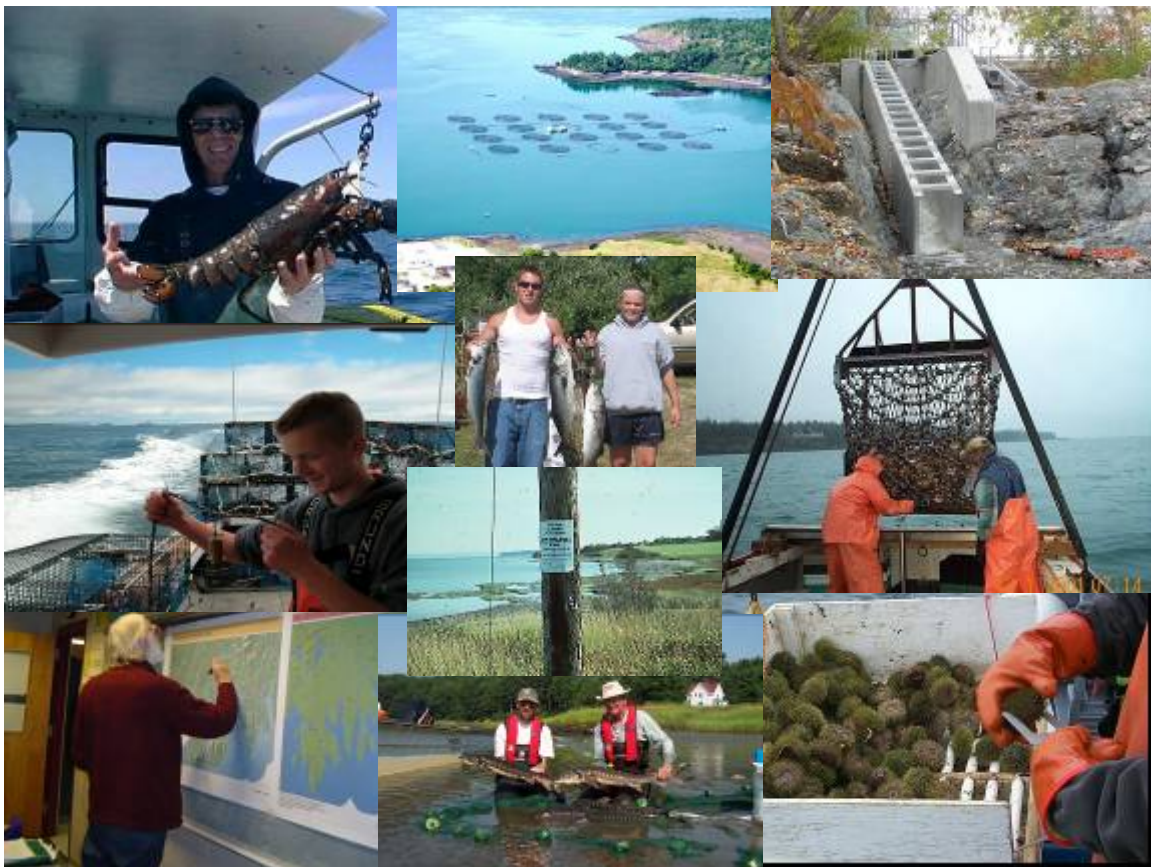


MAINE DEPARTMENT OF MARINE RESOURCES

2009 Research Plan



January 2009

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OVERVIEW OF DEPARTMENT RESEARCH

This research plan is intended to meet the Department of Marine Resources (DMR) statutory responsibility to report annually on the research of the department to the DMR Advisory Council (§6024.5). After reviewing the plan, the Council reports the plan, and any recommendations or comments, to the Joint Standing Committee on Marine Resources.

What do we mean by Research?

DMR defines research broadly to include both hypothesis-driven research to answer specific questions and monitoring to collect long-term data on species, the environment, and fisheries. Our research and monitoring programs target an increasing, but still relatively small, number of the marine and diadromous species of ecological, economic and social importance in the Gulf of Maine. Factors such as funding availability, resource status, management jurisdiction, value of the fishery, legislative mandates, and constituent interests determine the focus of DMR's research programs.

How is our research used and who uses it?

Results from our research and monitoring are used by local, state, federal, international, academic and private parties. Research and monitoring results from DMR science contributes to better decision making by regulatory bodies and legislators. Data collected by DMR sampling programs are integral components of stock assessments used to make management decisions, private investment decisions, respond to oil spills, and guide development. Lobster, scallop and urchin research and monitoring is used by the Lobster Zone Councils, Lobster Advisory Council, Scallop Scallop Advisory Council, and Sea Urchin Zone Council.

One of our most visible programs, public health, monitors water quality to ensure that shellfish products harvested in Maine are safe. Municipalities rely on data and information gathered by DMR's water quality monitoring and clam assessments to guide watershed land-use decisions, establish shellfish conservation areas, and set seasons and the number of licensees. Other state agencies such as the Department of Environmental Protection use DMR's water quality monitoring for identifying sources of pollution and prioritizing investments in sewage treatment.

Many of our species also migrate across state jurisdictional boundaries and become regulated by an additional layer of interstate, federal, and international bodies. For example, striped bass, shad and river herring, northern shrimp, American lobster are managed by the Atlantic States Marine Fisheries Commission (ASMFC). The New England Fishery Management (NEFMC) and National Marine Fisheries Service (NMFS) are responsible for management of species that occur primarily in the EEZ (3-200 mi from shore). These include the groundfish species complex, sea scallops, small pelagic species such as herring and mackerel, and large pelagic species such as sharks and tunas. Atlantic salmon and bluefin tuna are managed by international bodies such as the North Atlantic Salmon Conservation Organization (NASCO) and International Commission on the Conservation of Atlantic Tuna (ICCAT).

What types of research do we do?

Research covers the range from protecting public health to helping to restore a single species, from testing new methods of management to identifying critical habitats. Our research and monitoring is intended to be directly applied to managing of our marine resources.

Research programs include coast-wide water quality monitoring for the classification of shellfish growing areas; biotoxin monitoring of shellfish; commercial catch sampling of lobsters, sea urchins, shrimp, herring, scallops, groundfish, and sea cucumbers for use in stock assessments; collection of commercial catch statistics; recreational fisheries sampling;

aquaculture lease investigations; habitat mapping; seaweed management; oil spill response activities; and fishery independent surveys of marine, estuarine, and riverine fisheries resources. Of primary importance is evaluating the condition of and year-to-year changes in stocks, habitats, environmental conditions, and fisheries. Although not immediately obvious as research, we also invest in evaluating management techniques to assess how well they are working. And finally, we consider education and outreach to be integral to the delivery of our research results.

