Quality Assurance / Quality Control (QA/QC) program for the Community Aquatic Monitoring Program (CAMP).

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By

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En 2003, le Ministère des Pêches et Océans (MPO), Région du Golfe, a développé un Programme de Surveillance de la Communauté Aquatique (PSCA) qui engage les organisations non gouvernementales de l'environnement (ONGEs) à décrire l'assemblage des poissons et crustacés côtiers se retrouvant dans les baies et les estuaires à l'aide d'une seine de plage. Les objectifs de ce programme sont 1) de promouvoir l'intendance entre le MPO et les ONGEs dans le but de sensibiliser ces derniers sur l'écologie des estuaires et des baies, 2) de recueillir des données de bases pour des comparaisons futures, et 3) de tester le potentiel d'un programme de surveillance de la santé côtière mené par les ONGEs. Un programme d'assurance et de contrôle de la qualité (PACQ) des données a été entreprit à six sites en juillet et août 2007 pour déterminer l'exactitude et la précision de l'identification d'espèce et de l'estimation d'abondance des poissons et des crustacés énumérés par les ONGEs. Les ONGEs ont identifiés et énumérés les adultes et les jeunes de l'année pour chaque espèce capturée tels qu'indiqué dans le protocole du PSCA, mais au lieu de relâcher leur prise ils l'ont plutôt conservée de sorte à ce que les poissons et les crustacés pouvaient être comptés et identifiés à nouveau par les biologistes du MPO. Trois à cinq stations sur six stations habituellement échantillonné par site ont été examinées. La richesse en espèce et l'abondance totale pour chaque espèce par station et par site ont été comparées entre les biologistes du MPO et les ONGEs. Sur l'ensemble, les ONGEs ont enregistré le même nombre de groupe taxinomique par site que les biologistes avec une différence maximal de seulement une espèce en plus ou en moins. Le pourcentage de désaccord entre les biologistes et les ONGEs varie parmi les espèces mais est habituellement moins de 10%. Les ONGEs avec plus d'expérience ont démontré des réponses similaires aux biologistes dans la distinction entre les adultes et les jeunes de l'année comparativement aux groupes avec moins d'expérience. Les espèces les plus souvent confondus incluent les poissons plats (plie rouge *Pseudopleuronectes americanus* et plie lisse *Pleuronectes putnami*), les fondules (choquemort *Fundulus heteroclitus* et fondule barrée *F. diaphanus*), les crevettes (crevette de sable *Crangon*

septemspinosa et crevette d'herbe *Palaemonetes sp.*) et les épinoches (épinoches à trois épines *Gasterosteus aculeatus* et épinoche tâchetée *G. wheatlandi*), et surtout lorsque ces animaux était de petite taille (jeune de l'année). Les résultats du premier PACQ sont encourageants, en général la qualité des données recueillis par les ONGEs est élevée. Il y a encore du potentiel pour de l'amélioration mais le PACQ nous a procuré des directions sur les points qui nécessitent plus d'emphase pour les prochaines sessions de formations. Enfin, des recommandations ont été identifiées pour l'application de futur programme d'assurance et de contrôle de la qualité des données.

ABSTRACT

Thériault, M.-H., S. Courtenay and J. Weldon. 2008. Quality Assurance / Quality Control (QA/QC) program for the Community Aquatic Monitoring Program (CAMP). Can. Tech. Rep. Fish. Aquat. Sci. 2823: v + 29 p.

In 2003 the Department of Fisheries and Oceans (DFO), Gulf Region developed the Community Aquatic Monitoring Program (CAMP) which engaged environmental non-governmental organizations (ENGOs) in describing nearshore animal assemblages through monthly beach seining of estuaries and bays. Objectives of the program included 1) fostering stewardship with ENGOs to raise awareness of the ecology of estuaries and bays, 2) collecting baseline information for future comparisons, and 3) testing the potential of a community-led program for monitoring coastal health. A quality assurance and quality control (QA/QC) program was carried out at six CAMP sites in July-August 2007 to determine the accuracy and the precision of faunal identification and abundance estimates provided by ENGOs. ENGOs enumerated adults and young-of-the-year for each species, following CAMP protocols, but then retained the catch instead of releasing it live in order to be re-processed by DFO biologists. Three to five of the six stations normally sampled within each site were examined. Species richness and total abundance for each species, by station and site, were compared between DFO biologists and ENGOs. Overall, ENGOs recorded the same number of taxonomic groups per site as did the biologists and were within one species per station. Disagreement in abundance counts between the biologists and the ENGOs varied among species but was usually less than 10%. More experienced ENGOs showed better agreement with biologists than less experienced ENGOs on the separation of adults versus young-of-the-year within species. Species most often confused included flatfish (winter flounder *Pseudopleuronectes americanus* and smooth flounder *Pleuronectes putnami*), killifish (mummichog *Fundulus heteroclitus* and banded killifish *F. diaphanus*), shrimp (sand shrimp *Crangon septemspinosa* and grass shrimp *Palaemonetes sp.*) and sticklebacks (threespine *Gasterosteus aculeatus* and black-spotted *G. wheatlandi*), and especially when these animals were small (young-of-the-year). Results of this first QA/QC program were encouraging; overall the quality of the data being collected by ENGOs is high. There is potential for improvement and the QA/QC program provided direction on where more

emphasis should be placed in future ENGO training sessions. Recommendations for future QA/QC programs was also given.

INTRODUCTION

The Community Aquatic Monitoring Program (CAMP) was established by the Department of Fisheries and Oceans, Gulf Region, in 2003 as a pilot project at four sites (Thériault et al. 2006). The program involves identifying and counting the numbers and types of fish, crab and shrimp living in shallow coastal waters through monthly beach seining at six stations per site from May to September. In addition, water temperature, salinity and dissolved oxygen are measured at each station, submerged aquatic vegetation (SAV) is described and once a year in September, sediment is characterized by grain size, organic and moisture content. The objectives of this program are: 1) to provide an outreach program for the Department of Fisheries and Oceans (DFO) to interact with Environmental Non-Governmental Organizations (ENGOs) to raise awareness of the ecology of estuaries and bays, 2) to collect baseline data on abundance, diversity and community assemblage for future comparison, and 3) to test the potential of a community-led program for monitoring coastal health in the southern Gulf of St. Lawrence (sGSL).

