Executive Summary

This report summarizes monitoring and mitigation/restoration activities of the Division of Marine Fisheries (*MarineFisheries*) during the period 31 May 2003 through 31 May 2008 in response to assumed impacts from the construction of the HubLine natural gas pipeline in Massachusetts Bay. This program represents the first, large-scale, comprehensive effort by *MarineFisheries* to assess and mitigate for impacts from a major marine construction project in Massachusetts coastal waters.

The "HubLine" natural gas pipeline was constructed by Algonquin Gas Transmission Company in Massachusetts Bay during 2002-2003. This 29.4 mile long, 24" to 30" diameter pipe runs from Salem/Beverly to Weymouth and is buried at a minimum depth of 3 ft. with several exceptions. Horizontal directional drilling, conventional dredging, jetting, plowing, and blasting were all part of the construction process and collectively, they were assumed to have exerted an impact on the marine environment and living resources. Depending upon the type of equipment used, the area of disturbed sediments along the pipeline pathway caused by trenching and back-filling varied to as wide as ~70ft.

Specific Time-Of-Year (TOY) work windows were defined in the permitting process by the reviewing agencies in order to minimize the impact of construction activities on e.g., migratory movements or spawning seasons and the associated vulnerability of eggs and larvae of various species. Exceeding recommended TOY's beyond 30 April 2003 and 31 May 2003 work window end dates resulted in monetary compensation to the Commonwealth by Algonquin for mitigation and restoration for any short or long-term impacts to aquatic resources and habitat and for assessment. *MarineFisheries* was the designated lead agency in receipt of these funds and with the responsibility to provide effective mitigation and/or restoration of aquatic resources and habitat.

Public input and an inter-agency steering committee were solicited to help develop a monitoring plan and suite of mitigation/restoration proposals. The mitigation proposals included work in four areas: eelgrass restoration, habitat enhancement, anadromous fish restoration, and shellfish propagation. Recovery monitoring was initiated in 2003-2004 and all mitigation efforts were implemented during 2004-2008 and included mitigation-specific monitoring and evaluation of relative success in meeting program objectives.

Assessment Projects

MarineFisheries' post-construction assessment activities of the HubLine pathway were multi-faceted and intended to evaluate impacts from the construction and monitor recovery. This long term effort included specific assessment and monitoring plans which, in some cases, were associated with related and co-occurring mitigation project field activities. Acoustic and optical surveys of sediment and biota, species diversity investigations and on-going *MarineFisheries* surveys helped to contribute to the evaluation of potential impacts. Commercial lobster sea sampling, ventless lobster trap monitoring, early benthic phase lobster suction sampling, and standardized bottom trawl survey data were incorporated into the final assessment of relative abundance trends for species inhabiting the impacted area.

Acoustic and Optical Surveys of Pipeline Pathway

Monitoring studies were initiated by *MarineFisheries* in August 2003 with several localized sampling efforts. SCUBA surveys provided baseline data for future recovery monitoring and indicated that significant changes in vegetation and re-colonization of crustaceans and finfish had occurred in a relatively short time since the pipe was laid. There was no definitive evidence found during 2003 surveys conducted by either *MarineFisheries* or by Algonquin's subcontractors that surface-laid pipe or its trench construction blocked the seasonal inshore migration of lobsters.

Broader-based, multi-year monitoring of the pipeline pathway began in March 2004 after the construction schedule of trench back-filling and leveling was projected to be completed. Sonar and video monitoring indicated impacted

sediments along the 29.4-mile path had not yet been restored to pre-construction quality. A considerable amount of relief was evident in elongated spoil piles 1-2m in elevation. Width of disturbed sediments along the pathway generally significantly exceeded estimates provided during the pre-construction review process and approached 25 m (75ft). Overall, most of the back-filled trench, especially areas with cobble deposition or a cobble sand mix suggested early stages of flora and fauna colonization.

A series of 19 permanent monitoring sites, representing an array of habitat types, were established from this initial sonar imaging and surveyed in subsequent years.

Sediment Relief Monitoring—Sonar
Standardized transects, representative of relief profile, were defined at each site for annual relief monitoring with side-scan sonar (2004-2006). Side scan relief measurements were calculated from the shadow component of each site's side scan sonar record and reflect vertical profile relative to the surrounding natural seabed. Relief was also evaluated with multibeam sonar (2006-2007) which allowed interpretation of relief by calculating depth differentials.