The following is a description of DMR research and monitoring efforts planned for 2009. Many of these programs and projects are ongoing to meet management needs and legal mandates. Research needs that cannot currently be addressed by DMR are presented in the second half of this plan.

PUBLIC HEALTH

DMR's Public Health program operates under the guidelines of the National Shellfish Sanitation Program (NSSP). The NSSP is the federal/state cooperative program recognized by the U. S. Food and Drug Administration (FDA) and the Interstate Shellfish Sanitation Conference (ISSC) for the sanitary control of shellfish produced and sold for human consumption. The purpose of the NSSP is to promote and improve the sanitation of shellfish (oysters, clams, mussels and scallops) moving in interstate commerce through federal/state cooperation and uniformity of state shellfish programs. DMR has been a member of the ISSC since 1982. The ISSC provides the formal structure wherein state regulatory authorities with FDA concurrence can establish updated guidelines and procedures for sanitary control of the shellfish industry.

Water Quality Monitoring - This program is responsible for properly classifying the state's shellfish growing areas to allow for the commercial and recreational harvest of marine bivalve mollusks. Samples include seawater, well water, pollution sources and shellfish. Most sampling is done from shore with a few sites on offshore islands and at deep water fishing areas. Approximately 60 water samples are processed daily in two DMR laboratories, with well waters and shellfish samples tested as needed.

Both DMR laboratories are equipped to conduct male specific coliphage tests (MSC) on shellfish and water samples. FDA trained the Northeast Shellfish Laboratories in their proposed method in 2004. DMR research began in 2004 but was suspended in 2005 due to staffing changes. It will be conducted as time permits in 2009. The MSC test is a cost effective method for determining coliphage levels. MSC is not an NSSP approved indicator and the method is not an NSSP approved method; therefore any data generated at this time will not be used for shellfish growing area classification. The FDA has submitted a proposal to the ISSC for acceptance of coliphage as an indicator of viral pollution associated with wastewater treatment plants (WWTP) and the method has been proposed to the ISSC for acceptance as an approved method for the quantification of male specific coliphage. The DMR is participating in research to determine if it is an effective indicator test for viruses associated with WWTPs and to determine background levels in Maine coastal shellfish. Future use of the indicator and method will depend on the actions of the ISSC and results of ongoing research in Maine and other areas of the United States.

Volunteer Water Quality Monitoring - The DMR Volunteer Coordinator coordinates over fifty volunteers throughout Maine's coastal communities to aid staff in the annual collection of water samples for the program. Each year volunteers are trained and site certified for their areas while also reporting any new pollution issues that may affect water quality.

Biotoxin Monitoring - The Marine Biotoxin Monitoring Program uses the standards outlined in the National Shellfish Sanitation Program (NSSP) to monitor levels of Paralytic Shellfish Poison (PSP) and other marine biotoxins in the shellfish along the coast of Maine. When toxin is found at levels near or above where human illness may occur, closures to the harvest

of shellfish areas are implemented. Maine has historically had high levels of PSP, more commonly known as “Red Tide” during the warmer periods of the year. Shellfish samples are collected statewide between March and October and evaluated at the two PSP laboratories (Boothbay Harbor, in the western portion of the state and Lamoine, in the eastern portion) for interpretation and appropriate closures are made when necessary.

The DMR collects shellfish samples from approximately 100 primary stations along the coast weekly and from offshore islands. Secondary stations are added as toxin rises and spreads. In 2006, outside funding allowed for intensive sampling in the Casco Bay area which left more than 11,000 acres of surface waters open (except for existing pollution closures) for the harvest of soft-shell clams during the entire PSP event. Federal “Red Tide Relief” monies have been used to continue the same level of PSP sampling in Casco Bay, and expand the fine-scale sampling program to Cobscook Bay and other major bays in Maine that suffer from regular PSP closures. This portion of the program will better define the distribution of toxic shellfish and potentially minimize the extent of shellfish closures.

Phytoplankton Monitoring - The DMR Volunteer Coordinator trains volunteers to participate in monitoring their coastal waters for potentially toxic algae. The volunteers report their findings to the Department on a weekly basis during the sampling season and sample more frequently in areas when a toxic species are detected. We continue to work towards using phytoplankton monitoring as an early warning system for toxic blooms. In 2009 we will continue to use quantitative estimates of species abundance to complement offshore sampling conducted by Woods Hole Oceanographic Institute. A new microscope with fluorescence capabilities was purchased and housed in Boothbay to conduct in situ hybridization on water samples throughout the season to confirm *Alexandrium* numbers and establish baselines for the future. Other areas of research being explored in 2009 include DNA sequencing to identify species level toxins and high profile liquid chromatography for toxin profiling in coordination with the University of Maine and Bigelow laboratories.

We will also continue collaborations with Woods Hole Oceanographic Institute collecting samples for a three year study of *Pseudo-nitzschia* sp. We will continue the second year of a pilot study to determine the effectiveness of a rapid response test kit that will verify with greater accuracy the presence of *Alexandrium* spp. for early detection.

Shellfish Dealer Certification and Inspection Program - The Maine Shellfish Dealer Certification and Inspection Program uses the standards outlined by the National Shellfish Sanitation Program (NSSP) to evaluate and certify all wholesale shellfish dealers in Maine. These dealers must be certified under the NSSP to ship, or process shellfish for shipment, within and outside of the state of Maine. By making sure that wholesale shellfish dealers meet these standards, the safety and wholesomeness of the shellfish being purchased by consumers is ensured. DMR staff inspects and trains certified shellfish dealers throughout coastal Maine, and conduct food-borne illness investigations.

RESOURCE ASSESSMENTS

DMR conducts a variety of sampling programs and approaches to collect information on the species of commercial, recreational, and socio-economic importance in Maine waters and on the fisheries for those species. Some surveys target a broad array of species while others focus on individual species and fisheries. Long-term monitoring efforts are generally used to track trends in abundance and condition of stocks from year to year. Shorter-term projects are designed to answer specific questions such as how fast fish are growing or where their spawning grounds are located. Surveys also are divided into fisheries independent and fisheries dependent. Fisheries dependent surveys are used to collect information on landings by fishermen. However, because catches vary with the amount of time fished, gear used, weather, market price, and knowledge of where the fish are located, they are generally biased and thus are not reliable if one wishes to

compare changes over time. To overcome that bias, fisheries independent surveys are done using a standard and consistent effort to minimize all other factors that effect catch and focus on actual abundance. Combined, all are integral to making recommendations on management measures.