In 2004, the project was extended to 18 sites through the participation of ENGOs across the sGSL. This number increased over the years to 29 sites sampled in 2008 by 22 different ENGOs and three First Nation Groups. In 2007, 173 volunteers with different levels of experience in coastal ecology were involved in carrying out the program. The volunteers included: coordinators and technicians from watershed groups, most of whom had an environmental or biology background, summer university students with some basic knowledge in ecology and local community volunteers such as retired people with very little or no knowledge of coastal ecology. Some of these volunteers were trained in-class and in the field by DFO biologists at the beginning of the sampling season in May 2007. Those who did field work for the CAMP after May were usually trained by the watershed coordinator or other volunteers who had been trained earlier. When new groups applied CAMP in their watershed for the first time, DFO biologists were on site to help the groups select stations and sample for the first few months to make sure they were comfortable identifying the fauna and were applying the protocol correctly. DFO biologists also participated in CAMP sampling when a lack of volunteers occurred, especially in September when summer students returned to school. To help improve the program and increase the quality of the data collected, the Southern Gulf of St. Lawrence Coalition on Sustainability collaborated with DFO to hire 3 summer students in 2007 and 2008 to help coordinate the program, correctly identify the fauna and vegetation and apply the CAMP protocol. While elements of the protocols have been kept constant to permit comparisons over time, the program has nevertheless evolved with a few modifications and additions. For example, at some sites one or several stations have been changed to facilitate sampling within a certain salinity range. Furthermore, starting in September 2006, water samples were taken to measure concentrations of the waterborne nutrients such as nitrate, nitrite, phosphate, ammonia and silicate.

Stewardship and collaboration with community-based monitoring groups can provide a number of benefits and opportunities for both government and the ENGOs. Benefits to government include extension of an existing monitoring network, cost saving, promotion of public participation to achieve government mandates, and provision of an early warning system of ecological changes (Sharpe and Conrad, 2006). ENGOs can benefit from community-based monitoring though the engagement of their members and local individuals in environmental issues, access to scientific expertise and the opportunity for input into the management of natural resources (Whitelaw et al. 2003; Sharpe and Conrad, 2006). While community-based monitoring can confer benefits to all parties, one concern often expressed is the quality of the data gathered by ENGOs. The answer to this concern is to review the quality of data collected (e.g., Jamieson et al. 2002) or to directly compare data collected by volunteers and professionals (Fore et al. 2001; Nicholson et al. 2002). Therefore, in 2007 a quality control/quality assurance (QA/QC) program was carried out to determine the accuracy and the precision of identifications and abundance estimates of fish and crustaceans by the ENGOs staff and volunteers participating in CAMP.

METHODOLOGY

Two sites per province were chosen to conduct a QA/QC program from July 10th to August 2nd, 2007. Sites were selected depending upon the availability of biologists and ENGOs. The 6 sites were (see Figure 1):

1-Kouchibouguacis River in New Brunswick (NB), sampled by the Friends of Kouchibouguacis since 2004;
2-Shediac River in NB, sampled by the Shediac Bay Watershed Association since 2003;
3-River Phillip in Nova Scotia (NS), sampled by the Cumberland River Enhancement Group since 2004 and since 2007 as a full CAMP dataset of 6 stations;
4-Pugwash in NS, sampled by the Pugwash Community group since 2004 and since 2007 as a full CAMP dataset;
5-Summerside in Prince Edward Island (PEI), sampled by the Bedeque Bay Environmental Management Committee since 2007;
6-Murray River in PEI, sampled by the Southeast Environmental Association (SEA) since 2005.

At each site, three to five stations out of six stations were evaluated. Each community group coordinator, accompanied by their provincial CAMP coordinator, summer students and/or local volunteers, applied the CAMP protocol as described in Weldon et al. (2005) and Thériault et al. (2006) with the exception that instead of releasing the fauna back into the water, they were placed in buckets with aerated water. Each taxonomic group was placed in a separate bucket (see Figure 2). The QA/QC program was usually conducted by DFO biologists Jim Weldon, Marie-Hélène Thériault and Simon Courtenay who have considerable experience in identifying nearshore marine animals of the sGSL. After the community group had identified everything captured in their beach seine and placed the fauna into the species specific buckets, each species was re-counted and re-identified by the DFO biologists and then released to the water. The QA/QC was done for the fauna only and not for the aquatic vegetation survey or for the physical data collected through CAMP.

The objective of this research is to determine the accuracy and the precision of fish and crustacean identification and abundance estimates provided by ENGOs. Species richness and total abundance for each species, by station and site, were compared between DFO biologists and ENGOs and percent agreement was calculated between the two.

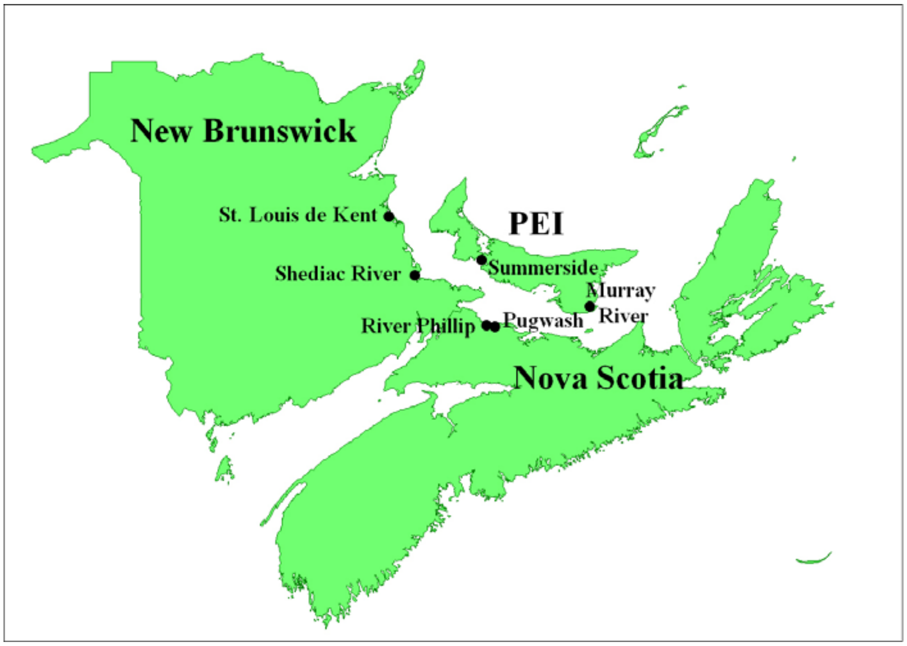

Figure 1: Map indicating the 6 sites sampled for the QA/QC program from July 10th to August 2nd, 2007.

