Gowanus Bay and Canal Ecosystem Restoration Studies
Fish and Epibenthic Invertebrate Sampling Program

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INTRODUCTION

The United States Army Corps of Engineers (USACE) - New York District is currently conducting a feasibility study to determine the potential biological response in the Gowanus Bay and Canal as a result of proposed habitat improvements (e.g. dredging, shoreline enhancements). As part of the feasibility study, a biological survey was conducted in Gowanus Bay and Canal during 2003-2004 to inventory the resident and migratory fish and invertebrate communities. Biological data were collected during fall, winter, spring and summer from five designated reaches along the Bay and Canal to identify spatial and temporal community patterns. The following sections describe the methods used, the results, and provide a brief discussion of the summarized data collected during the sampling program.

METHODS

Sampling Locations

Gowanus Bay and Canal aquatic biological data were collected over four seasonal sampling periods from October 2003 to June 2004 (Table 1). Sampling was conducted in five designated reaches extending from Gowanus Bay to the eastern terminus of the Gowanus Canal (Table 2; Figure 1). Sample reaches were selected to provide data on the aquatic community over the entire spatial extent of the Gowanus Bay and Canal (hereafter "Gowanus").

Within each reach, specific sampling locations were selected to correspond with sediment sample locations used by the USACE - Baltimore District, during summer 2003. At the USACE's "fixed" locations, data were collected on finfish (Reaches 1, 2, and 3), crab and benthic invertebrate communities, and water quality parameters. Ichthyoplankton (i.e. fish eggs and larvae) throughout the Gowanus and finfish in Reaches 4 and 5 were sampled with active gears that were towed for a distance and not fixed to one location. Descriptions of sampling gears and protocols are provided below.

Ichthyoplankton Sampling

Ichthyoplankton samples were collected using a 0.5-m diameter, 500-µ mesh conical plankton net with a 500-µ screened codend bucket (Table 3). A GO Model 2030R mechanical flowmeter was fitted within the mouth of the net to measure the volume of water filtered. A depressor was attached to the bridle connection ahead of the net so that the gear would sample at mid-depth.

Ichthyoplankton tows were conducted for 8-10 minutes (depending on obstacles and length of sample reach) at a tow speed of approximately 90 cm/sec over the bottom Each sample was washed from the plankton net into containers and preserved with 5% buffered formalin containing the vital stain rose bengal. Samples were returned to the laboratory for sorting and identification.

Eggs and larvae were sorted from each sample - if more than 400 fish larvae or 400 fish eggs were present in a sample, then the sample was split using a Motoda plankton splitter. In the event that a sample was split multiple times, the sample fraction selected for analysis was randomly selected. All specimens in the analyzed sample or fraction were identified to the lowest taxonomic level practicable, assigned a life stage based on morphometric characteristics (egg, yolk-sack larvae, post yolk-sac larvae, or juvenile) and enumerated (Table 4). Unidentified species were recorded when eggs or larvae could not be identified to species. For some larvae, it was not possible to discern between yolk-sac and post yolk-sac life stages because specimens were damaged. Indiscernible larval life stages were combined with the post yolk-sac larvae life stage in this analysis.

Strict quality control (QC) procedures consisting of a continuous sampling plan (CSP) to assure an average outgoing quality limit (AOQL) of = 90% were followed during sample sorting, enumeration, life-stage designation and identification.

Adult Fish Sampling (Trawls and Trap-nets)

An inventory of the adult finfish community of the Gowanus Bay and Canal was conducted using two different gear types because the areas sampled have significantly

different physical and hydrodynamic conditions that influence the effectiveness of the gear. In the Gowanus Bay reaches (Reaches 4 and 5), 16-ft semi-balloon otter trawl (Table 3) tows were conducted during each sampling event (Figure 1). Trawls were towed for 5-6 minutes at 150 cm/sec over the bottom against the direction of the tide. A towline to water depth ratio of 10:1 was used to ensure that the trawl maintained contact with the bottom.

Trap nets were set in the Gowanus Canal reaches (Reaches 1, 2 and 3) for approximately 24 hours (i.e. 22-25 hrs.) during each sampling event. Trap nets, which are a passive gear, were set perpendicular to the bulkhead or shoreline (Figure 1; Table 3). The trap net set locations in each reach corresponded with USACE sediment sampling stations – USACE Station 29 in Reach 1, USACE Station 21 in Reach 2 and USACE Station 14 in Reach 3.

All fish collected in the trawls and trap nets were identified and enumerated directly on the research vessel. Total length was measured for a minimum of 25 individuals of each species in each trawl sample. An unbiased selection of 25 specimens was made for each species when the number of fish collected exceeded 25.

Invertebrate Sampling

The crab community in the Gowanus was sampled using baited traps (Table 3) set in the five sample reaches. The specific trap net set locations in each reach corresponded with USACE Sediment Sampling Stations – USACE Station 30 in Reach 1, USACE Station 22 in Reach 2, USACE Station 18 in Reach 3, USACE Station 9 in Reach 4 and USACE Station 3 in Reach 5 (Figure 1). Crab traps were set for approximately 24 hours (i.e. 22-25 hrs.) during each sampling event.

A seasonal inventory of the macroinvertebrate community that colonizes hard substrates in the Gowanus Complex was conducted using Hester-Dendy style samplers. Three sampler assemblies were set within each of the five reaches. The Hester-Dendy samplers

were set adjacent to the crab pots and thus corresponded with the same USACE Sediment Sampling Stations.

Each Hester-Dendy sampler consisted of nine 3 x 3-in settling plates separated by two, three or five 1- inch diameter spacers. Samplers were suspended from the shoreline or a bulkhead below the low tide mark. On the first survey (October) three samplers were placed at each of the five fixed stations. On each subsequent survey (December, March and June) one sampler from each station was retrieved, placed on ice, and returned to the laboratory for analysis.

In the laboratory each Hester-Dendy sampler was immediately taken apart and the group of plates were placed in 10% formalin rose bengal solution. Each sample plate was scraped clean and only whole organisms or parts with heads attached were counted, but all identifiable fragments were saved. Organisms were identified to the lowest taxonomic level practicable. Samples containing excessive sand and detritus or organisms in significant numbers (>100), were split using a Caton Macroinvertebrate Subsampler. Organisms such as calanoid copepods – which cannot be quantitatively sampled with the settlement plates – were not counted, but their presence was noted.

Strict quality control (QC) procedures consisting of a continuous sampling plan (CSP) to assure an average outgoing quality limit (AOQL) of =90% were followed during sample sorting, enumeration and identification.

Water Quality

Water chemistry measurements (temperature, dissolved oxygen, conductivity, salinity and pH) were collected from single fixed stations within each of the five sampling reaches (Figure 1). These fixed collection points corresponded with USACE Sediment Sampling Stations – USACE Station 30 in Reach 1, USACE Station 22 in Reach 2, USACE Station 18 in Reach 3, USACE Station 9 in Reach 4 and USACE Station 1 in Reach 5. Additional water quality measurements were taken when trap nets, crab pots

and Hester-Dendy samplers were retrieved and during ichthyoplankton and bottom trawl tows. The data from the five fixed stations were used in the water quality analysis.

The YSI Model 85 Handheld Oxygen, Conductivity, Salinity and Temperature Meter and a pH Testr2 pen were used to collect in situ water quality data. The meters were checked prior to each sampling day against standards and calibrated to maintain a check of instrument performance and data quality. When the YSI Model 85 could not be used, water quality measurements were taken with a YSI Model 550 Handheld Oxygen and Temperature System and a YSI Model 30 Handheld Salinity, Conductivity and Temperature System.

Water chemistry measurements were taken at multiple depths depending on the depth at each specific sampling location. In areas with depths up to 5 ft only, mid-depth measurements were taken; when depths ranged from 6 ft to 10 ft, surface and 0.5-m above the bottom measurements were taken; at depths >10 ft, measurements were taken at the surface, mid depth and 0.5-m above the bottom.

Data Analysis

Ichthyoplankton densities (Number per 1000 cubic meters [1000 m^3]) were determined for each epibenthic sled tow. The volume of water sampled was determined using the area of the net mouth and the velocity meter revolutions.

Catch per unit effort (CPUE) was calculated for the trawl data (i.e. adult fish) and crab trap data. Trawl CPUE - defined as number per 5-min trawl tow - was determined for each tow based on the time each net sampled on the bottom. When tow times were less or more than 5 min, catch data were multiplied by the appropriate factor to standardize for a 5-min tow. Trap net and crab trap CPUE were similarly defined as the number per 24-hr set. When set times were less or more than 24 hrs, catch data were multiplied by the appropriate factor to standardize the CPUE.

Densities (number of organisms/m2) were determined for the organisms collected on each Hester - Dendy sampler.

Results

Ichthyoplankton, adult finfish, crab and benthic invertebrate data were analyzed together for the entire Gowanus Bay and Canal and independently across the five sample reaches. Results are typically presented by month. Note that during the March sampling period, sampling was conducted on 31 March and on 1 April – thus data presented as March or April are from the same period. Following is a summary of results, detailed station data are provided in Appendices A-C.

Note that the following data-unit definitions apply in the figures accompanying the main report text and Appendices:

- Ichthyoplankton tows: Ichthyoplankton density (number per 1000 m^3).
- Trap net sets: Catch per unit effort (CPUE), defined as number caught per 24-hour set period.
- Trawl CPUE: defined as number caught per 5-minute trawl tow.
- Crab pot CPUE: defined as number caught per 24-hour set period.
- Hester-Dendy sampler CPUE: defined as number per m^2.

Ichthyoplankton Results

A total of 20 ichthyoplankton samples were collected during the sampling program. Twelve species were identified, with eggs (five spp.) the most abundant lifestage collected (68%), followed by post yolk-sac larvae (Appendix A).

Few eggs were collected during the October through March sampling periods. During June, eggs were collected within every reach with the greatest densities in the two Gowanus Bay reaches (Figure 2). Five species were collected as eggs - the dominant species (>80%) was bay anchovy (*Anchoa mitchilli*) followed by Atlantic menhaden (*Brevoortia tyrannus*), Labridae spp., windowpane flounder (*Scophthalmus aquosus*) and Gadidae spp. (Figure 3 to Figure 7).

Yolk-sac larvae were collected at low densities in the Gowanus Canal and Bay during the sampling program - representing <1% of the overall ichthyoplankton density. Other Harbor sampling programs provide similar results, collecting yolk-sac larvae in the lowest densities of all early lifestages (USACE 2002). Yolk-sac larvae were collected during every sampling period except December, but yolk-sac larvae were not collected in every reach - none were collected in Reach 1 (Figure 8). Yolk-sac larvae of five species were collected during the sampling program (Figures 9 to Figure 13). Even though all of the species were collected in very low densities, bay anchovy made up half (50%) of the yolk-sac larvae catch. The greatest species diversity (n=3) was collected during June in Reach 4.

Post yolk-sac larvae were collected throughout the sample reaches with the greatest densities in Reach 1 and Reach 5 (Figure 14). Post yolk-sac larvae were collected during each sampling event in Reaches 4 and 5. Post yolk-sac larvae was the most diverse early lifestage collected (n=12) with the greatest number of taxa occurring during June in Reaches 4 and 5 (Figures 15 to Figure19). Winter flounder (*Pseudopleuronectes americanus*) post yolk-sac larvae were collected in relatively high densities throughout the Canal during March. The greatest density of winter flounder was collected in Reach 1. Bay anchovy was the most common species collected during June as post yolk-sac larvae.

Adult Fish Results (Trawls and Trap-nets)

A total of 11 trap nets and 8 bottom trawls were set or towed during the four survey periods. During the last survey period (June 2-3) access to Reach 1 was restricted because a barge broke free and was blocking the Canal – as a result a trap net was not set in the area during that event. Recall that trap nets were set in Reaches 1-3 and trawls were conducted in Reaches 4-5. Because two different sampling gears were used to target adult fish, direct quantitative comparisons of the CPUE data could not be made; however, these data provide good qualitative information on the adult fish community in Gowanus Bay and Canal.

In general, few fish were collected during the adult fish surveys even though fish were collected during every sampling period and were collected in every reach (Figure 20). Trap net CPUE was relatively high in Reach 1 during October 2003 – the only month that fish were collected in this reach – and was dominated by striped bass (*Morone saxatilis*) (Figure 21). White perch (*Morone americana*) and Atlantic silversides (*Menidia menidia*) combined made up a small percentage (5%) of the October catch in Reach 1. In Reaches 2-3, fewer fish were collected - striped bass, cunner (*Tautogolabrus adspersus*) and American eel (*Anguilla rostrata*) (Figure 22 and Figure 23). Species richness values in Reaches 4 and 5 (i.e. Gowanus Bay) were greater than the Canal reaches (Figure 24 and Figure 25) because of the presence of Atlantic tomcod (*Microgadus tomcod*), winter flounder, bay anchovy, spotted hake (*Urophycis regia*), striped bass and white perch. A relatively high CPUE (46 fish / 5-min tow) of juvenile Atlantic tomcod dominated (76%) the June survey in Reach 5. Blue crabs were present in the Gowanus Bay reaches during every sampling period.

Invertebrate Results

At the start of this project a total of 15 Hester Dendy samplers were deployed - a total of ten Hester-Dendy samplers were retrieved. Two samplers were lost at stations 4 and 5 from Gowanus Bay during Survey 2. These samplers were lost probably due to heavy tug boat activity or twisting in the currents. For the third survey a sampler was lost at station 4. This sampler was lost due to fraying of the line. Samplers from stations 1 and 5 were not retrieved for survey 4. The sampler at station 5 twisted off the line due to high currents. The sampler at station 1 was lost due to fraying of the line.

There was considerable variability recorded in the abundance of organisms colonizing the Hester - Dendy samplers among reaches (Table 5 through Table 7). The highest densities occurred in June after seven months of exposure. A total of 29 taxa were measured on settlement plates. Overall, tube dwelling amphipods and polychaetes were the dominant organisms to colonize the settlement plates in all five reaches. Mussels and barnacles were more abundant on settlement plates in Reaches 4 and 5 (i.e. Gowanus Bay).

Settlement plates in Gowanus Canal and Bay exhibited a successive pattern in colonization. The plates retrieved in December had relatively few settled organisms compared to those collected in other months. Amphipods and polychaetes were the most common colonizers. In March, following four months in the Canal and Bay, epifaunal colonization on test plates was different to that of December. There was an increase in diversity and abundance of amphipods and polychaetes. Mussels, barnacles and bryozoans were also present. In June, settlement surfaces were heavily colonized with tube dwelling and fouling amphipods. Blue mussels, isopods and barnacles were also abundant on several plates retrieved in June, polychaetes were less common.

A total of 18 crab pots were retrieved during the sampling program. Two crab pots were lost in Reach 5 - one during Survey 1 and the other during Survey 4 - due to tugboat traffic and the currents. During Survey 4, the crab pot in Reach 1 was not set at USACE 30 because there was a barge blocking the Canal - the pot was set outside the debris boom near USACE station 29.

Because the crab pots were baited, they caught a mix of crabs and fish (Appendix C). The Pacific shore crab (*Hemigrapsus sanguineus*) was the most abundant crab species collected in the Gowanus. Only one green crab (*Carcinus maenas*) was collected during the sampling program at Reach 5 in Gowanus Bay. Reach 1 at the head of the canal had the greatest CPUE (Figure 26) and species richness (Figure 27 through Figure 31) of all the reaches. No crabs were collected in Reaches 2 and 3 - crabs were only collected in Reaches 1, 4 and 5. Crabs were not caught during the fall and spring surveys.