Resource Surveys

Maine/New Hampshire inshore trawl survey - Each spring and fall, the DMR charters a commercial dragger to survey groundfish and invertebrate stocks at approximately 115 locations in the coastal waters of Maine and New Hampshire. The objective is to provide year to year relative abundance indices and distribution patterns for over 100 species of including lobster, cod, monkfish, winter flounder, herring, whiting, and shrimp. Catch is separated by species, counted, measure for length, weight, sex, and maturity stage. The spring 2009 survey will complete nine years of survey work. The survey is used by federal, state, and academic institutions throughout the Northeast to set quotas, effort, and understand life histories.

Juvenile recreational finfish survey – This is a long-term sampling program to determine occurrence, life history stage, and relative abundance of juvenile recreational finfish species such as cod, winter flounder, and pollock in representative habitat types such as intertidal mudflats, eelgrass beds, and channel areas less than 10 m in depth waters less along the coast of Maine. Additional sampling is focused on winter flounder and striped bass distribution, movements and life history.

Juvenile alosid and striped bass survey - Beach seine surveys in the Kennebec/Androscoggin estuary monitor the abundance of juvenile alosids (shad, alewives, and blueback herring) and striped bass at 14 permanent sampling sites in the tidal freshwater portion of the estuary and six additional sites in the lower salinity-stratified portion of the river, every other week from mid-May to the end of August. All fish are counted and the total length of a maximum of 50 of each species is measured.

Groundfish - Groundfish refers to the complex of species that include cod, haddock, pollock, yellowtail flounder, winter flounder, witch flounder, American plaice, redfish, white hake, ocean pout, halibut, and windowpane flounder. This complex is managed by the NEFMC. The NMFS is the primary agency responsible for monitoring the status of these species since most of the catch is taken from federal waters. These resources were overexploited by the foreign fleets prior to the establishment of the Exclusive Economic Zone (EEZ) under the passage of the Magnuson-Steven Fishery Conservation and Management Act in 1977. As the stocks began to rebuild, there was a rapid buildup in the domestic fleet which led to further overfishing. Fishing capacity reduction programs and a series of management actions have led to some rebuilding of fishery stocks, but some stocks such as cod have remained at low levels. DMR initiated the Maine-New Hampshire trawl survey in 1999 to collect data on the status of groundfish and other marine resources in the nearshore waters of the Gulf of Maine that are not sampled by the NMFS surveys.

Groundfish management - DMR will continue to develop a description of Maine's groundfish fishery by compiling data on number of licenses and permit types, demographics, fleet composition, sectors, capacity, effort, catch and bycatch. These data will be collected and compiled using NMFS, DMR, and ACCSP databases.

A DMR scientist will represent the State of Maine in meetings of the NEFMC's Multispecies Plan Development Team (PDT), participate in resource assessment and management activities, and participate in development of resource monitoring activities such as industry-based surveys. Relevant information relating to the groundfish fishery and the status of exploited stocks in the Gulf of Maine, especially the Gulf of Maine cod stock, will be assembled and reviewed in preparation for active participation on the respective PDT.

Groundfish port sampling – DMR will continue a port sampling program initiated in 2008 for groundfish landed in Maine ports. Biological data will be collected including length, weight, and maturity, and otoliths for aging. DMR has established an age and growth laboratory, since ageing is a key component of groundfish assessments. Scientists aged about 200 halibut in 2008 and will continue working on a backlog of eight years of otolith samples during 2009.

Halibut – DMR will continue a volunteer tagging study with halibut fishermen primarily fishing in state waters that began in 2000. Staff will monitor for tag returns from previous years including satellite tags released in an earlier federally-funded tagging and assessment study.

Conservation engineering - A DMR scientist will participate on the ASMFC Fishing Gear Technology Working Group. This group was convened to look at state managed fisheries and develop a prioritized list of which fisheries need gear improvement work. In addition, the members of this group are tasked with evaluating all state fisheries and recommend suggestions on how gear modifications can improve catch of targeted species and reduce bycatch of non-targeted species.

Grate raised footrope whiting fishery sea sampling program - The DMR will continue to monitor the development of this fishery and collect bycatch data of regulated species, July – November, if the fishery develops. Continued NEFMC approval for this fishery is dependent upon the results of this program. Participation in this fishery continues to be extremely limited to date.

Proposed research on Atlantic wolffish and cusk – A proposal was submitted to the Saltonstall-Kennedy Program of NOAA to conduct exploratory studies on two species of concern, Atlantic wolffish and cusk. If funded, the wolffish study will assess the catchability of wolffish using modified lobster traps for tagging to collect data on habitat preferences of this species using satellite tags. The goal of the cusk study is to estimate the mortality of cusk caught as bycatch in the logline and lobster trap fisheries. Notification of funding is expected in March 2009.

Monkfish - The monkfish fishery currently represents about 30% of the Maine groundfish fishery revenue. Monkfish is not considered a part of the NEFMC Multispecies Complex, but is managed under its own plan. The stock status of monkfish in both management areas (Mid-Atlantic and Northern Gulf of Maine) is uncertain. Using an index-based assessment, both stocks were considered overfished in 2006. In 2007, a new model was used and both stocks appear to be in fair condition.

Monkfish management - DMR will develop a description of Maine's monkfish fishery by compiling data on number of licenses and permit types, demographics, fleet composition, sectors, capacity, effort, catch and bycatch. These data will be collected and compiled using NMFS, DMR, and ACCSP databases.

A DMR scientist will represent the State of Maine on the NEFMC's Monkfish Plan Development Team (PDT), participate in resource assessment and management activities, and participate in development of resource monitoring activities such as industry-based surveys. Relevant information relating to the monkfish fishery will be assembled and reviewed in preparation for active participation on the PDT.

