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September 8, 2006

BY HAND

Magalie Roman Salas, Secretary
Federal Energy Regulatory Commission
888 First Street, NE
Washington, DC 20426

Re: *Broadwater Energy LLC*, Docket No. CP06-54-000
Broadwater Pipeline LLC, Docket Nos. CP06-55-000 & CP06-56-000

Dear Ms. Salas:

Broadwater Energy LLC and Broadwater Pipeline LLC (collectively, "Broadwater") enclose for filing in the referenced proceedings the following items:

1. Letter Report summarizing the results of ichthyoplankton sampling in the vicinity of the proposed Broadwater FSRU. Sampling event No. 5, April, 2006; and

2. Letter Report summarizing the results of ichthyoplankton sampling in the vicinity of the proposed Broadwater FSRU. Sampling event No. 6, May, 2006.

Please contact the undersigned with any questions regarding this submission.

Respectfully submitted

Brett A. Snyder

Enclosures

cc: James Martin, FERC
Cooperating Agencies
ENTRIX, Inc.
Roger Stebbing and Associates

June 8, 2006
Ref No. 20546.000

Mike Donnelly
Ecology and Environment, Inc.
Buffalo Corporate Center
368 Pleasant View Dr.
Lancaster, NY 14086

RE: Letter Report summarizing the results of ichthyoplankton sampling in the vicinity of the proposed Broadwater FSRU. Sampling event No. 5, April, 2006.

FIELD METHODS

Normandeau Associates, Inc. (Normandeau) conducted ichthyoplankton sampling in the vicinity of the proposed Broadwater Energy floating storage and regasification unit (FSRU) in the Central Basin of Long Island Sound on April 18, 2006. A one by one nautical mile square block centered on the location of the proposed FSRU facility was designated as the sampling area. Three random stations were selected within the sampling area using the Random Point Generator extension in Arcview (Figure 1). At each station the water column was divided into three depth strata based on an assumed depth of about 95 feet: near surface (0-30 feet), mid-depth (35-65 feet), near bottom (bottom, 70-95 feet). One ichthyoplankton tow was collected in each depth stratum of each station during daylight (defined as occurring between 1 hour after sunrise and 1 hour before sunset) and the daytime sampling was repeated again at night at the same three stations (defined as occurring between 1 hour after sunset and 1 hour before sunrise). A total of 18 valid samples (3 stations x 3 depths x 2 diel periods, Table 1) were collected on April 18, 2006 between 12:30-3:30 PM (day) and 8:00-11:00 PM (night).

All samples were collected with a 1.0 m^2 Tucker trawl with a 0.335 mm net and an 8:1 length to mouth ratio. The tucker trawl has a closing device that uses a double-trip release mechanism and a weighted lead bar to close the mouth of the net and insure that each sample is collected in each of the three discrete depth strata. Net towing speed was approximately 1.0 m/sec and tow duration was 5 minutes. A flume-calibrated digital flowmeter (GO Model 2030R) was placed in the mouth of the Tucker trawl to measure the distance (volume) of each tow. Tow depth was determined in the field using a cosine function relating wire length and wire angle to sampling depth. Tow volume was approximately 300 m^3 and ranged from 252-382 m^3 (Table 1). The start and end of each towpath was recorded using GPS. Samples were fixed at sea in 4% buffered formaldehyde and changed over to 80% ethanol within 18 hours. A conductivity, salinity, temperature, and dissolved oxygen profile was made at 5 foot intervals from one foot below the surface to one foot above the bottom at each of the three stations and two diel periods (6 total profiles) using a YSI Model 85 meter.

LABORATORY METHODS

Samples were sorted under magnification to remove all fish eggs, fish larvae, and lobster larvae which were then enumerated and identified to the lowest possible taxon (generally genus and species). Samples were further identified into the following life stages: egg, yolk-sac larvae and post yolk-sac larvae.

The accuracy of identifications, assignment to life stage, and counting was monitored and controlled by QC checks. A subset of the samples were randomly selected for re-identification by a quality control inspector according to a "10% AOQL" continuous sampling plan. This insured that at least 90% of the samples met specifications, because if any samples failed QC checks, data from those samples were corrected and the proportion of samples checked was increased. A sample failed identification QC if the original identifier's count differed from the QC inspector's count by 10% or more (or by more than two if the QC total was 20 or less). This acceptance criterion was applied separately by life stage to each taxon. An additional requirement for a sample to pass was that for each taxon, the sum of the percent errors for all life stages was required to be less than 10%.

RESULTS

Physical Profiles of Water Column

Water temperature, dissolved oxygen, and salinity were similar among the three stations (Table 2, Figures 2-4). Water temperature ranged from 5.9-10.0 °C, dissolved oxygen from 8.9-10.6 mg/l, and salinity 23.4-25.4 ‰. At all three stations, a slight (4°C) thermocline was apparent from the surface to about 60 ft. From about 60 ft to the bottom (about 95 ft.) the water was isothermal and about 6 °C. A spring zooplankton bloom that was observed in the March samples was still apparent during sampling on April 18. The zooplankton was primarily composed of the copepod *Temora longicornis* and to a lesser extent *Acartia hudsonica*.

Total Species Composition

Overall ichthyoplankton diversity was low. Fourbeard rockling (*Enchelyopus cimbrius*) eggs were abundant and comprised over 99% of all eggs collected on April 18, 2006 (Table 3). Windowpane (*Scophthalmus aquosus*) was the only other fish egg collected. Fourbeard rockling (*Enchelyopus cimbrius*), American sand lance (*Ammodytes americanus*), winter flounder (*Pseudopleuronectes americanus*), rock gunnel (*Pholis gunnellus*), and Atlantic seasnail (*Liparis atlanticus*) were the only fish larvae collected during sampling on April 28, 2006 (Table 3). Fourbeard rockling were the most abundant larvae and accounted for 53% of the total. Approximately 76% of the 315 fourbeard rockling larvae collected were in the yolk-sac stage. American sand lance were the next most abundant larvae taxa and they accounted for 28% of the total, all were in the post yolk-sac stage. Winter flounder larvae accounted for about 18 % of the total. Over 96% of the winter flounder larvae collected were in the post yolk-sac stage, but did not yet show signs of fin ray development or notochord flexion. It is possible that smaller yolk sac stage winter flounder larvae were present and undersampled due to net extrusion (NUSCO 2005). Rock gunnel and Atlantic seasnail larvae were collected in low concentrations and each accounted for < 1.0 % of the total number of larvae collected. No young of the year fish were collected.

Many aspects of the morphology and ecology of *Ammodytes* spp. along the east coast of the United States are potentially confounded by taxonomic problems differentiating between the American or inshore sand lance (*A. americanus*) and the offshore sand lance *A. dubius* (Nizinski et al. 1990). Because most estuarine collections of *Ammodytes* are *A. americanus* (Able and Fahay 1998) and *A. americanus* predominates in Long Island Sound (Monteleone et al. 1987), *Ammodytes* larvae were assumed to be *A. americanus*.

Ichthyoplankton Density Across Diel Period and Depth Strata

A two-way ANOVA on log (x+1) transformed egg density (#/100m^3) did not detect a significant difference between the two diel periods, however there was a significant ($p < 0.001$) difference between the three depth strata. Multiple range comparisons (Tukey's Studentized Range Test) revealed that egg density was significantly ($p < 0.05$) higher in the surface collections, and significantly lower in the near bottom collections with intermediate density in the mid-depth strata and this pattern was consistent during day and night collections (Table 4, Figure 5a) at all three stations (Tables 6,7).

A two-way ANOVA on log (x+1) transformed larvae (yolk sac+post yolk sac stages) density did not detect a significant difference between depth strata or diel period. Larval fish distribution during sampling on April 18, 2006 was explored further for abundant species (fourbeard rockling, winter flounder, American sand lance) which together comprised nearly 99% of larvae collected. A one way ANOVA was used to evaluate differences in density of fourbeard rockling across the three depth strata during daytime and also during nighttime sampling. Although fourbeard rockling appear to be more concentrated in the surface and mid-depth strata during daytime (Table 5, Figure 5b), this difference was not statistically significant. However, during nighttime collections, fourbeard rockling larvae density was significantly ($p < 0.01$) higher in the surface than in the mid-depth or near bottom strata (Table 5, Figure 5b). Winter flounder larvae were not collected in the surface or mid-depth tows during daytime samples, they were collected in near bottom tows (Table 5, Figure 5b). However, there was no significant difference in winter flounder larvae density between the three depth strata during daytime samples. At night, winter flounder were collected in significantly higher densities in the surface strata than in the mid-depth and deep strata. No winter flounder larvae were collected in the mid-depth strata during day or night collections on April 18, 2006. Sand lance larvae were more abundant at night (two way ANOVA, $p < .01$), however there was no significant difference between the three depth strata within each diel period.

Ichthyoplankon Community Similarity Across Diel Period and Depth Strata

Community similarity between the two diel periods and three depth strata was evaluated through ordination using non-metric multidimensional scaling (NMDS). Analysis was based on the Bray-Curtis similarity index generated from all pairwise sample comparisons on 4^{th} root transformed egg and larval (yolk-sac + post yolk-sac stages) densities. Like all multivariate techniques, NMDS is based on a similarity coefficient matrix calculated between every pair of samples. The Bray-Curtis similarity values were then transformed to ranks (the highest similarity between a pair of sites has the lowest rank, 1, and the lowest similarity has the highest rank, $(n(n-1)/2)$. NMDS then constructs a "map" or configuration of the samples. The NMDS map is constructed to preserve the similarity ranking as Euclidean distances on the two dimensional plot and attempts to satisfy all conditions imposed by the rank similarity matrix, e.g. if sample 1 has higher similarity to sample 2 than it does to sample 3 then sample 1 will be placed closer on the map to sample 2 than it is to 3. The principle of the NMDS algorithm is to choose a configuration of points which minimize the degree of *stress* or distortion between the similarity rankings and the corresponding distance rankings in the ordination plot. The stress value provides a "goodness of fit" measure, in general, stress < 0.05 gives an excellent representation with no prospect of misinterpretation, stress < 0.1 corresponds to a good ordination with no real prospect of a misleading interpretation, and stress < 0.2 still gives a potentially useful 2-dimensional picture, though for values at the upper end of this range too much reliance should not be placed on the detail of the plot (Clarke and Warwick 1994). NMDS is based on rank order about which samples are most or least similar, axes are non-metric and the ordination plot can say nothing about which direction is "up" or "down", or the absolute "distance apart" of two samples, what can be interpreted is relative distances apart (Clarke and Warwick 1994). NMDS can be recommended as one of the best (arguably the best) ordination technique available (Everitt 1978, Clarke and Warwick 1994). The few comprehensive studies that have compared ordination methods for community data give NMDS a high rating (Kenkel and Orloci 1986).

Because > 99% of the eggs collected on April 18, 2006 were fourbeard rockling, the NMDS analysis was primarily influenced by differences in abundance in fourbeard rockling eggs. It is apparent from Figure 5a that fourbeard rockling eggs were not evenly distributed throughout the water column and were more concentrated in the surface collections during both diel periods. This is apparent in the NMDS ordination plot (Figure 6) where the surface tows form a distinct cluster with two of the mid-depth, daytime tows.

The larval fish community also had low diversity (5 taxa) and was dominated by fourbeard rockling, sand lance, and winter flounder. There are not any obvious clusters in community similarity between the samples (Figure 7), although a weak distinction is apparent between the daytime and nighttime tows. This is likely primarily driven by sand lance larvae which were rare in the daytime collections and relatively abundant at night (Figure 5b, Table 5).

Entrainment Estimates Based on Ichthyoplankton Densities Collected on April 18, 2006

The average density (#/m^3) for eggs and larvae collected from the mid-depth strata on April 18, 2006 during daytime sampling (n=3) and during nighttime sampling (n=3) was multiplied by the average daily water intake of the FSRU and associated LNG carriers (106,750 m^3/day, 28.2 million gallons/day) to estimate daily entrainment rates for species and life stage (Table 9) because water intake locations are located 35-45 feet below the water's surface. It was assumed that the mid-depth strata is most representative of the FSRU intake for entrainment estimates because the water withdrawl zone has not been defined by hydrodynamic modeling. The patchy distribution of ichthyoplankton resulted in a relatively high variance between the samples and wide confidence intervals for the entrainment estimates. Three species of fish larvae (sand lance, fourbeard rockling, rock gunnel) and one egg taxa (fourbeard rockling) were collected from the mid-depth strata on April 18, 2006. Fourbeard rockling eggs were the dominant ichthyoplankton and the daily entrainment estimate based on mean density in the mid-depth strata from collections on April 18, 2006 was about 110,000 (Table 9). Fourbeard rockling and sand lance were the most abundant larvae with daily entrainment estimates of about 7,000 and 2,500 respectively. Rock gunnel larvae were collected in relatively low density and their daily entrainment estimate is about 200.

Entrainment estimates from Table 9 were expressed in terms of Age 1 fish using the Equivalent Adult Model. The Equivalent Adult Model (EAM) is an estimation method for expressing ichthyoplankton entrainment losses as an equivalent number of individuals at some other common life stage, referred to as the age of equivalency (Goodyear 1978). The method provides a convenient means of converting estimated losses of fish eggs and larvae into units of individual fish and provides a standard metric for comparing losses among species, years, and facilities (EPA 2004). The age of equivalency can be any life stage of interest. For the 316 (b) cooling water intake case studies, EPA (2004) expressed impingement and entrainment losses as an equivalent number of Age 1 individuals (the Age 1 fish considered in this analysis are typically less than 6 inches in length).

The EAM calculation requires life-stage specific entrainment counts and life-stage specific mortality rates from the life stage of entrainment to the life stage of equivalence. The losses at any given stage are multiplied by the fraction of fish at that stage or age that would be expected to survive to the age of equivalence:

$$EA = S_A N$$

Where: EA = equivalent age 1 loss, N= number of fish lost due to entrainment, S_A= fraction of fish expected to survive from the age at which they are entrained to the age of equivalence.

Survival rates of early life stages of fish are often expressed on a life-stage specific basis so that the fraction surviving from any particular life stage to the age of equivalency is expressed as the cumulative product of survival fractions for all of the life stages through which a fish must pass before reaching the age of equivalency. One of the benefits of this model is that it can be used to express losses imposed on different lifestages in common equivalent units.

$$EA = \sum S_{i,a} N_i$$

Where:

N_i= number of fish lost at age i

$S_{i,a}$= fraction of fish expected to survive from age i to the age of equivalence

Instantaneous total mortality (Z) is the sum of mortality from natural causes (M) and mortality from recreational and commercial fishing (F), (Z = M+F). Fishing mortality is zero for Age 1 fish species collected during sampling on April 18, 2006, therefore Z=M. Survival rate (S) is the estimated proportion of a lifestage that survives from the beginning to the end of that stage ($S= e^{-Z}$). It was conservatively assumed that no eggs or larvae survived entrainment and no larvae were able to actively avoid the intake.

The probability that a fish entrained at any given life stage would have survived to the age of equivalence is greater if the fish is near the end of that stage than if it at the beginning of the stage, because it would have already survived most of the natural mortality that occurs during that stage. Therefore, to find the expected survival rate from the day that a fish is entrained until the time that it would have passed into the subsequent age, an adjustment to S_i is required. The adjusted rate S^*_i describes the effective survival rate for the group of fish entrained at stage i considering the fact that the individual fish were entrained at various ages within stage i. This adjustment is applied only to the stage at which entrainment occurs, the unadjusted survival rate would be applied to subsequent lifestages until the age of equivalency (Age 1).

$S^*_i = 2S_i e^{-\ln(1+S_i)}$ (EPRI 2003, EPA 2004)

Lifestage specific mortality rates were obtained from EPA (2004) values used to evaluate impingement and entrainment in the Mid-Atlantic (http://www.epa.gov/waterscience/316b/casestudy/final/appd1.pdf) and North-Atlantic Region (http://www.epa.gov/waterscience/316b/casestudy/final/appc1.pdf) because location specific mortality rates are not available. The entrainment estimates for fish eggs and larvae in Table 9 were expressed in terms of Age 1 equivalents using the survival rates obtained from EPA (2004) in Table 10. For example, the daily entrainment estimate of 2,365 sand lance larvae is multiplied by the adjusted survival rate for the larval stage (0.10) resulting in an estimated 236 fish expected to survive until the end of the larval stage from the original 2,365 entrained. Of these 236 fish entering the juvenile stage, only 13 would be expected to survive natural mortality during that stage with S= 0.06. Therefore, 13 of the original 2,365 sand lance larvae entrained would be expected to survive to the beginning of Age 1 based on these natural mortality rates.

Five site specific collections to date have been collected and enumerated (August 28, 2005; October 4, 2005; February 8, 2006; March 28, 2006, April 18, 2006). A sixth collection was made on May 24, 2006, however these samples are still being processed in the laboratory. Details of each sampling event can be found in the individual letter reports. Mean ichthyoplankton density in the mid-depth strata was multiplied by the average daily withdrawal to estimate daily entrainment rates as previously discussed.

The daily entrainment rates derived from ichthyoplankton density in the mid-depth collections on each of the five sampling dates are presented in Table 11. Daily entrainment rates were greatest in August (about 80,000 eggs and 680,000 larvae) and lowest in February (about 100 eggs and 10,000 larvae) reflecting seasonal changes in ichthyoplankton density (Figures 8, 9).

Discussion

The ichthyoplankton community in the vicinity of the proposed Broadwater FSRU in the central basin of Long Island Sound during day and night sampling on April 18, 2006 was composed of relatively few species. There is a clear seasonal change in ichthyoplankton community composition between the five site-specific sampling dates from August 2005-April 2006 (Figures 8,9). August samples were composed of a relatively abundant and species rich community dominated by bay anchovy, with significant contributions from searobin, smallmouth flounder, butterfish, and fourspot flounder. In October samples, ichthyoplankton diversity and abundance was greatly reduced and the community was primarily Atlantic menhaden (eggs and larvae) and bay anchovy (larvae). The winter ichthyoplankton community represented by the February samples had low abundance and diversity and was primarily composed of American sand lance larvae. The March collection represents a seasonal transition to the springtime ichthyoplankton community with the appearance of fourbeard rockling eggs, winter flounder larvae and the persistence of sand lance larvae, although overall diversity and larval abundance remain low. The April collections were similar to the March collection in overall species composition and abundance. Egg collections were still dominated by fourbeard rockling. There was a shift in the larval community as fourbeard rockling comprised a significant proportion of the larval catch in April, fourbeard rockling larvae did not occur in the March sample. The majority of the fourbeard rockling larvae collected on April 18 were still in the yolk-sac stage and relatively early in their development. Sand lance larvae density in the April collections was reduced compared to February and March reflecting the development and metamorphosis of this winter spawning species to the juvenile stage.