Water Quality

Surface water temperatures ranged from a low near 4°C in December to a high of 22°C during June. Bottom temperatures were similar to surface temperatures across reaches (Figures 32-33) – likely related to the relatively shallow depth.

Salinity ranged between 10 ppt and 22 ppt over the course of the program. Salinities were similar between the surface and near bottom except in the Gowanus Bay reaches

(Reach 4 and Reach 5) where salinities were substantially higher near bottom than at the surface during December and March sampling dates.

DISCUSSION

Estuaries are typically productive ecological systems that have extensive vegetated shorelines, tidal wetlands and tidal creeks. Physical modifications associated with coastal development and urbanization often result in the loss of marginal wetland and shallow water habitats within estuaries. Impacted areas are generally characterized by lower species diversity, altered community composition and reduced habitat diversity (Dauer et al 2000). The New York/New Jersey Harbor (Harbor) is an example of an estuarine system that is impacted by urbanization. Despite extensive changes and urbanization the Harbor is a productive estuary supporting diverse communities of fish and invertebrates (Woodhead et al. 1999).

The Gowanus Canal has undergone extensive urbanization that has resulted in habitat loss and reduced water quality (Hazen and Sawyer 2001). As part of the urbanization, a combined sewer system was constructed with several outfalls discharging into the Gowanus. This urbanization has affected the aquatic community in the Canal, especially for organisms that have limited mobility (i.e. benthic invertebrates). Regardless, the Canal is used by multiple trophic levels of organisms that are common in the Harbor.

Over the years organic matter has accumulated and has contributed to low dissolved oxygen (DO) concentrations in the Canal (Hazen and Sawyer 2001). To improve water quality the Gowanus Flushing Tunnel, a system designed to pump water from the Buttermilk Channel to the head of the Canal, was re-activated in 1999. The input of "new" water has resulted in increased DO concentrations in the Canal.

Dissolved oxygen concentration in water is largely dependent on water temperature, and to a lesser degree, salinity. As water temperature increases, the amount of oxygen capable of being held in solution decreases. Similarly, as salinity increases, the amount

of oxygen that can be held in solution decreases. Trends in dissolved oxygen levels were similar across reaches, remaining between 4 mg/L and 10 mg/l. As a reference, dissolved oxygen in New York Harbor typically ranges between 6 mg/L and 12 mg/L during the same period.

Fish Community

The fish species composition in the Gowanus was dominated by migratory species that are common in the New York / New Jersey Harbor and Mid Atlantic estuaries. Few resident species (e.g. cunner and tautog) were collected as adults or early lifestage, indicating the Gowanus may not have the habitat necessary to support a resident fish community. The occurrence of migratory species in the Gowanus corresponds with periods of peak abundance for many of these species in the Harbor (USACE 2003). Striped bass – the most common species collected during the adult fish survey - was caught in every reach but only during the October and December surveys. Striped bass are one of the dominant species collected during adult fish surveys conducted in the Harbor during the colder water months (USACE 2003).

Urbanization in the Canal has limited the physical habitat and poor water quality (e.g. low dissolved oxygen, high temperatures) could present an abiotic barrier to the establishment of a resident fish community. Although dissolved oxygen levels are typically high in estuaries, dissolved oxygen levels are often reduced in areas with high inputs of organic material (Moyle and Cech 1988). In the Gowanus Canal, dissolved oxygen concentrations have been observed below 3.0 mg/l (the NYSDEC dissolved oxygen standard) during August – thought to result from increased water temperature and oxygen demand in the Canal (Hazen and Sawyer 2001). Extended periods of reduced dissolved oxygen can be lethal for some species while others will migrate from areas during periods of low dissolved oxygen (Moyle and Cech 1988).

The results of the ichthyoplankton sampling did not support that significant fish spawning occurs in Gowanus Canal, but some spawning likely occurs in Gowanus Bay. The few eggs that were collected in the Canal – especially in reach 1 – were dominated by pelagic

species. Because pelagic species spawn eggs that can drift, these results suggest that ichthyoplankton may be drawn into the Gowanus Canal from Buttermilk Channel through the Gowanus Flushing Tunnel or drift in from Gowanus Bay via the incoming tide.

Winter flounder is an important recreational and commercial species that is common as adults and early lifestages throughout the Harbor – other projects have collected winter flounder eggs in areas adjacent to Gowanus Bay (USACE 2003). No winter flounder eggs were collected in Gowanus Bay or Canal, but winter flounder have demersal, adhesive eggs that are believed to be hatched in close proximity to where they were spawned – thus the mid-water ichthyoplankton sampling conducted during the sampling program would not be expected to collect demersal eggs. Winter flounder were collected as post yolk-sac larvae at the extreme end of the Canal (Reach 1). Because winter flounder larvae have limited swimming ability – mostly relying on tidal currents for movement (Able and Fahay 1998) - it is not clear if spawning occurred in the Canal or if hydrodynamics of the Canal are such that winter flounder ichthyoplankton were transported in from the Bay or via the Gowanus Flushing Tunnel. If winter flounder spawning occurs throughout the canal, winter flounder larvae would be expected to be present in every sampling reach. The relatively high winter flounder larval densities in Reach 1 at the eastern terminus of the Canal during March compared to the other reaches suggest that spawning likely didn't occur in the Canal and that ichthyoplankton are probably transported into the Canal.

Invertebrate Community

The invertebrate species collected in the Gowanus are common throughout the New York / New Jersey Harbor. The species collected are primarily organisms that colonize hard substrates. Species abundance was low compared to a typical epibenthic community in the open waters of the New York / New Jersey Harbor (USACE 1999, Woodhead et al 1999). The community was dominated by opportunistic species that are common in disturbed habitats and are considered pollution tolerant. Opportunistic species are

typically found in areas with poor environmental conditions because they are able to colonize an area rapidly after an area is disturbed.

Benthic and epibenthic invertebrates living in the Gowanus are influenced by water flow at all stages in their life cycle. The hydrodynamic processes can influence community composition and density and the feeding mode of invertebrates (Eckman1983). The New York / New Jersey Harbor is thought to act as a source population for the invertebrate community in the Gowanus Canal because of the hydrodynamic connection with the Gowanus Canal through the Gowanus Flushing Tunnel and tidal exchange (Hazen and Sawyer 2001). Growth and feeding efficiency of suspension feeders is also related to local hydrodynamic conditions. Flow rates through an area affect the amount of seston, particulate matter such as plankton, organic detritus and inorganic particles that passes an organism, as well as the time the suspension feeder has to intercept the food (Muschenheim 1987). In turn the quantity and quality of seston influences the rate of growth for suspension feeders.

Polychaetes and amphipods dominated the benthic community and were collected at all sampling sites. Polychaetes are commonly used as bioindicators because they are in direct contact with the sediment and exhibit sensitivity to anthropogenic compounds. *Capitella spp*., and *Streblospio benedicti* have been identified as environmental indicator species because they are often found in sediments associated with high organic matter, petroleum, sewage and low oxygen levels. *Streblospio benedicti* are commonly found in silty sediments and are the most abundant and ubiquitous invertebrate species throughout the Harbor. *Streblospio benedicti* are also an important food source for winter flounder and spot. *Capitella spp*. are often one of the first groups to colonize areas impacted by dredging or oil spill (Llanso 1991, NOAA 2003). The presence of *Eumida sanquinea* on the settling plates was also expected because it is an epibenthic predator that is common in the Harbor (Pettibone 1983).

Amphipods were present in all five sampling reaches. The species collected (i.e. *Leptocheirus pinguis, Unciola sp., Corophium sp*. and *Gammarus spp*.) are all

opportunistic, feeding on detritus and are found in muddy and sandy substrates. The absence of the amphipod *Ampelesca abdita*, a common New York/New Jersey Harbor species indicates that the area is degraded, because this species is susceptible to pollution, has limited mobility, and are typically not found in highly polluted sediments (NOAA 2003). Amphipod densities and diversity varied with the seasons and between the Canal and Bay. Amphipod densities were low in the Gowanus Canal during the winter and spring, while during the same period no amphipods settled on plates in Gowanus Bay. During the summer, amphipod abundances increased in both the Canal and Bay. In the winter there were only three taxa of amphipods present in the Gowanus compared to eight taxa collected during the spring.

The most abundant crab species collected in the Gowanus was the nonnative Pacific shore crab (*Hemigrapsus sanguineus*). The Pacific shore crab is successful in the Canal because it is an opportunistic omnivore that inhabits shallow hard-bottom intertidal habitats or sometimes subtidal habitat. This species can tolerate wide ranges of salinity and temperature. Pacific shore crabs exhibit high fecundity with a breeding season that extends from May to September (twice the length of native crabs) and a larval stage that is suspended in the water for approximately one month. This period of suspension allows Pacific shore crab larvae to travel great distances to seek out new habitats (McDermott 1998). Pacific shore crabs also use of the same food source as many native species. These attributes make Pacific shore crabs a potential competitor of mud crabs in the Gowanus and potentially a competitor of other larger species (e.g. blue crabs, rock crabs, lobsters, and the nonnative green crabs) in the Harbor. Recent trends show numbers of the Pacific shore crab are steadily increasing while native crab populations are declining (USGS 2002).

Few green crabs were collected during the sampling program. Green crabs are found in a variety of habitats, including protected rocky shores, cobble beaches, sandflats, and tidal marshes. They can also tolerate wide ranges of salinities (4-54 ppt) and temperatures (0-33 °C). The feeding activity of the green crab can greatly impact populations of mussels

(*Mytilus* spp.), dogwhelks (*Nucella lapillus*), and quahogs (*Mercenaria mercenaria*) (Hughes and Hughes 1984).

Dissolved oxygen (DO) is an important factor in the development of an invertebrate community. In Gowanus Canal, the dissolved oxygen during this program ranged seasonally from 8.7 mg/l in December to 4.8 mg/l in June and as stated above have been observed below 3.0 mg/l in August (Hazen and Sawyer 2001). Extended periods of decreased dissolved oxygen levels can limit species diversity in an invertebrate community. Sediment type and life cycle characteristics are other factors that likely influence species diversity and the number of organisms observed in Gowanus Canal.

It is important to note that invertebrate densities on settlement plates can be skewed, because developing epibenthic communities usually have higher abundances of organisms than normally measured on well developed epibenthic communities. In mature epibenthic communities organisms such as mussels, sponges, hydroids and barnacles tend to grow larger and exclude smaller individuals. Amphipods and polychaetes are still present but in lower numbers. These organisms develop micro communities in interstitial spaces, in the byssal threads of mussels and the holdfasts of hydroids. Predation also plays a role in the abundance and diversity of epibenthic communities – for example, juvenile cunner were collected within the settlement plates when they were retrieved.

The epibenthic community living in Gowanus is an impoverished community, particularly in the Canal. Overall, the epibenthic community is low in complexity and diversity when compared to established epibenthic communities inhabiting hard surfaces in the East River (EEA 1989). During the East River Landing studies (1986-87), settlement plates were used to measure the colonization of epibenthic organisms off of South Manhattan and North Brooklyn piers. The colonization plates were retrieved over one year, for measurement of the extent of attachment and growth of epifauna. The highest densities occurred in August, after a full year of exposure; mean densities were about 82,000 organisms per m^2. A total of 40 taxa were reported although an average

number of 14 species were measured per plate. Test surfaces were dominated by the amphipods (*Microdeutopus gryllotalpa*, *Jassa sp*., and *Corophium* sp.) and polychaetes (*Polydora sp*.) (EEA 1989).

Gowanus Canal has undergone many transformations and epibenthic and benthic communities do not resemble a typical natural tidal creek, however, the Canal is home to developing epibenthic and benthic communities. The majority of invertebrate species found living in the Canal are tolerant of extreme fluctuations in dissolved oxygen, salinity and temperature. Many of the species present are opportunistic, but their occurrence was in relatively lower abundances than are typically found in environmentally degraded sites. If environmental conditions continue to improve in the Canal, these opportunistic species may be replaced by other less pollution tolerant species (Hazen and Sawyer 2001).

Recommendations

The scope of this current sampling program did not provide for late summer (e.g. July and August) sampling, therefore, a relationship among the late summer fish populations, benthic community and water quality could not be observed. These results suggest that additional sampling during the summer months will help identify how the fish community reacts to extreme water quality conditions (i.e. high temperatures and low dissolved oxygen) in the Canal.

The impact of the pumping mechanism on the potential entrainment of early lifestages or displacing fish and drifting benthic invertebrates to potentially less desirable habitat from the Buttermilk Channel should be considered in future sampling. Future effort should consider the Buttermilk Channel as a potential source population for the Canal, thus sampling locations should be added in the Buttermilk Channel. In addition, ichthyoplankton data should also be analyzed in conjunction with the hydrodynamic data from the Canal to help identify if the Buttermilk Channel and/or the Gowanus Bay are acting as a source population for Gowanus Canal ichthyoplankton.

The following bullets outline future sampling efforts that should be conducted in the Gowanus Canal and Bay to further assess the impact that habitat improvements will have on the aquatic community and to establish a baseline for conducting a successful restoration/reclamation program in the Gowanus.

- Continue early lifestages and adult fish sampling at selected locations.
- Add a sampling location at the head of the intake pipe in Buttermilk Channel
- Increase sampling frequency – especially in the summer months when water quality conditions could become limiting. Potentially sample on a stratified schedule to target those "critical periods" – (Example – sample twice a month from January to May and October to December – sample once a week from June to September)
- Collected long term WQ data at sampling stations (unless significant data exist from different sources) using remote monitors (e.g. hobo).
- Collect epi-benthic invertebrates at each station using a petite ponar.
- Continue and expand the duration of the Hester-Dendy sampling program. Potentially collect data at additional sites outside of the main canal (e.g. backwater areas).
- Model spatial temporal changes biological data and water quality data with hydrodynamic conditions.

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Table 1. Quarterly sample dates for the aquatic resource sampling component of the Gowanus Bay and Canal Ecosystem Restoration Studies, October 2003 to June 2004.

Event	Sampling Dates
1	October 22-23
2	December 16-17
3	March 31 - April 1
4	June 2-3

Table 2. Sample reaches within Gowanus Bay and Canal that were sampled from October 2003 to June 2004 as part for Gowanus Bay and Canal Ecosystem Restoration Studies.

Reach	Description
1	Carroll Street Bridge to east end of the Gowanus Canal
2	Mid point between Ninth and Third Street Bridge to Carroll Street Bridge
3	Hamilton Ave. Bridge to the mid point between Ninth and Third Street Bridge
4	20th Street (east end of Gowanus Bay) to Hamilton Ave. Bridge
5	Gowanus Bay

Table 3. Specifications of bottom trawl and trap nets used to collect adult finfish during October 2003 to June 2004 as part for Gowanus Bay and Canal Ecosystem Restoration Studies.

Ichthyoplankton Net Specifications	
Net type	0.5-m diameter conical plankton net
Net Mesh A	500μ mesh
Flow Meter Type	GO Model 2030R
Trawl Specifications	
Headrope	17 ft. (5.2 m)
Footrope	21 ft (6.4 m)
Body mesh (bar)	0.75-in (1.9 cm)
Cod end mesh (bar)	0.63-in (1.6 cm)
Cod end liner mesh (square)	0.25-in (0.64 cm)
Trawl doors	24 in x 12 in (61 cm x 30 cm)
Trap Net Specification	
Box frame	3 ft x 6 ft (1 m x 2 m)
Net length	20 ft (6.1 m)
Lead line	40 ft (12 m)
Net mesh	0.25 in (0.64 cm)
Crab Trap Specifications	
Trap frame	24 in x 24 in x 12 in (61 cm x 61 cm x 30 cm)
Mesh	0.25 in (0.64)

Table 4. Lifestage description of the fish collected within ichthyoplankton samples in Gowanus Bay and Canal that were sampled from October 2003 to June 2004 as part for Gowanus Bay and Canal Ecosystem Restoration Studies.