Herring - The Atlantic herring is one of the most biologically and economically important species in the Gulf of Maine. Herring are oceanic plankton-feeding fish that occur in large schools, and inhabit coastal and continental shelf waters from Labrador to Cape Hatteras. The fishery has changed since the mid 1980's from one that targeted juvenile herring (ages 1 to 2) along the coasts of Maine and New Brunswick to large-scale fisheries for adult herring, primarily occurring

in the Gulf of Maine, on Georges Bank, and in southern New England and mid-Atlantic waters. Annual commercial landings are currently around 200 million pounds with 60 percent of the catch utilized for lobster bait and 40 percent for the processing facilities in Maine and New Brunswick. In addition to their commercial importance, Atlantic herring are an important food source for many species of fish, mammals, and seabirds. The DMR is the primary state agency in the New England and Mid-Atlantic regions conducting research, resource monitoring, and assessment for Atlantic herring. Data from these programs are utilized in stock assessments that are used to guide management actions developed under ASMFC and NEFMC fishery management plans. The goal for 2009 is to continue resource monitoring and assessment activities for the U.S. Atlantic coastal stock complex and to provide biological information and advice for resource management purposes.

Herring catch program - Herring catches are monitored and compiled through the federal Interactive Voice Response System and from federally-mandated Vessel Trip Reports, and state-only herring catches.

Biological sampling program – Samples of 50 fish each are collected from commercial catches throughout the range of the fishery (Maine-New Jersey) and the fishing season, and processed to determine size, age, sex, and sexual maturity. This program also collects samples from the mackerel fishery for the NMFS.

Bycatch program - DMR conducts incidental catch surveys for vessels directly targeting Atlantic Herring and landing at major New England and Mid-Atlantic ports. Confidential data are analyzed, summarized, and provided to managers in aggregate form for development of management measures for the targeted herring fishery. Additionally, biological samples are taken for other incidental species (river herring, American shad, menhaden, and others upon request).

Herring stock assessment and management – A DMR scientist participates in all aspects of interstate and federal management for Atlantic herring including ASMFC/NMFS stock assessments, Plan Development Team, Advisory Panel, and Management Board.

Hagfish - In New England, a growing fishery for Atlantic hagfish (*Myxine glutinosa*) has initiated science and policy discussions about the development of the fishery, its potential for future expansion, and its effect on the resource. The hagfish fishery in New England was developed in the early 1990s, with the first reported landings of around one million pounds in 1993. Korean buyers recognized that the New England area could provide the high quality hagfish skins used in making leather as well as hagfish meat for human consumption. Since there is currently no management program for this fishery (except for a control date of 8/28/02), and consequently no permitting or reporting requirements, there is considerable uncertainty regarding the actual level of hagfish landings. The level of discards and discard mortality of hagfish culled at sea or rejected by the dealer/processor in port is unknown. With reported hagfish landings in New England quadrupling in the first four years of the fishery (1993-1996), and steadily increasing since, NMFS proposed in 2006 to collect information from dealers/processors to gain a better understanding of this fishery and its operations at the vessel/dealer level.

Hagfish port sampling program - DMR will continue to identify active hagfish dealers/processors along the Maine coast, conduct a port sampling program to collect commercial length/weight frequency data, and interview boat captains for appropriate measures of effective fishing effort.

Lobster - The DMR has been actively engaged in intensive studies of the American lobster and the coastal fishery it supports since 1966. The biological, catch/effort and socio-economic information derived from these investigations has provided a sound basis for the formulation and continued evaluation of an effective lobster management plan, not only for the State of Maine, but also the ASMFC and NMFS. Data collected in these sampling programs allow the DMR to

assess current resource and fishery conditions and to evaluate important biological characteristics and issues such as reproductive potential, stock-recruitment relationships, and sources of recruitment, and to evaluate gear performance and selectivity.

Lobster sea sampling program - Lobster catch, effort, and detailed biological data (sex, presence of eggs, stage of egg development, molt stage, V-notch, etc.) are collected on a trap-by-trap basis onboard fishermen's boats. A minimum of three boat trips per month are sampled from each of the seven lobster zones from May through November. Winter sampling has been added in recent years, but on a more limited basis.

Lobster port sampling program - This project began in 1967 as Maine's first comprehensive survey of the lobster fishery. Ten dealers are randomly selected each month from April through December. Dockside interviews are conducted to collect catch/effort information and biological data (length, weight, and sex).

Juvenile lobster settlement survey - Dive surveys and suction sampling are conducted by DMR to sample the number of newly settled lobsters at set locations along the coast. A minimum of four sentinel sites are sampled in each of the seven Lobster Management Zones in October of each year.

Lobster ventless trap survey – DMR proposes to continue a trap survey to index juvenile lobster abundance from Maine to New York. Modified lobster trap (small mesh wire, no escape vents) are set at randomly selected locations, stratified by statistical area and depth.

Lobster program peer review – An external peer review of the various components of the lobster program including non-DMR projects in Maine will be conducted by a panel of experts in February 2009. The purpose of this peer review is to provide a critique of ongoing programs for funding and management decisions.

Lobster stock assessment and management - DMR's chief lobster scientist participates in ASMFC's Lobster Technical Committee, participates in stock assessments, and management meetings. A lobster stock assessment will be completed in 2009.

Northern Shrimp - The northern shrimp fishery is an important winter fishery in the Gulf of Maine that is managed under an ASMFC interstate management program with the states of Maine, New Hampshire, and Massachusetts. The states' sampling programs provide essential data for annual stock assessments and management actions. The Gulf of Maine fishery has seen wide variations in landings with current estimates of stock abundance at a high level.

Shrimp port sampling program - to monitor the status of the northern shrimp fishery. Dockside interviews are conducted to determine the total catch of each vessel sampled and effort information such as total drag time, or total number of traps and soak time. Shrimp samples are collected as the vessels unload and are processed to determine the size, sex, and stage composition of the catch. Since Maine fishermen harvest 85% of the New England catch, information provided by the DMR is crucial to the shrimp assessment and management process.

State/federal cooperative summer shrimp survey - scientists from NMFS, Maine, New Hampshire, and Massachusetts collaborate to conduct a series of tows for shrimp in the Gulf of Maine. The survey data provide fishery independent data that are an important component of the assessment of the Gulf of Maine shrimp stock.

Annual shrimp assessment - ASMFC's Northern Shrimp Technical Committee, comprised of scientists from NMFS, New Hampshire, Massachusetts, and the Maine DMR, conduct the

annual shrimp stock assessment and report that evaluates the current status of the Gulf of Maine shrimp stock and recommends management measures for the next fishing season to the Northern Shrimp Advisory Committee and Northern Shrimp Section.