CALCULATIONS

For each station, the species richness, corresponding to the total number of different species captured, was compared between the ENGOs and the biologists (Table 1). Agreement between the biologists and the ENGOs for the total abundance of animals (YOY separately; adults separately and pooling YOY and adults) was calculated for each station and for each site by summing the total abundance of all animals across stations for ENGOs and biologists and then dividing the smaller value by the larger value and multiplying by 100 (Table 2). This calculation gave us an overview of the counting agreement between ENGOs and biologists but did not indicate the identification accuracy by the ENGOs. When differences in counts occurred between the biologists and the ENGOs it was very difficult to distinguish identification errors from counting or recording errors. It was sometimes possible to infer identification errors between similar species, such as the two shrimp species, two flounder species and two *Fundulus* species, by one species count being too high and the other similar species count being too low. For example, the ENGOs could have counted five sand shrimp and two grass shrimp, while the biologists identified all seven shrimp as sand shrimp indicating that the grass shrimp were misidentified by the ENGOs. However, it was more difficult to identify such misidentification errors among other species such as the sticklebacks because there is a total of four stickleback species.

Percent agreement between ENGOs and biologists was also calculated for each species (pooling YOY and adults) summing across the stations sampled for each site (Table 3). This calculation was also performed by grouping certain species that were often misidentified. For example, the percent agreement was calculated by summing the total abundance of the four stickleback species, the two *Fundulus* species (mummichog and killifish), the two shrimp species (sand and grass shrimp), the two flounder species (smooth and winter flounder), the three crab species (rock, green and mud crab) and finally the two species of gaspereau, *Alosa* sp. (blueback herring and alewife). The results of the calculations shown in Table 3 provide an indication of species ENGOs had most difficulty identifying. The actual number of each taxonomic group counted by the ENGOs and the biologists are reported in Table 4. Table 4 was added for readers to be able to determine how accurate and valuable the percent agreement was. For example, a difference of only 1 individual can generate a percent agreement as low as 50% (1 / 2 x 100 = 50%) or as high as 99% (99 / 100 x 100 = 99%). Note that the percent agreements by species for each developmental stage (YOY and adults) were not calculated due to the large amount of calculations needed. However, the actual YOY and adults abundance for each species per site was compiled into Appendix 1. Furthermore, all the Latin names, common names and abbreviations for each species mentioned in this report can be found in Appendix 2.

RESULTS AND DISCUSSION

ST. LOUIS DE KENT

In St. Louis de Kent (NB), ENGO and volunteers recorded the same number of taxa per station (i.e. species richness) as did the DFO biologists, plus or minus one species (Table 1). When pooling the taxa across all stations, the biologist found 14 species compared to 13 species by the ENGOs. The total animal count for the young-of-the-year (YOY) across the four stations by the ENGO agreed at 91.2% with the biologists count and the adult count agreed at 76.8% (Table 2). ENGO and biologists total counts pooling YOY and adults were within 10% for three out of four stations (Table 2). Total abundance (YOY + adults) by ENGO at station 1 was underestimated by 30% due primarily to the dip net method used to estimate adult shrimp numbers which would also explain the low % agreement found for adults only. The dip net method is recommended for estimating very abundant taxa and involves averaging the number of YOY and adult (sand shrimp in this case) present in three dip nets and then counting how many dip nets of sand shrimp are needed to empty the bucket (Weldon et al. 2005). While the ENGO followed this procedure at station 1, the biologists actually counted all the captured sand shrimp. The community group estimated 75 YOY and 1101 adult compared to 79 and 1834, respectively, by the biologists. This indicates that the dip net technique can underestimate (or perhaps overestimate) the true number of animals and should be regarded as an “order of magnitude” estimate rather than a true count.

Other differences included: ENGOs assigning juvenile *Gasterosteus* sp. to blackspotted stickleback or threespine stickleback when biologists could not tell which species these very small *Gasterosteus* fish belonged to (Appendix 1). Agreement for ninespine stickleback between ENGO and biologists was poor (51.4%) (Table 3). The volunteers counted 17 more ninespine stickleback than did the biologists and underestimated the fourspine stickleback suggesting a possible misidentification of certain fourspine stickleback for ninespine stickleback (Table 4). Agreement on mummichog was excellent with a 98.4% between ENGO and biologists (Table 3). There was some uncertainty in distinguishing between killifish and mummichog since a low % agreement of 55.6% for killifish was calculated (Table 3).   Sand shrimp counts were variable. The low % agreement (74.3%) for sand shrimp was mainly due to the under estimation of sand shrimp with the dip net method (Table 3). Grass shrimp counts were excellent with 92.5% agreement. Agreement was also excellent for silverside with 97.9% between ENGO and biologists. Uncertainty was observed between the smooth and winter flounder. In St. Louis de Kent, the biologists identified 3 winter flounder and the ENGO none, hence the 0% agreement for the winter flounder (Table 3 and 4). The mud crab counts were excellent with 93.1% agreement.   Perfect agreement (i.e. 100%) was also found for the striped bass and the cunner. Finally, during the QA/QC exercise, a total of six volunteers sampled the Kouchibouguacis River in St. Louis de Kent which included the ENGO coordinator and technician, as well as Park Canada representatives and a First Nation member. Their experience in applying the monthly CAMP protocol ranged from 18 to 0 months (Table 5).

SHEDIAC RIVER

In Shediac River (NB), fewer species were captured and volunteers agreed 100% with biologists on the species richness (Table 1). The numbers of animals were also very low and agreement in total abundance (YOY + adults) between biologists and ENGOs was excellent (within 5%) when summing the total abundance across stations and when looking at each station individually (Table 2). Biologists and ENGOs agreed poorly on the total abundance of the YOY (51.1%) but had a good percent agreement for the adults (89.5%) (Table 2). Table 2 shows that ENGO volunteers tended to underestimate numbers of YOY silverside and mummichog (Appendix 1). This was in part explained by ENGO volunteers classifying some mummichog YOY as adults and thereby simultaneously underestimating the YOY and overestimating the adults.

The percent agreement for the total abundance of each species (YOY + adult) in Shediac River was relatively good with 100% agreement for the ninespine stickleback, silverside, grass shrimp, smooth flounder and mud crab (Table 3). Mummichog were also well identified with a percent agreement of 98.7%. Lower percent agreement was found for the fourspine stickleback (66.7%) and the sand shrimp (83.3%). However, the total abundance of these two species only differed by one between the biologists and the ENGO (Table 4). Overall, high agreement between biologists and the Shediac River ENGO was found which could be attributed to fewer species and lower numbers of animals captured. Furthermore, five samplers were tested for the quality control and quality assurance in Shediac which included the coordinator and technician of the ENGO as well as a summer student and the NB CAMP coordinator. Their experience level varied from 15 to 0 months (Table 5). Having well experienced members applying the CAMP protocol in Shediac River could also explain their good performance and accuracy in identifying the different species.