LIFE STAGE	DESCRIPTION
Egg	Embryonic stage from spawning to hatching
Yolk-sac larvae	From hatching to development of a complete and functional digestive system
Post yolk-sac larvae	From development of a complete digestive system to transformation to juvenile form (complete fin ray count)

Table 5. Species composition and density of benthic invertebrates collected on Hester-Dendy Settlement Plates set for 55 days (October 2003 to December 2003) in the 5 reaches of the Gowanus Bay and Canal.

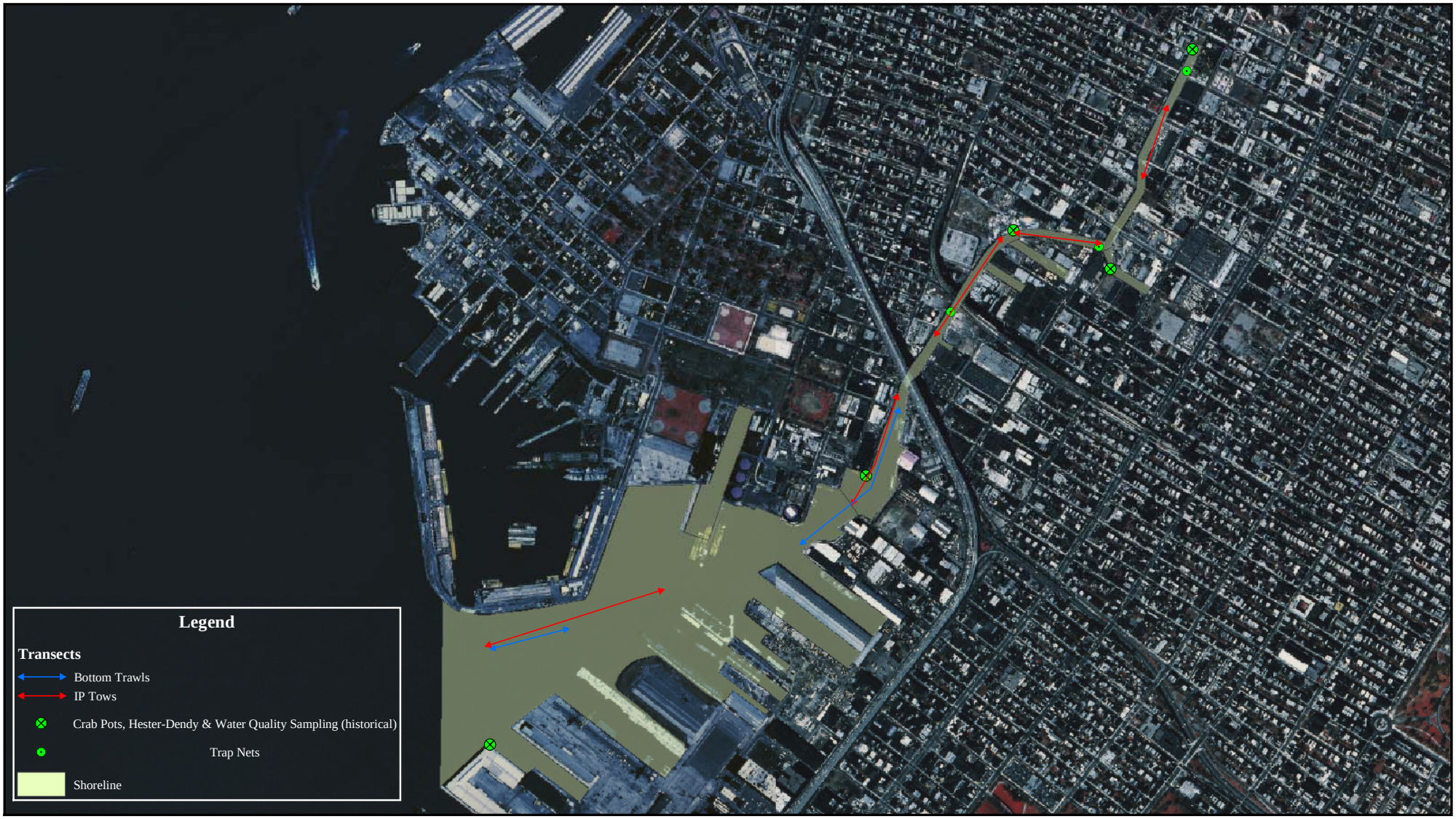
Phylum	Class	Order	Family	Scientific Name	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5
Annelida	Polychaeta				530	0	0	0	0
		Capitellida	Capitellidae		0	0	0	0	0
				Capitella sp.	50	100	50	0	0
		Phyllodocida	Nereidae		0	0	0	0	0
				Nereis sp.	10	0	0	0	0
			Phyllodocidae	*Eumida Sanguinea*	10	0	0	0	0
		Sabellida	Sabellidae		0	0	0	0	0
				Fabricia Sabella	0	0	0	0	0
		Spionida	Paraonidae		0	0	0	0	0
			Spionidae	*Polydora ligni*	120	0	20	0	0
				Streblospio benedicti	0	0	0	0	0
Arthropoda	Crustacea	Amphipoda	Ampithoidae		0	0	0	0	0
			Aoridae		0	0	0	0	0
				Leptocheirus pinguis	380	0	4320	0	0
				Unciola sp.	0	0	0	0	0
			Corophiidae		0	0	0	0	0
				Corophium sp.	220	110	0	0	0
			Gammaridae	*Gammarus sp.*	170	30	0	0	0
			Ischyroceridae	*Jassa falcata*	0	0	0	0	0
			Melitidae		0	0	0	0	0
				Melita netida	0	0	0	0	0
		Decapoda	Xanthidae	*Dyspanopeus sayi*	0	0	0	0	0
		Isopoda	Cirolanidae	*Politlana polita*	0	30	0	0	0
			Limnoriidae	*Limnoria lignorum*	0	0	0	0	0
			Sphaeromatidae	*Sphaeroma sp.*	0	0	0	0	0
		Thoracica	Balanidae	*Semibalanus balanoides*	20	0	0	0	0
Bryzoa					0	0	0	0	0
Mollusca	Bivalvia	Mytioida	Mytilidae	*Mytilus edulis*	0	0	0	0	0
Nematoda					20	40	10	0	0
Platyhelminthes					40	0	40	0	0

Table 6. Species composition and density of benthic invertebrates collected on Hester-Dendy Settlement Plates set for 161 days (October 2003 to March 2004) in five reaches of the Gowanus Bay and Canal.

Phylum	Class	Order	Family	Scientific Name	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5
Annelida	Polychaeta				0	0	0	0	0
		Capitellida	Capitellidae		60	0	0	0	0
				Capitella sp.	0	0	0	0	0
		Phyllodocida	Nereidae		0	0	0	0	40
				Nereis sp.	50	0	0	0	0
			Phyllodocidae	*Eumida Sanguinea*	0	0	0	0	0
		Sabellida	Sabellidae		50	0	0	0	0
				Fabricia Sabella	420	0	90	0	0
			Paraonidae		210	0	90	0	0
			Spionidae	*Polydora ligni*	60	0	0	0	410
				Streblospio benedicti	30	0	0	0	0
Arthropoda	Crustacea	Amphipoda	Ampithoidae		0	0	0	0	0
			Aoridae		0	0	0	0	0
				Leptocheirus pinguis	140	0	0	0	0
			Aoridae	*Unciola sp.*	0	0	0	0	0
			Corophiidae		1870	0	50	0	10
				Corophium sp.	0	0	0	0	0
			Gammaridae	*Gammarus sp.*	20	0	0	0	0
			Ischyroceridae	*Jassa falcata*	0	0	0	0	0
			Melitidae		0	0	0	0	0
				Melita netida	50	0	0	0	0
		Decapoda	Xanthidae	*Dyspanopeus sayi*	10	0	0	0	0
		Isopoda	Cirolanidae	*Politlana polita*	0	0	0	0	0
			Limnoriidae	*Limnoria lignorum*	0	0	0	0	0
			Sphaeromatidae	*Sphaeroma sp.*	0	0	0	0	0
		Thoracica	Balanidae	*Semibalanus balanoides*	0	0	0	0	30
Bryzoa					0	0	0	0	40
Mollusca	Bivalvia	Mytioida	Mytilidae	*Mytilus edulis*	0	0	0	0	100
Nematoda					0	0	0	0	0
Platyhelminthes					0	0	0	0	0

Table 7. Species composition and density of benthic invertebrates collected on Hester-Dendy Settlement Plates set for 224 days (October 2003 to June 2004) in the 5 reaches of the Gowanus Bay and Canal.

Phylum	Class	Order	Family	Scientific Name	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5
Annelida	Polychaeta					750	0	0	
		Capitellida	Capitellidae			0	0	0	
				Capitella sp.		0	0	0	
		Phyllodocida	Nereidae			0	0	0	
				Nereis sp.		10	0	30	
			Phyllodocidae	*Eumida Sanguinea*		0	0	0	
		Sabellida	Sabellidae			0	0	0	
				Fabricia Sabella		10	0	0	
		Spionida	Paraonidae			0	0	0	
			Spionidae	*Polydora ligni*		10	0	0	
				Streblospio benedicti		0	0	0	
Arthropoda	Crustacea	Amphipoda	Ampithoidae			100	0	0	
			Aoridae			200	0	0	
				Leptocheirus pinguis		7200	0	12960	
				Unciola sp.		200	0	0	
			Corophiidae			0	0	0	
				Corophium sp.		700	10	5440	
			Gammaridae	*Gammarus sp.*		600	20	640	
			Ischyroceridae	*Jassa falcata*		0	0	320	
			Melitidae			0	0	320	
				Melita netida		0	0	0	
		Decapoda	Xanthidae	*Dyspanopeus sayi*		0	0	0	
		Isopoda	Cirolanidae	*Politlana polita*		0	0	0	
			Limnoriidae	*Limnoria lignorum*		0	0	640	
			Sphaeromatidae	*Sphaeroma sp.*		110	90	0	
		Thoracica	Balanidae	*Semibalanus balanoides*		0	0	1400	
Bryzoa						0	0	0	
Mollusca	Bivalvia	Mytioida	Mytilidae	*Mytilus edulis*		10	10	260	
Nematoda						0	0	0	
Platyhelminthes						0	0	0	



Gowanus Bay and Canal Biological Sampling Locations

Figure 1

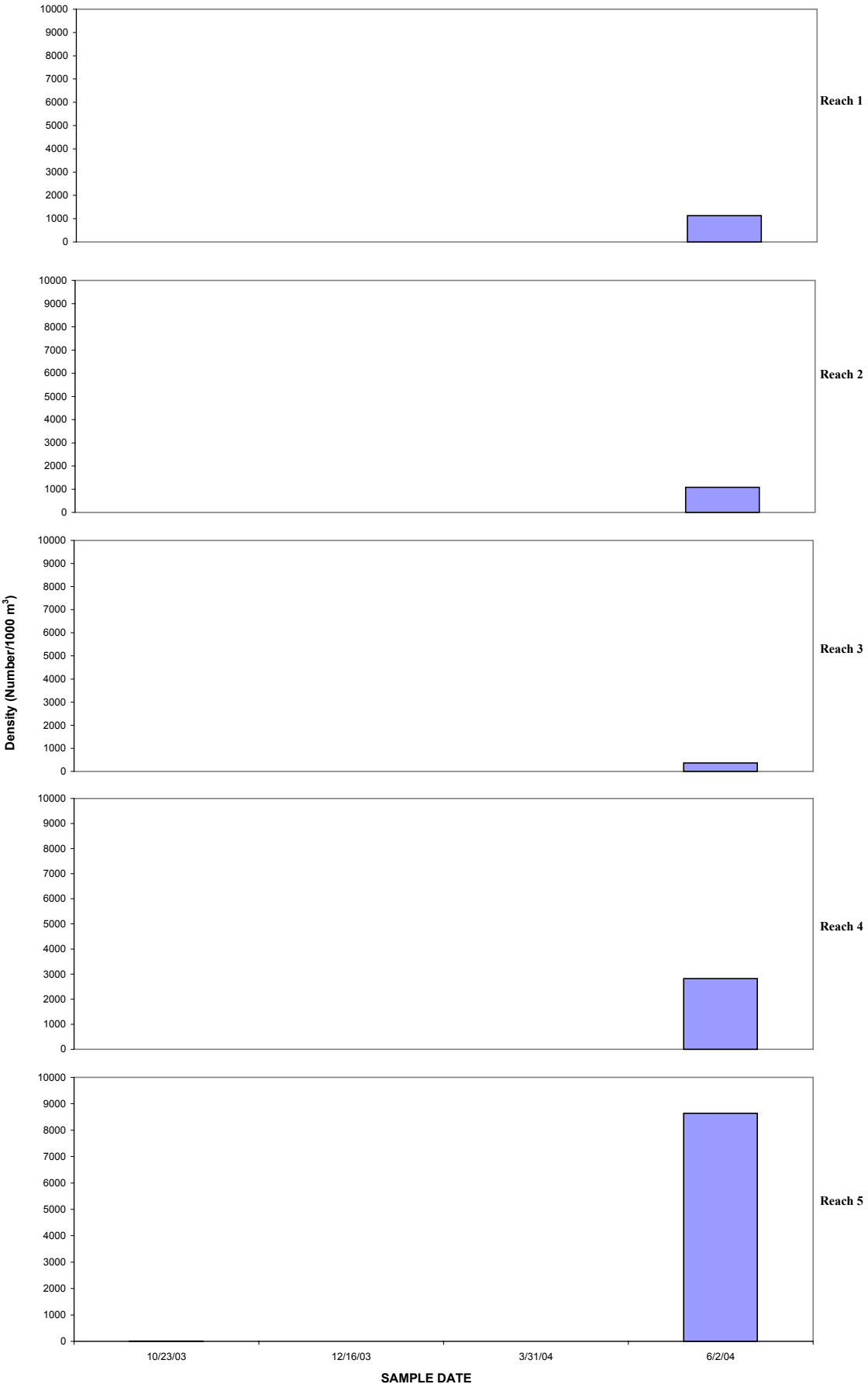


Figure 2. Egg density of all species combined within reaches sampled during the Gowanus Bay and Canal Aquatic Biological Sampling program from October 2003 to June 2004.

2003-October (total collected=0)

No Eggs Collected

2003-December (total collected=0)

No Eggs Collected

2004-March (total collected=0)

No Eggs Collected

2004-June (total collected=44)

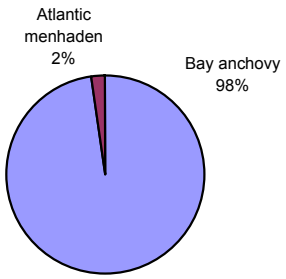


Figure 3. Species composition of eggs collected in Reach 1 during the Gowanus Bay and Canal Aquatic Biological Sampling program from October 2003 to June 2004.