Horseshoe Crab - Beginning in 2001, annual surveys of horseshoe crab spawning populations and breeding sites were undertaken through a joint effort of the DMR, several coastal watershed volunteer monitoring groups, and a private contractor. Following the drastic depletion of the resource in the Mid-Atlantic States, and the resultant increased harvesting of Maine crabs, anecdotal information was collected which indicated that Maine populations have experienced decline in recent years. These surveys are intended to provide a much-needed update to the last significant assessment of Maine horseshoe crabs and breeding locations, which was conducted in 1977 for the Maine State Planning Office.

Horseshoe crab spawning survey – A visual count of spawning horseshoe crabs is made at four sites along the coast during May and June spring tides. This survey relies heavily on volunteers who walk a standard survey transect at high tide counting crabs observed within a two meter band. Since 2005, sites have been reduced from 14 to four for budget reasons. Horseshoe crabs are considered to be declining along the Atlantic seaboard. The survey is intended to measure success of a ban on taking horseshoe crabs or eggs during the spawning season (May 1-October 30); however, because horseshoe crabs take upwards of six years to reach maturity, we do not expect to note an increase in young crabs until about 2009-2010. Data are also used to comply with ASMFC management.

Green Sea Urchin - The fishery for green sea urchins developed rapidly in the late 1980s as a result of expanding export markets, and peaked at 39 million pounds in the 1992-93 fishing season. Landings declined steadily because of overfishing and in 2005, only 3.5 million pounds were landed. Actions were not taken to management the fishery during its boom years and it was not until 1995 that the state established the Sea Urchin Research Fund that has since funded a series of studies and long-term monitoring programs that have led to an improved understanding of Maine's sea urchin biology and fishery.

Sea urchin port sampling program - DMR samplers visit randomly selected Maine ports from Portland to Lubec where urchins are being landed, between September and April, depending on the fishing season. The 2008-2009 fishing season has 10 days of fishing in Zone 1 and 45 days of fishing in Zone 2. Dockside interviews of urchin divers, draggers, and buyers are conducted for catch and fishing effort data and information on market trends and fishing practices, and biological data on the size of the catch are collected.

Sea urchin dive survey - DMR and industry divers count and measure urchins at 144 sites each spring from Kittery to Eastport. This survey provides fishery independent data that are used in stock assessments to describe the status of the resource and provide a scientific basis for the development of management measures.

Larval sea urchin monitoring - DMR divers deploy settlement plates at Pemaquid Point each spring, collect them during the summer, and examine the plates in the laboratory to enumerate the number of new young-of-the-year sea urchins. This continues a time series begun at that site in the mid 1990s by the University of Maine, which tracks annual sea urchin larval settlement.

Sea urchin assessment and management - DMR personnel conduct stock assessments of sea urchins and provide fishery sampling, survey and stock assessment information to the sea urchin management council in their deliberations and decisions in managing the resource.

Acanthazanthin in urchin tissue— Acanthazanthin is a nutrient necessary for healthy growth of marine fish. Natural sources derive from crustaceans. Synthetic acanthazanthins are added to salmon feed to provide the essential nutrient and enhance flesh color. Reports from Japan that urchins from Maine exceeded the allowable concentration of acanthazanthin have caused concern amongst urchin dealers. Those results have never been confirmed and are, in fact, questionable. A small study will be completed under contract with a researcher at the University of Maine in 2009, to compare tissue concentrations of acanthazanthin from samples of urchins collected under salmon cages with urchins never exposed to aquaculture to determine whether or not this is a valid issue,

Sea Cucumber - Sea cucumbers were first harvested in Maine in 1988, but it was not until 1994 when the fishery began to increase to meet the Asian market demand. Concern about overfishing and the lack of knowledge about this resource led to the enactment of emergency regulations under the 1999 Sustainable Development of Emerging Fisheries Act that limited the fishing season, drag size, and number of harvester endorsements, and required the submission of harvester logbooks. DMR worked with Dr. Yong Chen and a graduate student at the University of Maine on a federally-funded study to assess the stock status in the Frenchman's Bay region, examine spawning times, and conduct depletion studies.

Fishery monitoring program - DMR will continue a port sampling initiative to collect catch, effort and biological data from the sea cucumber fishery in 2009. Work will be done on trying to develop a protocol for evaluating maturity from a subsample of animals collected during the port sampling process.

Sea Scallop - Maine's scallop resource is currently at its lowest since 1977. It is difficult to say to what degree this recent in stock levels is due to natural factors or over-exploitation. The establishment of the Scallop Management Fund has enabled a statewide survey to characterize the coastal scallop population, initiation of sea and port sampling programs for scallops, and gear research to develop less damaging and more selective gear.

Port sampling - DMR samplers visit randomly selected Maine ports from Portland to Lubec where scallops are being landed, between December and April. Dockside interviews of divers and draggers are conducted for catch and fishing effort data and information on market trends and fishing practices, and biological data on the size of the catch are collected.

Coastal resource assessment - DMR and industry partners survey the Maine scallop resource annually. The Eastern Maine strata were surveyed in 2008 and in 2009 the western strata and Cobscook Bay are proposed for surveying. Sampling occurs before the start of the scallop season on December 1st. This survey provides fishery independent data that are used in stock assessments to describe the status of the resource and provide a scientific basis for the development of management measures.

Gulf of Maine scallop assessment - A project entitled "Assessment of Sea Scallop Distribution and Abundance in Federal Waters of the Gulf of Maine" was awarded funding through the 2008 Research TAC Set-Aside (RSA) Scallop Exemption Program administered by NMFS. The major objective is to develop a survey program to assess scallop distribution and abundance in the Northern Gulf of Maine Management Area. This area was defined by the NEFMC in Amendment 11 and a "stand-in" total allowable catch limit was implemented until a survey could be conducted to estimate a biologically sustainable TAC for the stock.

Ocean Quahog - The ocean or mahogany quahog fishery began in 1976 in Maine state waters around Machias Bay, but began to expand into federal waters in the 1980's, in part because of paralytic shellfish poison (PSP) closures of several areas in state waters. The fishery is now managed under the Mid-Atlantic Council's Amendment 10 to the Surf Clam and Ocean Quahog Fishery Management with a maximum quota allocation of 100,000 bushels. Additional quota can be obtained by purchasing ITQ shares from mid-Atlantic fishermen. DMR monitors the resource for PSP and has conducted two stock assessment surveys to determine the status of the resource.