Four years after pipeline construction, relief created by trenching and back-filling persisted at most sites. Side scan data exhibited some changes to relief morphology and elevation at all sites; some exhibited subtle changes while others showed moderate to major changes. Most of the sites which exhibited smoothing or weathering were at depths <70ft where the impact of storm surge is more likely to affect the ocean floor. Analyses of multibeam data for changes >0.25m, indicated little difference in the profiles of all sites between 2006 and 2007.

ROV Video Monitoring
Most sites already exhibited some algal growth plus various macro-invertebrate and finfish species presence when ROV video surveys began in 2004. It is clear that mobile species repopulated the construction area relatively quickly. However, video imaging of the 19 sites in 2007 indicated that full recovery had not yet occurred. More algal, hydroid, and sponge growth was present on nearby natural bottom compared to sites on the back-filled pipeline trench.

Algal growth and invertebrate and finfish presence/abundance was related to bottom type and depth. Sites at >50 ft depth exhibited invertebrate and finfish presence, but minimal attached growth. Hard substrate facilitated attachment of algae, but the proliferation of algal growth was largely dependent upon shallow water depths to allow light penetration for photosynthesis. A more detailed analysis of hard bottom recovery is provided in the mitigation section of this report, **Section IVB: Habitat Enhancement Project**.

Species Diversity
In 2007, benthic infaunal communities at 5 soft-bottom stations located along the HubLine pipeline construction route were investigated for evidence of impact from the construction process which occurred between 2002 and 2003. Results indicate that biological samples taken on the disturbed HubLine trench and on natural bottom adjacent to it were more similar to each other then when compared across stations. Pipeline trenching and trench back-filling may have originally impacted these benthic infaunal communities, but this 2007 survey indicated that the benthic communities along the HubLine route appeared to be largely recovered. Their species diversity and evenness values were similar to those at ambient control stations located outside the HubLine area of disturbance and within the mean baseline range of MWRA's Harbor Outfall Monitoring program.

Species diversity of epibenthic fauna on hard-bottom sites was investigated in 2005 and 2007. The 2005 analyses demonstrated that natural reef sites had a higher measure of species richness than similar, but disturbed, sediment on a HubLine site. Biological monitoring during 2006-2007 allowed comparative evaluations of species diversity using three SCUBA survey procedures: 1) air-lift suction sampling, 2) transect surveys, and 3) percent cover evaluations in quadrats. In most cases, species diversity on the natural reef was significantly different and still higher, with some seasonal variation, than that on the HubLine back-

filled trench approximately 4 years after pipeline construction.

Commercial Lobster Sampling

Initial concerns about pipeline construction effects on the commercial lobster fishery in Massachusetts Bay focused our attention on enhancing existing commercial lobster sea sampling activities in the general Massachusetts Bay area in calendar year 2003. *MarineFisheries'* commercial lobster sea sampling is a cooperative effort with commercial lobstermen and is conducted twice per month during May-November when over 90% of commercial lobster landings occur. Standardized catch rate trends encompassing the HubLine study period depict a general downward trend from 1999-2007, however, this is consistent with a broader-based downward trend elsewhere in the Gulf of Maine.

Suction Sampling Juvenile Lobsters

Suction sampling of early benthic phase (EBP) lobsters also was conducted in the Massachusetts Bay area to help evaluate larval lobster settlement in the area of construction. Sampling was conducted annually, using a diver-operated suction device, and augmented with site-specific suctioning of impacted sediments on the pipeline pathway.

Generally, catch densities increased through about 2004-2005 then declined thereafter to 2002-2003 levels. However, interpretation of these data should be done cautiously since they are characterized by high variances. Consequently, these time series show no obvious correlation with the 2002-2003 HubLine construction period.

Ventless Lobster Trap Survey

A pilot ventless lobster trap survey was started in fall, 2004 (October-November) as part of HubLine assessment initiatives to assist with monitoring the lobster population in and around the HubLine-affected region. An expanded 80 station, seven month survey was subsequently launched in Massachusetts Bay in 2005 and 2006. This research design, if modified for finer-scaled site investigations, represents a potentially useful tool for evaluating future marine construction projects.

The use of ventless gear extends lobster size structure information to the smaller sizes that do not normally occur in commercially-deployed vented traps. Trap placement was stratified by bottom sediment type and bathymetry.

No significant trends in catch per unit effort (CPUE) by substrate type were observed throughout Massachusetts Bay. However, depth (or its associated temperature gradient) was an important variable influencing catch rates and size distribution. Sublegal CPUE was fairly evenly distributed throughout the study area in all three years, while legal CPUE was consistently higher in the deepest strata.