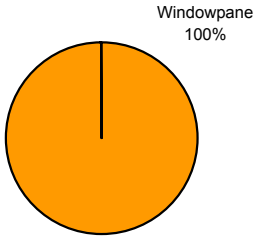
2003-October (total collected=0)

No Eggs Collected

2003-December (total collected=0)

No Eggs Collected

2004-March (total collected=1)



2004-June (total collected=100)

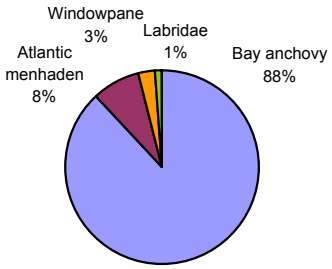


Figure 4. Species composition of eggs collected at Reach 2 during the Gowanus Bay and Canal Aquatic Biological Sampling program from October 2003 to June 2004.

2003-October (total collected=0)

No Eggs Collected

2003-December (total collected=0)

No Eggs Collected

2004-March (total collected=0)

No Eggs Collected

2004-June (total collected=38)

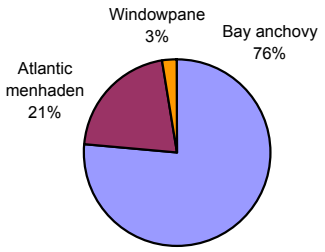


Figure 5. Species composition of eggs collected at Reach 3 during the Gowanus Bay and Canal Aquatic Biological Sampling program from October 2003 to June 2004.

2003-October (total collected=0)

No Eggs Collected

2003-December (total collected=0)

No Eggs Collected

2004-March (total collected=0)

No Eggs Collected

2004-June (total collected=336)

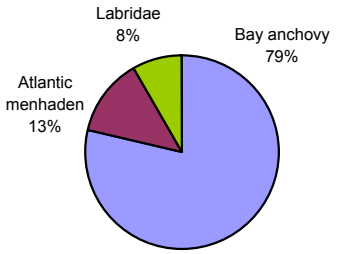


Figure 6. Species composition of eggs collected at Reach 4 during the Gowanus Bay and Canal Aquatic Biological Sampling program from October 2003 to June 2004.

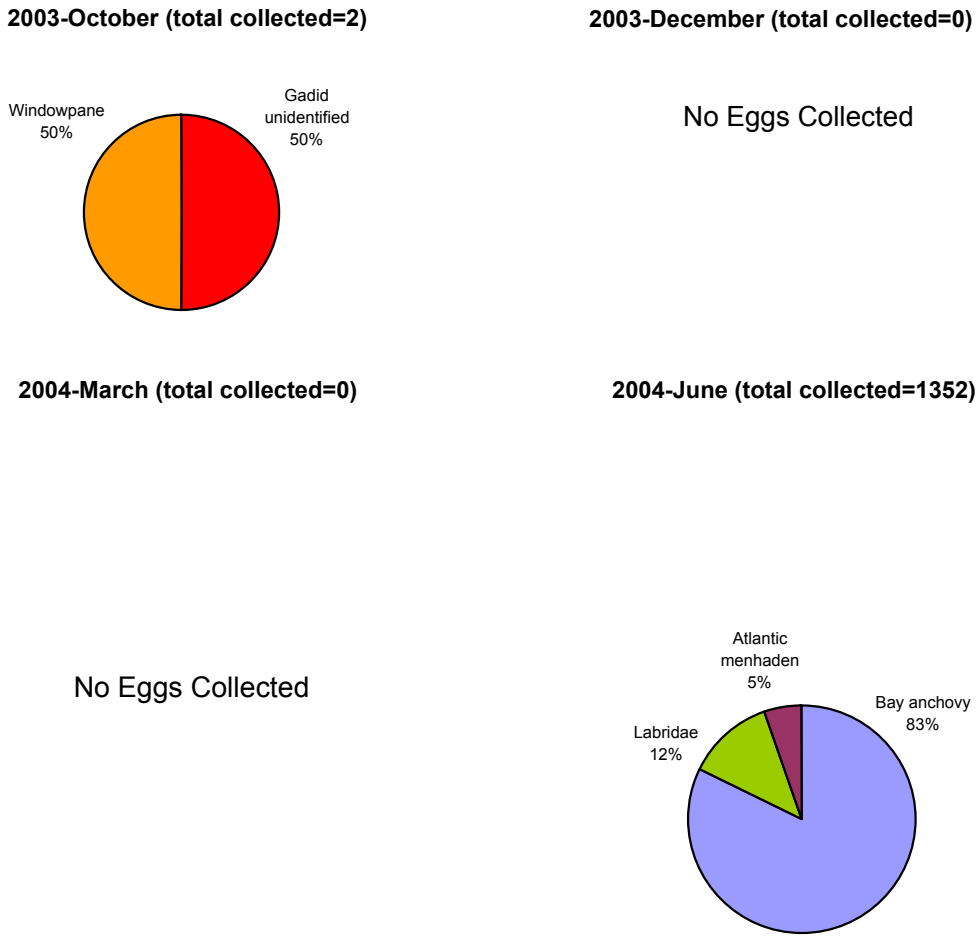


Figure 7. Species composition of eggs collected at Reach 5 during the Gowanus Bay and Canal Aquatic Biological Sampling program from October 2003 to June 2004.

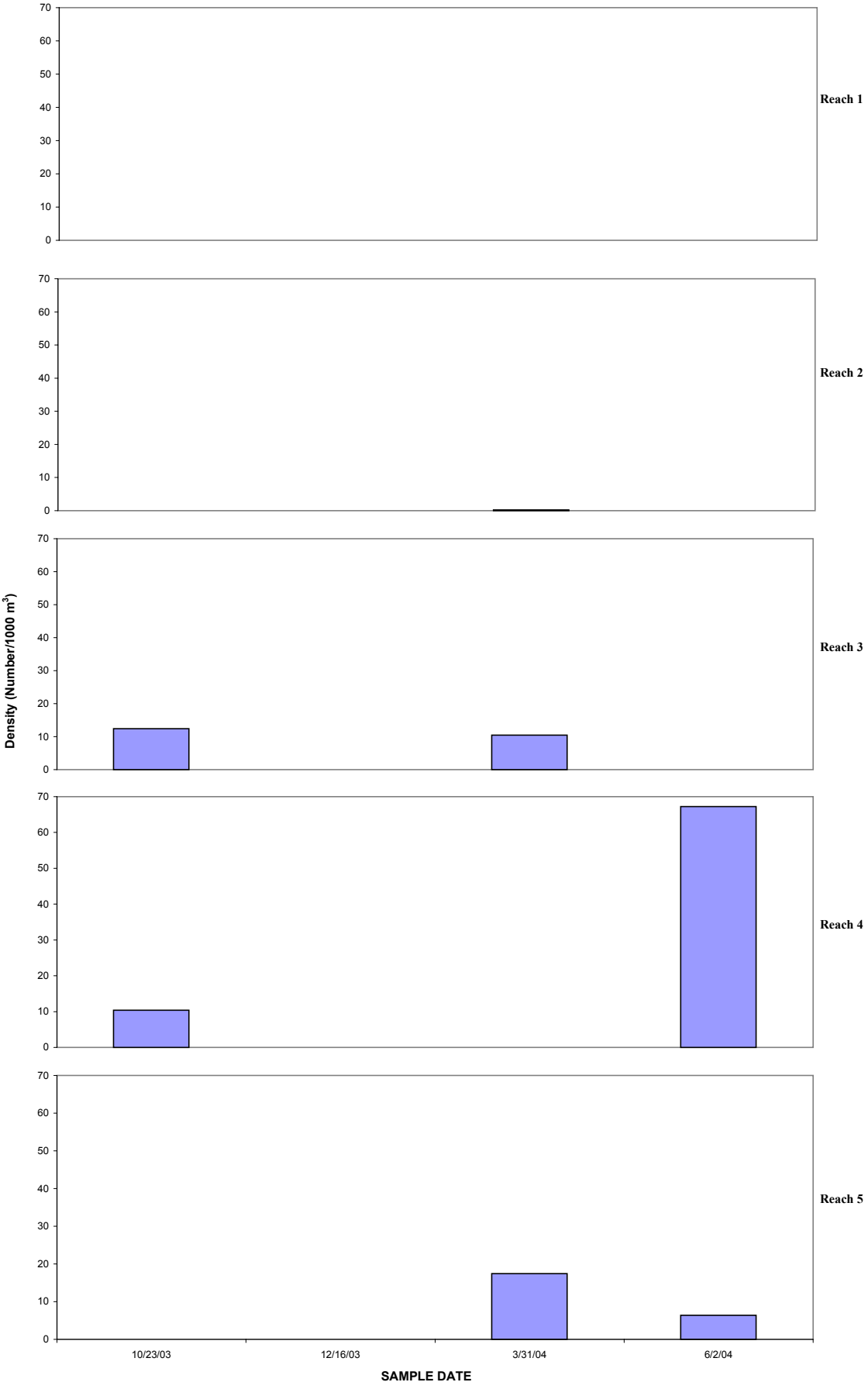


Figure 8. Yolk-sac larvae density of all species combined within Reaches sampled during the Gowanus Bay and Canal Aquatic Biological Sampling program from October 2003 to June 2004.

2003-October (total collected=0)

No Yolk-Sac Larvae Collected

2003-December (total collected=0)

No Yolk-Sac Larvae Collected

2004-March (total collected=0)

No Yolk-Sac Larvae Collected

2004-June (total collected=0)

No Yolk-Sac Larvae Collected

Figure 9. Species composition of yolk-sac larvae collected in Reach 1 during the Gowanus Bay and Canal Aquatic Biological Sampling program from October 2003 to June 2004.

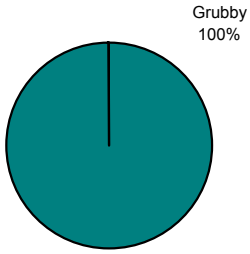
2003-October (total collected=0)

No Yolk-Sac Larvae Collected

2003-December (total collected=0)

No Yolk-Sac Larvae Collected

2004-March (total collected=1)



2004-June (total collected=0)

No Yolk-Sac Larvae Collected

Figure 10. Species composition of yolk-sac larvae collected in Reach 2 during the Gowanus Bay and Canal Aquatic Biological Sampling program from October 2003 to June 2004.

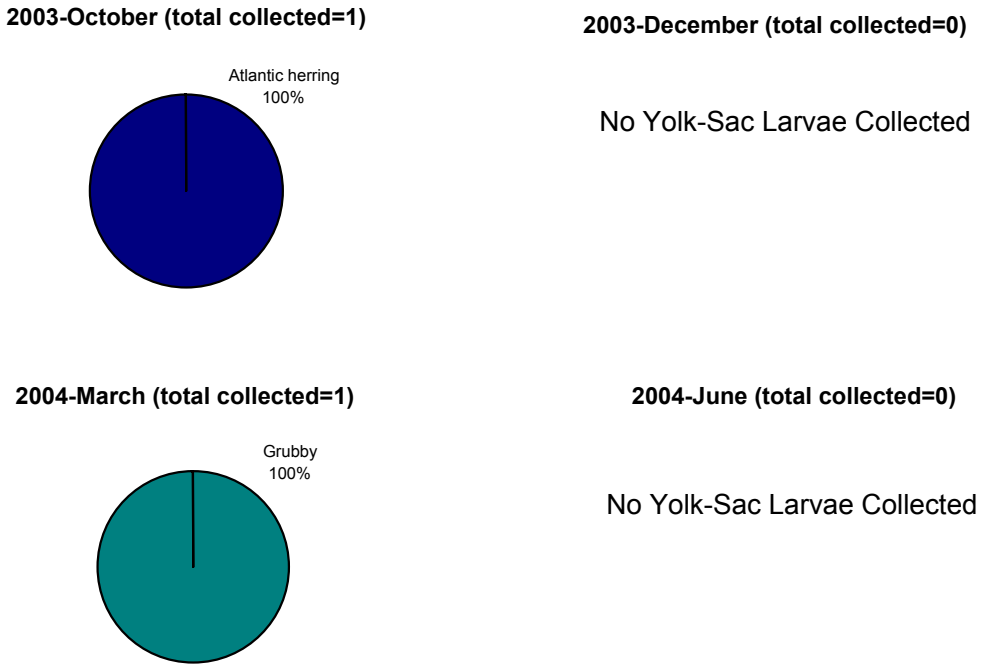
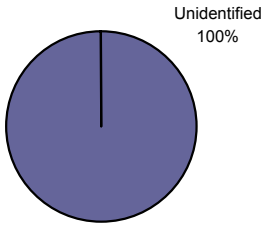


Figure 11. Species composition of yolk-sac larvae collected in Reach 3 during the Gowanus Bay and Canal Aquatic Biological Sampling program from October 2003 to June 2004.

2003-October (total collected=1)



2003-December (total collected=0)

No Yolk-Sac Larvae Collected

2004-March (total collected=0)

No Yolk-Sac Larvae Collected

2004-June (total collected=8)

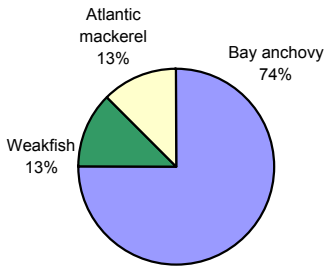


Figure 12. Species composition of yolk-sac larvae collected in Reach 4 during the Gowanus Bay and Canal Aquatic Biological Sampling program from October 2003 to June 2004.

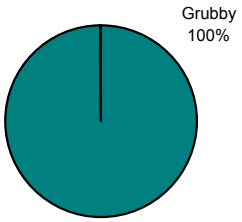
2003-October (total collected=0)

No Yolk-Sac Larvae Collected

2003-December (total collected=0)

No Yolk-Sac Larvae Collected

2004-March (total collected=2)



2004-June (total collected=1)

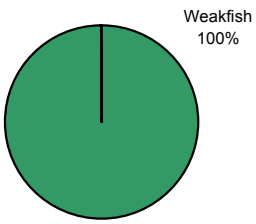


Figure 13. Species composition of yolk-sac larvae collected in Reach 5 during the Gowanus Bay and Canal Aquatic Biological Sampling program from October 2003 to June 2004.