Resource assessment - A survey of the resource was conducted in 2008 and will not be conducted again until 2010. The purpose of the survey is to assess stock abundance and size composition of ocean quahogs from the primary quahog fishing grounds. Results are provided to the NMFS and Mid Atlantic Fishery Management Council in order to set quotas based on current resource information.

Age and growth study - Quahog shells were retained from previous stock assessment surveys. Ageing techniques will be researched and age composition of the samples will be determined to improve future stock assessments.

Blue Mussel

Impact of mussel dragging on soft-shell clams – In 2007, DMR staff began working with the mussel dragging industry to identify and close areas to dragging in order to protect sensitive habitats such as eelgrass and other resources such as clams. Work in 2009 will focus on characterizing bottom disturbance by different types of mussel drags. We will also be working with the Gouldsboro Shellfish Committee and the mussel industry to develop a protocol by which mussels may be removed from clam flats without harming the clam resource.

Soft-shell Clam - The Shellfish Management Program is responsible for the oversight of coastal communities with Municipal Shellfish Conservation Programs for soft-shell clams. Area Biologists will continue to provide technical assistance and scientific knowledge on shellfish management, biology, mariculture, and stock enhancement techniques to town officials and local harvesters. Area Biologists will train their communities to do shellfish surveys for establishing their conservation measures best suited to the town and provide annual training and certification of all Municipal Shellfish Wardens in the state.

Soft-shell clam recruitment, protection and grow-out - There are several continuing and planned small research projects taking place with town's with conservation ordinances. The projects involve the monitoring the effectiveness of techniques for soft-shell clam recruitment, protection and grow-out. Some of these projects involve various forms of Municipal Aquaculture, from town controlled aquaculture, i.e. upwellers to towns leasing, limited areas, inter-tidal flats to private individuals for soft-shell clam culture. This research will help communities determine the best methods to manage and increase their harvest of shellfish. Some of these research projects involve work being done by the Downeast Institute and the University of Maine system.

Evaluation of municipal shellfish programs - Analysis of research data from the Municipal Shellfish Annual Review database will continue to determine the effectiveness of the program. Diverse management techniques and shellfish habitats of each community make this a challenge. Yearly and seasonal environmental changes can have devastating results to any form of natural or human manipulated recruitment. There are data showing improved harvest quantities in communities with active shellfish enhancement programs.

Marine Worms - Research into the biology of marine worms and effects of their harvest on species such as soft-shell clams continues to be conducted by Dr. William Ambrose of Bates College. The Wiscasset Worm Conservation Area has been extremely valuable as an indicator of

natural trends of unharvested worm populations, to which harvested populations can be compared. Dr. Ambrose will continue in 2009 to assess growth and long-term abundance patterns of bloodworms in the Wiscasset and Montsweag areas and relating this work to work done in the 1960s and 1970s by the DMR.

Seaweed - In Maine, the 3,000-plus miles of rocky coast, nutrient-rich waters, climate, and large tidal flow all contribute to one of the most productive seaweed growing areas in the world. The dense vegetative stands of dominant plants such as rockweed, Irish moss, and kelps provide habitat for juvenile fish and crustaceans and food for many invertebrates and microorganisms. Currently there are ~11 species harvested commercially, mostly by hand with cutting rakes or knives, although there is at least one mechanical rockweed harvesting vessel. The Seaweed Fund is used to conduct periodic assessments and research.

Assessing ecological impact of rockweed harvest regulation – Existing regulations control minimum height rockweed may be cut in order to ensure sustainability of the rockweed resource. However, given the habitat value of rockweed, a small contract was let to conduct a controlled experiment comparing cut and uncut areas to learn the effect of DMR's rockweed regulations on epifauna. Pre-harvest and post-harvest sampling was done in 2008 and a third sampling event is planned for spring 2009.

COMMERCIAL AND RECREATIONAL STATISTICS

Commercial Landings Program - Harvest and effort data provide another estimate of resource condition. Landings also provide insights into the status and condition of the industry that fishes for those resources and is an opportunity for the DMR staff to hear directly from harvesters and dealers about emerging concerns. In 2008, DMR implemented a mandatory dealer reporting system for all commercial fisheries according to protocols established under the Atlantic Coastal Cooperative Statistics Program, a cooperative state-federal program including all of the Atlantic coast states, the National Marine Fisheries Service, the U.S. Fish and Wildlife Service, and the regional Fishery Management Councils.

Dealer reporting program – As defined in Chapter 8 regulations, DMR staff will collect mandatory landings information from all 1,600 licensed dealers. Information includes dealer name, date purchased/& landed, harvester identification & vessel identification, species, amount, grade & market category, gear type, disposition, and port landed.

Harvester reporting program – As defined in Chapter 8 regulations, DMR staff will collect mandatory catch information from over 11,500 licensed harvesters for the following fisheries: green crab, sea cucumber, seaweed, horseshoe crab, eel, halibut, whiting, herring, sea scallop, shrimp, spiny dogfish, shellfish bait, and bait gillnet. A new program to collect mandatory catch and effort reports from at least 10% of the lobster fishery was implemented January 1, 2008, as required by Addendum VIII to Amendment III of ASMFC's Fishery Management Plan for American lobster, will continue with a new set of harvesters in 2009.

Angler Surveys - Saltwater recreational fishing has become an increasingly important component of Maine's marine fishery. DMR conducts several marine recreational fishery sampling programs to determine the extent of recreational fishing effort for saltwater species, the impact on marine species, and the economic importance to the state.

Marine Recreational Finfish Statistics Survey (MRFSS)

May through October, DMR interviews anglers to estimate of the total number of fish caught, released and harvested; the weight of the harvest; total number of angler trips; and number of people participating in marine recreational fishing in Maine. This part of a NMFS program to estimate the impact of recreational fishing on marine resources. Sampling in Washington

County will continue with the assistance of Maine Sea Grant's Marine Extension Agent and students from the University of Maine at Machias.

Large pelagics survey

The DMR conducts the NMFS Large Pelagic Survey from July through October to monitor catch and effort of tunas and sharks. This survey consists of dockside vessel interviews and telephone calls to Atlantic Tuna permit holders.

Striped bass logbook survey - The Volunteer Logbook Program targets avid striped bass fishermen to collect additional length data. In this program, anglers record information about fish harvested or released during each trip, time spent fishing, area fished, number of anglers and target species. DMR staff compiles information from returned logbooks at the end of each season and returns the logbooks to the anglers.