SUMMERSIDE

In Summerside (PEI), ENGO volunteers and biologists agreed on species richness except at station 6, where the ENGO identified one extra species (i.e. grass shrimp) (Table 1). The total number of taxa across the stations only differed by one with 8 species identified by the biologist and 9 by the ENGO. Total abundance count (YOY + adults) agreed very well between ENGO and biologists with 96.8% agreement on average (Table 2). When looking at the developmental stages separately, ENGO and biologists only agreed at 3.2% for the YOY and at 93.9% for adults when summing across stations (Table 2). This extremely low percent agreement for YOY is the result of the biologists identifying 287 YOY sand shrimp and 23 YOY smooth flounder compared to zero for both species by the ENGO (Appendix 1).

Differences occurred once more between the *Gasterosteus* sp. because one YOY blackspotted stickleback was identified by the ENGO and one YOY threespine stickleback by the biologists (Appendix 1). The blackspotted and threespine stickleback are the same genus (*Gasterosteus* sp.) and are very difficult to distinguish in the juvenile stage. In addition, some flounders could not be identified as either smooth or winter flounder; requiring the biologists to place those very small flounders into the YOY flounder species category, which was not accounted for when counting the total number of taxonomic groups captured. Furthermore, large disagreement was found between

YOY and adult smooth flounder (Appendix 1). For the most part, the biologists placed the smooth flounder as YOY, as opposed to the ENGOs who placed the majority of those flounders as adults. Low agreement was seen for the grass shrimp with only 42.3% agreement on average between the biologists and the ENGO. Average agreement for the sand shrimp was 98.3% when summing the total abundance of sand shrimp across the stations. Good agreement was found for the fourspine stickleback (85.3%) and excellent agreement was found for mummichog (98.3%) (Table 2). Finally, even if it was the community group's first year applying CAMP in their watershed in 2007, the Bedeque Bay Environmental Management Committee from Summerside managed to have high percent agreement within the adult fish group. Their level of experience varied from 2 to 0 months which could explain their difficulty with distinguishing young-of-the-year (Table 5). Overall, the percent agreement between the ENGO and the biologist for the total abundance (YOY + adult) was comparable to other groups suggesting that CAMP is easy to apply and understood within a few months.

MURRAY RIVER

In Murray River (PEI), both groups agreed at 100% for species richness except at station 6 where the ENGO identified an extra species (winter flounder) (Table 1). The count for total abundance of fauna (YOY + adults) captured across stations was excellent between biologists and ENGO (94.4% agreement) with two out of three stations having over 90% agreement. Percent agreement in Murray River was lowest at station 3 (84.1%) which was mostly driven by the adult sand shrimp being under-estimated by the community group (data for each species per station are not shown in this report, see Appendix 1 for abundance data per species pooled across station). Zero percent agreement for YOY between the biologists and the ENGO was found in Murray River (Table 2) since biologists identified two green crab as YOY which the community group identified as adult (Appendix 1). Both groups identified the rest of the fauna as adults for 94.5% agreement across stations (Table 2).

In Murray River, good percent agreement (between 100 and 96%) was seen for total counts of blackspotted stickleback, threespine stickleback, American eel and green crab (Table 3). In the stickleback species, lower agreement was found for the fourspine and ninespine stickleback (89.2% and 86.4% respectively), but when combining the four stickleback species together, agreement was very good at 95.2%. In total, 715 stickleback fish were identified by the biologists compared to 681 by the ENGO. Percent agreement between the ENGO and the biologists for mummichog was the lowest (80.4%) of all 6 sites (Table 3). This was mostly driven by one station where the adult mummichog were overestimated 40% by volunteers (data not shown in this report, see Appendix 1 for information across station). This overestimation of mummichog by the ENGO might be explained by the volunteers releasing them into the water by mistake before biologists were able to identify them or by recording error. Low percent agreement was calculated for the Atlantic silverside (66.7%) (Table 3), but the difference in total count between the biologists and the ENGO was only 1 (Table 4). As for the cunner, the volunteers identified ten less than the biologists which gave a percent agreement of only 63%. The underestimation of cunner and over estimation of mummichog by the ENGO might demonstrate that the cunner were misidentified for mummichog (Table 4). Misidentification between the grass and sand shrimp also occurred with the community group misidentifying some sand shrimp as grass shrimp (Table 4). Similarly, volunteers misidentified some smooth flounder as winter flounder explaining why the % agreement calculated for the winter flounder in Murray River was 0% and only 60% for the smooth flounder (Table 3).

Finally, the level of experience among the summer students and the PEI CAMP coordinator ranged from 1 to 2 months (Table 5). Being relatively new at identifying the different species could explain their lower performance than some other ENGOs in identifying certain species such as mummichog (80.4% agreement with the DFO biologists), grass shrimp (44.9%), silverside (66.7), smooth flounder (60%), winter flounder (0%) and cunner (63%) (Table 3).

RIVER PHILLIP

In River Phillip (NS), biologists and ENGO volunteers agreed at 100% for species richness (Table 1). The total abundance counts (YOY + adults) when summing across stations was 96.4%. When looking at the percent agreement for each station individually, the lowest agreement took place at station 4 with 89.3% (Table 2). This 10.7% disagreement at station 4 was mostly driven by the underestimation of fourspine stickleback, ninespine stickleback, mummichog and silverside by the ENGO (Appendix 1). This lower number of animals recorded by the ENGO may be explained either by recording error or counting error or both. Overall, the community group had a good agreement with the DFO biologists for the two developmental stages when summing across stations with 92.8% agreement for YOY and 97.6% agreement for adults (Table 2). In general, over 93% agreement was found between the ENGO volunteers and biologists when counting and identifying blackspotted stickleback, threespine stickleback, mummichog, sand shrimp, silverside, winter flounder, rock crab, green crab and cunner (see Table 3). Lower percent agreement occurred for fourspine and ninespine stickleback (76.9%; 86.7%, respectively) and for the *Alosa* sp. (87.5%) (Table 3) with only a difference between the ENGO and biologists count of 6, 4 and 1 individuals, respectively (Table 4).

Finally, the two members tested for the quality control and quality assurance in River Phillip consisted of the NS CAMP coordinator who had 7 months of experience and a summer student working for the ENGO who had only two months of experience (Table 5).