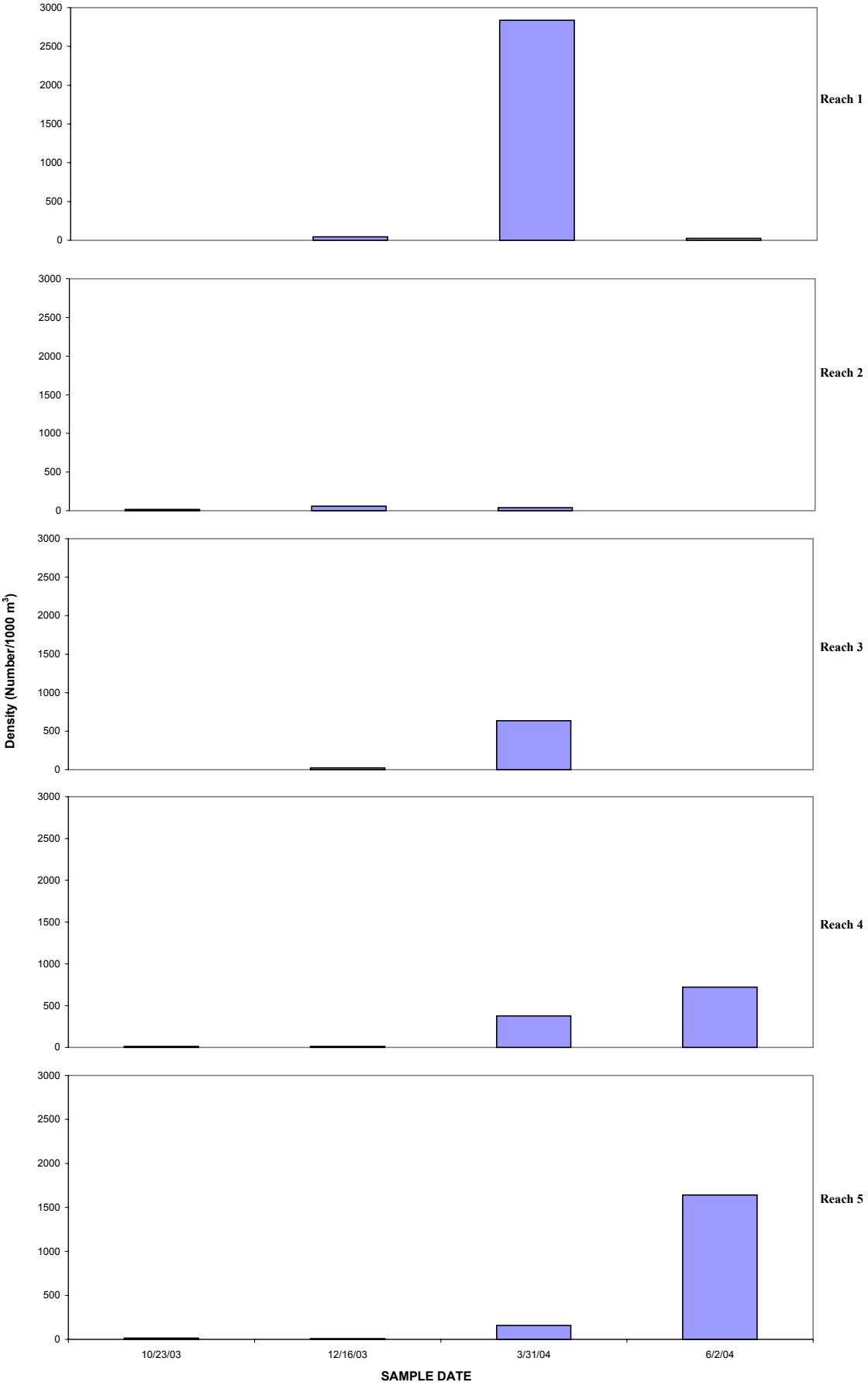
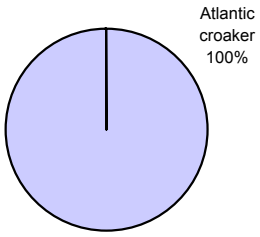


Figure 14. Post yolk-sac larvae density of all species combined within reaches sampled during the Gowanus Bay and Canal Aquatic Biological Sampling program from October 2003 to June 2004.

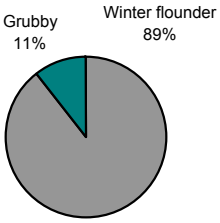
2003-October (total collected=0)

No Post Yolk-Sac Larvae Collected

2003-December (total collected=2)



2004-March (total collected=170)



2004-June (total collected=1)

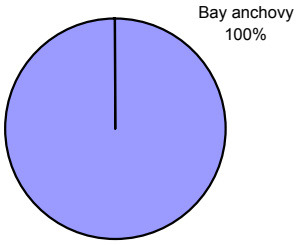


Figure 15. Species composition of post yolk-sac larvae collected in Reach 1 during the Gowanus Bay and Canal Aquatic Biological Sampling program from October 2003 to June 2004.

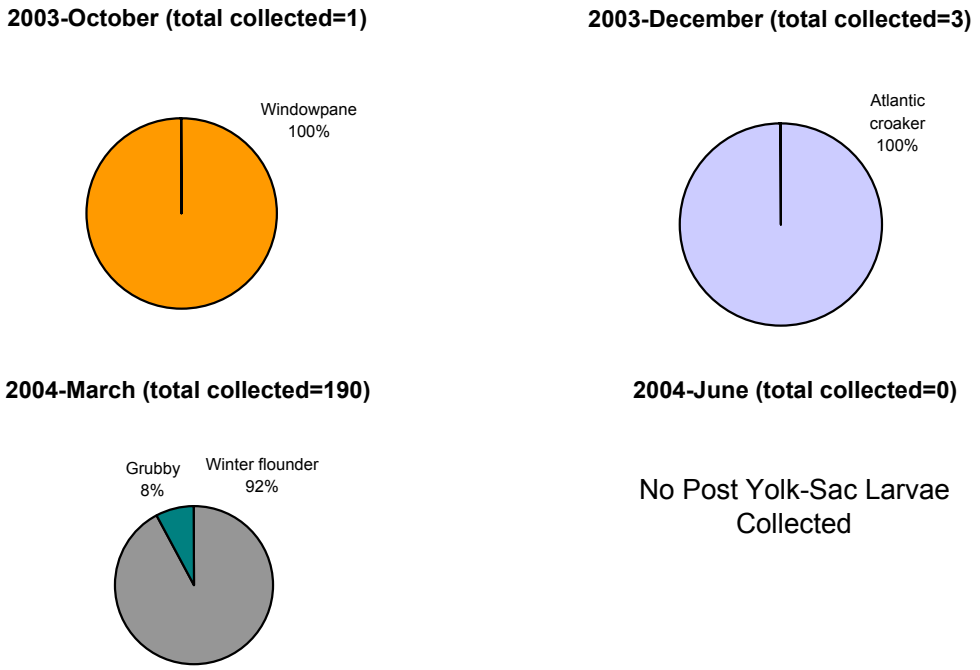


Figure 16. Species composition of post yolk-sac larvae collected in Reach 2 during the Gowanus Bay and Canal Aquatic Biological Sampling program from October 2003 to June 2004.

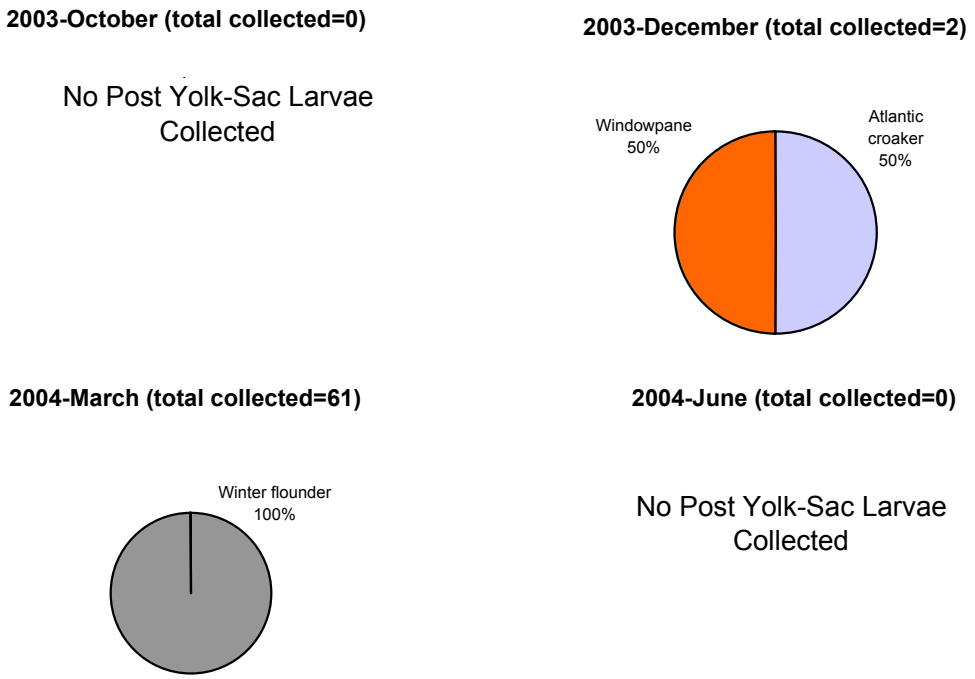


Figure 17. Species composition of post yolk-sac larvae collected in Reach 3 during the Gowanus Bay and Canal Aquatic Biological Sampling program from October 2003 to June 2004.

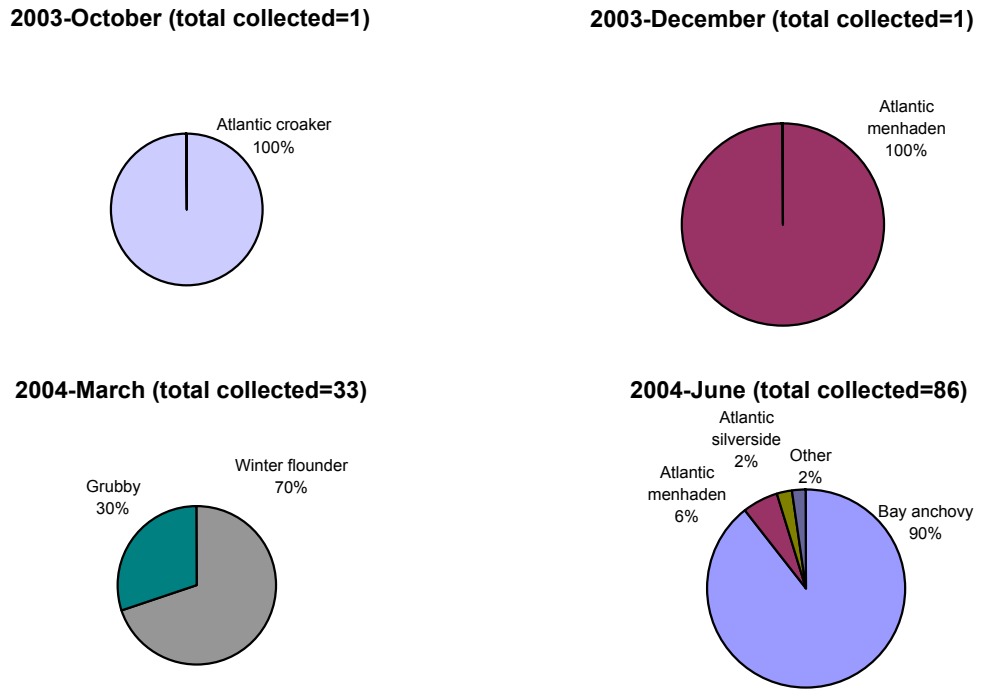


Figure 18. Species composition of post yolk-sac larvae collected in Reach 4 during the Gowanus Bay and Canal Aquatic Biological Sampling program from October 2003 to June 2004.

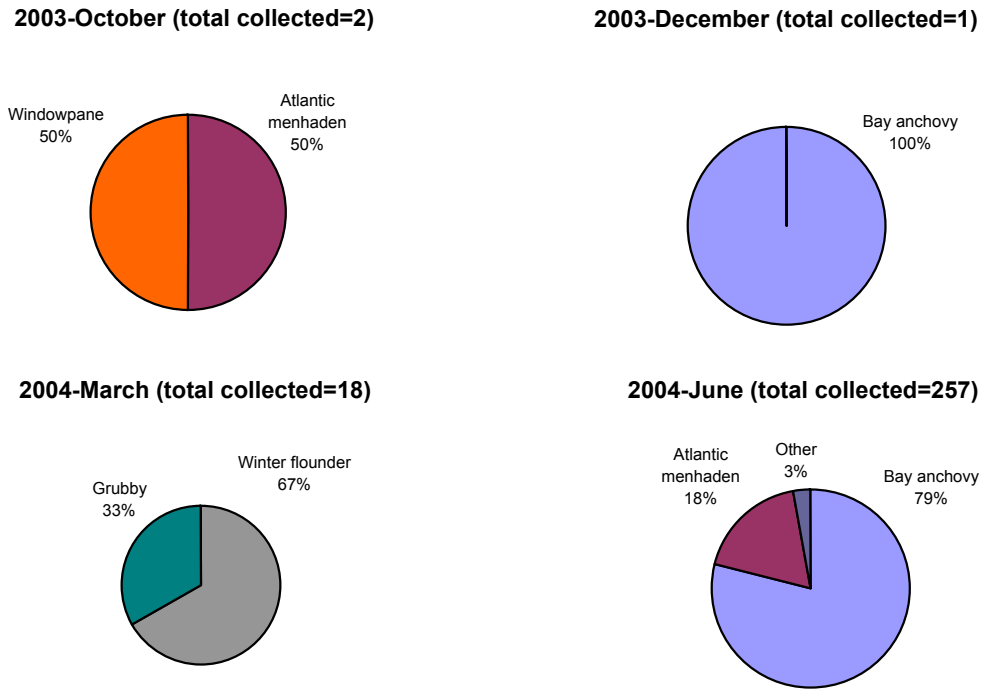


Figure 19. Species composition of post yolk-sac larvae collected in Reach 5 during the Gowanus Bay and Canal Aquatic Biological Sampling program from October 2003 to June 2004.

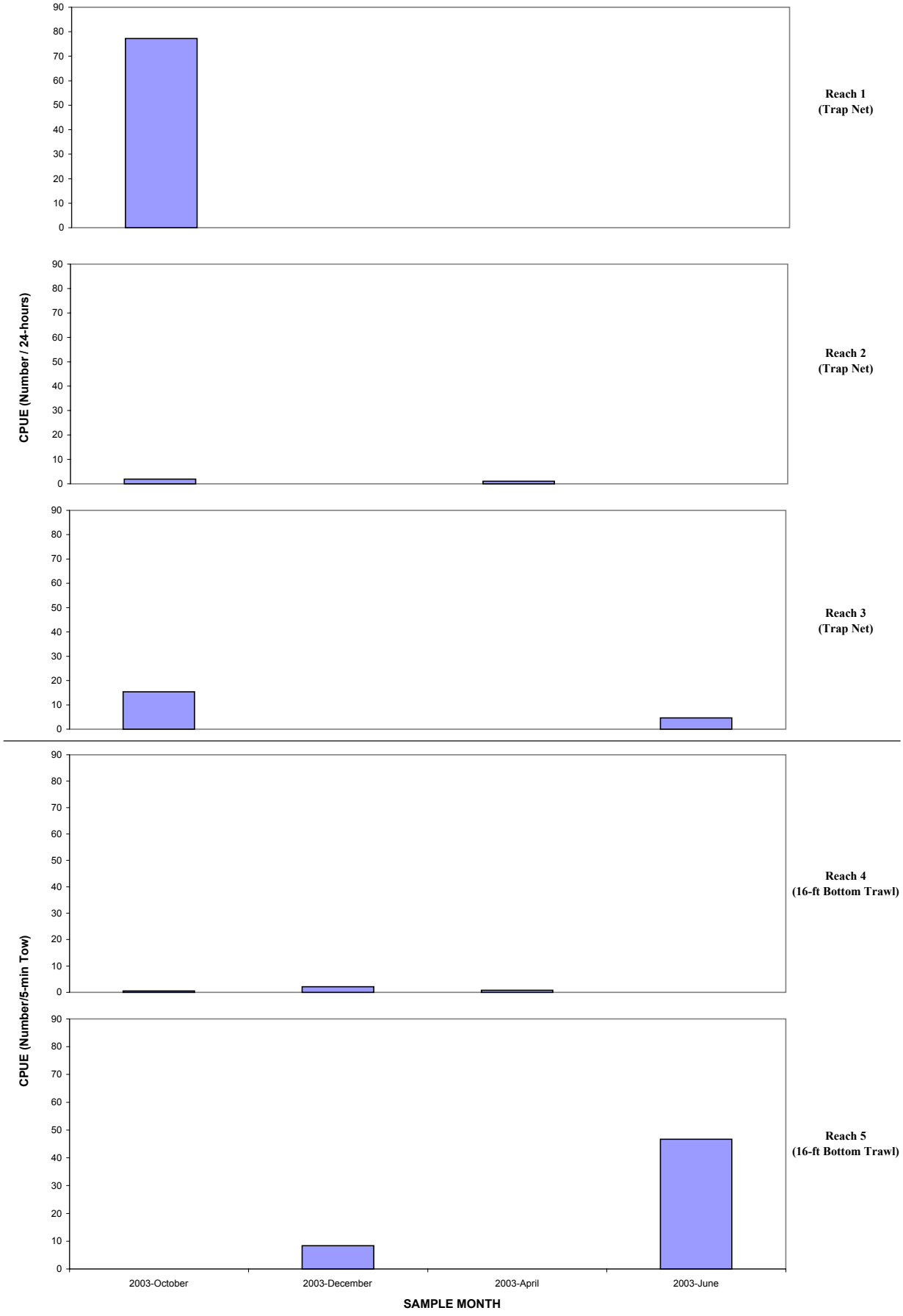
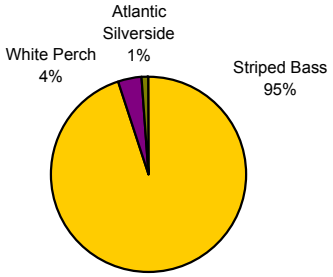


Figure 20. CPUE of all species combined within reaches sampled during the Gowanus Bay and Canal Aquatic Biological Sampling program from October 2003 to June 2004.