Atlantic salmon logbook survey - The one-month spring Atlantic salmon season on the Penobscot River has a mandatory logbook program to collect catch and effort data. Anglers record information about salmon caught and released during each trip, time spent fishing, pool fished, and non-target species. DMR staff compiles information from returned logbooks at the end of each season.

Tackle Busters - DMR staff maintains records of fish and weights from saltwater anglers who have landed a fish that meets the minimum qualifying weights and lengths of the program in Maine.

MARINE MAMMALS AND SEA TURTLES (PROTECTED RESOURCES)

DMR has continually increased its role in the conservation and management of protected species, including pinnipeds (seals), endangered and threatened large whales and sea turtles that occur in Maine coastal waters. The Maine Whale Plan began in response to conservation and research needs that arose as a result of the federal Atlantic Large Whale Take Reduction Program process and has since grown to include a comprehensive Conservation Plan that was drafted and implemented by the state in accordance with its Section 6 agreement with the Federal government. Additionally, DMR has assumed response responsibilities for strandings of pinnipeds, cetaceans and sea turtles from Kittery to Rockland to fill a need identified there by NOAA Fisheries.

Marine Mammal Stranding Program - DMR receives federal funds to respond to, document, and collect data regarding live and dead stranded cetaceans, pinnipeds and sea turtles along the coast of western Maine. The project maintains staff that triages response through a 24hr hotline and coordinates a volunteer animal response network including training of volunteers. This program also provides public outreach and education on what to do when they may come upon a marine mammal that may be in distress.

Disentanglement Networks - DMR maintains a trained network of staff, Maine Marine Patrol Officers, commercial fishermen, Harbor Masters and volunteers to respond to live entangled whales and sea turtles. Kits of specialized disentanglement tools are located throughout the state for this purpose. DMR has the authority to disentangle minke whales and sea turtles and maintains a supportive role for endangered whales that include finback whales, humpback whales and right whales. This program is supported by the 24hr hotline maintained by the Stranding Program.

Gear Research and Development - DMR works with commercial fishermen statewide to conduct research and develop new fishing gear and practices that decrease the risk of entanglement to large whales in lobster gear. This has included several years of development and testing of a low profile groundline that will yield some flotation over a rocky bottom as an alternative to sink line. Additionally, DMR is compiling baseline information on

the densities and seasonality of vertical lines in lobster fishing areas from a survey sent to license holders in 2008. This information will allow DMR to frame a research plan for reducing the entanglement risk of these lines to whales as well as inform discussions regarding appropriate reduction levels. Entanglement risk reduction for vertical lines will continue to be discussed by the Atlantic Large Whale Take Reduction Team in 2009.

Sightings Network - DMR maintains a near real time sightings network for large whales sighted in Maine fishing waters. Boat-based and aerial surveys, whale watch boats, fishermen, researchers, and others submit sightings that are updated on a publicly available website. This interactive website allows the user to track the movement of whales and therefore avoid them during normal fishing practices.

Large Whale Foraging - DMR continues to expand the large whale foraging research that began in 2006 with the formation of many fruitful collaborations with the fishing industry, universities, and other academic institutions. These have included comprehensive CTD and plankton surveys statewide, a right whale habitat monitoring program and digitizing whale sightings data. Several projects were initiated in 2008, including a near-shore right whale prediction model, Dtagging humpbacks whales near Mount Desert Rock, passive acoustics to locate right whales and assessing historic photographic catalogues to determine the scarification and therefore entanglement rate of humpback whales in Maine coastal waters. Research planned for 2009 will include the continuation of plankton surveys, right whale habitat monitoring and near-shore modeling. Additionally, DMR plans to expand the scarification study as a way to monitor the effectiveness of new gear regulations as well as passive acoustics to areas of potential winter right whale habitats.

DIADROMOUS FISH RESTORATION RESEARCH AND MONITORING

Anadromous fishes (alewife, blueback herring, American shad, striped bass, rainbow smelt, Atlantic salmon, Atlantic tomcod, sea lamprey, Atlantic sturgeon) and catadromous fish (American eel), collectively referred to as diadromous fishes, historically occurred in most major and minor coastal watersheds in the state. Declines in these populations were caused by the construction of dams and water pollution, which rendered many waters unsuitable for their migration into freshwater production areas. The successful water pollution abatement program of the 1970s re-established a clean environment that now enables the restoration of these species to their historic habitats. Atlantic salmon, shad, and alewives are stocked in waters that historically supported these species. Fish passage requirements at hydroelectric dams, a DMR fishway construction program, and other habitat connectivity projects over the past 30 years have significantly increased the amount of habitat available to diadromous fishes.

Sea-Run Smelt - The Department is lead agency on a Gulf of Maine wide project to assess the status of and threats to sea-run smelt in Maine, New Hampshire and Massachusetts. Listed as Species of Concern by the National Marine Fisheries Service, this is a five year project intended to identify and eliminate threats to the species to improve status of the species and avoid listing these species as federally threatened and endangered. In 2007, work begins in Maine to map the distribution of smelt, location of fish passage obstructions and habitat. We continue to assess population structure, endemic pathogens and parasites, and water quality. The outcome of this work will result in a habitat model that will enable Maine to identify populations most at risk, likelihood for restoration for former populations and identify what management measures are needed to hold or regain populations.

Atlantic Sturgeon - Atlantic sturgeon is also listed as Species of Concern by the National Marine Fisheries Service. Sturgeon work began in 2008 and will continue in 2009 with emphasis on habitat use. Sonic tags will be implanted in fish in the lower Kennebec and fish movement monitored using an array of receivers that have been in place to monitor striped bass movement. Samples for genetics, toxic contaminants, and pathology will be collected to develop a baseline characterization on sturgeon.

Atlantic Salmon - Research on Atlantic salmon is directed at determining the causes of the precipitous decline in Atlantic salmon returning to Maine waters. Ongoing DMR research projects are aimed at determining survival among freshwater life stages and understanding the biological and environmental factors affecting survival. NOAA-Fisheries salmon research focuses on the same questions in estuarine and marine waters. The two agencies conduct cooperative research designed to link freshwater rearing conditions and smolt emigration to better understand the biotic and abiotic factors affecting the freshwater-marine transition. Components of the cooperative projects are currently underway on the Pleasant, Narraguagus, Dennys, and Penobscot Rivers. These include: parr density and growth, basin-wide estimates of large parr; indices or estimates of smolt emigration; smolt physiology, marine and estuarine smolt trawling, and smolt tracking through estuaries. As part of this collaborative effort, DMR works with the Mitchell Center at the University of Maine to monitor water quality within Downeast rivers. DMR staff is measuring cobble embeddedness in juvenile rearing habitat and permeability in spawning habitat to evaluate the relative quality of these across Maine salmon rivers. The water quality and habitat work are important background for further studies of over-winter parr survival and smolt physiology.