PUGWASH

In Pugwash (NS), the ENGO volunteers recorded the same number of species per station as biologists, except at station 4 where biologists identified one more species than the ENGO (i.e. blackspotted stickleback) (Table 1). Overall, the total abundance of fauna (YOY + adults) captured was low in Pugwash and agreement was high (94.3%) between

ENGO and biologists when summing across the stations (Table 2). When individual stations were analyzed, the percent agreement was excellent (i.e. within 10%) at four out of five stations sampled. Station 5 had the lowest % agreement (86%) for total abundance (YOY + adults). This low percent agreement was mostly driven by the difference in the total abundance of sand shrimp (Table 4). When looking at the total abundance for each developmental stage separately, very low percent agreement occurred for YOY (39.2%) and very high for adults (98.5%) (Table 2). Table 2 shows that the ENGO underestimated the YOY at all five stations which were mostly driven by low numbers of YOY silverside and sand shrimp counted by the ENGO (Appendix 1).

When calculating the percent agreement for each species individually, the ENGO had excellent agreement with biologists (within 7% difference). For several species, biologists and the ENGO had the exact same count number producing 100% agreement for three, four and ninespine stickleback and also for green and mud crab. The lowest % agreement was calculated for blackspotted stickleback for which the biologists identified one and the ENGO zero.

Finally, during the QA/QC exercise a total of four people sampled in Pugwash which included the ENGO coordinator and summer students, as well as the NS CAMP coordinator. Their experience in applying the monthly CAMP protocol ranged from 7 to 2 months (Table 5).

OVERVIEW OF THE SIX SITES

Overall, the ENGOs recorded the same number of taxonomic groups as the biologists did, plus or minus one species (Figure 3). When differences occurred in the species richness they were usually found between species that were difficult to identify such as: winter flounder and smooth flounder; blackspotted stickleback and threespine stickleback; sand shrimp and grass shrimp, mummichog and banded killifish. The mean number of species and total abundance (YOY + adults) per beach seine haul (Figure 3) also showed that biologists and ENGOs produced very similar results. Percent agreement was considered excellent when above 90%. Over 10% disagreement for total abundance (YOY + adults) was calculated on only four out of 22 stations sampled (Table 2) and only occurred in St. Louis de Kent when doing the sum across the stations (81.7%). As discussed, this was largely due to using the dipnet technique of estimating the very abundant sand shrimp at station 1 in St. Louis de Kent. When calculating the % agreement without station 1, the value for St. Louis de Kent was comparable to the other sites (97.5%).

The community groups were asked to separate the fauna in two developmental stages (i.e. YOY and adults) by visual observation of the total fish length. The ENGOs had most difficulty distinguishing the YOYs because the percent agreement with the biologists, when summing the total abundance of YOY across the stations, was very variable and ranged from 0% to 92.8% agreement (Table 2). ENGOs with the least experience in applying the CAMP protocol in Summerside and Murray River had very low percent agreement for the YOY. However, the adults were very well identified and ENGOs agreed over 90% with the biologists at five out of six sites. In St. Louis de Kent the % agreement for adults was only 81.7% because of the high percent error at station 1 generated by the dip net method.

Table 3 shows the % agreement for each species. Eight out of 18 species identified showed over 10% disagreement in the total abundance of fauna counted across stations. Of these eight species the lowest % agreement was found for winter flounder (44.4%) which was followed by killifish (55.6%), cunner (66.7%), blackspotted stickleback (75.9%) and smooth flounder (79.3%). The other three species had close to 90% agreement and therefore were less often misidentified or incorrectly counted by the ENGOs. These species were ninespine stickleback (88.2%), sand shrimp (87.6%) and *Alosa* sp. (87.5%) (Table 3). Some species were very well identified and counted such as threespine stickleback (99.8%), mummichog (99.8%), grass shrimp (99.3%), Atlantic silverside (94.1%), fourspine stickleback (91.3%) and all three crab species. The identification and counts for the two species at risk identified by the committee on the status of endangered wildlife in Canada (COSEWIC), American eel and the striped bass, were excellent with 100% agreement between biologists and ENGOs (Table 3). These numbers also show that for the stickleback species, the blackspotted stickleback seems to be the species causing most problems for ENGOs. Killifish and mummichog were hard to distinguish for both the ENGOs and biologists. Between the two species of shrimp, the most common mistake by ENGOs seems to be sand shrimp misidentified as grass shrimp. The winter flounder was often misidentified as smooth flounder by the ENGOs. This is completely understandable as the two species are very similar and even professional biologists had difficulty distinguishing small specimens.

RESEARCH RECOMMENDATIONS

- Training and refresher sessions at the start of the sampling season should put more emphasis on identifications of species, particularly those with which volunteers in the present study found difficulty. Clarification should also be offered on the size delimitation between the YOY and adult stage for all the species captured with CAMP.
- In the years to come, possibly repeat the QA/QC exercise with different ENGOs and at a different time of year (i.e., the beginning of the sampling season in May or June). If similar results to this QA/QC are found and that the same species are misidentified, this may indicate that it’s the best estimate the community groups can produce with such turnover of students, volunteers and coordinators between months and years.
- Emphasize the importance of accurate record keeping and clearly marking the abundance for the different species identified on the datasheet. Minimizing recording error will improve the quality of the data.
- Evaluate the accuracy and precision of the dip net method to estimate large numbers of animals by counting the exact number of animal estimated after performing the dip net method. This should only be done for the sand shrimp because they are more resistant to stressful conditions (i.e. low oxygen) than other fish and crustaceans.

RECOMMENDATION FOR FUTURE AUDITS

Future QA/QC program should be done on a sub-sample rather than the entire beach seine catch. This smaller sample size will allow the biologist to evaluate the volunteer on a one on one basis as the volunteer is going through the sample. To do this, the sub-sample should be chosen by DFO biologists and should include as much species and size diversity as possible. The sub-sample should be counted, identified and recorded first by the DFO biologist. Each volunteer should be tested individually by a professional and asked to identify and count every individual in the sub-sample. This will allow DFO biologists to monitor and distinguish the identification and counting errors separately and also eliminate any recording error by the volunteers, something that could not be done in the present QA/QC program.