Egg collections were dominated by fourbeard rockling which were more concentrated in the surface samples in both the day and night collections. In Long Island Sound, Williams (1968) found fourbeard rockling eggs to be strongly stratified with most eggs occurring in the top 5 m of the water column. Fourbeard rockling was the most common egg collected during April in the Central Basin area of Long Island Sound during the 2002 Poletti Program (Normandeau 2006, Table 12). Only two fourbeard rockling eggs were collected during the February 8, 2006 site specific sample suggesting that peak spawning had not yet occurred. Fourbeard rockling eggs were collected in comparable densities during the March 28, 2006 sample, however they were more evenly distributed through the water column than observed during the April 18 collections when they were concentrated in the surface tows (Figure 8). During the Poletti program, fourbeard rockling eggs were present in low density at the start (March 4, 2002) of the program and peaked from mid-March though mid-April (Normandeau 2006). Fourbeard rockling eggs comprised the overwhelming majority of eggs collected from March through mid-May when eggs of summer spawning species emerged in the Poletti collections (Normandeau 2006). Site specific fourbeard rockling egg density collected on April 18, 2006 was less than the observed density during a comparable biweekly survey period (April 15-28, 2002) of the Poletti Program (Table 12). Wheatland (1956) found fourbeard rockling eggs in Long Island Sound from March-June with peak density in April. Fish egg abundance displayed a bi-modal peak during the March-July, 2002 Poletti ichthyoplankton program with a spring peak from mid-March to mid-April dominated by fourbeard rockling and a peak in June dominated by tautog, searobin, weakfish/scup, and Atlantic menhaden eggs (Normandeau 2006). Data collected during the April 18, 2006 sample suggests that the overwhelming majority of fish eggs that are likely to be entrained in the proposed FSRU facility in April are fourbeard rockling and that entrainment values are likely lower than would be expected if the intake was located closer to the surface where fourbeard rockling eggs are more concentrated.

Five species of larval fish were collected during sampling on April 18, 2006, fourbeard rockling, American sand lance, and winter flounder comprised nearly 99% of the total. Fourbeard rockling were the most abundant larvae and most (76%) were in the yolk-sac stage of development. No fourbeard rockling larvae were collected in the March 28, 2006 samples. In the 2002 Poletti Ichthyoplankton Program data subset to represent the Broadwater study area, fourbeard rockling larvae were collected from April through June with a peak in mid to late May and sharp decline in abundance during June. Fourbeard rockling larvae density during the site specific April 18, 2006 collections was higher than the observed density during a comparable biweekly survey period (April 15-28, 2002) of the Poletti Program (Table 12). Fourbeard rockling larvae are typically found at the surface and show no evidence of vertical migration (Hermes 1985).

Density of American sand lance larvae in collections on April 18, 2006 was lower than observed during collections in February and March, 2006. All sand lance larvae were in the post yolk sac stage and are likely approaching juvenile metamorphosis. Sand lance larvae were uniformly distributed between the three depth strata and were more abundant at night. This is likely partially due to greater gear avoidance ability with more advanced development and swimming capability. Sand lance have a long spawning season, typically from November through March in Long Island Sound (Wheatland 1956, Monteleone et al. 1987). Incubation, hatch and larval duration and are particularly long for this species. Smigielski et al. (1984) incubated eggs in the laboratory at a range of temperatures (2, 4, 7, and 10 °C). Start of hatching ranged from 61 days (2 °C) to 25 days (10 °C) after fertilization. Larval collections in Long Island Sound indicate that sand lance hatching commences sometime in late November-early December, peaks from December through February when they are the dominant larval fish collected, and continues into March and April (Wheatland 1956). Monteleone et al. (1987) presented 17 years of data of American sand lance larvae in Long Island Sound collected over a 32 year interval and found approximately 94% of the annual catch of sand lance larvae occurred from December to March with reduced densities occurring April. In the 2002 Poletti Program, sand lance larvae abundance was also reduced in April and they were not collected past mid-May. Sand lance larvae density during the site specific April 18, 2006 collections was similar to that observed during a comparable biweekly survey period (April 15-28, 2002) of the Poletti Program (Table 12).

Bourne and Govoni (1988) found winter flounder larvae to be most common in shoal water, in or near coves and small bays and rare in deeper waters in Narragansett Bay. Winter flounder larvae are planktonic and although many remain near the shallow, estuarine spawning grounds, others are carried into coastal waters by tidal currents (Smith et al. 1975). Pearcy (1962) found larvae most common from March to June in the Mystic River estuary and they were typically more abundant near the bottom. In the 2002 Poletti Ichthyoplankton Program, winter flounder were relatively evenly distributed in the Central Basin area between the three sampling strata and two gear types, although the greatest proportion of the catch did occur in the shallow, epibenthic sled samples (Normandeau 2006). In the 2002 Poletti Ichthyoplankton Program data subset to represent the location of the proposed FSRU facility's intake, density of larval winter flounder peaked during survey 2 (March 18-March 31), they were collected until early June in lower densities. Larval winter flounder density observed during the site specific April 18, 2006 collections was lower than densities observed during a comparable biweekly survey period (April 15-28, 2002) of the Poletti Program (Table 12). No winter flounder larvae were collected in the mid-depth strata during sampling on April 18, 2006. During daytime collections, winter flounder larvae appear to be more concentrated on the bottom, as was also observed by NUSCO (2005). During nighttime collections, winter flounder larvae were more concentrated in the surface collections. Data from the April 18, 2006 collections suggest that winter flounder larvae prefer deeper water during the day and surface water at night, and therefore may be exposed to water intake at the FSRU facility (35-45 ft. below surface) during limited periods of diel vertical migration between the surface and bottom.

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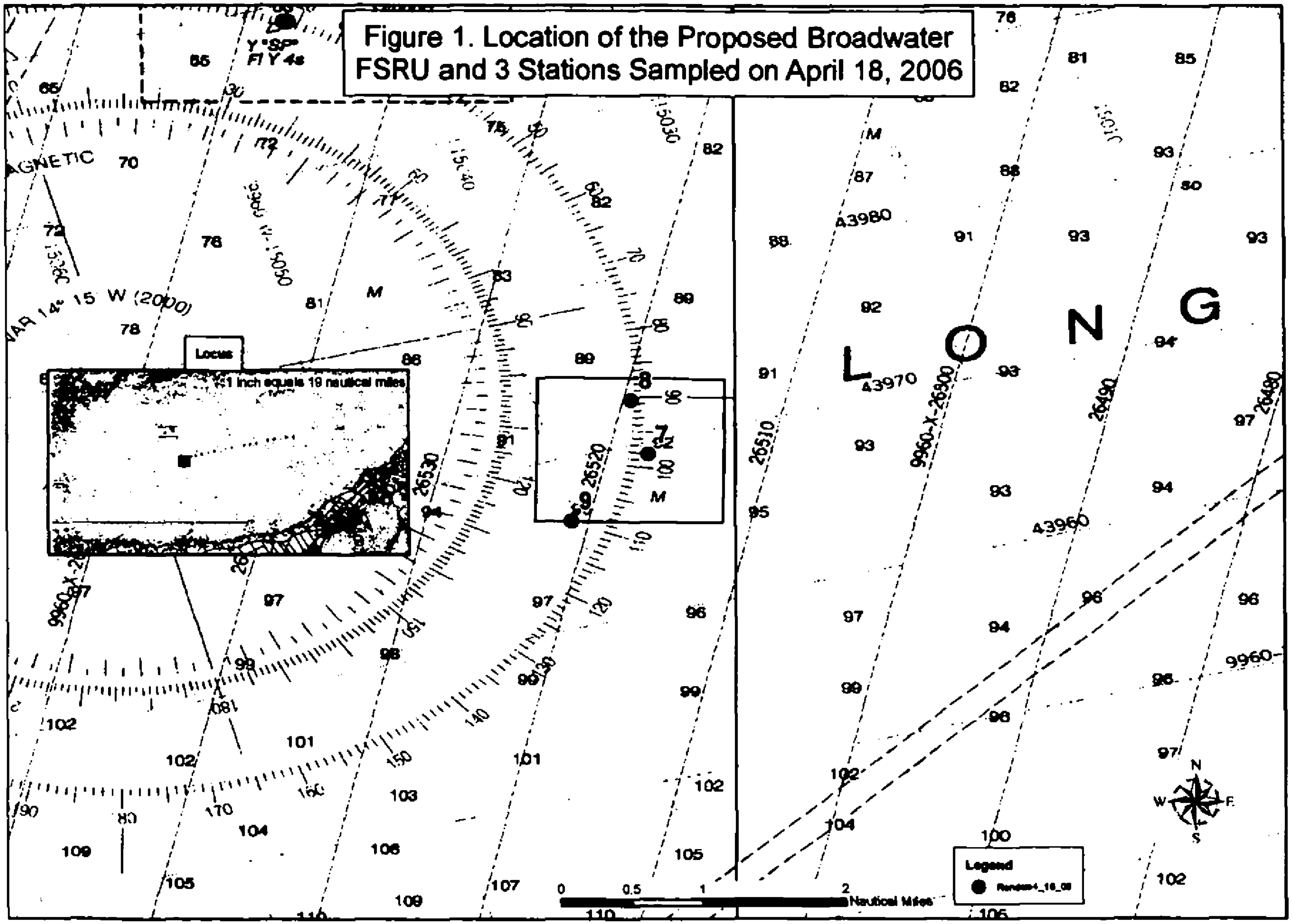

Figure 1. Three random sampling locations within a 1 nautical mile square block centered on the location of the proposed Broadwater FSRU sampled on April 18, 2006.

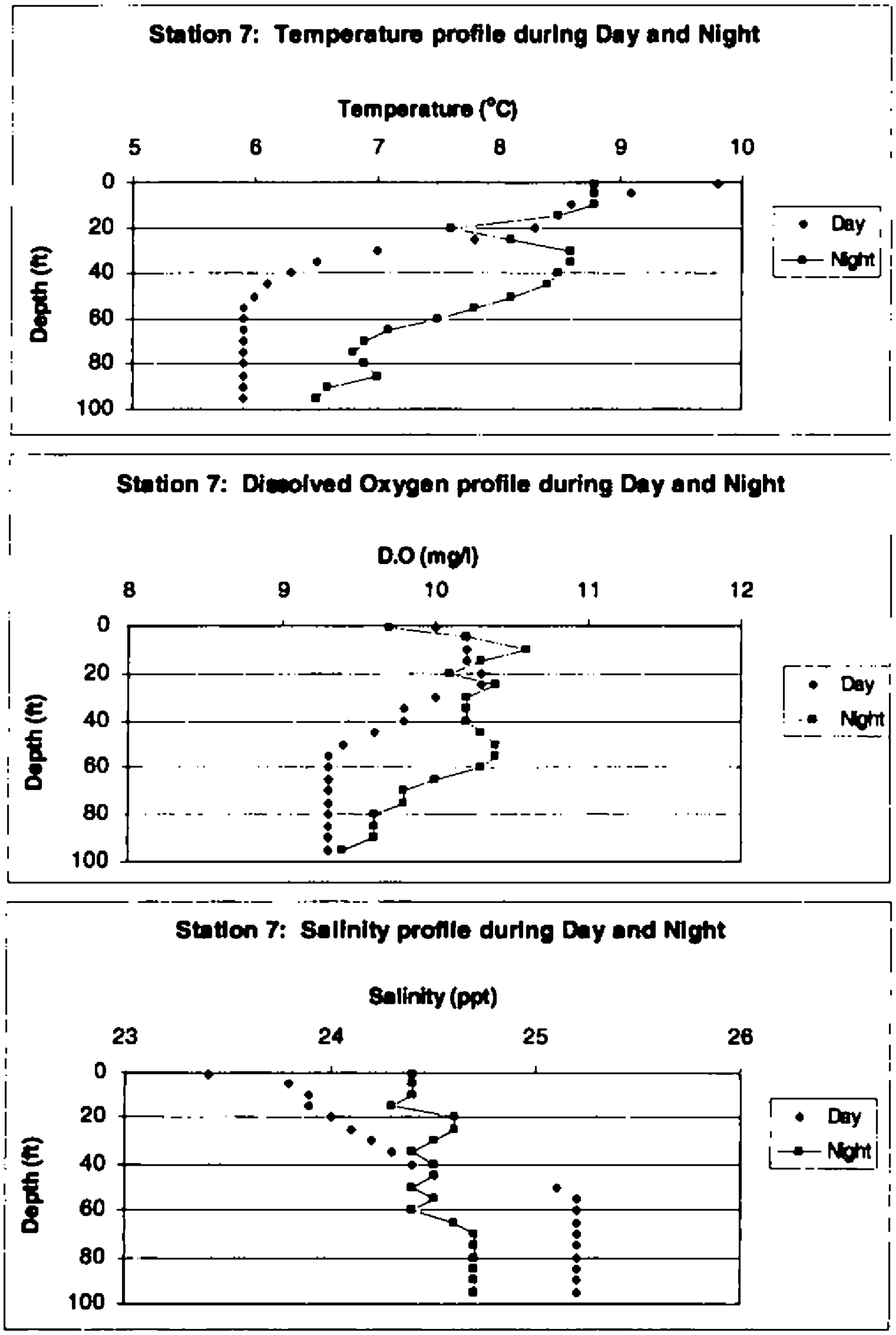

Figure 2. Physical profile (temperature, dissolved oxygen, and salinity) of the water column during Day and Night sampling at Station 7 on April 18, 2006.

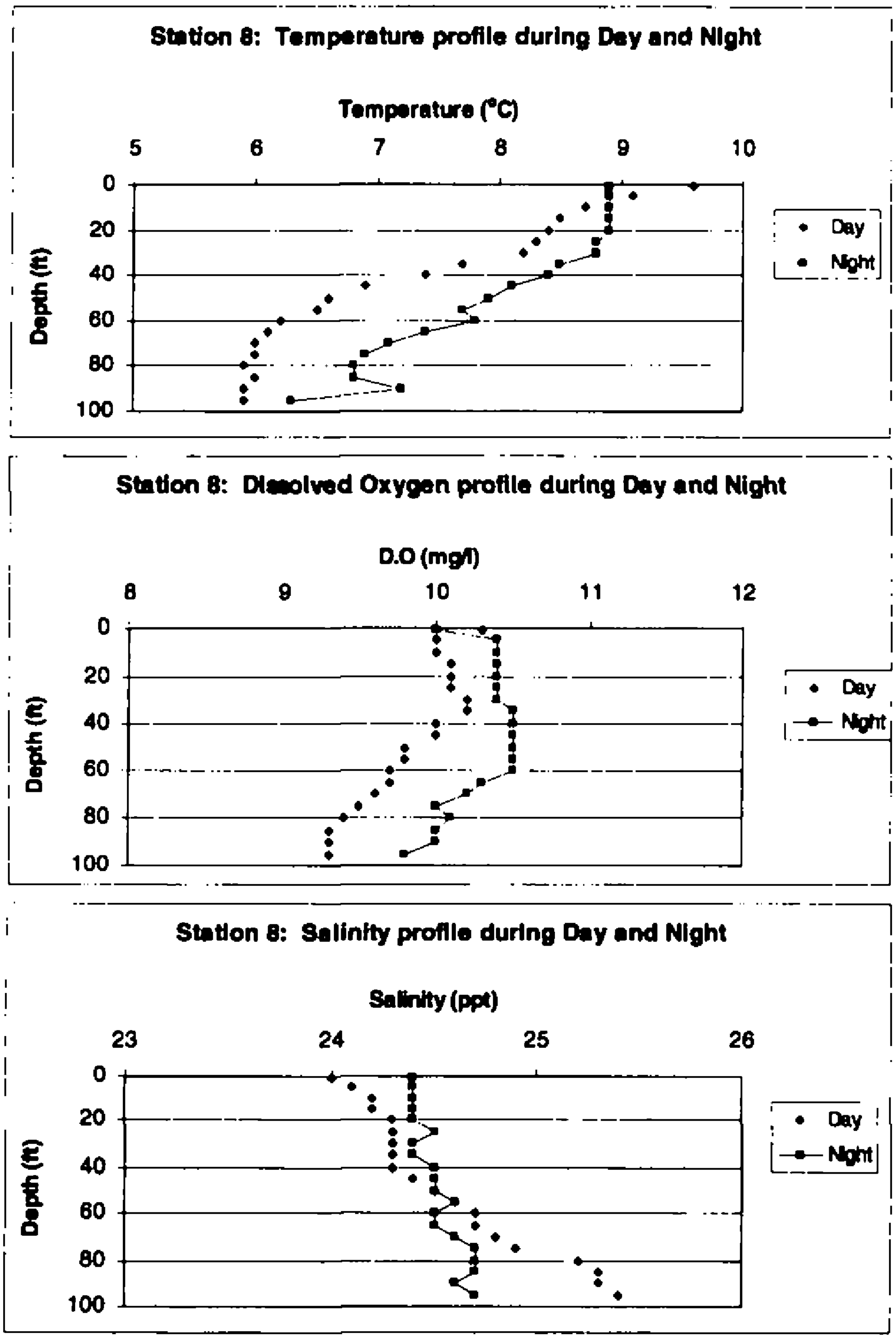

Figure 3. Physical profile (temperature, dissolved oxygen, and salinity) of the water column during Day and Night sampling at Station 8 on April 18, 2006.