2003-October (total collected=77)



2003-December (total collected=0)

No Fish Collected

2004-April (total collected=0)

No Fish Collected

2004-June (total collected=0)

No Fish Collected

Figure 21. Species composition of fish collected within Reach 1 (Trap Net) during the Gowanus Bay and Canal Aquatic Biological Sampling program from October 2003 to June 2004.

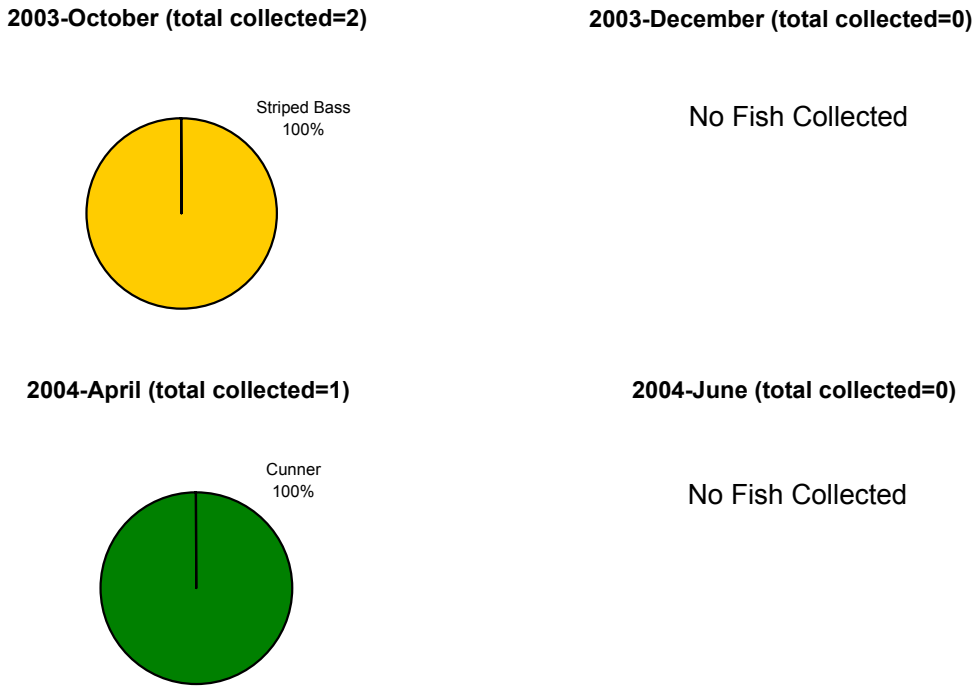


Figure 22. Species composition of fish collected within Reach 2 (Trap Net) during the Gowanus Bay and Canal Aquatic Biological Sampling program from October 2003 to June 2004.

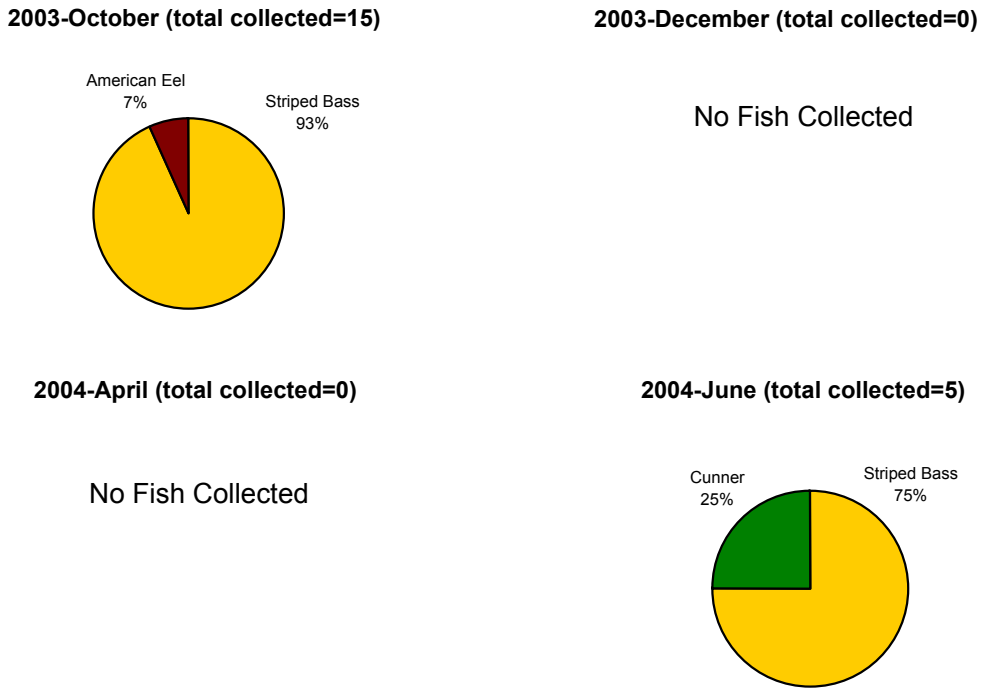


Figure 23. Species composition of fish collected within Reach 3 (Trap Net) during the Gowanus Bay and Canal Aquatic Biological Sampling program from October 2003 to June 2004.

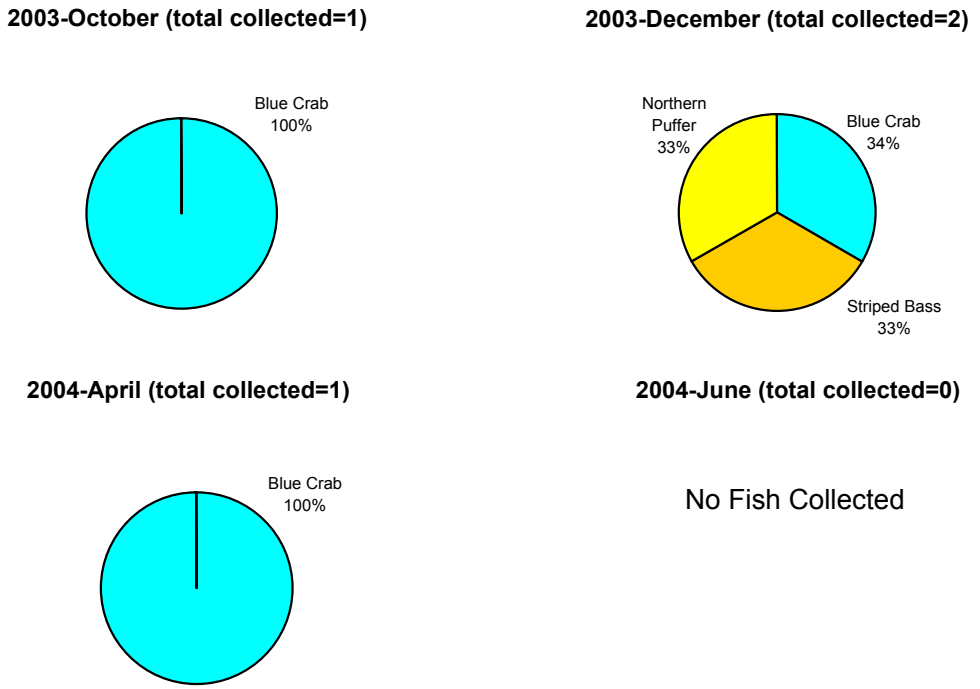
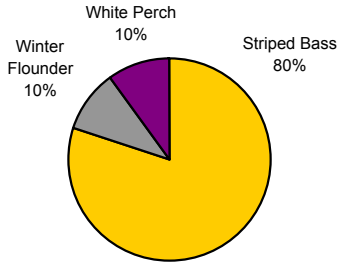


Figure 24. Species composition of fish collected within Reach 4 (16-ft Bottom Trawl) during the Gowanus Bay and Canal Aquatic Biological Sampling program from October 2003 to June 2004.

2003-October (total collected=0)

No Fish Collected

2003-December (total collected=8)



2004-April (total collected=0)

No Fish Collected

2004-June (total collected=47)

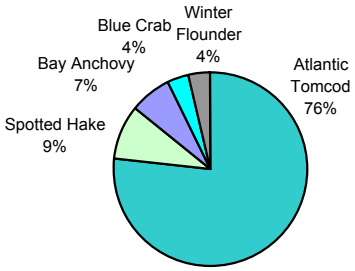


Figure 25. Species composition of fish collected within Reach 5 (16-ft Bottom Trawl) during the Gowanus Bay and Canal Aquatic Biological Sampling program from October 2003 to June 2004.

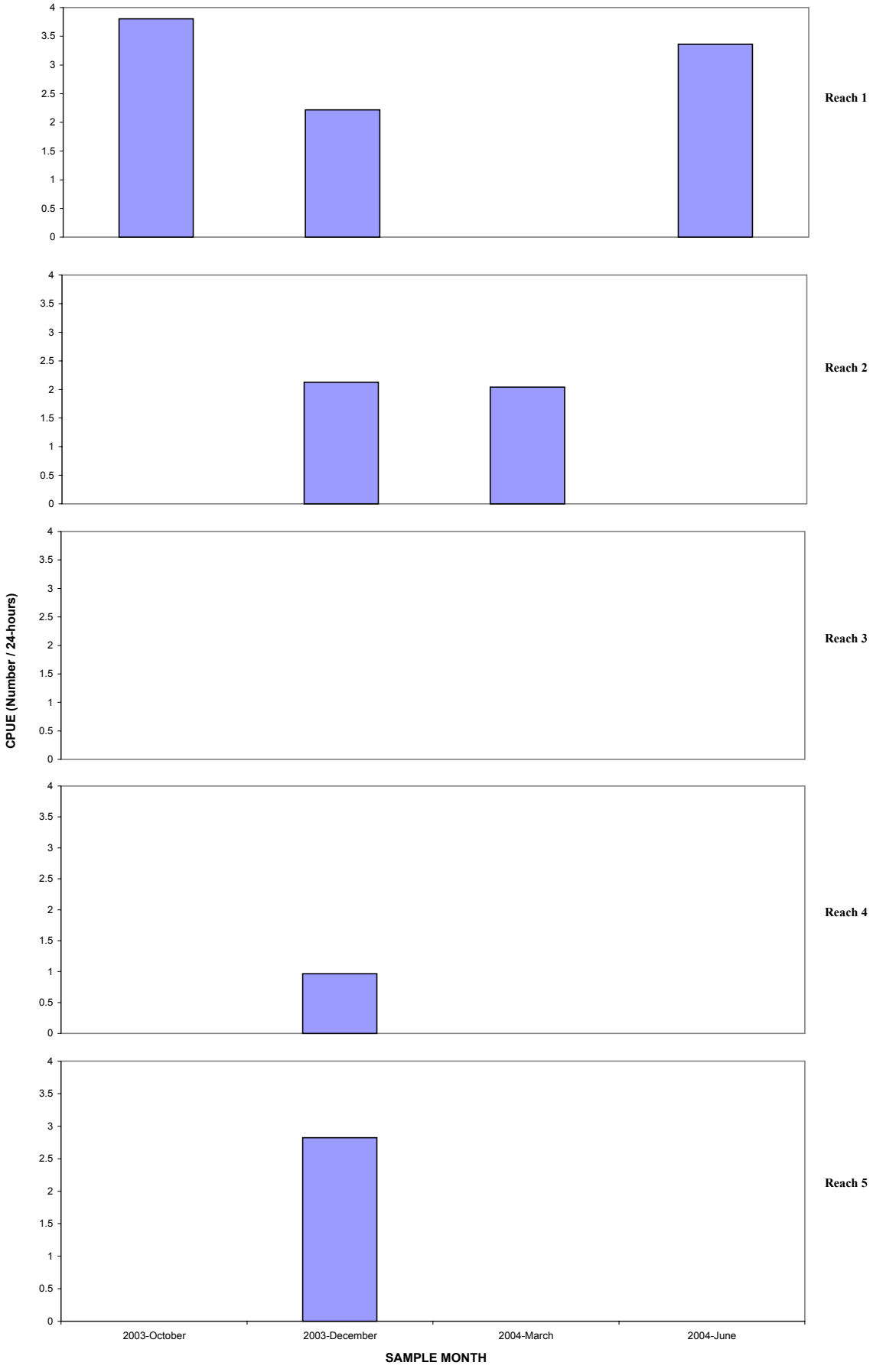


Figure 26 **Crab CPUE of all species combined within reaches sampled during the Gowanus Bay and Canal Aquatic sampling program from October 2003 to June 2004.**

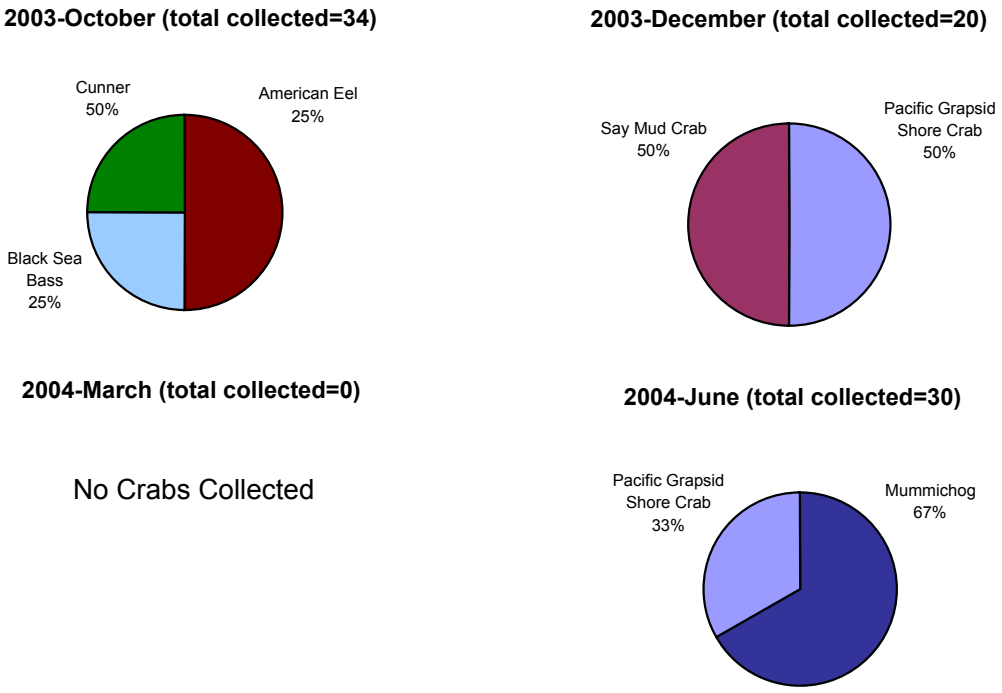


Figure 27. Species composition of crabs collected in Reach 1 during the Gowannus Bay and Canal Aquatic Biological Sampling program from October 2003 to June 2004