CONCLUSION

Percent disagreement varied among species but was usually close to 10%. This study challenges the accuracy of the dip net method. Further comparisons should be made between the estimated counts and the real counts to determine if this method should be replaced. We can also conclude that ENGOs have difficulty identifying between YOY and adult stages for many species. Most of the time, the volunteers underestimated the YOY. Confusion between growth stages (i.e YOY and adult) was usually observed in silverside, mummichog, shrimp species and flounder species. Most of the disagreement could be due to the lack of experience from the students and the volunteers gathering the data in the field because these people are often new to the program from year to year. Level of experience varied highly from one ENGO group to the other (overall ranged from 18 to 0 months). However, relatively inexperienced community groups seemed to learn quickly and did not show lower percent agreement in the total abundance (YOY + adult) (e.g. Summerside vs. Shediac River) than more experienced groups but did show very low percent agreement for the YOY stage (i.e. Summerside and Murray River). Highly experienced members seem be more comfortable in identification and also in distinguishing between the two developmental stages. The correct identification of every organism found in any community is complex and even professional biologists may have some trouble in distinguishing YOY of similar taxa. Finally, the QA/QC program proved to be an excellent exercise for CAMP and determined that the accuracy of the volunteers was acceptable. Hence, the data gathered by CAMP volunteers accurately depicts coastal fauna in these areas.

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Table 1: Total number of taxa found at each station within each site.

		Total number of taxa	
Site	**Station**	**BIOLOGISTS**	**ENGOs**
St. Louis de Kent	1	13	12
	2	11	11
	4	7	7
	6	10	11
Taxa across stations		**14**	**13**
Shediac River	1	7	7
	2	7	7
	3	6	6
	4	4	4
Taxa across stations		**8**	**8**
Summerside	3	2	2
	5	9	9
	6	7	8
Taxa across stations		**8**	**9**
Murray River	3	6	6
	5	7	7
	6	12	13
Taxa across stations		**12**	**13**
River Phillip	1	8	8
	3	8	8
	4	7	7
Taxa across stations		**12**	**12**
Pugwash	2	7	7
	3	2	2
	4	5	4
	5	3	3
	6	4	4
Taxa across stations		**9**	**8**

Table 2: Total abundance of young-of-the-year and adult fish and crustaceans counted by the biologists and the ENGOs for CAMP QA/QC program from July 10th to August 2nd 2007. Percent agreement between biologists and ENGO is calculated for each station and across the stations by dividing the smaller value by the larger value and multiplying the result by 100.

		Young-of-the-year (YOY)			Adult (A)			YOY + A
Site	**Station #**	**Biologists**	**ENGOs**	**% Agree***	**Biologists**	**ENGOs**	**% Agree**	**% Agree**
St. Louis de Kent	1	238	226	95.0	2400	1631	68.0	70.4
	2	161	210	76.7	699	650	93.0	100
	4	189	190	99.5	205	202	98.5	99.5
	6	74	100	74.0	543	473	87.1	92.9
Sum across stations		**662**	**726**	**91.2**	**3847**	**2956**	**76.8**	**81.7**
Shediac River	1	6	10	60.0	25	20	80.0	96.8
	2	24	18	75.0	35	40	87.5	98.3
	3	33	12	36.4	97	114	85.1	96.9
	4	76	31	40.8	363	407	89.2	99.8
Sum across stations		**139**	**71**	**51.1**	**520**	**581**	**89.5**	**98.9**
Summerside	3	2	0	0.0	52	58	89.7	93.1
	5	133	5	3.8	1791	1815	98.7	94.6
	6	210	6	2.9	1507	1694	89.0	99
Sum across stations		**345**	**11**	**3.2**	**3350**	**3567**	**93.9**	**96.8**
Murray River	3	0	0	-	471	396	84.1	84.1
	5	0	0	-	703	638	90.8	90.8
	6	2	0	0.0	1038	1056	98.3	98.5
Sum across stations		**2**	**0**	**0.0**	**2212**	**2090**	**94.5**	**94.4**
River Phillip	1	288	260	90.3	37	34	91.9	90.5
	3	297	287	96.6	2182	2179	99.9	99.5
	4	342	313	91.5	484	425	87.8	89.3
Sum across stations		**927**	**860**	**92.8**	**2703**	**2638**	**97.6**	**96.4**
Pugwash	2	75	42	56.0	745	759	98.2	97.7
	3	44	22	50.0	484	506	95.7	100
	4	23	1	4.3	686	658	95.9	92.9
	5	52	11	21.2	620	567	91.5	86
	6	5	2	40.0	40	47	85.1	91.8
Sum across stations		**199**	**78**	**39.2**	**2575**	**2537**	**98.5**	**94.3**

* Percent agreement = (smaller value / larger value) x100

Table 3: The percent agreement in total abundance (YOY + adults) for each species. For each site, the % agreement was calculated by summing the total abundance of each species across the stations sampled by the ENGOs and the biologists and then the smaller sum was divided by the larger sum and the result was multiplied by 100. The % agreement was then calculated across all six sites for each species. See Appendix 2 for species abbreviation.

Site	BSS	3SS	4SS	9SS	STICK	MUM	KILL	FUND	SSH	GSH	SHRIMP	SILV
St. Louis de Kent	53.3	100.0	93.1	51.4	96.7	98.4	55.6	97.6	74.3	92.5	74.7	97.9
Shediac River	-	-	66.7	100.0	75.0	98.7	-	98.7	83.3	100.0	85.7	100.0
Summerside	0.0	0.0	85.3	-	85.7	98.3	-	98.3	98.3	42.3	97.0	92.3
Murray River	100.0	99.7	89.2	86.4	95.2	80.4	-	80.4	83.3	44.9	87.6	66.7
River Phillip	100.0	93.3	76.9	86.7	86.1	97.8	-	97.8	100.0	-	100.0	93.0
Pugwash	0.0	100.0	100.0	100.0	92.9	99.5	-	99.5	92.2	-	92.2	95.5
% agreement	**75.9**	**99.8**	**91.3**	**88.2**	**95.2**	**99.8**	**55.6**	**99.7**	**87.6**	**99.3**	**87.8**	**94.1**

Site	SFL	WFL	FLOU	EEL	RCR	GCR	MCR	CRAB	SBA	CUNN	ALOSA
St. Louis de Kent	71.4	0.0	87.5	-	-	-	93.1	93.1	100.0	100.0	-
Shediac River	100.0	-	100.0	-	-	-	100.0	100.0	-	-	-
Summerside	76.0	0.0	88.0	-	-	-	95.7	95.7	-	-	-
Murray River	60.0	0.0	85.0	100.0	-	96.0	-	96.0	-	63.0	-
River Phillip	-	100.0	100.0	-	100.0	94.1	-	94.4	-	100.0	87.5
Pugwash	-	-	-	-	-	100.0	100.0	100.0	-	-	-
% agreement	**79.3**	**44.4**	**88.7**	**100.0**	**100.0**	**95.5**	**95.2**	**95.4**	**100.0**	**66.7**	**87.5**

- Absent

Table 4: Species total counts by biologists (and ENGOs in brackets) at each of six sites. Counts represent the sum (YOY + adult) of each species counted across 3-5 stations sampled at each site. See Appendix 2 for species abbreviations.