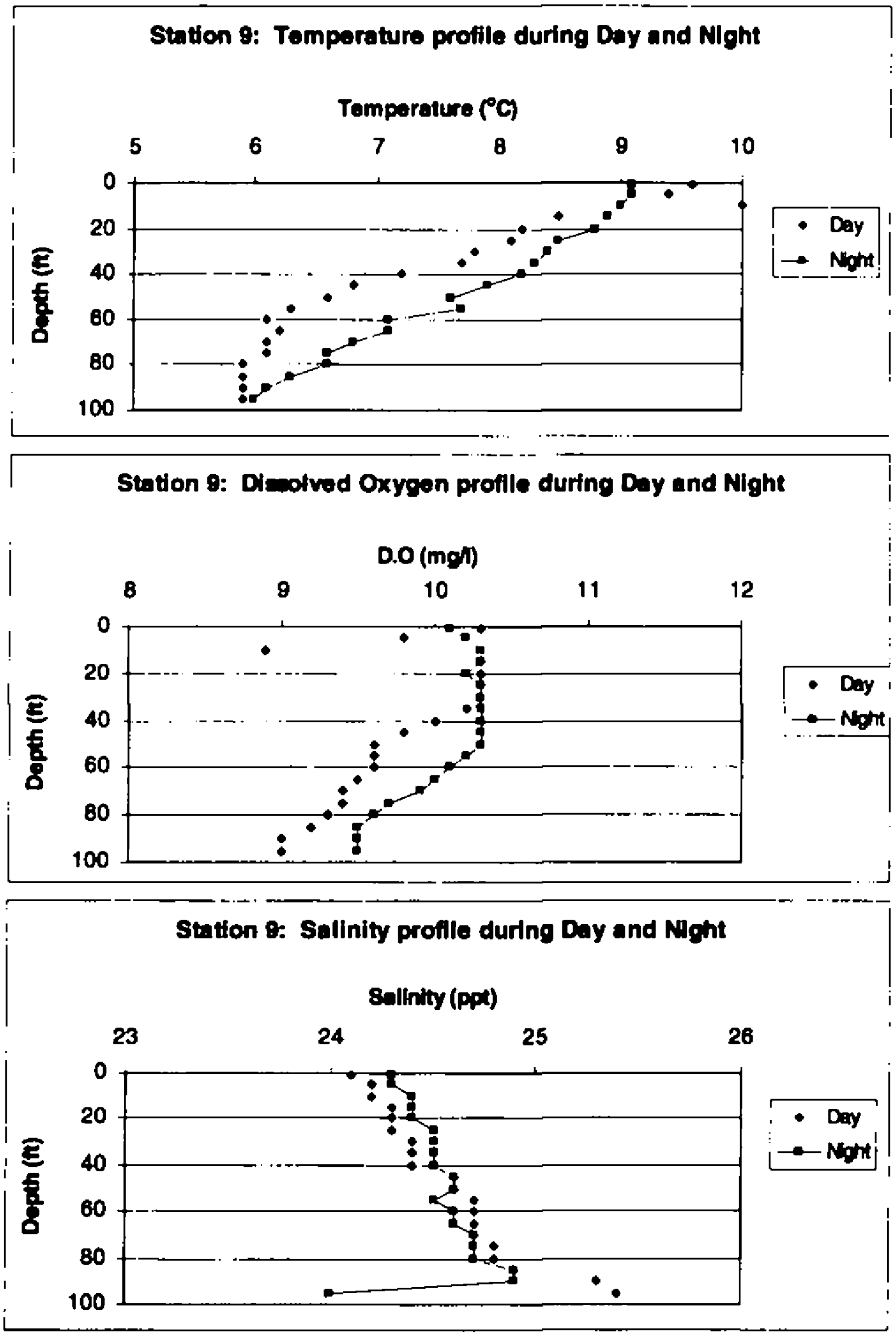

Figure 4. Physical profile (temperature, dissolved oxygen, and salinity) of the water column during Day and Night sampling at Station 9 on April 18, 2006.

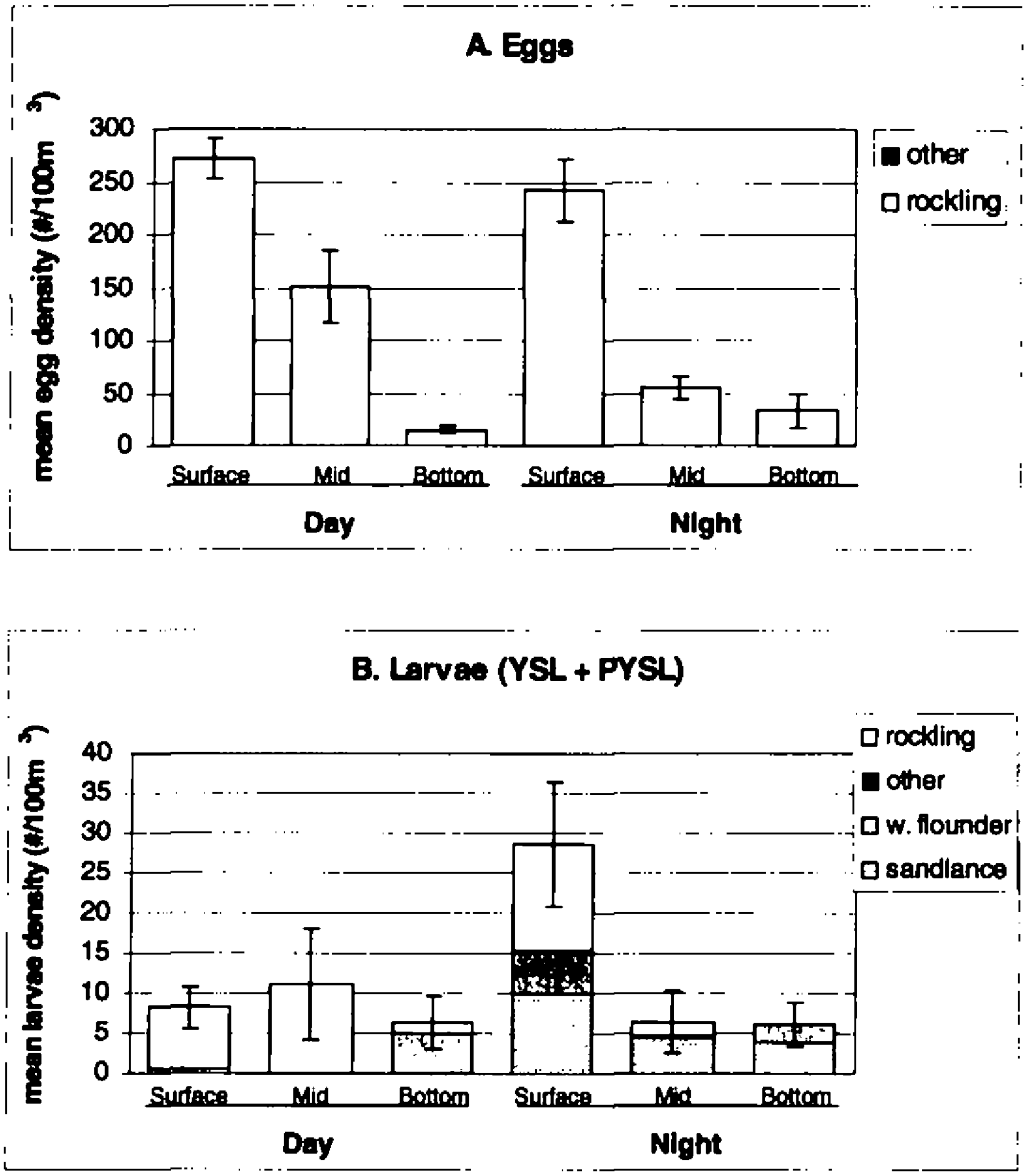

Figure 5. Mean (A) Egg and (B) larvae (PYSL+YSL) density (#/100m^3) ± standard error from the three replicate tows conducted at the surface (0-30 ft), mid-depth (35-65 ft) and bottom (70-95 ft) strata during daytime and nighttime sampling in the vicinity of the proposed FSRU facility on April 18, 2006.

BROADWATER ICHTHYOPLANKTON - EGGS - 18APR06

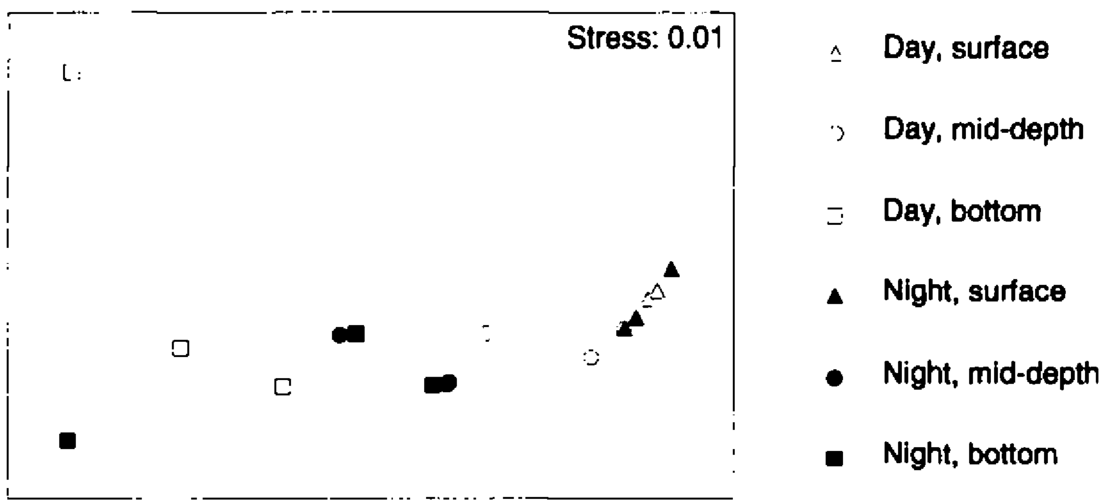

Figure 6. Non-metric multidimensional scaling ordination of 18 (3 replicate stations, 2 diel periods, 3 depth strata) samples collected on April 18, 2006 for 4[th] root transformed fish egg density (#/100m^3) based on Bray-Curtis similarities.

BROADWATER ICHTHYOPLANKTON - LARVAE - 18APR06

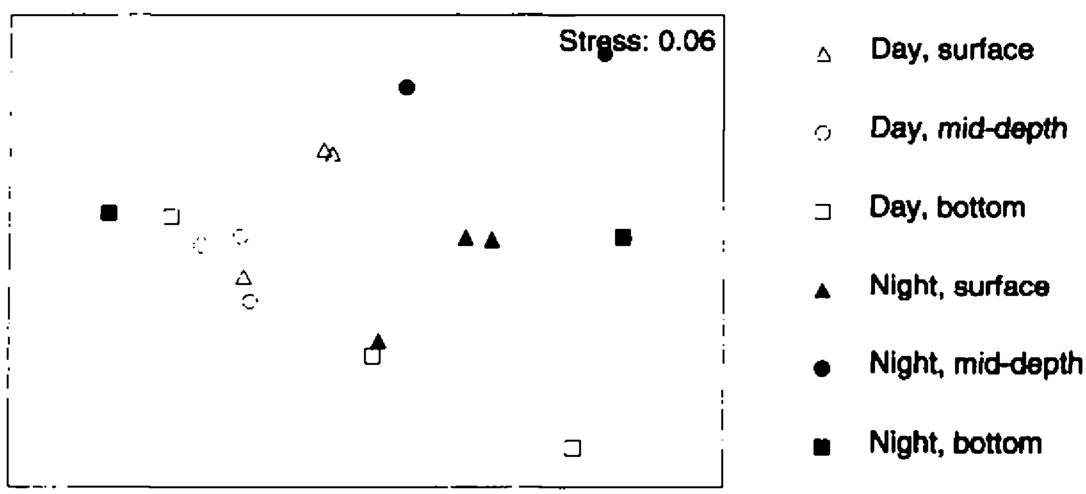

Figure 7. Non-metric multidimensional scaling ordination of 18 (3 replicate stations, 2 diel periods, 3 depth strata) samples collected on April 18, 2006 for 4[th] root transformed fish larvae density (#/100m^3) based on Bray-Curtis similarities.

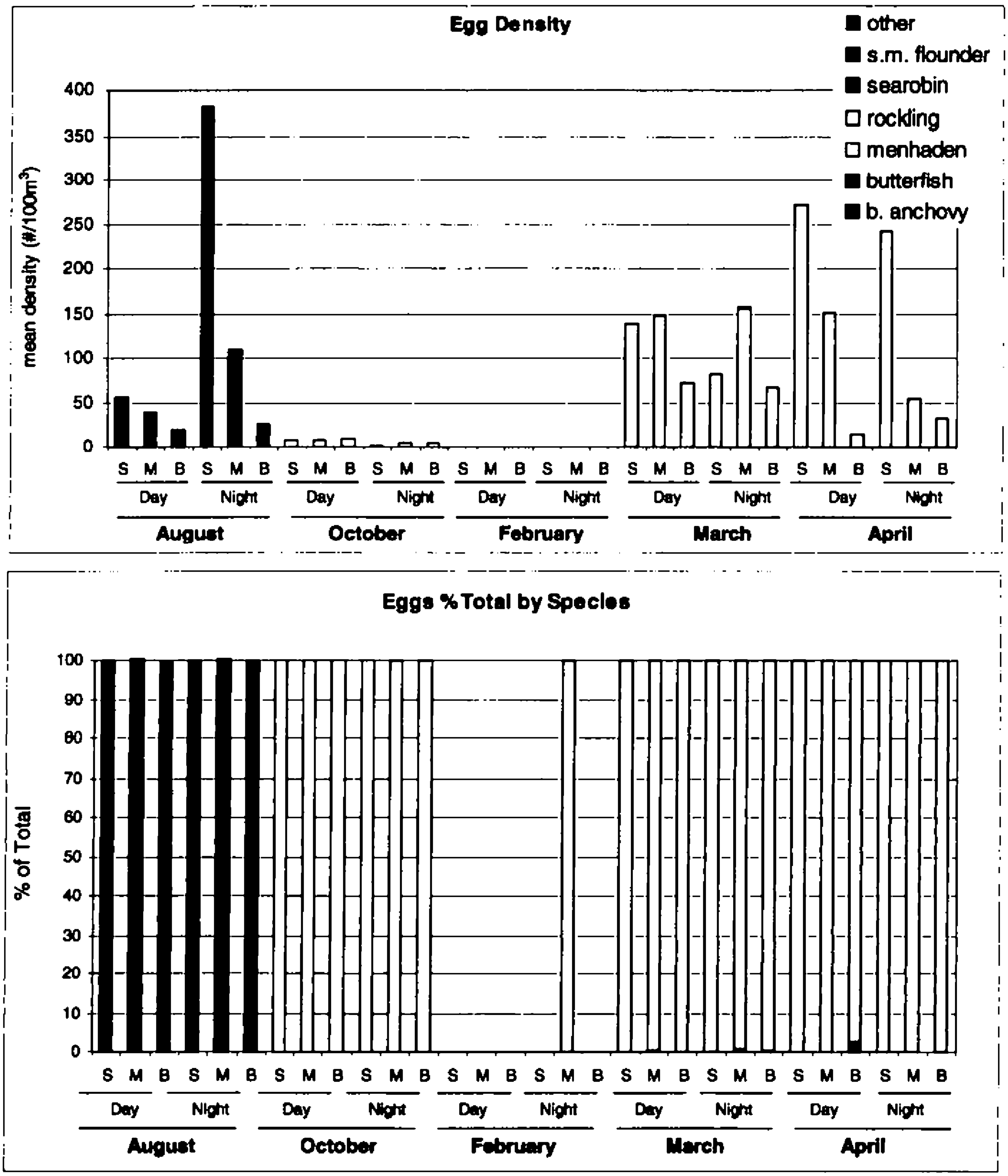

Figure 8. Fish egg density (upper) and percent species composition (lower) in each diel/depth (S= surface, M= mid-depth, B= bottom) strata during site specific collections at the proposed FSRU facility on August 28, 2005, October 4, 2005, February 8, 2006, March 28, 2006, and April 18, 2006.

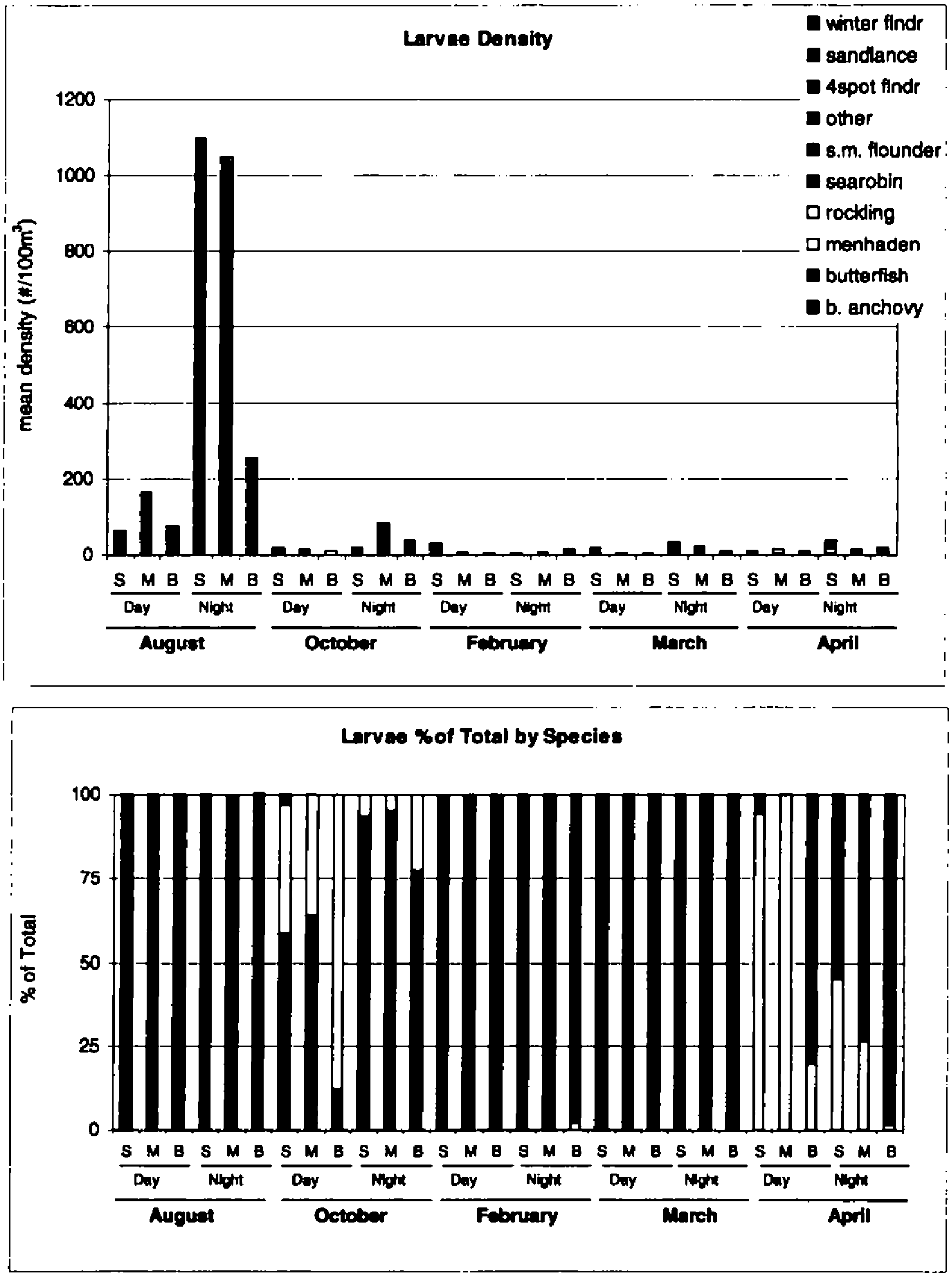

Figure 9. Larval fish density (upper) and percent species composition (lower) in each diel/depth (S= surface, M= mid- depth, B= bottom) strata during site specific collections at the proposed FSRU facility on August 28, 2005, October 4, 2005, February 8, 2006, March 28, 2006, and April 18, 2006.

Table 1. Sample allocation, sample depths and volume of water sampled (m^3) among the three random stations, three depth strata, and two diel periods sampled in the vicinity of the proposed Broadwater FSRU facility on April 18, 2006.

Station	Depth Strata	Sample Depth (ft.)	Diel Period	Volume Sampled
7	Surface	20	Day	317.9
	Mid-depth	48		322.3
	Bottom	86		297.8
	Surface	20	Night	219.6
	Mid-depth	47		265.7
	Bottom	84		315.1
8	Surface	20	Day	281.1
	Mid-depth	47		382.1
	Bottom	84		327.1
	Surface	20	Night	307.6
	Mid-depth	47		329.9
	Bottom	84		282.1
9	Surface	20	Day	297.9
	Mid-depth	49		305.2
	Bottom	88		317.5
	Surface	20	Night	269.7
	Mid-depth	47		295.7
	Bottom	84		252.3

Table 2. Temperature, dissolved oxygen, and salinity at the three stations during day and night sampling in the vicinity of the proposed Broadwater FSRU on April 18, 2006.