A 3-year, October-November, time series (2004-2006) of these data was inadequate to draw meaningful conclusions about lobster relative abundance trends, since it was not only too short (at the time of this writing) but did not encompass the entire molting season. However CPUE of sublegals was significantly less in 2004 compared to 2005 and similar to 2006, while legal CPUE exhibited no differences across years.

This initial effort led to a coastwide survey, adopted by the Atlantic States Marine Fisheries Commission (ASMFC), which was implemented in coastal waters from Maine to Long Island, NY in 2006, 2007, and 2008. The ASMFC coastwide ventless trap survey is based on the sampling methodology and survey design developed for this initial ventless trap sampling effort, and it is planned to continue indefinitely as an additional means to monitor American lobster relative abundance in U.S. coastal waters.

Bottom Trawl Survey Trends

MarineFisheries' bottom trawl survey data were used to evaluate relative abundance trends for selected species from the HubLine study area. This bottom trawl survey was not a HubLine-funded effort and it was not designed to detect fluctuations in abundance on a fine geographic scale, e.g., the HubLine trench, but its statistical precision is appropriate for detecting larger scale changes as may be evident in annual trends. Relative biomass (mean weight per tow) and relative abundance (mean catch per tow in number

of animals) from 1978-2007 was analyzed for Atlantic cod, winter flounder, yellowtail flounder, American lobster, and Sea Scallops. Species trend analyses did not depict any obvious relationship with the HubLine construction period.

Mitigation Projects

Four mitigation projects were undertaken by *MarineFisheries* staff. They addressed eelgrass restoration, habitat enhancement, anadromous fish restoration (including anadromous fish run restoration, smelt restoration, and shad restoration), and shellfish restoration and stock enhancement:

Eelgrass Restoration Project

The primary goal of the *MarineFisheries* Eelgrass Restoration Project was to re-establish eelgrass in Boston Harbor as partial mitigation for assumed impacts to the environment from the pipeline construction. Restoration of eelgrass habitat will provide shelter, food, and has the potential to positively affect abundance of a number of finfish and invertebrate species judged to be potentially impacted.

Extensive site selection work was conducted during fall 2004 and spring 2005 to identify areas suitable for eelgrass growth. Twelve sites were originally identified, received (phase I) small scale test transplants (200 shoots in a $1m^2$ area), and were monitored for survival. Five of those sites exhibited acceptable survival and were selected for secondary test transplants (phase II, 1000 shoots) and later full-scale plantings between 2005 and 2006: Long Island North , Long Island South, Peddocks E, Portuguese Cove, off the west side of Peddocks Island, and Weymouth.

Planting was conducted using a combination of hand- and frame-planting, and seed dispersal followed by monitoring for shoot density expansion. The site selection process achieved successful results at 4 of our 5 sites. Shoot density expanded significantly and by late 2007, total areal coverage was over 2 hectares (~ 5 acres).

Biological monitoring was undertaken to determine ecosystem function of transplanted beds compared to existing beds in Boston Harbor, a healthy bed in Nahant, and an unvegetated control site in Boston Harbor. Parameters investigated included demersal, epibenthic, and benthic infaunal species richness and diversity; percent cover of eelgrass; shoot density; above-ground biomass; and, leaf area index. Transplant sites compared favorably to existing Boston Harbor eelgrass beds, and approached healthy beds in Nahant for several indices.

Hydrodynamic modelling results indicated that it was unlikely that seeds would spread naturally from existing remnant beds in Boston Harbor to sites we selected. However, it did show that, with our planted beds as "feeders," natural spreading via seed shoots was likely within and near most transplant locations, thus more efficiently focusing restoration efforts.

Outreach was an important part of the Eelgrass Restoration Project. We provided a "hands-on" educational experience for members of the community and promoted stewardship of this valuable resource. Volunteers were an essential part of our restoration effort. We enlisted the help of a number of volunteer divers and shore helpers. A total of 428 hours were donated by 155 volunteers during our restoration activities.

Habitat Enhancement Project

In March-April, 2006, *MarineFisheries* constructed a six unit cobble-boulder reef off Boston Harbor in order to provide partial mitigation for the assumed impacts to biological resources and habitat from HubLine construction. This Project enhances complex substrate in Massachusetts Bay, thereby providing niches for multiple life stages of numerous finfish and invertebrate species.

Reef Site Selection

A simple site selection model used seven systematic steps: exclusion mapping, depth and slope verification, surficial substrate assessment, data weighting and subsequent ranking analysis, visual transect surveys, benthic air-lift sampling, and larval settlement collector deployment. Results from each step in this process ultimately

allowed us to select a site for habitat enhancement at a target depth that received little wave action, had no slope, and possessed a surficial substrate type that could support the weight of a reef. The site also had the presence of a natural larval supply and low species diversity prior to reef installation. Each step in this site selection model was designed for adaptation by others interested in future artificial reef development.