Site	BSS	3SS	4SS	9SS	STICK	MUM	KILL	FUND	SSH	GSH	SHRIMP	SILV
St. Louis de Kent	8 (15)	2 (2)	700 (652)	18 (35)	728 (704)	493 (485)	9 (5)	502 (490)	3048 (2264)	37 (40)	3085 (2304)	141 (138)
Shediac River	0 (0)	0 (0)	3 (2)	1 (1)	4 (3)	543 (536)	0 (0)	543 (536)	5 (6)	1 (1)	6 (7)	80 (80)
Summerside	0 (1)	1 (0)	34 (29)	0 (0)	35 (30)	58 (59)	0 (0)	58 (59)	3437 (3377)	78 (33)	3515 (3410)	13 (12)
Murray River	5 (5)	391 (392)	297 (265)	22(19)	715 (681)	271 (337)	0 (0)	271 (337)	1098 (915)	35 (78)	1133 (993)	3 (2)
River Phillip	8 (8)	15 (14)	26 (20)	30 (26)	79 (68)	2623 (2565)	0 (0)	2623 (2565)	1 (1)	0 (0)	1 (1)	898 (835)
Pugwash	1 (0)	8 (8)	1 (1)	4 (4)	14 (13)	733 (729)	0 (0)	733 (729)	1912 (1763)	0 (0)	1912 (1763)	112 (107)

Site	SFL	WFL	FLOU	EEL	RCR	GCR	MCR	CRAB	SBA	CUNN	ALOSA
St. Louis de Kent	5 (7)	3 (0)	8 (7)	0 (0)	0 (0)	0 (0)	27 (29)	27 (29)	2 (2)	1 (1)	0 (0)
Shediac River	8 (8)	0 (0)	8 (8)	0 (0)	0 (0)	0 (0)	10 (10)	10 (10)	0 (0)	0 (0)	0 (0)
Summerside	25 (19)	0 (3)	25 (22)	0 (0)	0 (0)	0 (0)	22 (23)	22 (23)	0 (0)	0 (0)	0 (0)
Murray River	20 (12)	0 (5)	20 (17)	1 (1)	0 (0)	24 (25)	0 (0)	24 (25)	0 (0)	27 (17)	0 (0)
River Phillip	0 (0)	1 (1)	1 (1)	0 (0)	1 (1)	16 (17)	0(0)	17 (18)	0 (0)	2 (2)	8 (7)
Pugwash	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (2)	1 (1)	3 (3)	0 (0)	0 (0)	0 (0)

Table 5: Months of experience for each sampler tested for quality control and quality assurance between July and August 2007.

Site	sampler	months of experience
St. Louis de Kent	1	18
	2	6
	3	8
	4	4
	5	0
	6	12
average monthly experience		**8**
Shediac River	1	15
	2	0
	3	1
	4	1
	5	2
average monthly experience		**4**
Summerside	1	2
	2	0
	3	2
	4	1
	5	0
	6	1
	7	0
average monthly experience		**1**
Murray River	1	1
	2	1
	3	2
	4	1
	5	1
	6	1
average monthly experience		**1**
River Phillip	1	7
	2	2
average monthly experience		**4.5**
Pugwash	1	6
	2	2
	3	2
	4	7
average monthly experience		**4.25**

Figure 2: Pictures of summer students and PEI provincial CAMP coordinator identifying and counting the fauna caught in Murray River with the beach seine and placing each species into the individual buckets**.**

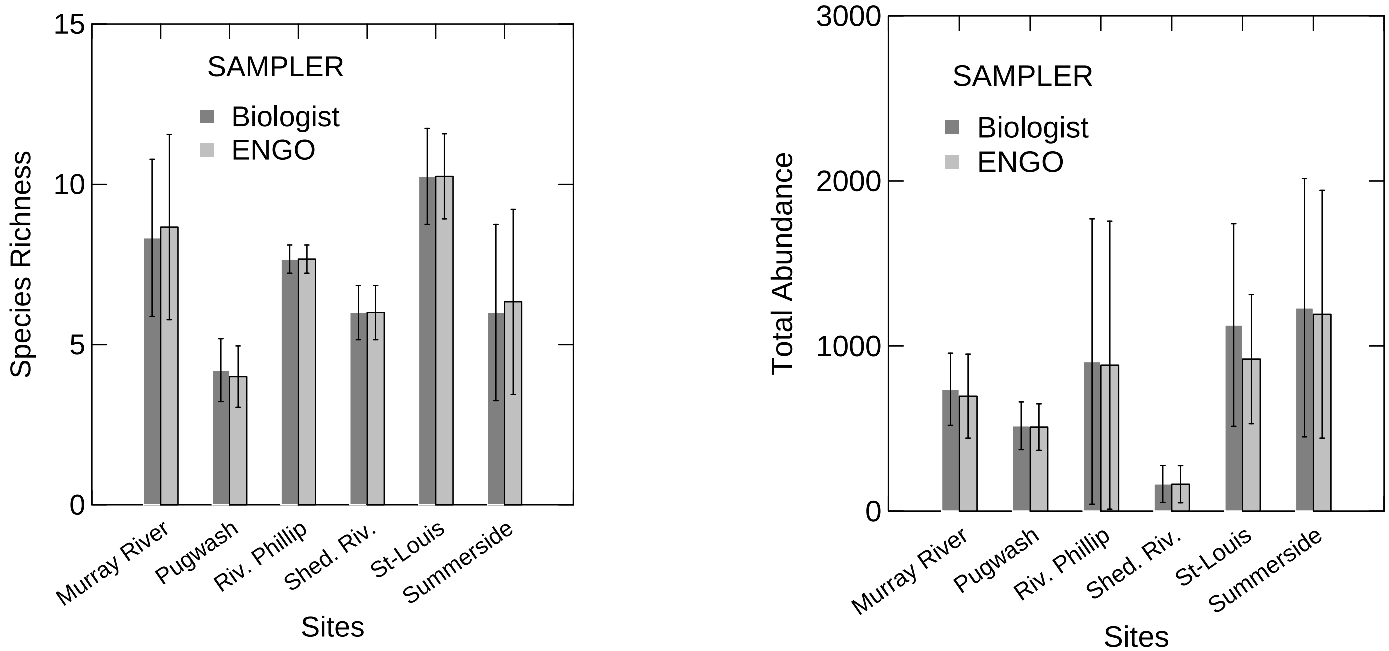

Figure 3: Mean number of species and total abundance of fauna (± SE) captured per beach seine haul by the biologists and ENGOs at six CAMP sites sampled from July 10th to August 2nd, 2007. Three to five stations were sampled at each site.