	Temperature (°C)				Dissolved Oxygen (mg/l)				Salinity (‰)			
	min	max	mean	stdev.	min	max	mean	stdev.	min	max	mean	stdev.
Station 7												
Day	5.9	9.8	6.9	1.3	9.3	10.3	9.7	0.4	23.4	25.2	24.6	0.6
Night	6.5	8.8	7.8	0.8	9.4	10.6	10.1	0.3	24.3	24.7	24.5	0.1
Station 8												
Day	5.9	9.6	7.2	1.3	9.3	10.3	9.8	0.3	24.0	25.4	24.6	0.4
Night	6.3	8.9	8.0	0.9	9.8	10.5	10.3	0.2	24.4	24.7	24.5	0.1
Station 9												
Day	5.9	10.0	7.2	1.4	8.9	10.3	9.7	0.5	24.1	25.4	24.6	0.3
Night	6.0	9.1	7.7	1.1	9.5	10.3	10.0	0.3	24.0	24.9	24.5	0.2

Table 3. Number of fish eggs, larvae (yolk-sac + post yolk-sac stages) and young of the year (YOY) and the percent contribution to the total catch by species in the 18 ichthyoplankton tows conducted in the vicinity of the proposed Broadwater FSRU on April 18, 2006.

Common Name	Scientific Name	# Eggs	% Total Eggs	# YSL	# PYSL	# Larvae	% Total Larvae	# YOY	% Total YOY
Fourbeard rockling	*Enchelyopus cimbrius*	6884	99.94	240	75	315	53.12		
American sand lance	*Ammodytes americanus*				164	164	27.66		
Winter flounder	*Pseudopleuronectes americanus*			4	102	106	17.88		
Rock gunnel	*Pholis gunnellus*				4	4	0.67		
Windowpane	*Scophthalmus aquosus*	4	0.06						
Atlantic seasnail	*Liparis atlanticus*			4		4	0.67		
TOTAL		6888		248	345	593		0	

Table 4. Mean egg density (#/100m³) and percent of the total catch for each species collected in the three replicate samples in each diel period and depth strata in the vicinity of the proposed Broadwater FSRU on April 18, 2006.

	Day						Night					
	Depth Strata						Depth Strata					
	Surface		Mid-depth		Bottom		Surface		Mid-depth		Bottom	
Fish Eggs	# per 100m³	% Total	# per 100m³	% Total	# per 100m³	% Total	# per 100m³	% Total	# per 100m³	% Total	# per 100m³	% Total
Fourbeard rockling	272.88	100.00	151.13	100.00	15.26	97.30	242.25	100.00	54.91	100.00	33.37	100.00
Windowpane	0.00	0.00	0.00	0.00	0.41	2.70	0.00	0.00	0.90	0.57	0.00	0.00
Total	272.88	100.00	151.13	100.00	15.66	100.00	242.25	100.00	54.91	100.00	33.37	100.00

Table 5. Mean larvae (yolk sac + post yolk sac stage) density (#/100m³) and percent of the total catch for each species collected in the three replicate samples in each diel period and depth strata in the vicinity of the proposed Broadwater FSRU on April 18, 2006.

	Day						Night					
	Depth Strata						Depth Strata					
	Surface		Mid-depth		Bottom		Surface		Mid-depth		Bottom	
Species	# per 100 m³	% Total	# per 100 m³	% Total	# per 100 m³	% Total	# per 100 m³	% Total	# per 100 m³	% Total	# per 100 m³	% Total
American sandlance	0.45	5.41	0.00	0.00	0.00	0.00	9.96	35.59	4.43	66.67	4.01	65.45
Atlantic seasnail	0.00	0.00	0.00	0.00	0.00	0.00	0.43	1.69	0.00	0.00	0.00	0.00
Fourbeard rockling	7.84	94.59	11.22	100.00	1.26	20.00	13.30	45.76	1.62	26.67	0.13	1.82
Rock gunnel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40	6.67	0.00	0.00
Winter flounder	0.00	0.00	0.00	0.00	5.01	80.00	4.98	16.95	0.00	0.00	2.00	32.73
Total	8.29	100.00	11.22	100.00	6.28	100.00	28.67	100.00	6.45	100.00	6.14	100.00

Table 6. Egg, yolk-sac larvae (YSL) and post yolk-sac larvae (PYSL) densities (#/100m³) at the three randomly selected sampling stations and three depth strata during daytime sampling in the vicinity of the proposed Broadwater FSRU on April 18, 2006.

Daytime Survey		Station 7			Station 8			Station 9		
		Surface	Mid-depth	Bottom	Surface	Mid-depth	Bottom	Surface	Mid-depth	Bottom
American sandlance	PYSL	0.63			0.71					
Fourbeard rockling	Egg	309.85	85.63	12.09	248.31	163.31	11.01	260.49	204.46	22.68
	YSL	2.20	1.24	1.34	4.27	6.28	2.45	6.71	18.35	
	PYSL	2.20	1.24		1.42			6.71	6.55	
Windowpane	Egg						1.22			
Winter flounder	PYSL						2.45			12.60

Table 7. Egg, yolk-sac larvae (YSL), and post yolk-sac larvae (PYSL) densities (#/100m³) at the three randomly selected sampling stations and three depth strata during nighttime sampling in the vicinity of the proposed Broadwater FSRU on April 18, 2006.

Nighttime Survey		Station 7			Station 8			Station 9		
		Surface	Mid-depth	Bottom	Surface	Mid-depth	Bottom	Surface	Mid-depth	Bottom
American sandlance	PYSL		6.02	6.35	9.10	7.27	5.67	20.76		
Atlantic seasnail	YSL				1.30					
Four bearded rockling	Egg	220.40	33.12	36.81	301.69	66.69	58.14	204.67	64.93	5.15
	YSL	9.11			6.50	4.85		17.80		0.40
	PYSL				6.50					
Rock gunnel	PYSL					1.21				
Winter flounder	YSL							1.48		
	PYSL	5.46		3.17	6.50		2.84	1.48		

Table 8. **Species richness (# species identified to at least genus level in a sample), Shannon-Wiener diversity index (H'), and density (#/100m³) of eggs and larvae (yolk-sac + post yolk-sac stage) at the three random sampling stations, three depth strata, and two diel periods sampled in the vicinity of the proposed Broadwater FSRU on April 18, 2006.**

Station	Depth Strata	Diel Period	Species Richness		Diversity (H')		Density (#/100m³)	
			Eggs	Larvae	Eggs	Larvae	Eggs	Larvae
7	Surface	Day	1	2	0.00	0.54	309.85	5.03
	Mid-depth		1	1	0.00	0.00	85.63	2.48
	Bottom		1	1	0.00	0.00	12.09	1.34
	Surface	Night	1	2	0.00	0.66	220.40	14.57
	Mid-depth		1	1	0.00	0.00	33.12	6.02
	Bottom		1	2	0.00	0.64	36.81	9.52
8	Surface	Day	1	2	0.00	0.35	248.31	6.40
	Mid-depth		1	1	0.00	0.00	163.31	6.28
	Bottom		2	2	0.33	0.69	12.23	4.89
	Surface	Night	1	4	0.00	1.19	301.69	29.91
	Mid-depth		1	3	0.00	0.92	66.69	13.34
	Bottom		1	2	0.00	0.64	58.14	8.51
9	Surface	Day	1	1	0.00	0.00	260.49	13.43
	Mid-depth		1	1	0.00	0.00	204.46	24.90
	Bottom		1	1	0.00	0.00	22.68	12.60
	Surface	Night	1	3	0.00	0.90	204.67	41.53
	Mid-depth		1	0	0.00		64.93	0.00
	Bottom		1	1	0.00	0.00	5.15	0.40

Table 9. Average density (#/100m^3) of fish larvae collected during day (n=3) and night (n=3) tows from the mid-depth strata in the vicinity of the proposed Broadwater FSRU on April 18, 2006. Daily entrainment estimates were determined by multiplying the average density by the average daily withdrawal by the FSRU and associated LNG carriers (28.2 MGD, 106,750 m^3/day).

Species	Stage	Average Density (#/100m^3)	Daily Entrainment Estimate	95 % Confidence Intervals
American sand lance	PYSL	2.22	2,365	1,160-3,569
Fourbeard rockling	Egg	103.02	109,977	89,908-133,047
	YSL	5.12	5,466	3,030-7,901
	PYSL	1.30	1,386	472-2300
rock gunnel	PYSL	0.20	215	43-388

Table 10. **Lifestage specific mortality rates used by EPA (2004) to calculate daily Age-1 equivalent estimates lost to entrainment in the FSRU facility from samples collected in the mid-depth strata on April 18, 2006. Instantaneous Total Mortality (Z) is the sum of Natural Mortality (M) and Fishing Mortality (F), (Z=M+F). Survival rate (S) is the estimated proportion of a lifestage that survives from the beginning to the end of that stage ($S=e^{-z}$). An adjusted survival rate (S*) was applied to the stage at which entrainment occurs as explained in the text.**

Species	Stage Name	M[a]	F[a]	Z	S	S*	# Entrained/Day	Estimated number entrained/day that would survive			
								Egg to Later Stages	Larvae to Later Stages	Juvenile to Later Stages	Estimated total # Age 1 Entrained
American sandlance	Larvae	2.97	0	2.97	0.05	0.10	2,365		236		
	Juvenile	2.90	0	2.90	0.06		0		13		13
[a] From Table C1-3 in EPA (2004)											
Fourbeard rockling	Eggs	2.30	0	2.30	0.10	0.18	109,977	19,796			
	Larvae	4.25	0	4.25	0.01	0.03	6,852	282	193		
	Juvenile	0.92	0	0.92	0.40		0	113	77		190
[a] From Table C1-17 in EPA (2004)											
Rock gunnel	Larvae	1.66	0	1.66	0.19	0.32	215		69		
	Juvenile	0.92	0	0.92	0.40		0		28		28
[a] From Table C1-26 in EPA (2004)											

Table 11. Summary of daily entrainment estimates collected in the vicinity of the proposed Broadwater FSRU on five sampling dates (August 23, 2005, October 4, 2005, February 8, 2006, March 28, 2006, and April 18, 2006). Entrainment estimates were generated by multiplying average ichthyoplankton density from the six replicate tows (3 day, 3 night) in the mid-depth strata (35-65 feet) by the average daily withdrawal by the FSRU facility (106,750m³).

Species	Stage	Daily Entrainment Estimates				
		23-Aug-05	4-Oct-05	8-Feb-06	28-Mar-06	18-April-06
American sand lance	PYSL			8,444	8,878	2,365
Atlantic mackerel	YSL	356				
	PYSL	4,092				
Atlantic menhaden	Egg		6,245			
	PYSL		5,071			
Bay Anchovy	Egg	47,860				
	YSL	356				
	PYSL	543,358	47,557			
	YOY		1,245			
Black sea bass	PYSL	3,736				
Butterfish	Egg	6,583				
	PYSL	23,485				
Cunner	PYSL	2,135				
Fourbeard rockling	Egg			109	162,054	109,977
	YSL					5,466
	PYSL					1,386
Fourspot flounder	PYSL	13,344				
Grubby	PYSL			59		
Longhorn sculpin	PYSL			109		
Northern Puffer	PYSL	356				
Rock gunnel	PYSL			1,471	475	215
Searobin	Egg	7,650				
	YSL	178				
	PYSL	25,264				
Smallmouth Flounder	Egg	17,080				
	YSL	7,117				
	PYSL	53,019				
Striped Cuskeel	PYSL	4,092				
Unidentified	Egg	356				
	YSL	356				
Weakfish	PYSL	890				
Windowpane	Egg				479	
	PYSL	356				
Winter flounder	YSL				2,368	
	PYSL				2,441	
Yellowtail flounder	Egg				235	
SUM	**Egg**	**79,529**	**6,245**	**109**	**162,768**	**109,977**
	YSL	**8,363**	**0**	**0**	**2,368**	**5,466**
	PYSL	**674,127**	**52,628**	**10,083**	**11,794**	**3,966**

Table 12. Comparison of mean ichthyoplankton density from Poletti Program Survey # 4 (April 15-28, 2002) from the central basin region of Long Island Sound in the Deep (total water depth > 98 ft) and Intermediate (total water depth 6-98 ft) depth strata and the April 18, 2006 site specific collections (daytime, mean of three replicate tows in each of the three depth strata (n=9) ± standard error). Poletti tows were collected during the daytime and sample variance is not available because all samples within a given gear/survey/depth strata were combined in the laboratory to form a composite sample*.

Species	Stage	Density (#/100m^3)		
		Poletti-Deep	Poletti-Intermediate	Broadwater
Fourbeard rockling	eggs	281.0	273.8	146.4 (± 38.9)
	larvae	0.9	2.0	6.8 (± 2.6)
American sandlance	larvae	0.3	0.4	0.2 (± 0.1)
	YOY		0.1	
Winter flounder	larvae	7.3	12.8	1.7 (± 1.4)
Windowpane	eggs		3.6	0.1 (± 0.1)
Bay anchovy	larvae	0.1		
Grubby	larvae	0.8	0.4	
Striped cusk-eel	larvae	0.1		
Gadidae	larvae		<0.1	

* A composite sample was formed from 11 Tucker trawl tows in Regions 7-9 during Poletti Survey # 4 in the Deep depth strata, and from 21 tows in the Intermediate depth strata (see Normandeau 2006 for details).

July 27, 2006
Ref No. 20546.000

Mike Donnelly
Ecology and Environment, Inc.
Buffalo Corporate Center
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RE: Letter Report summarizing the results of ichthyoplankton sampling in the vicinity of the proposed Broadwater FSRU. Sampling event No. 6, May, 2006.

FIELD METHODS

Normandeau Associates, Inc. (Normandeau) conducted ichthyoplankton sampling in the vicinity of the proposed Broadwater Energy floating storage and regasification unit (FSRU) in the Central Basin of Long Island Sound on May 24, 2006. A one by one nautical mile square block centered on the location of the proposed FSRU facility was designated as the sampling area. Three random stations were selected within the sampling area using the Random Point Generator extension in Arcview (Figure 1). At each station the water column was divided into three depth strata based on an assumed depth of about 95 feet: near surface (0-30 feet), mid-depth (35-65 feet), near bottom (bottom, 70-95 feet). One ichthyoplankton tow was collected in each depth stratum of each station during daylight (defined as occurring between 1 hour after sunrise and 1 hour before sunset) and the daytime sampling was repeated again at night at the same three stations (defined as occurring between 1 hour after sunset and 1 hour before sunrise). A total of 18 valid samples (3 stations x 3 depths x 2 diel periods, Table 1) were collected on May 24, 2006 between 1:00-4:00 PM (day) and 9:00-11:30 PM (night).

All samples were collected with a 1.0 m^2 Tucker trawl with a 0.335 mm net and an 8:1 length to mouth ratio. The tucker trawl has a closing device that uses a double-trip release mechanism and a weighted lead bar to close the mouth of the net and insure that each sample is collected in each of the three discrete depth strata. Net towing speed was approximately 1.0 m/sec and tow duration was 5 minutes. A flume-calibrated digital flowmeter (GO Model 2030R) was placed in the mouth of the Tucker trawl to measure the distance (volume) of each tow. Tow depth was determined in the field using a cosine function relating wire length and wire angle to sampling depth. Tow volume was approximately 300 m^3 and ranged from 250-333 m^3 (Table 1). The start and end of each towpath was recorded using GPS. Samples were fixed at sea in 4% buffered formaldehyde and changed over to 80% ethanol within 18 hours. A conductivity, salinity, temperature, and dissolved oxygen profile was made at 5 foot intervals from one foot below the surface to one foot above the bottom at each of the three stations and two diel periods (6 total profiles) using a YSI Model 85 meter.

LABORATORY METHODS

Samples were sorted under magnification to remove all fish eggs, fish larvae, and lobster larvae which were then enumerated and identified to the lowest possible taxon (generally genus and species). Samples were further identified into the following life stages: egg, yolk-sac larvae and post yolk-sac larvae.

The accuracy of identifications, assignment to life stage, and counting was monitored and controlled by QC checks. A subset of the samples were randomly selected for re-identification by a quality control inspector according to a "10% AOQL" continuous sampling plan. This insured that at least 90% of the samples met specifications, because if any samples failed QC checks, data from those samples were corrected and the proportion of samples checked was increased. A sample failed identification QC if the original identifier's count differed from the QC inspector's count by 10% or more (or by more than two if the QC total was 20 or less). This acceptance criterion was applied separately by life stage to each taxon. An additional requirement for a sample to pass was that for each taxon, the sum of the percent errors for all life stages was required to be less than 10%.

RESULTS

Physical Profiles of Water Column

Water temperature, dissolved oxygen, and salinity were similar among the three stations (Table 2, Figures 2-4). Water temperature ranged from 11.3-13.4 °C, dissolved oxygen from 8.9-11.1 mg/l, and salinity 22.7-25.5 ‰. At all three stations, a slight (2°C) thermocline was apparent from the surface to about 30 ft. From about 40 ft to the bottom (about 95 ft.) the water was isothermal and about 11.0-11.5 °C.

Total Species Composition

Seven taxa of fish eggs were collected on May 24, 2006. Windowpane (*Scophthalmus aquosus*) was the most abundant egg taxa and accounted for 25.4% of the total number collected. Atlantic menhaden (*Brevoortia tyrannus*) and fourbeard rockling (*Enchelyopus cimbrius*) eggs were also common and accounted for 23.9% and 23.1% of the total number of eggs collected respectively (Table 3). The labrid species tautog (*Tautoga onitis*) and cunner (*Tautogolabrus adspersus*) were collected and comprised 17.0% and 6.3% of the total number of eggs respectively. Atlantic mackerel (*Scomber scombrus*) and searobin (*Prionotus* spp.) eggs were collected in lower numbers and accounted for 3.3% and 0.9% of the total (Table 3). Six taxa of fish larvae were collected on May 24, 2006. All larvae species were also collected in the egg stage with the exception of winter flounder (*Pseudopleuronectes americanus*). Fourbeard rockling was the dominant fish larvae and accounted for 62.6% of the total (Table 3). Windowpane was the second most common fish larvae and accounted for 21.5% of the total. Winter flounder larvae accounted for 10.3% of the total number collected. Tautog (3.8% of the total), cunner (0.1%), and Atlantic mackerel (1.7%) larvae were also collected. The majority (92%) of the larvae collected were in the post yolk-sac stage. Fourbeard rockling and windowpane were the only species collected as yolk-sac larvae. All winter flounder were in the post yolk-sac stage, about half (47%) of these did not yet show signs of fin ray development or notochord flexion. It is possible that smaller yolk sac stage winter flounder larvae were present and under sampled due to net extrusion (NUSCO 2005). No young of the year or adult fish were collected.