Artificial Reef Monitoring Program:
An intensive, long-term monitoring program was implemented to measure ecological variation on the artificial reef and to determine how well the artificial reef met specific goals. Two primary questions were addressed with this monitoring program: (1) can a cobble/boulder artificial reef establish similar levels of species abundance and diversity as a nearby natural reef, and (2) if so, in what timeframe? *MarineFisheries* also investigated smaller scale questions such as: does the artificial reef augment post-larval lobster settlement and the settlement of other fish and invertebrates; does the artificial reef provide mitigation for the hard-bottom encrusting community; and does the artificial reef provide shelter for multiple life stages of various marine organisms?

To investigate these questions, a research plan was developed which incorporated three different monitoring methods: annual air-lift sampling for crustacean and fish larvae, semi-annual small fish trap sampling, and seasonal permanent transect sampling using SCUBA. Four primary areas were monitored: the artificial reef, a nearby natural reef, a cobble fill point on the HubLine pipeline, and a sand site. Results from the first year and a half of monitoring showed that young-of-the-year lobster densities on the artificial reef, as determined by air-lift sampling, were similar to the natural reef, HubLine, and sand. Fish trap sampling showed that significantly more cunner, Massachusetts' most common reef-dwelling species, were caught on the artificial reef and the HubLine than on the natural reef and the sand and that cunner had high site fidelity, only occasionally moving from one site to another. The artificial reef had the highest diversity of enumerated species, yet the lowest diversity of species assessed by percent cover. This difference was likely due to species life histories, as the artificial reef quickly attracted mobile invertebrates and fish species that preferred complex habitat with high relief, whereas sessile, slower-growing species take longer to settle and establish.

Species composition on the artificial reef will most likely take years to follow fluctuations in composition similar to that of a natural reef. The HubLine cobble fill point is a few years older than the artificial reef and does not yet mimic the natural reef in species abundance or diversity. If the artificial reef never resembles a natural reef or if it takes more than five to ten years to reflect the conditions of a natural reef, the effectiveness of artificial reefs as mitigation tools in New England waters should be viewed cautiously. However, in the present timeframe of comparison, some conclusions can be drawn from this on-going monitoring program. The cobble and boulder artificial reef did provide habitat for the hard-bottom encrusting community, larval settlement occurred in similar densities to adjacent comparison sites, and the abundance of cunner is currently higher on the artificial reef than the natural reef.

Anadromous Fish Restoration Project (3 Parts)
The Anadromous Fish Restoration Project enhanced the anadromous fish resources in the embayments and associated watersheds adjacent to the HubLine Pipeline. These are resources that were potentially impacted by the HubLine construction. The project consisted of propagation/stocking, monitoring, construction and repair of anadromous fish passage, and improvements to habitat. There were three parts to this restoration effort:

1. <u>The Anadromous Fish Passage Enhancement Project</u> had the objective of enhancing and increasing the spawning habitat for alosid fishes (alewives, *Alosa pseudoharengus*; blueback herring, *Alosa aestivalis*; American shad, *Alosa sapidissima*). *MarineFisheries* selected and completed 20 projects in 13 systems in the HubLine region that (a) ranged from minor to major fishway improvements, (b) created new passage for anadromous fish, (c) evaluated the feasibility for restoring anadromous fish

populations, (d) restored or enhanced spawning habitat, and (e) developed innovative technology for assessing river herring passage and run size.

2. The Rainbow Smelt Culture and Enhancement Project assisted the restoration of rainbow smelt (*Osmerus mordax*) populations in several river systems in the Massachusetts Bay area. A two-year pilot project began in 2004 using HubLine funds to develop smelt culture and early life-stage marking techniques. This effort was linked to a NOAA Protected Species Program grant to develop population indices for smelt. The population index project developed fyke net sampling stations in 2004 and 2005 that also served as a source for mature smelt for laboratory culture and for re-capturing marked smelt that were stocked in specific rivers. The project goals were to achieve high survival of smelt eggs in a hatchery incubation setting, develop otolith marking protocols and verify restoration success following stocking in a control river.

