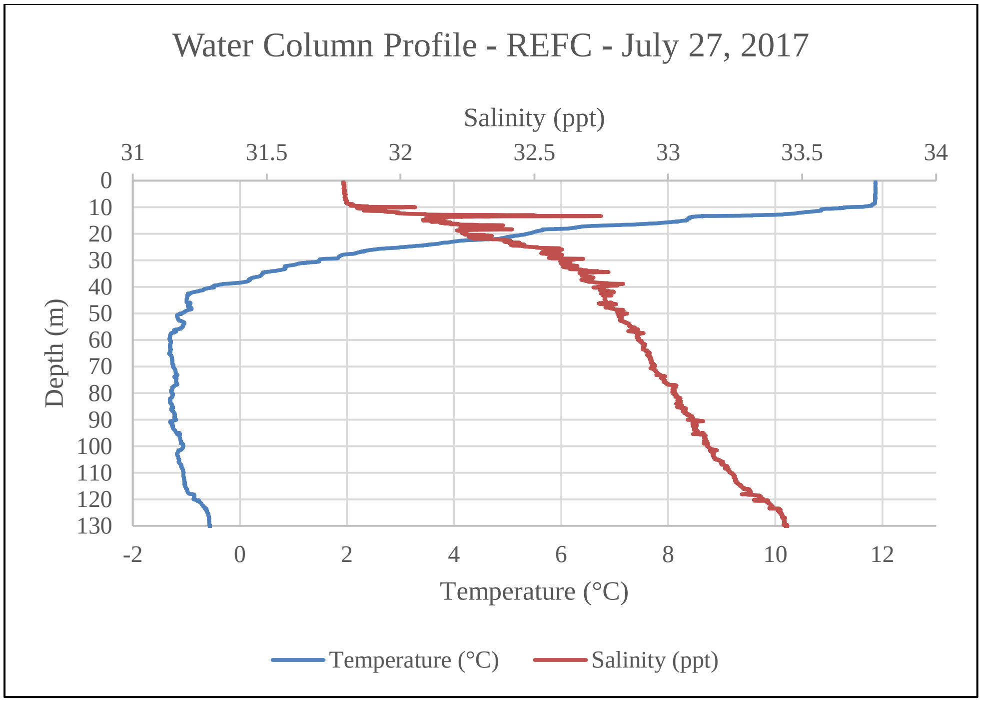
CTD water column profile at Reference Area Site B on July 21, 2017 @ 11:00.



CTD water column profile at Reference Area Site B on July 21, 2017 @ 18:10.



CTD water column profile at Reference Area Site C on July 26, 2017 @ 22:35.



CTD water column profile at Reference Area Site C on July 27, 2017 @ 7:20.