Ichthyoplankton Density Across Diel Period and Depth Strata

Egg density was relatively uniform between the two diel periods and three depth strata for collections made on May 24, 2006 (Table 4, Figure 5). A two-way ANOVA on log (x+1) transformed egg density (#/100m^3, all species combined) did not detect a significant ($p < 0.05$) difference between the two diel periods or between the three depth strata. A two-way ANOVA on log (x+1) transformed egg density was run for individual species as well. There was no significant difference between the two diel periods or three depth strata for Atlantic mackerel, cunner, or searobin eggs. Atlantic menhaden eggs were collected in higher density during daytime ($p < 0.05$); there was no difference between the three depth strata. Fourbeard rockling eggs were collected in higher density during daytime ($p < 0.01$), and density was higher in the surface collections than in the mid-depth or near-bottom tows ($p < 0.01$). There was no difference in tautog egg density between the two diel periods, and density was higher in the surface collections than in the mid-depth or near-bottom tows ($p < 0.05$). Windowpane eggs were collected in higher density during the night collections ($p < 0.01$); there was no significant difference between the three depth strata. There was not a significant interaction term (diel period*depth strata) for the two-way ANOVA on egg density for all species combined or for individual species.

A two-way ANOVA on log (x+1) transformed larvae (yolk sac+post yolk sac stages, all species combined) density did not detect a significant difference between depth strata or diel period during sampling on May 24, 2006. A two-way ANOVA on log (x+1) transformed larvae density was run for individual species as well. There was no significant difference in larvae density between the two diel periods or three depth strata for fourbeard rockling, tautog, or windowpane. Winter flounder larvae were collected in higher densities at night ($p < 0.05$) and in the mid-depth strata than in the surface or near bottom samples ($p < 0.05$; Table 5, Figure 5). There was not a significant interaction term (diel period*depth strata) for the two-way ANOVA on larvae density for all species combined or for individual species.

Ichthyoplankon Community Similarity Across Diel Period and Depth Strata

Community similarity between the two diel periods and three depth strata was evaluated through ordination using non-metric multidimensional scaling (NMDS). Analysis was based on the Bray-Curtis similarity index generated from all pairwise sample comparisons on 4^{th} root transformed egg and larval (yolk-sac + post yolk-sac stages) densities. Like all multivariate techniques, NMDS is based on a similarity coefficient matrix calculated between every pair of samples. The Bray-Curtis similarity values were then transformed to ranks (the highest similarity between a pair of sites has the lowest rank, 1, and the lowest similarity has the highest rank, (n(n-1)/2). NMDS then constructs a "map" or configuration of the samples. The NMDS map is constructed to preserve the similarity ranking as Euclidean distances on the two dimensional plot and attempts to satisfy all conditions imposed by the rank similarity matrix, e.g. if sample 1 has higher similarity to sample 2 than it does to sample 3 then sample 1 will be placed closer on the map to sample 2 than it is to 3. The principle of the NMDS algorithm is to choose a configuration of points which minimize the degree of *stress* or distortion between the similarity rankings and the corresponding distance rankings in the ordination plot. The stress value provides a "goodness of fit" measure, in general, stress < 0.05 gives an excellent representation with no prospect of misinterpretation, stress < 0.1 corresponds to a good ordination with no real prospect of a misleading interpretation, and stress < 0.2 still gives a potentially useful 2-dimensional picture, though for values at the upper end of this range too much reliance should not be placed on the detail of the plot (Clarke and Warwick 1994). NMDS is based on rank order about which samples are most or least similar, axes are non-metric and the ordination plot can say nothing about which direction is "up" or "down", or the absolute "distance apart" of two samples, what can be interpreted is relative distances apart (Clarke and Warwick 1994). NMDS can be recommended as one of the best (arguably the best) ordination technique available (Everitt 1978, Clarke and Warwick 1994). The few comprehensive studies that have compared ordination methods for community data give NMDS a high rating (Kenkel and Orloci 1986).

The NMDS ordination plot for fish egg assemblage on May 24, 2006 does not reveal any distinct community clusters between the two diel periods and three depth strata (Figure 6). This was expected because egg species composition and density was distributed relatively evenly between the two diel periods and three depth strata (Figure 5, Table 4). The were also not any distinct clusters between the two diel periods and three depth strata for the larval fish assemblage sampled on May 24, 2006 (Figure 7). As was observed with fish eggs, fish larvae were relatively evenly distributed both in terms of species composition and overall density between the two diel periods and three depth strata (Figure 5, Table 5).

Entrainment Estimates Based on Ichthyoplankton Densities Collected on April 18, 2006

The average density (#/m^3) for eggs and larvae collected from the mid-depth strata on May 24, 2006 during daytime sampling (n=3) and during nighttime sampling (n=3) was multiplied by the average daily water intake of the FSRU and associated LNG carriers (106,750 m^3/day, 28.2 million gallons/day) to estimate daily entrainment rates for species and life stage (Table 9) because water intake locations are located 35-45 feet below the water's surface. It was assumed that the mid-depth strata is most representative of the FSRU intake for entrainment estimates because the water withdrawal zone has not been defined by hydrodynamic modeling. The patchy distribution of ichthyoplankton resulted in a relatively high variance between the samples and wide confidence intervals for the entrainment estimates. Five species of fish larvae (fourbeard rockling, windowpane, winter flounder, tautog, Atlantic mackerel) and seven fish egg taxa (Atlantic menhaden, windowpane, fourbeard rockling, tautog, cunner, Atlantic mackerel, and searobin) were collected from the mid-depth strata on May 24, 2006. Atlantic menhaden and windowpane eggs were the dominant ichthyoplankton and the daily entrainment estimate based on mean density in the mid-depth strata from collections on May 24, 2006 was about 80,000 for each species (Table 9). Fourbeard rockling was the most abundant larvae with a daily entrainment estimates of about 48,000.

Entrainment estimates from Table 9 were expressed in terms of Age 1 fish using the Equivalent Adult Model. The Equivalent Adult Model (EAM) is an estimation method for expressing ichthyoplankton entrainment losses as an equivalent number of individuals at some other common life stage, referred to as the age of equivalency (Goodyear 1978). The method provides a convenient means of converting estimated losses of fish eggs and larvae into units of individual fish and provides a standard metric for comparing losses among species, years, and facilities (EPA 2004). The age of equivalency can be any life stage of interest. For the 316 (b) cooling water intake case studies, EPA (2004) expressed impingement and entrainment losses as an equivalent number of Age 1 individuals (the Age 1 fish considered in this analysis are typically less than 6 inches in length).

The EAM calculation requires life-stage specific entrainment counts and life-stage specific mortality rates from the life stage of entrainment to the life stage of equivalence. The losses at any given stage are multiplied by the fraction of fish at that stage or age that would be expected to survive to the age of equivalence:

$$EA = S_A N$$

Where: EA = equivalent age 1 loss, N= number of fish lost due to entrainment, S_A= fraction of fish expected to survive from the age at which they are entrained to the age of equivalence.

Survival rates of early life stages of fish are often expressed on a life-stage specific basis so that the fraction surviving from any particular life stage to the age of equivalency is expressed as the cumulative product of survival fractions for all of the life stages through which a fish must pass before reaching the age of equivalency. One of the benefits of this model is that it can be used to express losses imposed on different lifestages in common equivalent units.

$$EA = \sum S_{i,a} N_i$$

Where:

N_i= number of fish lost at age i

$S_{i,a}$= fraction of fish expected to survive from age i to the age of equivalence

Instantaneous total mortality (Z) is the sum of mortality from natural causes (M) and mortality from recreational and commercial fishing (F), (Z = M+F). Fishing mortality is zero for Age 1 fish species collected during sampling on May 24, 2006. Therefore Z=M because none of the species collected are utilized in commercial or recreational fisheries prior to the completion of Age 1. Survival rate (S) is the estimated proportion of a lifestage that survives from the beginning to the end of that stage ($S= e^{-Z}$). It was conservatively assumed that no eggs or larvae survived entrainment and no larvae were able to actively avoid the intake.

The probability that a fish entrained at any given life stage would have survived to the age of equivalence is greater if the fish is near the end of that stage than if it at the beginning of the stage, because it would have already survived most of the natural mortality that occurs during that stage. Therefore, to find the expected survival rate from the day that a fish is entrained until the time that it would have passed into the subsequent age, an adjustment to S_i is required. The adjusted rate S^*_i describes the effective survival rate for the group of fish entrained at stage i considering the fact that the individual fish were entrained at various ages within stage i. This adjustment is applied only to the stage at which entrainment occurs, the unadjusted survival rate would be applied to subsequent lifestages until the age of equivalency (Age 1).

$S^*_i = 2S_i e^{-\ln(1+S_i)}$ (EPRI 2003, EPA 2004)

Lifestage specific mortality rates were obtained from EPA (2004) values used to evaluate impingement and entrainment in the Mid-Atlantic (http://www.epa.gov/waterscience/316b/casestudy/final/appd1.pdf) and North-Atlantic Region (http://www.epa.gov/waterscience/316b/casestudy/final/appc1.pdf) because location specific mortality rates are not available. The entrainment estimates for fish eggs and larvae in Table 9 were expressed in terms of Age 1 equivalents using the survival rates obtained from EPA (2004) in Table 10. For example, the daily entrainment estimate of 84,443 Atlantic menhaden eggs is multiplied by the adjusted survival rate for the egg stage (S* = 0.224) resulting in an estimated 18,923 menhaden eggs that would be expected to survive until the end of the egg stage from the original 84,443 entrained on May 24, 2006. Of these 18,923 menhaden entering the larval stage, only 63 would be expected to survive natural mortality during that stage with S= 0.003. Of the 63 larvae entering the juvenile (young of the year) stage, only 4 would be expected to survive to the end of that stage and the beginning of the Age 1 stage. Therefore, 4 of the original 84,443 Atlantic menhaden eggs entrained on a daily basis based on sampling conducted on May 24, 2006 would be expected to survive to the beginning of Age 1 based on these natural mortality rates.

Six site specific collections to date have been collected and enumerated (August 28, 2005; October 4, 2005; February 8, 2006; March 28, 2006; April 18, 2006; May 24, 2006). Details of each sampling event can be found in the individual letter reports. Mean ichthyoplankton density in the mid-depth strata was multiplied by the average daily withdrawal to estimate daily entrainment rates as previously discussed. The daily entrainment rates derived from ichthyoplankton density in the mid-depth collections on each of the six sampling dates is presented in Table 11.

Discussion

There is a clear seasonal change in ichthyoplankton community composition between the six site-specific sampling dates from August 2005-May 2006 (Figure 8, Figure 9). August samples were composed of a relatively abundant and species rich community dominated by bay anchovy, with significant contributions from searobin, smallmouth flounder, butterfish, and fourspot flounder. In October samples, ichthyoplankton diversity and abundance was greatly reduced and the community was primarily Atlantic menhaden (eggs and larvae) and bay anchovy (larvae). The winter ichthyoplankton community represented by the February samples had low abundance and diversity and was primarily composed of American sand lance larvae. The March collection represents a seasonal transition to the springtime ichthyoplankton community with the appearance of fourbeard rockling eggs, winter flounder larvae and the persistence of sand lance larvae, although overall diversity and larval abundance remain low. The April collections were similar to the March collection in overall species composition and abundance. Egg collections were still dominated by fourbeard rockling. There was a shift in the larval fish community as fourbeard rockling comprised a significant proportion of the larval catch in April, fourbeard rockling larvae did not occur in the March sample. The majority of the fourbeard rockling larvae collected on April 18 were still in the yolk-sac stage and relatively early in their development. Sand lance larvae density in the April collections was reduced compared to February and March reflecting the development and metamorphosis of this winter spawning species to the juvenile stage.

The ichthyoplankton community in the vicinity of the proposed Broadwater FSRU in the central basin of Long Island Sound during day and night sampling on May 24, 2006 was considerably more diverse than observed during sampling on April 18, 2006 (Figure 8, Figure 9). During the April samples, egg collections were composed of only two species (fourbeard rockling and windowpane) and 99.9% of the eggs collected were fourbeard rockling. During collections on May 24, 2006, seven taxa of fish eggs were collected and at least 5 taxa were collected during each of the 18 tows (Table 8). Fish eggs collected on May 24 that were not observed during the April 18 collections include Atlantic mackerel, Atlantic menhaden, cunner, searobin (*Prionotus* spp.), and tautog. Fourbeard rockling and windowpane eggs were also collected on May 24, windowpane eggs were two orders of magnitude more abundant than in April, while fourbeard rockling eggs were collected in lower density and comprised a smaller proportion of the overall catch than in April (Figure 8).

Six species of larval fish were collected during the May 24 collections and abundance and diversity was lower than was observed for fish eggs (Table 8). Overall species richness of larval fish on May 24 was similar to that observed during the April 18 collections (5 species), however there was a notable shift in species composition with an increased proportion of fourbeard rockling, occurrence of windowpane, tautog, cunner, and Atlantic mackerel, and the absence of sand lance larvae which had been present in the February, March, and April collections (Figure 9). The larval fish community in the May 24, 2006 collections was dominated by fourbeard rockling and windowpane post-yolk sac larvae while the April 18, 2006 collections were dominated by fourbeard rockling yolk-sac larvae and sand lance post-yolk sac larvae.

This seasonal shift in species composition and early-summer increase in diversity of fish eggs is typical of estuarine and coastal systems in the Middle-Atlantic Bight (Able and Fahay 1998, Witting et al. 1999). Few species spawn in the region during mid-winter (American sand lance being an exception). Ichthyoplankton abundance and diversity begin to increase in the early spring and abundance and diversity reach a peak during mid-late summer when many species reproduce, spawning is curtailed in the fall (Able and Fahay 1998). In Long Island Sound, Richards (1959) found a seasonal ichthyoplankton cycle of increasing density and diversity in the spring to a peak in summer followed by a decline in autumn, with only American sand lance larvae collected in significant numbers in the winter. Wheatland (1956) found egg density to increase in Long Island Sound from March through May with a peak in density and diversity in June and July, larvae density peaked later from August through October. During the 2002 Poletti Ichthyoplankton Program, egg density was bi-modal with a spring peak during late March to late April and a second peak in early summer during late May through June. The spring peak was dominated by fourbeard rockling eggs while the early summer peak was more diverse with significant contributions from tautog, searobin, weakfish/scup, Atlantic menhaden, windowpane, bay anchovy and cunner eggs (Normandeau 2006). Egg density dropped markedly in early July during the 2002 Poletti Ichthyoplankton Program and remained low through the end of the program in late July. Larval fish abundance during the Poletti Program was relatively low from March though late May and peaked in middle to late June a few weeks after the beginning of the fish egg peak in late May as waters continue to warm. The mid-late June peak in fish larvae observed during the 2002 Poletti Program was dominated by Atlantic menhaden with significant catches of tautog, cunner, scup, and searobin. Larval fish abundance dropped markedly by mid-July during the Poletti Program. Larval fish collections from the start of the 2002 Poletti Program in March through June were relatively low in abundance and dominated by winter and early spring spawners such as winter flounder, sand lance, grubby, rock gunnel, and fourbeard rockling, similar to what was observed during the site specific collections at the proposed FSRU facility in 2005-2006 (Figure 9).

During the Poletti Program's biweekly survey # 6 (May 13-26, 2002) Tucker trawl egg collections in the deep (total depth > 98 ft) strata were dominated by fourbeard rockling with significant contribution by Atlantic menhaden, tautog, and windowpane similar to that observed in the site-specific daytime collections on May 24, 2006 (Table 12). Egg species composition was similar in the Poletti collections in the Intermediate depth strata (6-98 ft. total depth) except that Atlantic menhaden eggs were considerably more abundant (about $13/m^3$) than observed in the deep sampling strata or during the site-specific collections on May 24, 2006. Fourbeard rockling, windowpane, and winter flounder were the most abundant larvae collected during Poletti Survey # 6 (May 13-26, 2002) in both the deep and intermediate depth strata as well as the site specific collections on May 24, 2006 (Table 12).

There was not a significant difference in overall egg density or species composition between the two diel periods and three sampling strata for collections made on May 24, 2006 (Figure 5). Fourbeard rockling and tautog were the only two species for which a significant difference in egg density was observed between the three depth strata, both species were more abundant in the surface collections than in either the mid-depth or near bottom collections. Fourbeard rockling eggs were more concentrated in the surface samples during sampling on April 18, 2006 as well. In Long Island Sound, Williams (1968) found fourbeard rockling, tautog, cunner, and bay anchovy eggs to be strongly stratified with most eggs occurring in the top 5 m of the water column. Searobin and Atlantic menhaden eggs were more evenly distributed throughout the water column, although they were not numerous enough for detailed conclusions (Williams 1968). Although windowpane eggs were more concentrated at the surface, they were not as strongly stratified as observed for rockling, tautog and cunner and windowpane eggs were distributed from the surface to the bottom (30 m, 98 ft., Williams 1968) as was observed in the site specific collections on May 24, 2006 (Table 4, Figure 5).

There was also not a significant difference in overall larval density between the two diel periods or three depth strata for collections made on May 24, 2006. Winter flounder larvae were the only individual species for which a difference in depth distribution was detected; they were most abundant in the mid-depth strata and at night. Winter flounder larvae are planktonic and although many remain near the shallow, estuarine spawning grounds, others are carried into coastal waters by tidal currents (Smith et al. 1975). Pearcy (1962) found larvae most common from March to June in the Mystic River estuary and they were typically more abundant near the bottom.

Bourne and Govoni (1988) found winter flounder larvae to be most common in shoal water, in or near coves and small bays and rare in deeper waters in Narragansett Bay. Monitoring at the Millstone Power Station in Waterford, Connecticut consistently observes greater abundance of winter flounder larvae in the Niantic River than in Niantic Bay during most years and relates this difference to preferred winter flounder spawning habitat in the shallow waters of the Niantic River estuary (NUSCO 2005). In the 2002 Poletti Ichthyoplankton Program, winter flounder were relatively evenly distributed in the Central Basin area between the three sampling strata and two gear types, although the greatest proportion of the catch did occur in the shallow (3-6 meter total depth), epibenthic sled samples taken from the bottom meter of the water column (Normandeau 2006). In the 2002 Poletti Ichthyoplankton Program data subset to represent the location of the proposed FSRU facility's intake, density of larval winter flounder peaked during survey 2 (March 18-March 31), in the deep depth strata (total water depth > 30 meters) where mean density was 51/100m^3 and during survey 3 (April 1-14) in the intermediate depth strata (total water depth 6-30 meters) where mean density was 30/100m^3. Mean density of winter flounder in the site specific, daytime collections in 2006 were lower in comparison to those observed in the 2002 Poletti Program. Mean density of winter flounder larvae during the 2006 daytime site specific collections on March 28 was 3.4/100m^3, on April 18 density was 1.7/100m^3 and on May 24 density was 3.1/100m^3 (Table 12). The site specific collections in 2005/2006 used a 1 meter Tucker trawl with 0.335 mm mesh while the 2002 Poletti Program used a 1 meter Tucker trawl with a 0.500 mm mesh, therefore it is unlikely that the lower density of winter flounder larvae observed in the site specific collections in 2006 was due to extrusion of larvae through the net because it is a smaller mesh than was used in the Poletti Program.