Approximately 5.3 million marked smelt larvae were stocked into the Crane River during 2005-2008. The analysis of age-1 smelt otoliths from 2008 fyke net catches at restoration river stations found 16% of the Crane River age-1 smelt and 14% of the North River age-1 smelt were stocked as larvae by this project. Conclusions cannot be reached on the contributions of larvae stocked in 2005 and 2006 because these smelt were marked as eggs and subsequent investigations found that the OTC mark in smelt marked as eggs did not persist in hatchery specimens reared for one year. The smelt larvae stocked in 2007 and 2008 were marked as larvae with 500 mg/l OTC which our laboratory investigations indicated is more durable than the egg marking and does not negatively influence egg or larval survival.

Smelt fyke nets successfully captured smelt at all six stations during 2005-2008 revealing unique population signals of spawning run seasonality, age composition, and size at age. This technique shows promise for tracking age composition and cohort strength. The catch data also contributed information on other species of diadromous fish that are poorly documented in Massachusetts.

We believe these efforts mark the first time rainbow smelt have been reared on a dry diet and to maturity in a closed-loop hatchery system. The recapture of OTC-marked rainbow smelt in the Crane River is also a novel achievement that may develop into a restoration tool that can be applied in other river systems. Continued sampling and larval stocking in 2009 should provide a better assessment of the contribution of stocking to smelt runs and the overall utility of these methods for smelt population restoration.

3. The American Shad Propagation Project is a collaborative effort between *MarineFisheries* and the U.S. Fish and Wildlife Service to restore viable populations of shad to the Charles and Neponset Rivers by establishing a fry-stocking program and improving fish passage in these systems. Significant fish passage improvements were made to the Charles River, but passage in the Neponset River was not projected to be realized during this study period, so all American shad fry production was allocated to the Charles River.

Despite coincident high water flow events in the Merrimack River that limited broodstock availability, the HubLine American Shad Propagation Project successfully produced and stocked shad fry in the Charles River between 2005 and 2008. In June 2005, following infrastructure installation, limited pilot production was conducted at Essex Dam and at the North Attleboro National Fish Hatchery and by spring 2006, full-scale spawning and rearing was operational at the Nashua and North Attleboro National Fish Hatcheries and at Essex Dam. From 2006 through 2008, approximately 3000 adult American shad broodstock were captured at the Essex Dam, Merrimack River, injected with hormone and successfully spawned. A total 3.6 million shad fry were immersed in an oxy-tetracycline bath to mark their otoliths and stocked in the Charles River.

Otolith marking allows identification and quantification of hatchery-origin shad in 3-4 years when these fish reach maturity and return to spawn. A successful restoration will be indicated in future years by the presence of a greater number of naturally-spawned individuals as compared to hatchery-spawned individuals.

Shellfish Stock Enhancement Project

The Shellfish Stock Enhancement Project is restoring/enhancing soft-shell clam (*Mya arenaria*) populations in five Boston Harbor communities Winthrop, Quincy, Weymouth, Hingham and Hull. The soft-shell clam was identified as an impacted species from the construction of the HubLine gas pipeline along near shore areas. Restoration is being conducted through cooperative programs with local municipalities, commercial shellfishers, and Salem State Northeast Massachusetts Aquaculture Center (NEMAC), with funding and technical assistance from *MarineFisheries.*

In 2006, the study team seeded over one million hatchery-reared juvenile clams within five enhancement sites on tidal flats in Quincy, Weymouth and Hingham. Clam size, sediment type and beach kinetics were found to influence clam survival. Planted clams larger than 10mm in length exhibited a higher survival rate than smaller juveniles. Juvenile clams that were planted in silty mud did not survive. Similarly, enhancement sites that were exposed to significant tidal current, stream flows, wind driven waves or vessel wake suffered high levels of clam mortality.

During summer 2007, an additional 870,000 juvenile clams that averaged between 10.5 to 16.8 mm SL were stocked at eight enhancement sites in Hull, Winthrop, Quincy, Weymouth and Hingham. In 2008, 42 plots were seeded with 756,000 seed clams at four enhancement sites in Winthrop, Quincy and Weymouth. Subsequently, temporary restrictions placed on the sale of seed clams from the NEMAC hatchery facility reduced the plan to plant 1.62 million clams. Routine pathology tests of juvenile clams within Salem State's hatchery revealed the presence of an ectoparasite which warranted further investigation by *MarineFisheries*.

A controlled harvest of two of the 2006 enhancement plots was undertaken in 2008. Legal-sized clams were depurated at the Newburyport plant and later sold by the Master digger. Under-sized clams were replanted within the harvested plots.

Efforts to collect wild clam spat were unsuccessful. No significant numbers of YOY clams were found within any of the 44 spat collectors that were sampled. This was likely due to currently small resident spawning stocks of softshell clams in Boston Harbor since this collection method has been used successfully in other coastal Massachusetts areas.