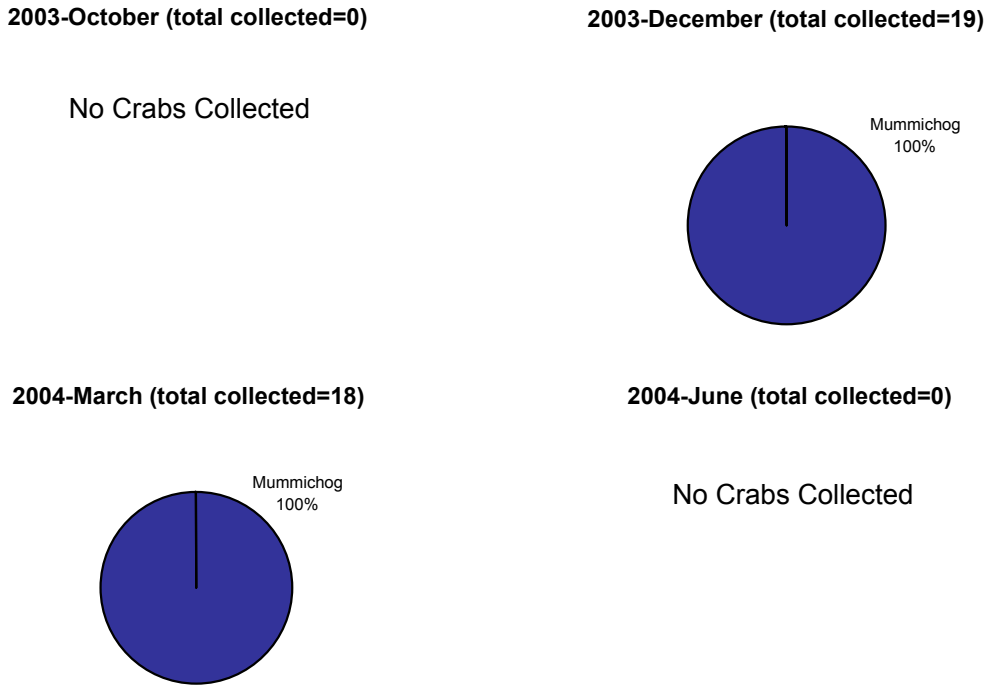


Figure 28. Species composition of crabs collected in Reach 2 during the Gowannus Bay and Canal Aquatic Biological Sampling program from October 2003 to June 2004

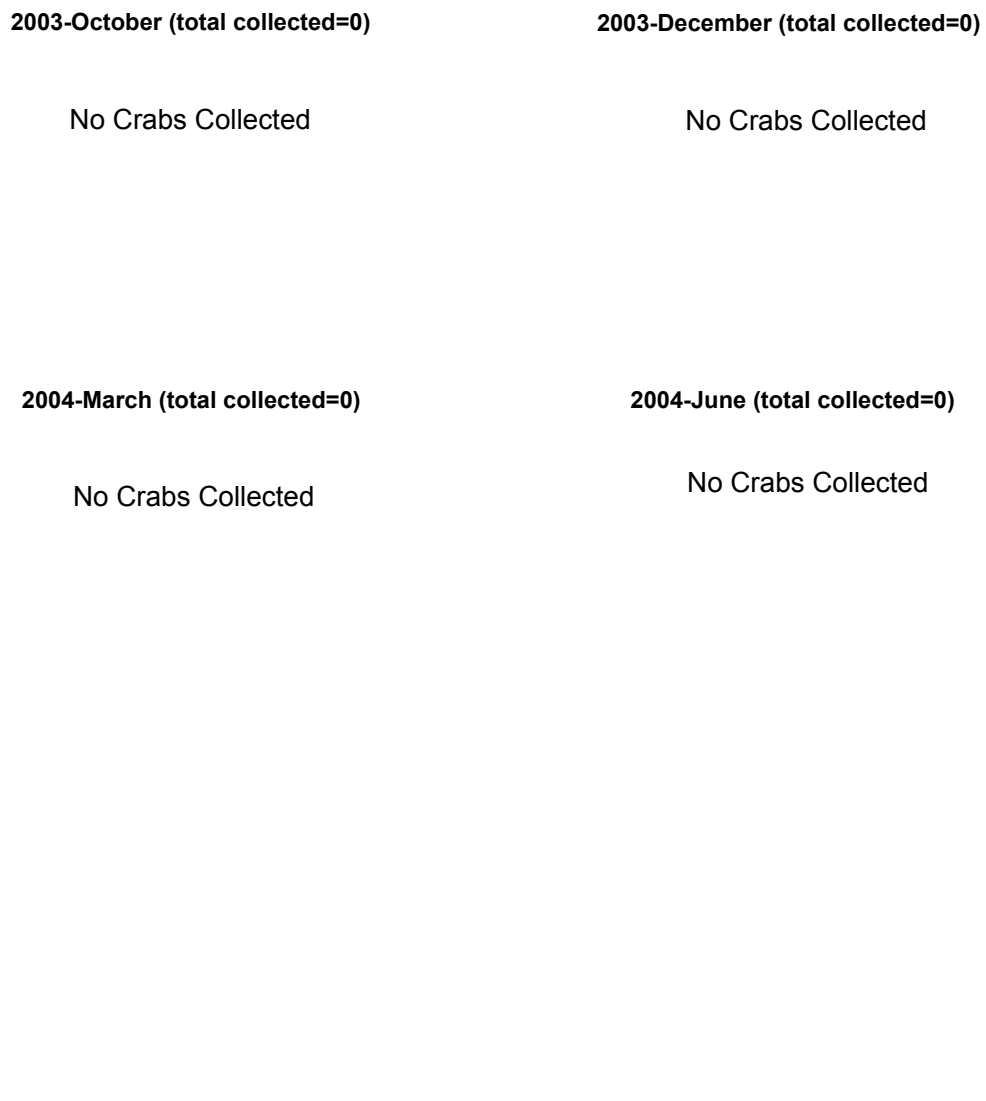
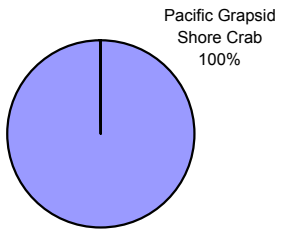


Figure 29. Species composition of crabs collected in Reach 3 during the Gowannus Bay and Canal Aquatic Biological Sampling program from October 2003 to June 2004

2003-October (total collected=0)

No Crabs Collected

2003-December (total collected=9)



2004-March (total collected=0)

No Crabs Collected

2004-June (total collected=0)

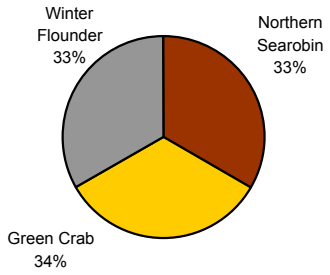
No Crabs Collected

Figure 30. Species composition of crabs collected in Reach 4 during the Gowannus Bay and Canal Aquatic Biological Sampling program from October 2003 to June 2004

2003-October

No Valid Samples

2003-December (total collected=25)



2004-March

No Valid Samples

2004-June (total collected=0)

No Crabs Collected

Figure 31. Species composition of crabs collected in Reach 5 during the Gowannus Bay and Canal Aquatic Biological Sampling program from October 2003 to June 2004

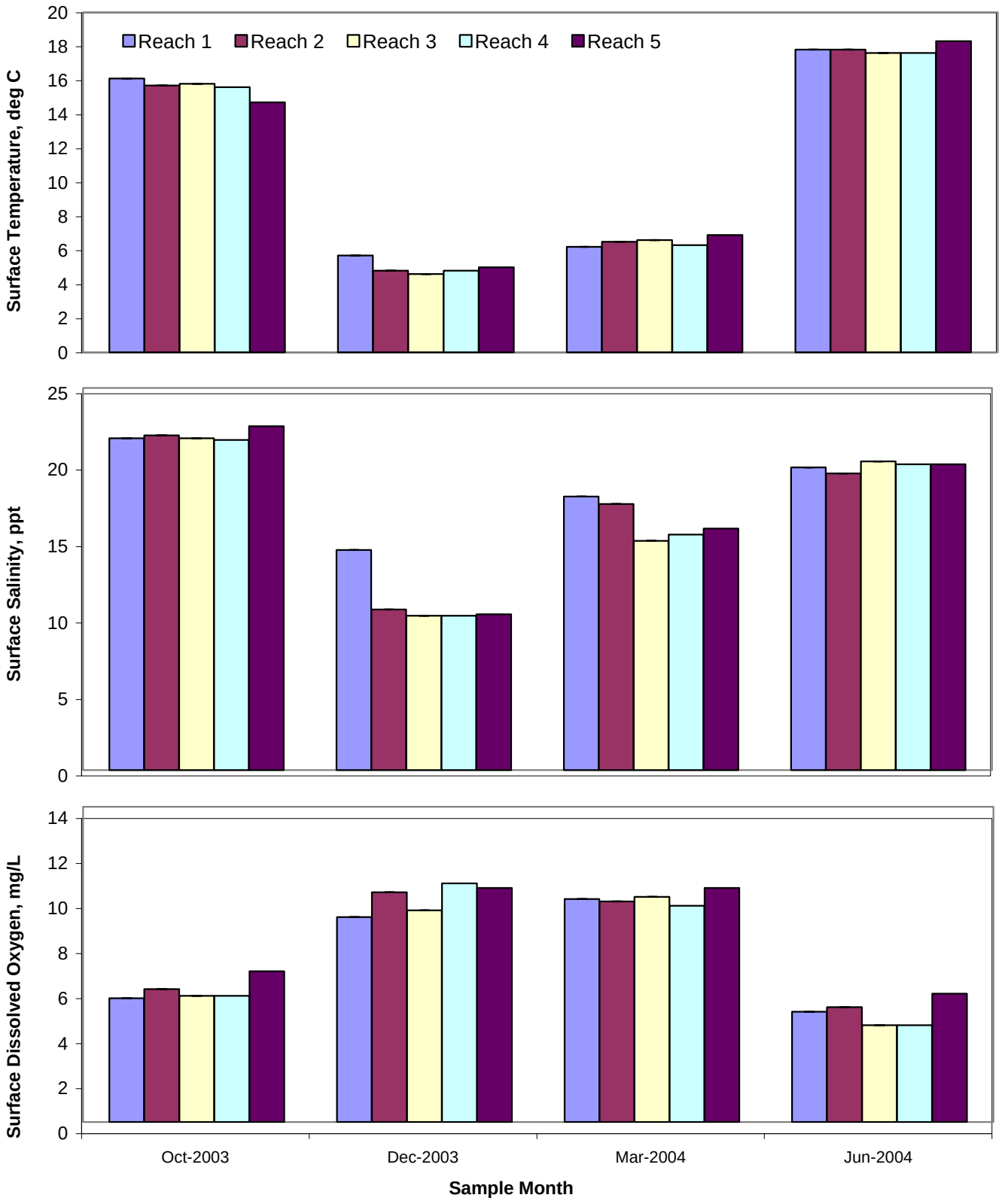


Figure 32. Surface strata temperature, salinity and dissolved oxygen measurements by station within reaches sampled during the Gowanus Bay and Canal Aquatic Biological Sampling program from October 2003 to June 2004.

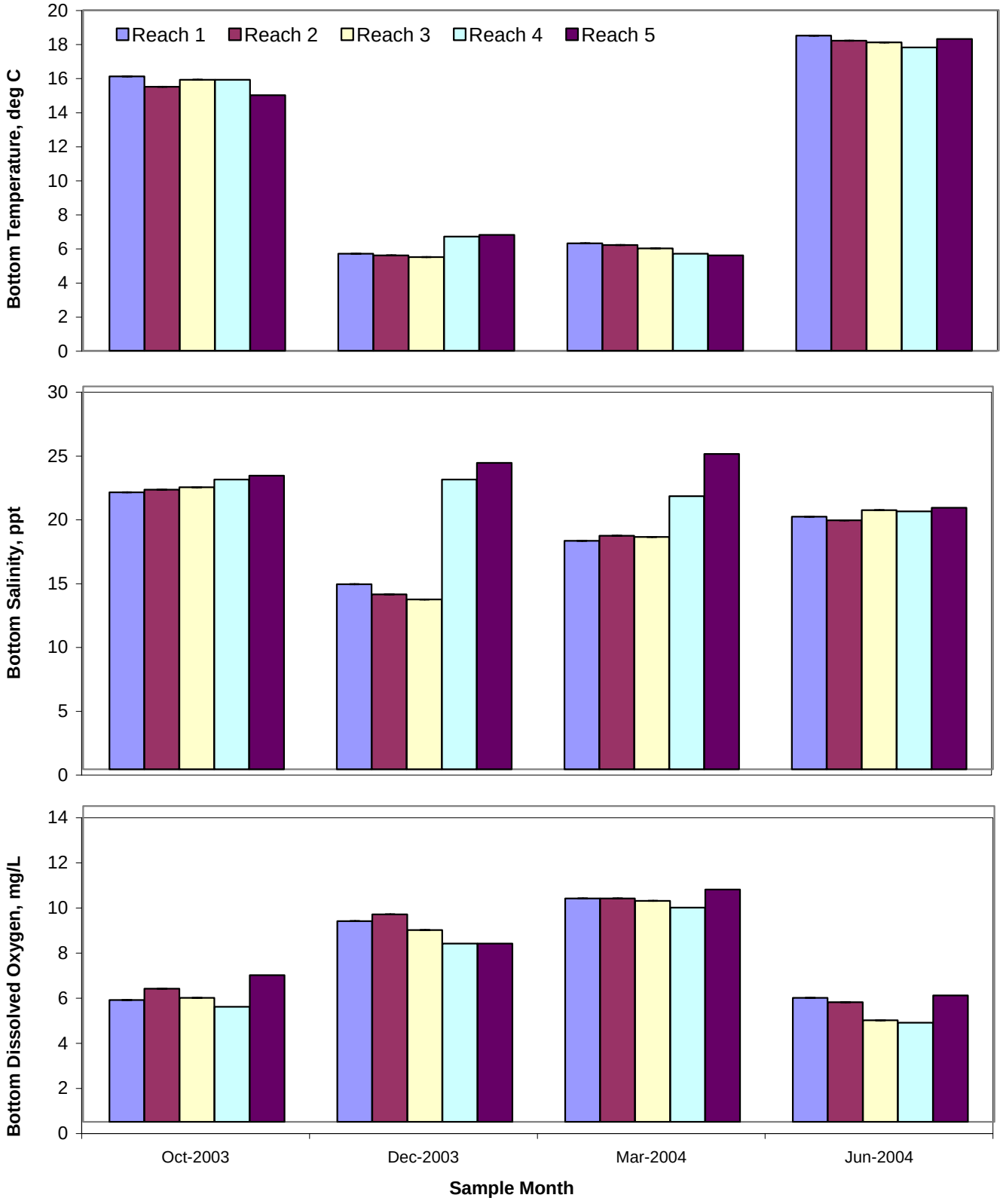


Figure 33. Bottom temperature, salinity and dissolved oxygen measurements by station within reaches sampled during the Gowanus Bay and Canal Aquatic Biological Sampling program from October 2003 to June 2004.