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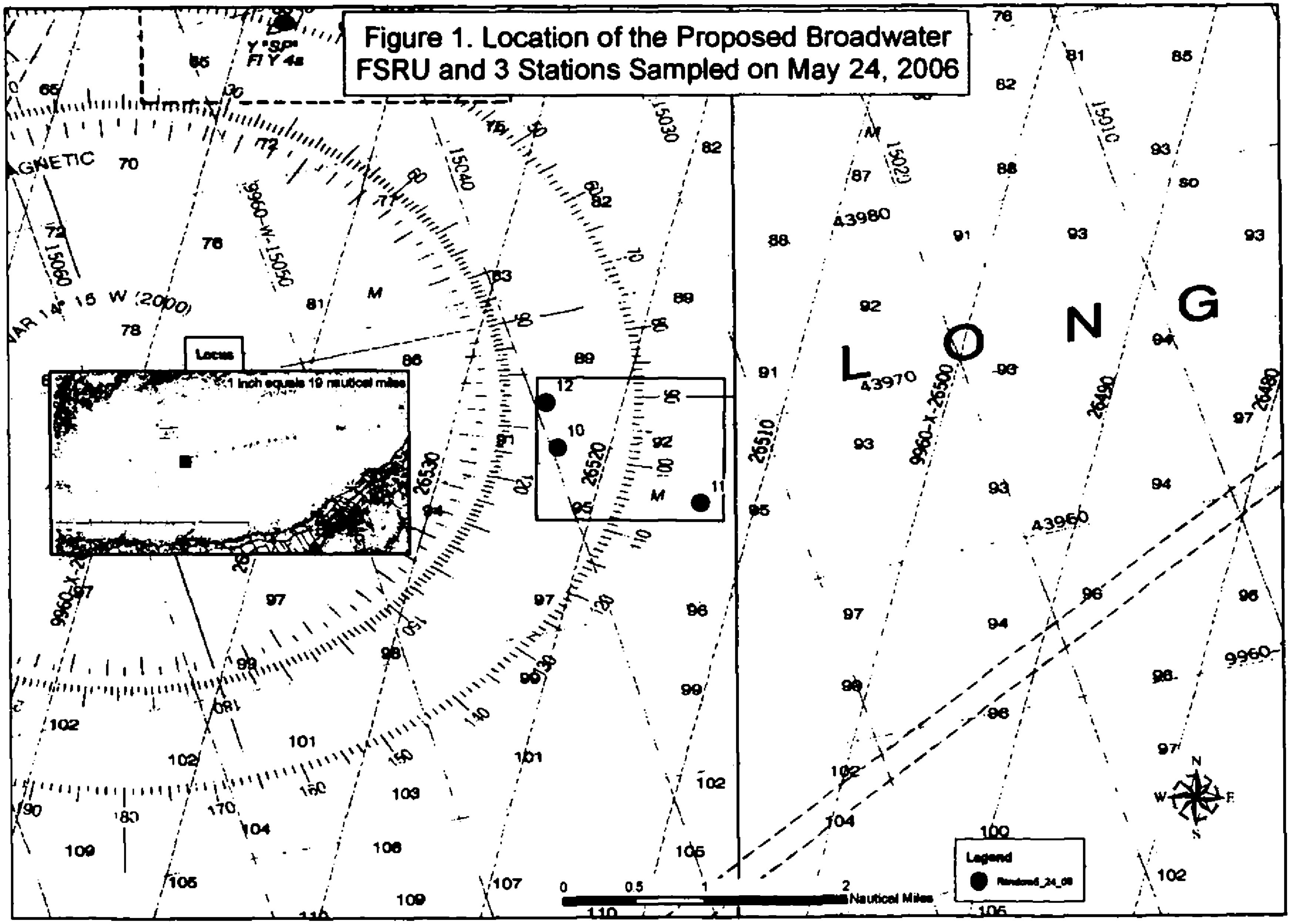


Figure 1. Three random sampling locations within a 1 nautical mile square block centered on the location of the proposed Broadwater FSRU sampled on May 24, 2006.

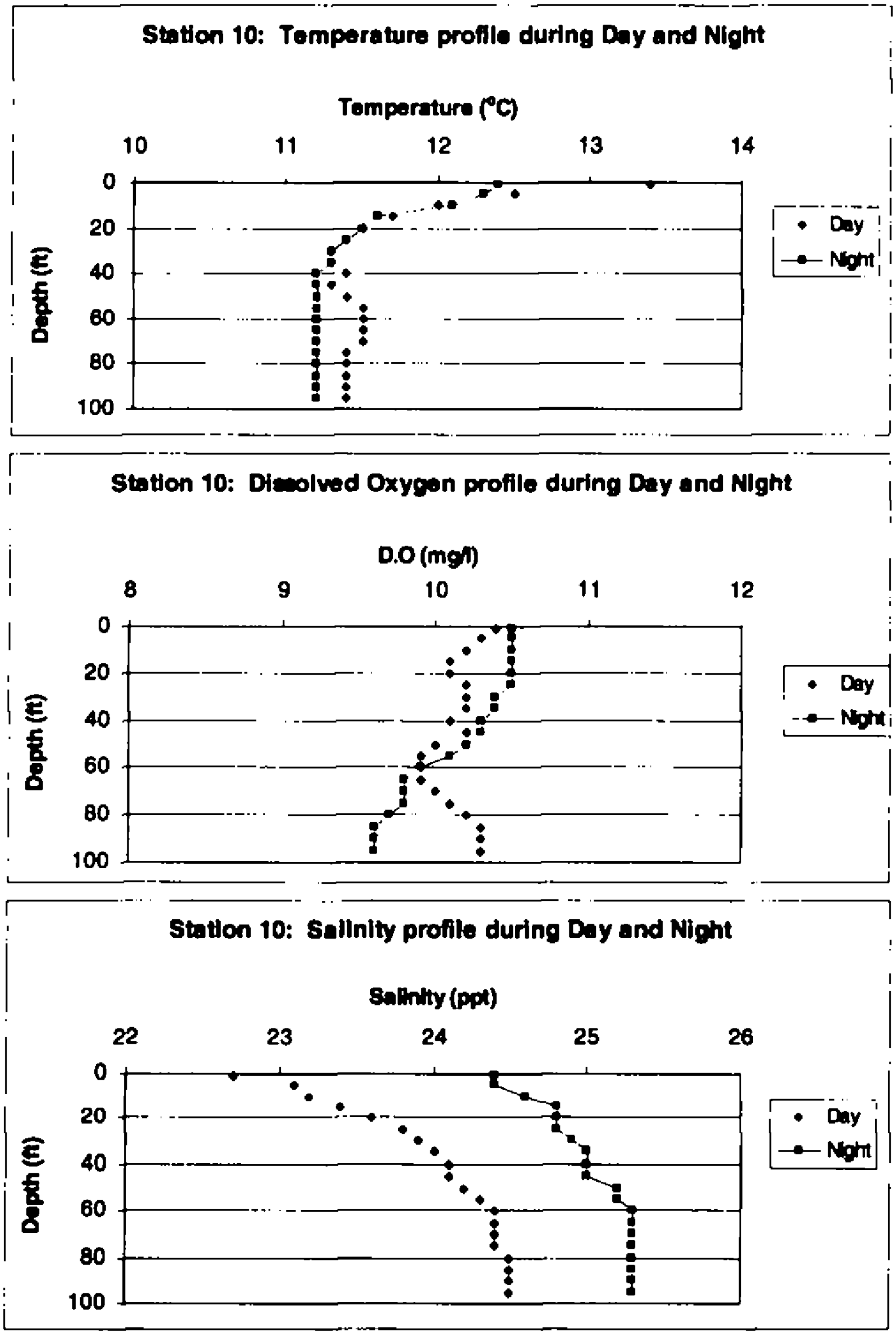


Figure 2. Physical profile (temperature, dissolved oxygen, and salinity) of the water column during Day and Night sampling at Station 10 on May 24, 2006.

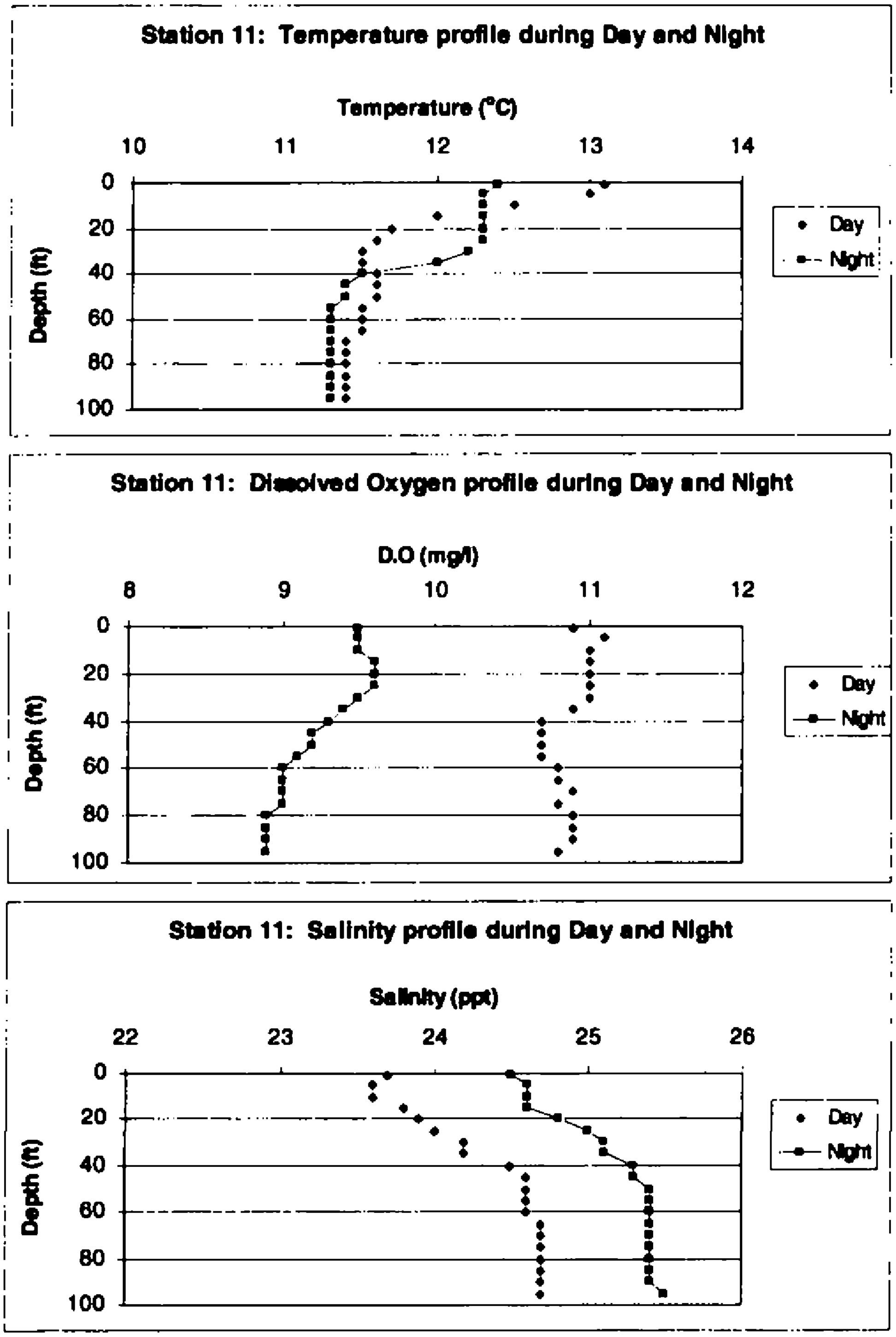


Figure 3. Physical profile (temperature, dissolved oxygen, and salinity) of the water column during Day and Night sampling at Station 11 on May 24, 2006.

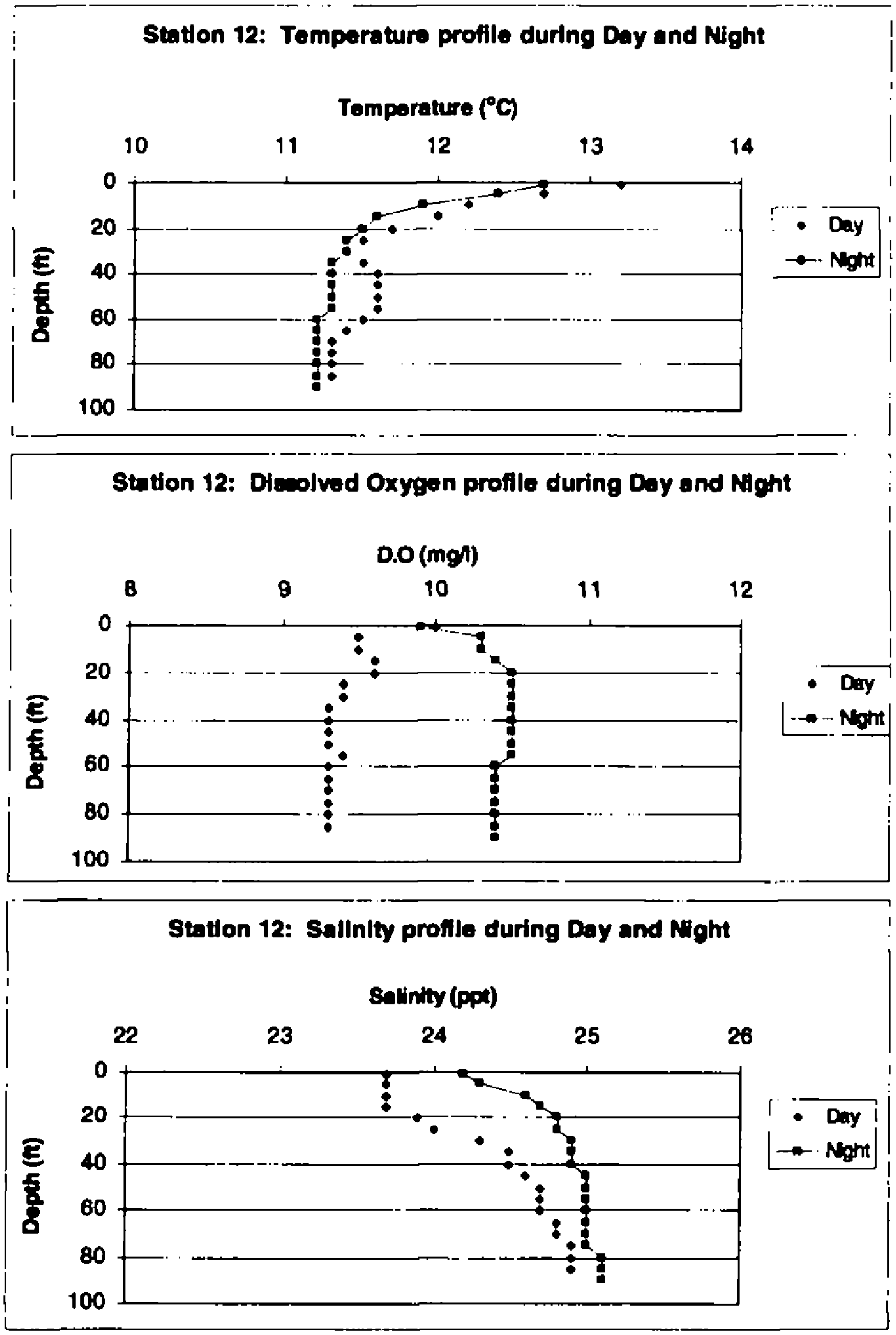


Figure 4. Physical profile (temperature, dissolved oxygen, and salinity) of the water column during Day and Night sampling at Station 12 on May 24, 2006.

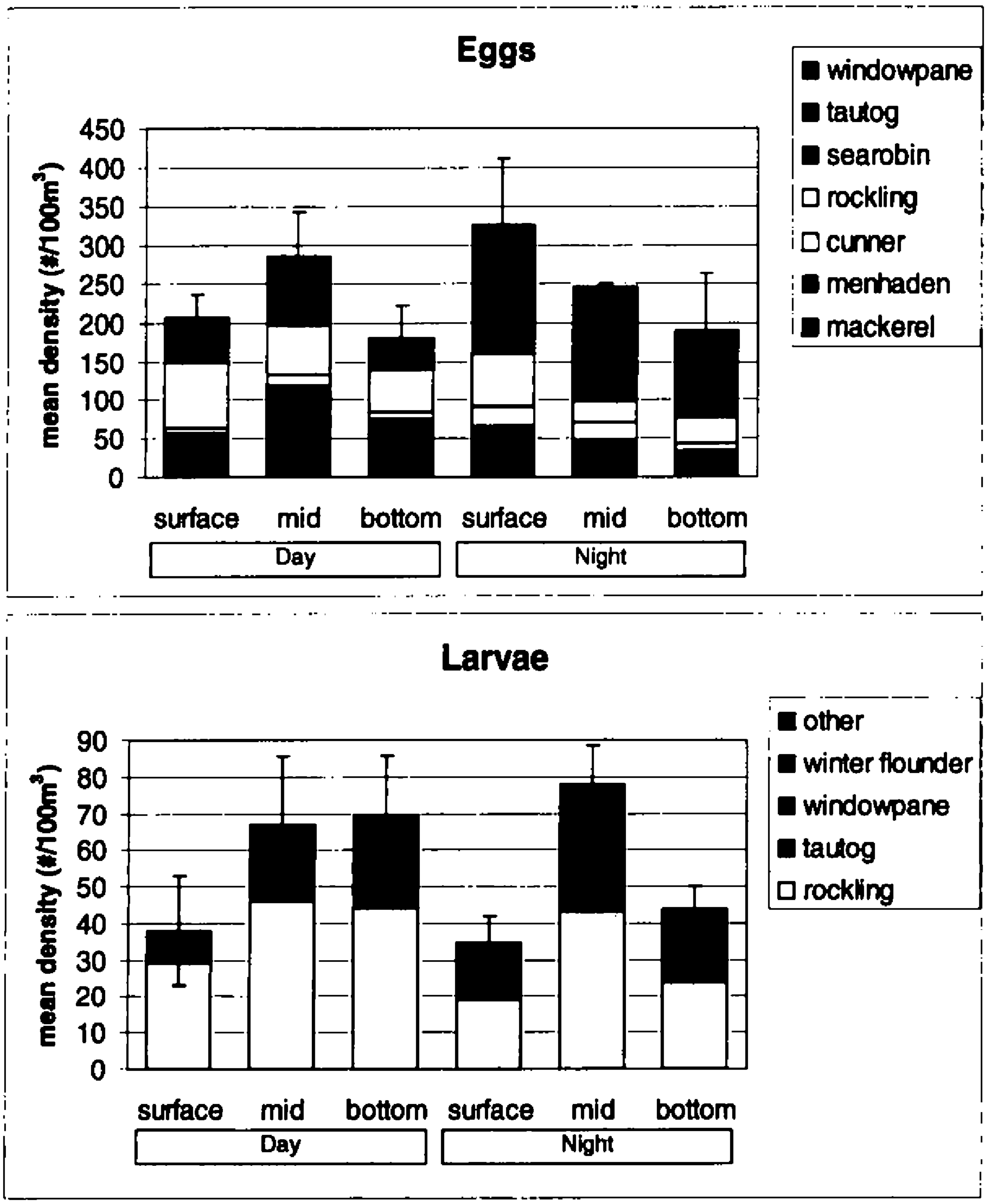


Figure 5. Mean Egg (upper plot) and larvae (PYSL+YSL, lower plot) density (#/100m^3) ± standard error from the three replicate tows conducted at the surface (0-30 ft), mid-depth (35-65 ft) and bottom (70-95 ft) strata during daytime and nighttime sampling in the vicinity of the proposed FSRU facility on May 24, 2006.