Appendix 1: Abundance of young-of-the-year and adult for each species (summed across stations) for each site. See Appendix 2 for species abbreviations.

	St-Louis		Shediac River		Summerside		Murray River		River Phillip		Pugwash	
SPECIES	BIO	ENGO	BIO	ENGO	BIO	ENGO	BIO	ENGO	BIO	ENGO	BIO	ENGO
BSS (YOY)	2	8	0	0	0	1	0	0	0	0	0	0
BSS (A)	6	7	0	0	0	0	5	5	8	8	1	0
3SS (YOY)	0	1	0	0	1	0	0	0	5	4	0	0
3SS (A)	2	1	0	0	0	0	391	392	10	10	8	8
Gasterosteus*	7	0	0	0	2	2	0	0	0	0	0	0
4SS (YOY)	153	143	0	0	0	0	0	0	0	0	0	0
4SS (A)	547	509	3	2	34	29	297	265	26	20	1	1
9SS (YOY)	5	1	0	0	0	0	0	0	0	0	0	0
9SS (A)	13	34	1	1	0	0	22	19	30	26	4	4
STICK (YOY)	160	153	0	0	1	1	0	0	5	4	0	0
STICK (A)	568	551	4	3	34	29	715	681	74	64	14	13
MUM (YOY)	184	183	84	15	0	0	0	0	29	26	6	2
MUM (A)	309	302	459	521	58	57	271	337	2594	2539	727	727
KILL (YOY)	0	0	0	0	0	0	0	0	0	0	0	0
KILL (A)	9	5	0	0	0	0	0	0	0	0	0	0
FUND (YOY)	184	183	84	15	0	0	0	0	29	26	6	2
FUND (A)	318	307	459	521	58	57	271	337	2594	2539	727	727
SSH (YOY)	163	251	0	0	287	0	0	0	0	0	90	23
SSH (A)	2885	2013	5	6	3150	3377	1098	915	1	1	1822	1740
GSH (YOY)	0	2	0	0	0	0	0	0	0	0	0	0
GSH (A)	37	38	1	1	78	33	35	78	0	0	0	0
SHRIMP (YOY)	163	253	0	0	287	0	0	0	0	0	90	23
SHRIMP (A)	2922	2051	6	7	3228	3410	1133	993	1	1	1822	1740
SILV (YOY)	138	125	51	46	9	8	0	0	883	821	103	53
SILV (A)	3	13	46	34	4	4	3	2	15	14	9	54
SFL (YOY)	4	5	2	5	23	0	0	0	0	0	0	0
SFL (A)	1	2	6	3	2	19	20	12	0	0	0	0
WFL (YOY)	0	0	0	0	0	0	0	0	1	1	0	0
WFL (A)	3	0	0	0	0	3	0	5	0	0	0	0
FLOU (YOY)	4	5	2	5	23	0	0	0	1	1	0	0
FLOU (A)	4	2	6	3	2	22	20	17	0	0	0	0
EEL (YOY)	0	0	0	0	0	0	0	0	0	0	0	0
EEL (A)	0	0	0	0	0	0	1	1	0	0	0	0
RCR (YOY)	0	0	0	0	0	0	0	0	0	0	0	0
RCR (A)	0	0	0	0	0	0	0	0	1	1	0	0
GCR (YOY)	0	0	0	0	0	0	2	0	0	0	0	0
GRC (A)	0	0	0	0	0	0	22	25	16	17	2	2
MCR (YOY)	0	0	0	0	0	0	0	0	0	0	0	0
MCR (A)	27	28	10	10	22	23	0	0	0	0	1	1
CRAB (YOY)	0	0	0	0	0	0	2	0	0	0	0	0
CRAB (A)	27	28	10	10	22	23	22	25	17	18	3	3
SBA (YOY)	2	2	0	0	0	0	0	0	0	0	0	0
SBA (A)	0	0	0	0	0	0	0	0	0	0	0	0
CUNN (YOY)	0	0	0	0	0	0	0	0	0	0	0	0
CUNN (A)	1	1	0	0	0	0	27	17	2	2	0	0
ALOSA (YOY)	0	0	0	0	0	0	0	0	8	7	0	0
ALOSA (A)	0	0	0	0	0	0	0	0	0	0	0	0

*Gasterosteus species YOY

Appendix 2: Species abbreviation, common English and French names and Latin name.

Species Abbrev.	Common Name English	Common Name French	Latin name
BSS	Blackspotted Stickleback	Épinoche tachetée	*Gasterosteus wheatlandi*
3SS	Threespine Stickleback	Épinoche 3 épines	*Gasterosteus aculeatus*
4SS	Fourspine Stickleback	Épinoche 4 épines	*Apeltes quadracus*
9SS	Ninespine Stickleback	Épinoche 9 épines	*Pungitius pungitius*
STICK*	Stickleback sp.	Épinoche sp.	
MUM	Mummichog	Choquemort	*Fundulus heteroclitus*
KIL	Banded Killifish	Fondule barrée	*Fundulus diaphanus*
FUND**	Fundulus sp.	Fondule sp.	
SSH	Sand Shrimp	Crevette de sable	*Crangon septemspinosa*
GSH	Grass Shrimp	Crevette d'herbe	*Hippolyte zostericola*
SHRIMP[&]	Shrimp sp.	Crevette sp.	
SILV	Atlantic Silverside	Capucette d'Atlantique	*Menidia menidia*
SFL	Smooth Flounder	Plie lisse	*Liopsetta putnami*
WFL	Winter Flounder	Plie rouge	*Pseudopleuronectes americanus*
FLOU[$]	Flounder sp.	Plies sp.	
EEL	American Eel	Anguille d'Amérique	*Anguilla rostrata*
RCR	Rock Crab	Crabe de roche (commun)	*Cancer irroratus*
GCR	Green Crab	Crabe vert	*Carcinus maenas*
MCR	Mud Crab	Crabe de vase	Xanthidae Family
CRAB[%]	Crab sp.	Crabe sp.	
SBA	Striped Bass	Bar rayé	*Morone saxatilis*
CUN	Cunner	Tanche-tautogue	*Tautogolabrus adspersus*
ALOSA	Blueback Herring or Alewife	Alose d’été ou Gaspereau	*Alosa sp.*

* STICK = BSS + 3SS + 4SS + 9SS
** FUND = MUM + KIL
[&] SHRIMP = SSH + GSS
[$] FLOU = SFL + WFL
[%] CRAB = RCR + GCR + MCR