Appendix A

Table A1. Monthly average ichthyoplankton density (Number/1000 m^3) by species in Reach 1 of the Gowanus Bay and Canal Sampling Program

Egg

Species	Oct-03	Dec-03	Mar-04	Jun-04
Atlantic menhaden				25.79
Bay anchovy				1108.83

Yolk-sac Larvae

Species	Oct-03	Dec-03	Mar-04	Jun-04

Post-yolk sac Larvae

Species	Oct-03	Dec-03	Mar-04	Jun-04
Atlantic croaker		43.20		
Bay anchovy				25.79
Grubby			300.21	
Winter flounder			2535.10	

Table A2. Monthly average ichthyoplankton density (Number/1000 m^3) by species in Reach 2 of the Gowanus Bay and Canal Sampling Program

Egg

Species	Oct-03	Dec-03	Mar-04	Jun-04
Atlantic menhaden				86.36
Bay anchovy				949.97
Labridae				10.80
Windowpane			0.20	32.39

Yolk-sac Larvae

Species	Oct-03	Dec-03	Mar-04	Jun-04
Grubby			0.20	

Post-yolk sac Larvae

Species	Oct-03	Dec-03	Mar-04	Jun-04
Atlantic croaker		57.16		
Grubby			3.06	
Windowpane	17.11			
Winter flounder			35.71	

Table A3. Monthly average ichthyoplankton density (Number/1000 m^3) by species in Reach 2 of the Gowanus Bay and Canal Sampling Program

Egg

Species	Oct-03	Dec-03	Mar-04	Jun-04
Atlantic menhaden				76.50
Bay anchovy				277.32
Windowpane				9.56

Yolk-sac Larvae

Species	Oct-03	Dec-03	Mar-04	Jun-04
Atlantic herring	12.41			
Grubby			10.43	

Post-yolk sac Larvae

Species	Oct-03	Dec-03	Mar-04	Jun-04
Atlantic croaker		11.36		
Windowpane		11.36		
Winter flounder			636.10	

Table A4. Monthly average ichthyoplankton density (Number/1000 m^3) by species in Reach 4 of the Gowanus Bay and Canal Sampling Program

Egg

Species	Oct-03	Dec-03	Mar-04	Jun-04
Atlantic menhaden				369.59
Bay anchovy				2217.51
Labridae				235.19

Yolk-sac Larvae

Species	Oct-03	Dec-03	Mar-04	Jun-04
Atlantic mackerel				8.40
Bay anchovy				50.40
Unidentified	10.39			
Weakfish				8.40

Post-yolk sac Larvae

Species	Oct-03	Dec-03	Mar-04	Jun-04
Atlantic croaker	10.39			
Atlantic menhaden		12.97		42.00
Atlantic silverside				16.80
Bay anchovy				646.77
Grubby			114.14	
Tautog				8.40
Windowpane				8.40
Winter flounder			262.53	

Table A5. Monthly average ichthyoplankton density (Number/1000 m^3) by species in Reach 5 of the Gowanus Bay and Canal Sampling Program

Egg

Species	Oct-03	Dec-03	Mar-04	Jun-04
Atlantic menhaden				459.83
Bay anchovy				7101.85
Gadid unidentified	6.38			
Labridae				1072.94
Windowpane	6.38			

Yolk-sac Larvae

Species	Oct-03	Dec-03	Mar-04	Jun-04
Grubby			17.43	
Weakfish				6.39

Post-yolk sac Larvae

Species	Oct-03	Dec-03	Mar-04	Jun-04
Atlantic menhaden	6.38			300.17
Bay anchovy		7.34		1296.47
Cunner				6.39
Grubby			52.29	
Northern pipefish				6.39
Tautog				12.77
Weakfish				19.16
Windowpane	6.38			
Winter flounder			104.59	

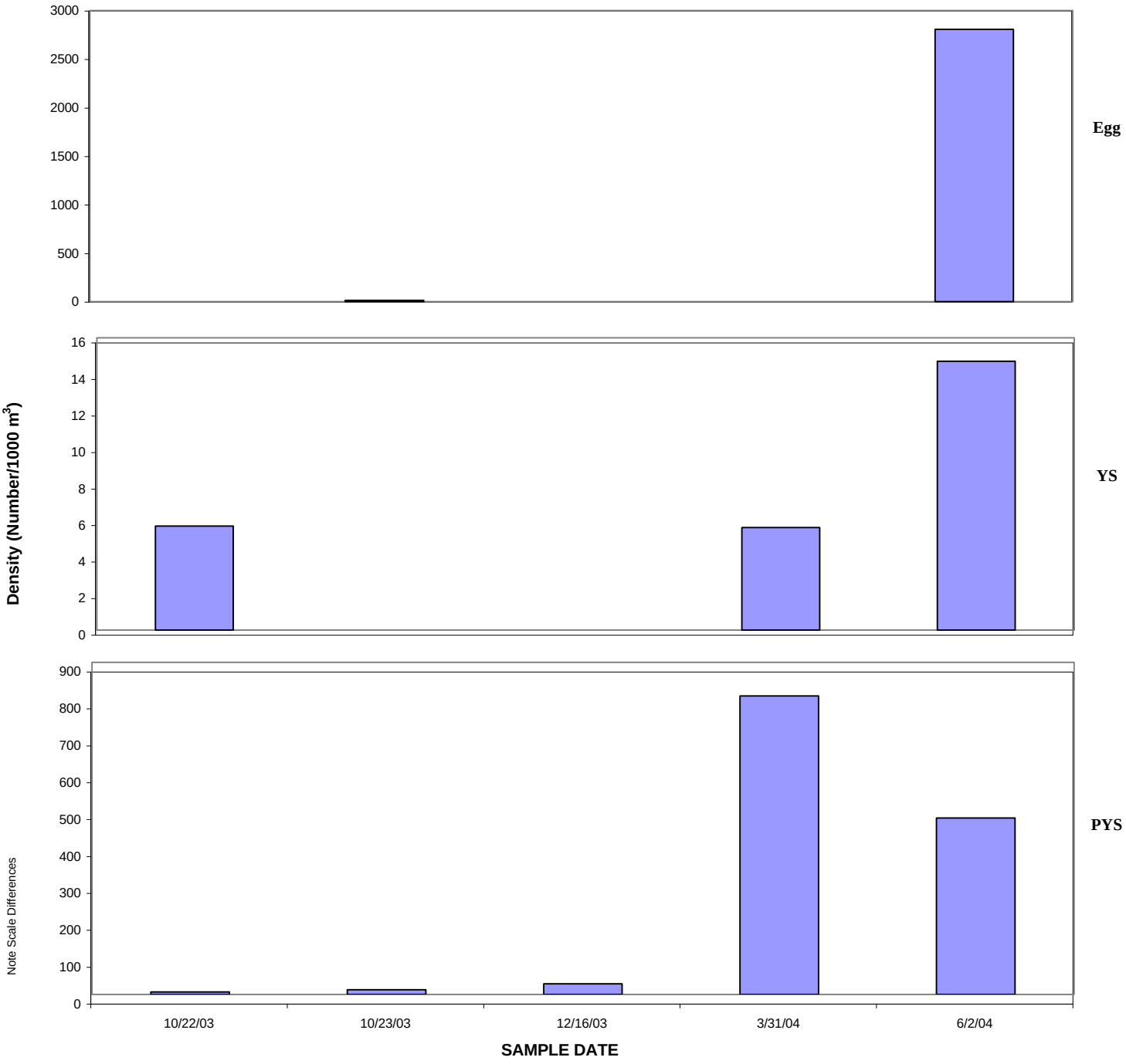


Figure A1. Density of all species combined by life stage within reaches sampled during the Gowanus Bay and Canal Aquatic Biological Sampling program from October 2003 to June 2004.

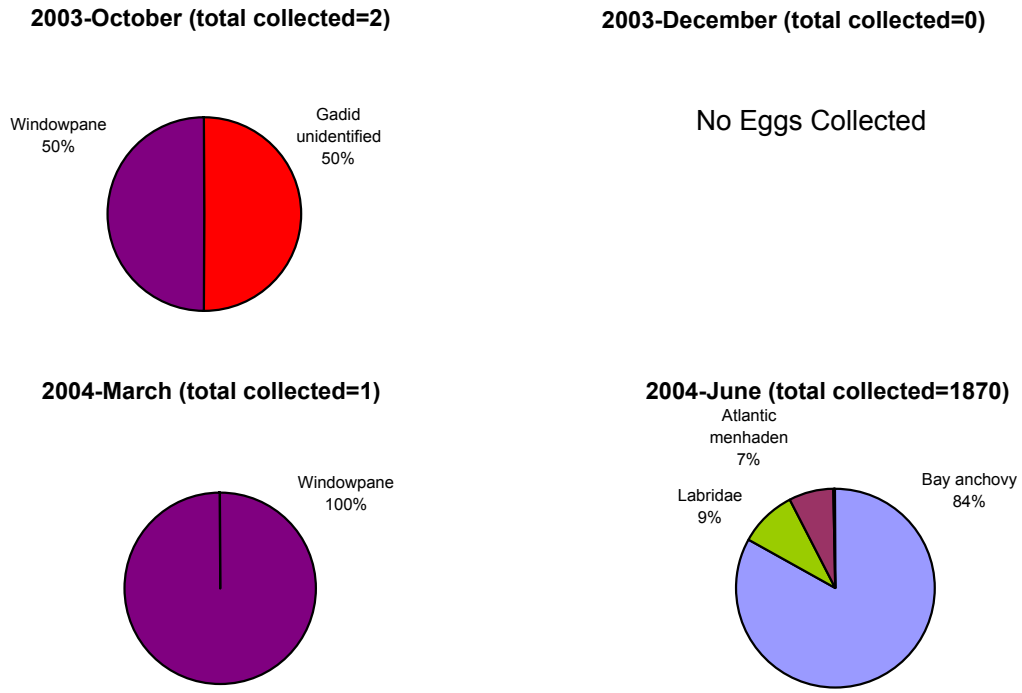


Figure A2. Species composition of eggs collected at all Reaches combined during the Gowanus Bay and Canal Aquatic Biological Sampling program from October 2003 to June 2004.

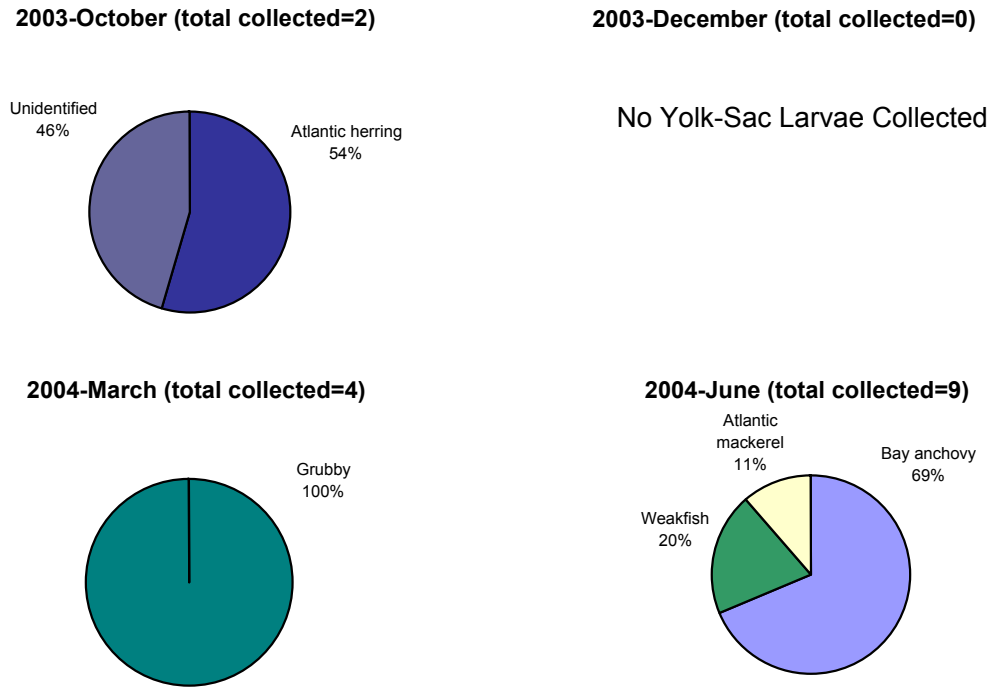


Figure A3. Species composition of yolk-sac larvae collected in all Reaches combined during the Gowanus Bay and Canal Aquatic Biological Sampling program from October 2003 to June 2004.

Figure A4. Species composition of post yolk-sac larvae collected in all Reaches combined during the Gowanus Bay and Canal Aquatic Biological Sampling program from October 2003 to June 2004.

Appendix B

Table B-1. Monthly average fish CPUE by species within reaches sampled during the Gowanus Bay and Canal Aquatic Biological Sampling Program.

Reach 1 (Trap Net)

Species	Oct-03	Dec-03	Apr-04	Jun-04
Atlantic Silverside	0.95			
Striped Bass	73.43			
White Perch	2.86			

Reach 2 (Trap Net)

Species	Oct-03	Dec-03	Apr-04	Jun-04
Cunner			1.05	
Striped Bass	1.93			

Reach 3 (Trap Net)

Species	Oct-03	Dec-03	Apr-04	Jun-04
American Eel	1.02			
Cunner				1.16
Striped Bass	14.35			3.47

Reach 4 (16-ft Bottom Trawl)

Species	Oct-03	Dec-03	Apr-04	Jun-04
Blue Crab	0.57	0.71	0.78	
Northern Puffer		0.71		
Striped Bass		0.71		

Reach 5 (16-ft Bottom Trawl)

Species	Oct-03	Dec-03	Apr-04	Jun-04
Atlantic Tomcod				35.83
Bay Anchovy				3.33
Blue Crab				1.67
Spotted Hake				4.17
Striped Bass		6.67		
White Perch		0.83		
Winter Flounder		0.83		1.67

Appendix C

Table C-1. Monthly average crab CPUE by species within reaches sampled during the Gowanus Bay and Canal Aquatic Biological Sampling Program.

Reach 1

Species	Oct-03	Dec-03	Apr-04	Jun-04
American Eel	0.95			
Black Sea Bass	0.95			
Cunner	1.90			
Say Mud Crab		1.11		
Pacific Grapsid Shore Crab		1.11		1.12
Mummichog				2.24

Reach 2

Species	Oct-03	Dec-03	Apr-04	Jun-04
Mummichog		2.13	2.04	

Reach 3

Species	Oct-03	Dec-03	Apr-04	Jun-04

Reach 4

Species	Oct-03	Dec-03	Apr-04	Jun-04
Pacific Grapsid Shore Crab		0.97		

Reach 5

Species	Oct-03	Dec-03	Apr-04	Jun-04
Green Crab		0.94		
Northern Searobin		0.94		
Winter Flounder		0.94		