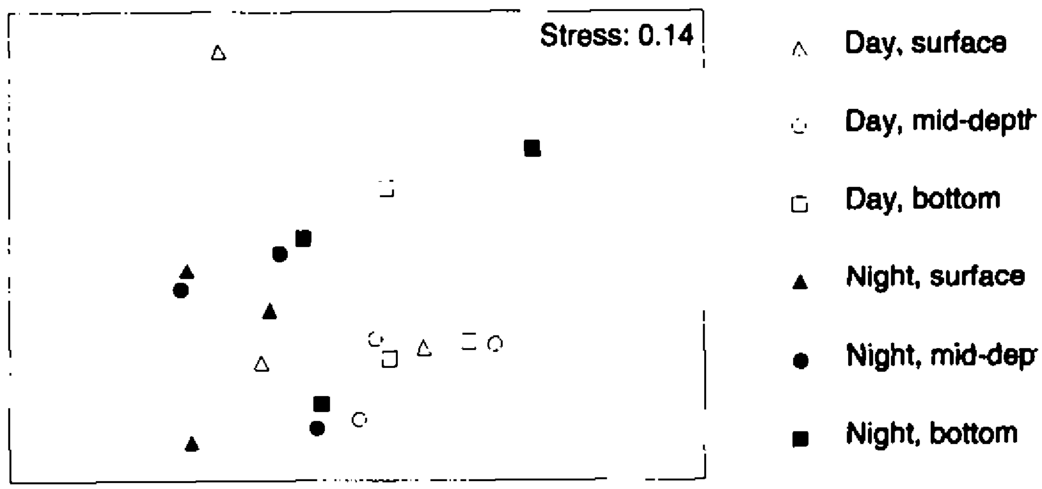


Figure 6. Non-metric multidimensional scaling ordination of 18 (3 replicate stations, 2 diel periods, 3 depth strata) samples collected on May 24, 2006 for 4th root transformed fish egg density (#/100m^3) based on Bray-Curtis similarities.

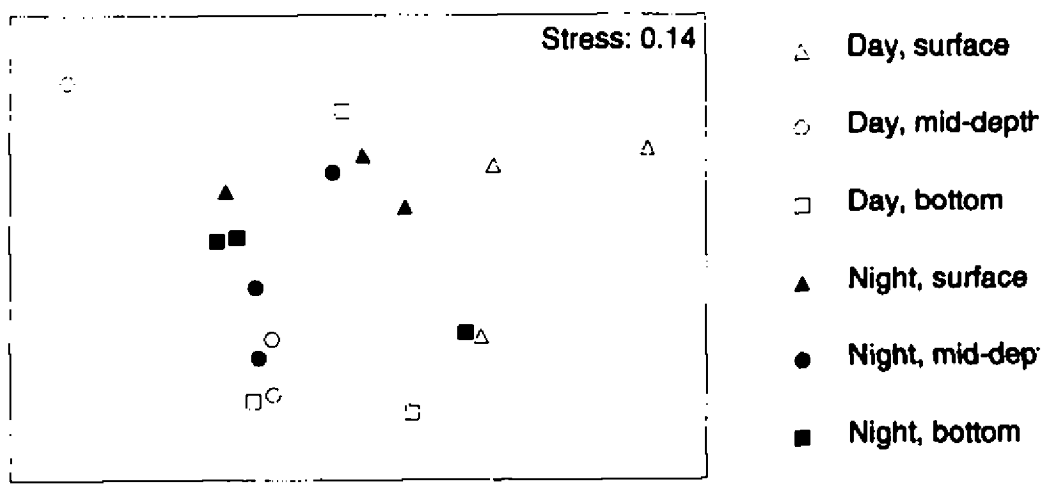
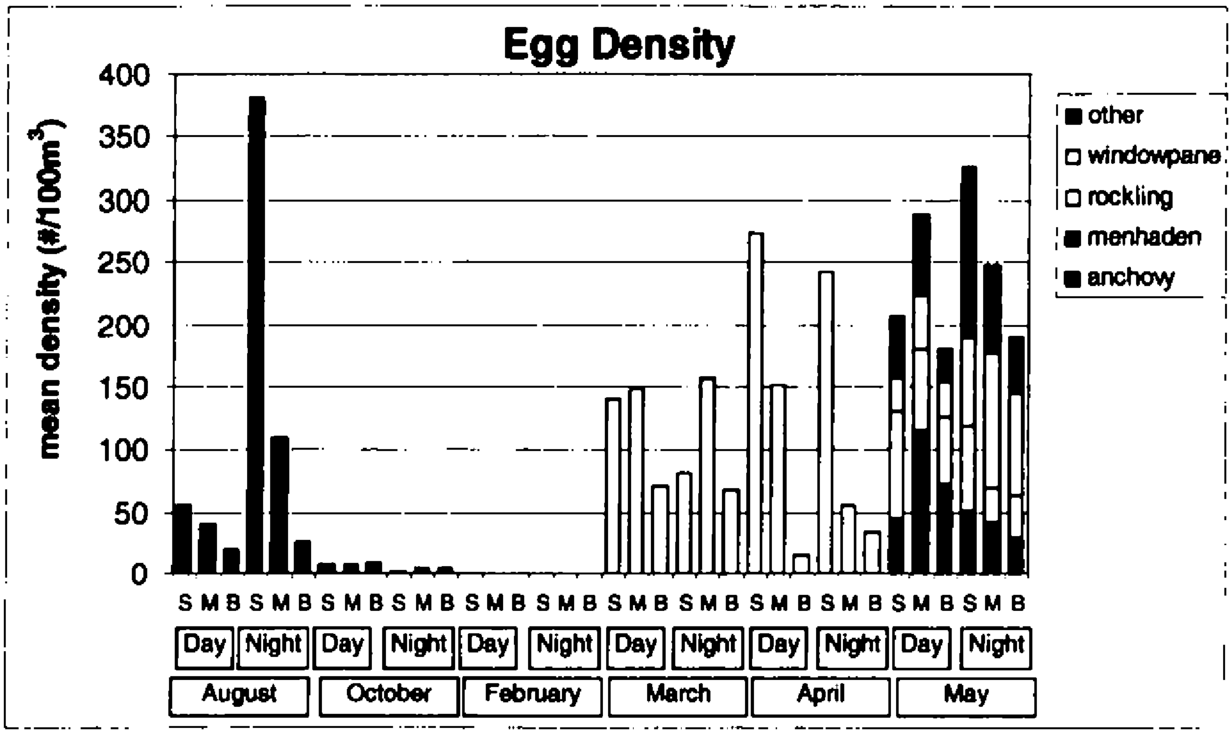


Figure 7. Non-metric multidimensional scaling ordination of 18 (3 replicate stations, 2 diel periods, 3 depth strata) samples collected on May 24, 2006 for 4th root transformed fish larvae density (#/100m^3) based on Bray-Curtis similarities.



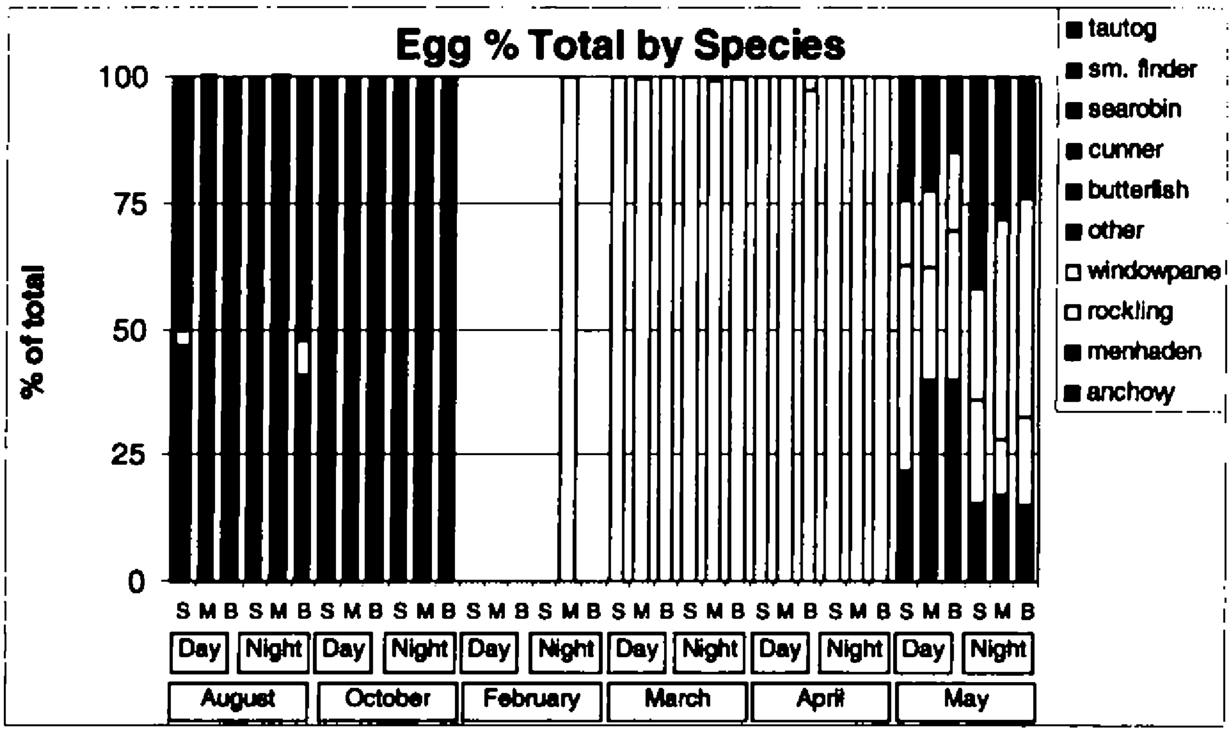
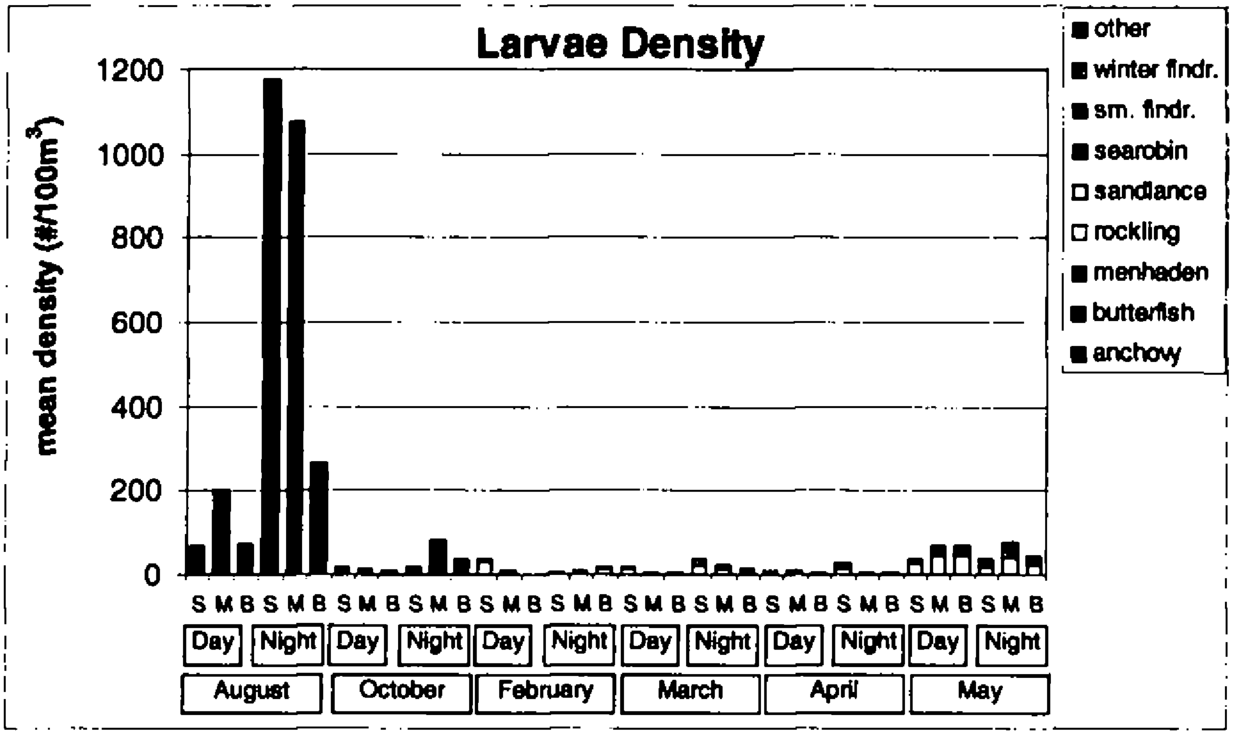


Figure 8. Fish egg density (upper) and percent species composition (lower) in each diel/depth (S= surface, M= mid-depth, B= near bottom) strata during site specific collections at the proposed FSRU facility on August 28, 2005, October 4, 2005, February 8, 2006, March 28, 2006, April 18, 2006, and May 24, 2006.



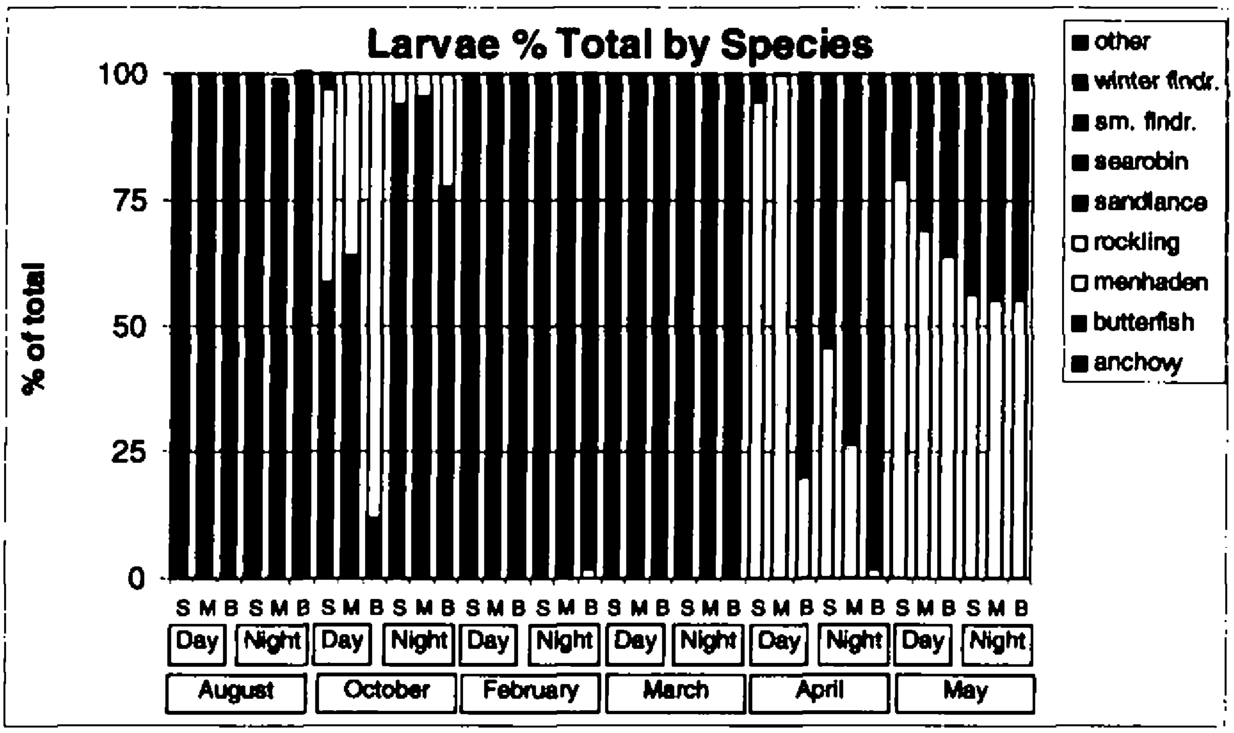


Figure 9. Larval fish density (upper) and percent species composition (lower) in each diel/depth (S= surface, M= mid- depth, B= near bottom) strata during site specific collections at the proposed FSRU facility on August 28, 2005, October 4, 2005, February 8, 2006, March 28, 2006, April 18, 2006, and May 24, 2006.

Table 1. **Sample allocation, sample depths and volume of water sampled (m^3) among the three random stations, three depth strata, and two diel periods sampled in the vicinity of the proposed Broadwater FSRU facility on May 24, 2006.**

Station	Depth Strata	Sample Depth (ft.)	Diel Period	Volume Sampled
10	Surface	20	Day	332.6
	Mid-depth	46		262.3
	Bottom	81		272.8
	Surface	20	Night	298.9
	Mid-depth	48		285.4
	Bottom	87		276.2
11	Surface	10	Day	288.8
	Mid-depth	46		247.6
	Bottom	82		274.8
	Surface	20	Night	312.2
	Mid-depth	49		306.2
	Bottom	88		301.6
12	Surface	20	Day	279.4
	Mid-depth	44		251.1
	Bottom	78		249.9
	Surface	20	Night	275.6
	Mid-depth	47		301.8
	Bottom	84		290.2

Table 2. **Temperature, dissolved oxygen, and salinity at the three stations during day and night sampling in the vicinity of the proposed Broadwater FSRU on May 24, 2006.**

	Temperature (°C)				Dissolved Oxygen (mg/l)				Salinity (°/oo)			
	min	max	mean	stdev.	min	max	mean	stdev.	min	max	mean	stdev.
Station 10												
Day	11.3	13.4	11.6	0.5	9.9	10.4	10.1	0.1	22.7	24.5	24.0	0.5
Night	11.2	12.4	11.4	0.4	9.6	10.5	10.1	0.4	24.4	25.3	25.0	0.3
Station 11												
Day	11.4	13.1	11.7	0.5	10.7	11.1	10.9	0.1	23.6	24.7	24.3	0.4
Night	11.3	12.4	11.7	0.5	8.9	9.6	9.2	0.3	24.5	25.5	25.2	0.3
Station 12												
Day	11.3	13.2	11.7	0.5	9.3	10.0	9.4	0.2	23.7	24.9	24.4	0.5
Night	11.2	12.7	11.5	0.4	9.9	10.5	10.4	0.1	24.2	25.1	24.9	0.3

Table 3. Number of fish eggs, larvae (yolk-sac + post yolk-sac stages) and young of the year (YOY) and the percent contribution to the total catch by species in the 18 ichthyoplankton tows conducted in the vicinity of the proposed Broadwater FSRU on May 24, 2006.

Common Name	Scientific Name	# Eggs	% Total Eggs	# YSL	# PYSL	# Larvae	% Total Larvae	# YOY	% Total YOY
Atlantic mackerel	*Scomber scombrus*	410	3.3		48	48	1.7		
Atlantic menhaden	*Brevoortia tyrannus*	2,952	23.9						
Cunner	*Tautogolabrus adspersus*	782	6.3		4	4	0.1		
Fourbeard rockling	*Enchelyopus cimbrius*	2,856	23.1	160	1,598	1,758	62.6		
Searobin	*Prionotus spp.*	108	0.9						
Tautog	*Tautoga onitis*	2,102	17.0		106	106	3.8		
Windowpane	*Scophthalmus aquosus*	3,132	25.4	64	540	604	21.5		
Winter flounder	*Pseudopleuronectes americanus*				288	288	10.3		
TOTAL		12,342	100.0	224	2,584	2,808	100.0		

Table 4. Mean egg density (#/100m^3) and percent of the total catch for each species collected in the three replicate samples in each diel period and depth strata in the vicinity of the proposed Broadwater FSRU on May 24, 2006.

	Day						Night					
	Depth Strata						Depth Strata					
	Surface		Mid-depth		Bottom		Surface		Mid-depth		Bottom	
Fish Eggs	# per 100m^3	% Total	# per 100m^3	% Total	# per 100m^3	% Total	# per 100m^3	% Total	# per 100m^3	% Total	# per 100m^3	% Total
Atlantic mackerel	11.60	5.83	3.69	1.28	3.11	1.65	15.49	4.89	6.16	2.55	5.34	2.86
Atlantic menhaden	44.94	21.42	115.83	40.18	72.91	40.22	50.35	15.49	42.38	17.09	28.88	15.24
Cunner	7.01	3.50	13.24	4.59	9.47	5.23	26.57	8.15	23.57	9.45	10.44	5.48
Fourbeard rockling	86.25	41.57	64.39	22.39	53.61	29.48	68.69	20.92	27.17	10.91	34.4	17.86
Searobin	0.46	0.21	6.88	2.39	3.06	1.65	0.00	0.00	0.88	0.36	2.33	1.19
Tautog	29.75	14.74	40.22	13.94	10.88	6.06	94.25	28.80	38.83	15.64	26.92	14.29
Windowpane	26.77	12.73	43.82	15.23	28.1	15.70	71.02	21.74	107.43	44.0	81.68	43.10
Total	206.77	100.00	288.06	100.00	181.13	100.00	326.37	100.00	246.43	100.00	190.00	100.00

Table 5. Mean larvae (yolk sac + post yolk sac stage) density (#/100m^3) and percent of the total catch for each species collected in the three replicate samples in each diel period and depth strata in the vicinity of the proposed Broadwater FSRU on May 24, 2006.

	Day						Night					
	Depth Strata						Depth Strata					
	Surface		Mid-depth		Bottom		Surface		Mid-depth		Bottom	
Species	# per 100 m^3	% Total	# per 100 m^3	% Total	# per 100 m^3	% Total	# per 100 m^3	% Total	# per 100 m^3	% Total	# per 100 m^3	% Total
Atlantic mackerel	1.42	3.41	0.00	0.00	0.53	0.72	2.64	7.39	0.88	1.15	0.00	0.00
Cunner	0.00	0.00	0.00	0.00	0.53	0.72	0.00	0.00	0.00	0.00	0.00	0.00
Fourbeard rockling	29.57	78.98	46.34	69.29	44.28	64.03	19.47	56.41	43.22	55.17	23.92	55.21
Tautog	0.23	0.57	4.79	7.09	6.31	9.35	0.89	2.56	0.87	1.15	0.00	0.00
Windowpane	6.68	17.05	9.96	14.96	13.93	20.14	9.00	25.64	18.97	24.14	12.48	28.13
Winter flounder	0.00	0.00	5.73	8.66	3.49	5.04	2.71	7.69	14.19	18.39	7.54	16.67
Total	37.90	100.00	66.82	100.00	69.08	100.00	34.71	100.00	78.14	100.00	43.94	100.00

Table 6. **Egg, yolk-sac larvae (YSL) and post yolk-sac larvae (PYSL) densities (#/100m^3) at the three randomly selected sampling stations and three depth strata during daytime sampling in the vicinity of the proposed Broadwater FSRU on May 24, 2006.**

Daytime Survey		Station 10			Station 11			Station 12		
		Surface	Mid-depth	Bottom	Surface	Mid-depth	Bottom	Surface	Mid-depth	Bottom
Atlantic mackerel	Egg	21.65	3.05	1.47	13.16	3.23	1.46	0.00	4.78	6.40
	PYSL	0.00	0.00	0.00	1.39	0.00	0.00	2.86	0.00	1.60
Atlantic menhaden	Egg	40.89	73.20	55.72	59.56	135.70	98.98	34.36	138.59	64.03
Cunner	Egg	12.03	10.67	2.93	9.00	25.85	17.47	0.00	3.19	8.00
	PYSL	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.60
Fourbeard rockling	Egg	96.21	48.80	41.06	105.26	71.08	66.96	57.27	73.28	52.82
	YSL	2.41	6.10	10.26	0.00	8.08	10.19	0.00	6.37	4.80
	PYSL	52.92	39.65	21.99	7.62	54.93	56.77	25.77	23.89	28.81
Searobin	Egg	0.00	3.05	0.00	1.39	4.85	4.37	0.00	12.74	4.80
Tautog	Egg	50.51	33.55	4.40	18.70	77.54	21.83	20.04	9.56	6.40
	PYSL	0.00	3.05	2.93	0.69	11.31	16.01	0.00	0.00	0.00
Windowpane	Egg	26.46	39.65	21.99	16.62	72.70	49.49	37.22	19.12	12.81
	YSL	0.00	3.05	4.40	0.00	4.85	8.73	0.00	0.00	3.20
	PYSL	7.22	10.67	16.13	1.39	11.31	2.91	11.45	0.00	6.40
Winter flounder	PYSL	0.00	9.15	0.00	0.00	6.46	7.28	0.00	1.59	3.20

Table 7. **Egg, yolk-sac larvae (YSL), and post yolk-sac larvae (PYSL) densities (#/100m^3) at the three randomly selected sampling stations and three depth strata during nighttime sampling in the vicinity of the proposed Broadwater FSRU on May 24, 2006.**

Nighttime Survey		Station 10			Station 11			Station 12		
		Surface	Mid-depth	Bottom	Surface	Mid-depth	Bottom	Surface	Mid-depth	Bottom
Atlantic mackerel	Egg	0.00	0.00	0.00	43.56	5.23	13.26	2.90	13.25	2.76
	PYSL	5.35	0.00	0.00	2.56	0.00	0.00	0.00	2.65	0.00
Atlantic menhaden	Egg	45.50	56.06	8.69	79.44	33.96	50.40	26.12	37.11	27.57
Cunner	Egg	10.71	36.44	7.24	48.69	13.06	18.57	20.32	21.21	5.51
Four beard rockling	Egg	61.56	42.05	33.31	92.25	20.90	45.09	52.25	18.56	24.81
	YSL	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.60	0.00
	PYSL	24.09	56.06	10.14	25.62	41.80	45.09	8.71	21.21	16.54
Searobin	Egg	0.00	0.00	4.34	0.00	0.00	2.65	0.00	2.65	0.00
Tautog	Egg	77.62	50.46	2.90	138.37	15.68	53.05	66.78	50.36	24.81
	PYSL	2.68	0.00	0.00	0.00	2.61	0.00	0.00	0.00	0.00
Windowpane	Egg	85.65	70.08	33.31	89.69	154.15	153.85	37.74	98.08	57.89
	PYSL	8.03	28.03	13.03	10.25	18.29	10.61	8.71	10.60	13.78
Winter flounder	PYSL	2.68	8.41	11.59	2.56	20.90	0.00	2.90	13.25	11.03

Table 8. Species richness (# species identified to at least genus level in a sample), Shannon-Wiener diversity index (H'), and density (#/100m³) of eggs and larvae (yolk-sac + post yolk-sac stage) at the three random sampling stations, three depth strata, and two diel periods sampled in the vicinity of the proposed Broadwater FSRU on May 24, 2006.

Station	Depth Strata	Diel Period	Species Richness		Diversity (H')		Density (#/100m³)	
			Eggs	Larvae	Eggs	Larvae	Eggs	Larvae
10	Surface	Day	6	2	1.59	0.36	247.75	62.54
	Mid-depth		7	4	1.58	1.00	211.97	71.67
	Bottom		6	3	1.28	0.84	127.57	55.72
	Surface	Night	5	5	1.47	1.24	281.03	42.82
	Mid-depth		5	3	1.58	0.88	255.08	92.50
	Bottom		6	3	1.42	1.09	89.79	34.76
11	Surface	Day	7	4	1.44	0.95	223.68	11.08
	Mid-depth		7	4	1.59	1.01	390.95	96.93
	Bottom		7	4	1.52	1.00	260.55	101.89
	Surface	Night	6	4	1.72	0.99	491.99	41.00
	Mid-depth		6	4	1.19	1.13	242.98	83.61
	Bottom		7	2	1.53	0.49	336.87	55.70
12	Surface	Day	4	3	1.32	0.83	148.89	40.09
	Mid-depth		7	2	1.28	0.20	261.25	31.86
	Bottom		7	5	1.46	0.98	155.26	49.62
	Surface	Night	6	3	1.57	1.00	206.10	20.32
	Mid-depth		7	4	1.60	1.12	241.22	58.32
	Bottom		6	3	1.49	1.09	143.35	41.35

Table 9. **Average density (#/100m^3) of ichthyoplankton collected during day (n=3) and night (n=3) tows from the mid-depth strata in the vicinity of the proposed Broadwater FSRU on May 24, 2006. Daily entrainment estimates were determined by multiplying the average density by the average daily withdrawal by the FSRU and associated LNG carriers (28.2 MGD, 106,750 m^3/day).**

Species	Stage	Average Density (#/100m^3)	Daily Entrainment Estimate	95 % Confidence Intervals
Atlantic mackerel	Egg	4.92	5,256	3,696-6,816
	PYSL	0.44	471	94-849
Atlantic menhaden	Egg	79.10	84,443	68,006-100,880
Cunner	Egg	18.40	19,646	15,495-23,796
Fourbeard rockling	Egg	45.78	48,868	40,647-57,090
	YSL	5.19	5,542	4,032-7,052
	PYSL	39.59	42,262	37,100-47,425
Searobin	Egg	3.88	4,144	2,495-5,792
Tautog	Egg	39.53	42,193	33,393-50,993
	PYSL	2.83	3,019	1,491-4,547
Windowpane	Egg	75.63	80,735	64,233-97,237
	YSL	1.32	1,406	667-2,144
	PYSL	13.15	14,038	10,778-17,297
Winter flounder	PYSL	9.96	10,632	8,341-12,924

Table 10. Lifestage specific mortality rates used by EPA (2004) to calculate daily Age-1 equivalent estimates lost to entrainment in the FSRU facility from samples collected in the mid-depth strata on May 24, 2006. Instantaneous Total Mortality (Z) is the sum of Natural Mortality (M) and Fishing Mortality (F), (Z=M+F). Survival rate (S) is the estimated proportion of a lifestage that survives from the beginning to the end of that stage ($S = e^{-z}$). An adjusted survival rate (S*) was applied to the stage at which entrainment occurs as explained in the text.

Species	Stage Name	M[a]	S	S*	# Entrained/ Day	Estimated Daily Number Entrained That Would Survive			
						Egg to Later Stages	Larvae to Later Stages	Juvenile to Later Stages	Estimated Total # Age 1 Entrained
Atlantic Mackerel	Eggs	2.39	0.092	0.1679	5,256	882			
	Larvae	5.30	0.005	0.0099	471	4	5		
	Juvenile (YOY)	5.30	0.005	0.0099	0	0	0		0
[a] From Table C1-7 in EPA (2004)									
Atlantic Menhaden	Eggs	2.07	0.126	0.2241	84,443	18923			
	Larvae	5.71	0.003	0.0066	0	63			
	Juvenile (YOY)	2.85	0.058	0.1094	0	4			4
[a] From Table D1-7 in EPA (2004)									
Cunner	Eggs	3.49	0.031	0.0592	19,646	1163			
	Larvae	2.90	0.055	0.1043	0	64			
	Juvenile (YOY)	2.90	0.055	0.1043	0	4			4
[a] From Table C1-16 in EPA (2004)									
Fourbeard Rockling	Eggs	2.30	0.100	0.1822	48,868	8906			
	Larvae	4.25	0.014	0.0281	47,804	127	1345		
	Juvenile (YOY)	0.92	0.400	0.5715	0	51	538		589
[a] From Table C1-17 in EPA (2004)									
Searobin	Eggs	2.30	0.100	0.1822	4,144	755			
	Larvae	3.66	0.026	0.0502	0	19			
	Juvenile (YOY)	0.92	0.400	0.5715	0	8			8
[a] From Table C1-30 in EPA (2004)									
Tautog	Eggs	1.40	0.247	0.3956	42,193	16693			
	Larvae	5.86	0.003	0.0057	3,019	48	17		
	Juvenile (YOY)	5.02	0.007	0.0131	0	0	0		0
[a] From Table C1-35 in EPA (2004)									
Windowpane	Eggs	1.41	0.244	0.3925	80,735	31686	-		
	Larvae	6.99	0.001	0.0018	15,443	29	28		
	Juvenile (YOY)	2.98	0.051	0.0967	0	1	1		3
[a] From Table D1-28 in EPA (2004)									
Winter Flounder	Eggs	0.29	0.750	0.8570	0	0			
	Larvae	4.37	0.013	0.0250	10,632	0	266		
	Juvenile (YOY)	2.38	0.093	0.1694	0	0	25		25
[a] From Table D1-29 in EPA (2004)									

Table 11. Summary of daily entrainment estimates collected in the vicinity of the proposed Broadwater FSRU on six sampling dates (August 23, 2005, October 4, 2005, February 8, 2006, March 28, 2006, April 18, 2006, and May 24, 2006). Entrainment estimates were generated by multiplying average ichthyoplankton density from the six replicate tows (3 day, 3 night) in the mid-depth strata (35-65 feet) by the average daily withdrawal by the FSRU facility (106,750m³).

Species	Stage	Daily Entrainment Estimates					
		23-Aug-05	4-Oct-05	8-Feb-06	28-Mar-06	18-Apr-06	24-May-06
American sand lance	PYSL			8,444	8,878	2,365	
Atlantic mackerel	Egg						5,256
	YSL	356					
	PYSL	4,092					471
Atlantic menhaden	Egg		6,245				84,443
	PYSL		5,071				
Bay Anchovy	Egg	47,860					
	YSL	356					
	PYSL	543,358	47,557				
	YOY		1,245				
Black sea bass	PYSL	3,736					
Butterfish	Egg	6,583					
	PYSL	23,485					
Cunner	Egg						19,646
	PYSL	2,135					
Fourbeard rockling	Egg			109	162,054	109,977	48,868
	YSL					5,466	5,542
	PYSL					1,386	42,262
Fourspot flounder	PYSL	13,344					
Grubby	PYSL			59			
Longhorn sculpin	PYSL			109			
Northern Puffer	PYSL	356					
Rock gunnel	PYSL			1,471	475	215	
Searobin	Egg	7,650					4,144
	YSL	178					
	PYSL	25,264					
Smallmouth Flounder	Egg	17,080					
	YSL	7,117					
	PYSL	53,019					
Striped Cuskeel	PYSL	4,092					
Tautog	Egg						42,193
	PYSL						3,019
Unidentified	Egg	356					
	YSL	356					
Weakfish	PYSL	890					
Windowpane	Egg				479		80,735
	YSL						1,406
	PYSL	356					14,038
Winter flounder	YSL				2,368		
	PYSL				2,441		10,632
Yellowtail flounder	Egg				235		
SUM	**Egg**	**79,529**	**6,245**	**109**	**162,768**	**109,977**	**285,284**
	YSL	**8,363**	**0**	**0**	**2,368**	**5,466**	**6,948**
	PYSL	**674,127**	**52,628**	**10,083**	**11,794**	**3,966**	**70,423**

Table 12. Comparison of mean ichthyoplankton density from Poletti Program Survey # 6 (May 13-26, 2002) from the central basin region of Long Island Sound in the Deep (total water depth > 98 ft) and Intermediate (total water depth 6-98 ft) depth strata and the May 24, 2006 Broadwater site specific collections (daytime, mean of three replicate tows in each of the three depth strata (n=9) ± standard error). Poletti tows were collected during the daytime and sample variance is not available because all samples within a given gear/survey/depth strata were combined in the laboratory to form a composite sample*.

Species	Stage	Density (#/100m³)		
		Poletti-Deep	Poletti-Intermediate	Broadwater
Fourbeard rockling	eggs	66.7	145.9	68.1 (± 7.1)
	larvae	20.8	22.6	40.1 (± 6.4)
American lobster	larvae	0.1	0.2	
American sandlance	larvae		0.1	
Atlantic mackerel	eggs			6.1 (± 2.3)
	larvae	1.2	0.5	0.7 (± 0.4)
Atlantic menhaden	eggs	19.7	1,339.4	77.9 (± 12.8)
	larvae		2.2	
Cod (unidentified Gadidae)	eggs		2.1	
Cunner	eggs	3.9	2.2	9.9 (± 2.7)
	larvae			0.2 (± 0.2)
Grubby	eggs	0.1		
Searobin	eggs	3.7	7.8	3.5 (± 1.3)
Tautog	eggs	19.2	45.6	26.9 (± 7.9)
	larvae	0.1		3.8 (± 2.0)
Weakfish/Scup	eggs	4.6	10.4	
Windowpane	eggs	15.9	34.3	32.9 (± 6.4)
	larvae	9.7	4.6	10.2 (± 3.4)
Winter flounder	larvae	7.9	7.5	3.1 (± 1.2)

* A composite sample was formed from 10 Tucker trawl tows in Regions 7-9 during Poletti Survey # 6 in the Deep depth strata, and from 21 tows in the Intermediate depth strata (see Normandeau 2006 for details).

CERTIFICATE OF SERVICE

I hereby certify that I have this day served the foregoing document upon each person designated on the service list compiled by the Secretary in this proceeding in accordance with the requirements of Rule 2010 of the Commission's Rules of Practice and Procedure.

Dated at Washington, D.C. this 8th day of September 2006.

Brett A. Snyder