DMR is investigating the effects of physical habitat and hydrology on juvenile salmon survival. As part of this effort DMR is working with USGS (United States Geological Service) to gauge Atlantic salmon rivers and increase the data available to link hydrology, habitat, and juvenile production and survival. USGS is also conducting analyses of historic data to determine if the timing and duration of summer and winter low flow periods has changed over the last century. USGS hydrologists have developed a surface-water and ground-water (SW-GW) watershed model for the Dennys River that is being generalized to apply in other watersheds. These models may prove valuable tools for assessing the effects of surface-water and groundwater withdrawals, and the land use/land cover changes on river flows, groundwater, and salmon habitat.

A series of cooperative research project with the University of Maine have documented the upstream migration of adult Atlantic salmon in the Penobscot River using Passive Integrated Transponder (PIT) and acoustic tag technologies. The movements of individual adult salmon were used to evaluate upstream movements, thermal refuge use, the probability that fish were able to access spawning habitat, and the distribution of salmon within the drainage prior to spawning. These assessments, in conjunction with return rates of marked smolts, and survival of acoustically tagged smolts were used to alter smolt stocking locations strategies.

Juvenile Atlantic salmon population assessment – DMR staff conducts routine monitoring of the abundance and status of juvenile salmon in most of Maine’s Atlantic salmon watersheds. Staff collects detailed abundance data for juvenile Atlantic salmon on the Narraguagus River and estimates the Atlantic salmon parr population for the entire drainage using a Basinwide Geographic and Ecologic Stratification Technique. DMR also annually samples a set of index sites in all salmon rivers and use a Catch per Unit Effort electrofishing protocol and sampling scheme to provide a broad index of population abundance and distribution. Data are used to adaptively managing stocking, and assess alternative stocking strategies, hatchery fish quality, and habitat improvement projects. Maine data are used in a range wide juvenile abundance index for US Atlantic Salmon Assessment Committee status of stock reporting.

Atlantic salmon smolt emigration monitoring – DMR staff trap smolt on the Pleasant River, a Penobscot basin tributary and in the upper Narraguagus River. The objective of the Pleasant River study is to understand the influence of parr size at stocking on smolt emigration timing and either improve use of the current hatchery product or request a more consistent sized parr from the hatchery program. On the Narraguagus, smolt trapping is designed to document emigration timing and estimate the smolt production in the upper river from natural reproduction, and stocked fry and parr.

Atlantic salmon redd surveys - DMR staff conducts redd counts on rivers within the geographic range of the GOM DPS, and on selected habitat segments in other drainages. Redd counts are an index of adult salmon abundance and distribution at spawning time, and are related to known spawning escapement to provide sub-reach level estimates of egg deposition within a basin. Relating redd counts to trap counts allows redd counts to be used as a stock assessment tool for rivers without salmon trapping facilities.

Atlantic salmon habitat surveys - DMR conducts field inventories to classify and map juvenile rearing habitat in rivers where Atlantic salmon occur. Habitat data for GIS applications are data housed on the web by the Maine Office of Geographic Information Services. DMR is adding information on habitat quality to these basic surveys; measuring cobble embeddedness, gravel permeability, the occurrence of large woody debris, channel geomorphology, water quality, thermal conditions, leaf processing rates, and fish and invertebrate communities.

Atlantic salmon stocking - The USFWS is responsible for the spawning and culture of Atlantic salmon at two hatcheries in Maine. However, the operation of these hatcheries depends on DMR collecting parr for captive reared broodstock. from throughout drainages containing the GOM DPS, with extra care taken to include areas where natural spawning occurred in previous years. Without these collections USFWS hatcheries could not maintain the "living gene bank" for the DPS. Stocking in the Penobscot River and other rivers using that stock depend on DMR broodstock collections at the Veazie fishway. DMR is responsible for planning annual releases of hatchery-reared adults, eggs, fry, parr, and smolts in all Maine waters. DMR staff distributes Penobscot and GOM DPS fry in their rivers of origin either by point or scatter stocking. Adults, parr, and smolts are point stocked by USFWS with DMR assistance.

Alosids (Alewives, American Shad, and Blueback Herring)

American shad stocking - DMR contracts the Waldoboro Fish Hatchery to raise American shad fry to release in the Kennebec and Androscoggin rivers as part of DMR's shad restoration efforts. DMR staff collects adult shad from the Saco and Kennebec Rivers when possible and from the Merrimack River in Massachusetts for broodstock.

Alewife stocking - Returning adult alewives are captured by a fish pump installed at the base of the Fort Halifax Dam in Winslow for the Kennebec River Alewife Restoration Program. Alewives are transferred to 10 lakes and ponds outlined in the Kennebec River Anadromous Fish Restoration Plan, and to other lakes and ponds in the Kennebec and other drainages located throughout the State. The stocking of alewives is an interim management measure to enhance alewife runs prior to the provision of fish passage. Fish passage became available on the Sebasticook River in 2006 with the completion of the fish lifts at the Benton and Burnham dams. DMR reduced the stocking effort in 2006 and sorted and passed alewives directly into the Fort Halifax Dam headpond. Adult alewives are captured at the Brunswick fishway on the Androscoggin River and transferred to six lakes and ponds and other suitable river segments.

Striped Bass

Striped bass spawning and overwintering habitat - DMR scientists will locate, map, and characterize striped bass spawning habitat and overwintering habitat in the Kennebec, Androscoggin, and Sheepscot estuarine complex, using a combination of targeted sampling with gill nets and ichthyoplankton nets (D-nets) and ultrasonic telemetry.

American Eel

Young-of-year (Glass) eel survey - Each spring, DMR scientists install three eel passageways at the entrance of West Harbor Pond (located in West Boothbay Harbor), enumerate all young-of-year (glass) eels that migrate upstream for a period of six weeks, and collect biological information (length, weight, pigmentation) on subsamples. This survey

provides an annual index of recruitment of a single year class, and is a requirement of the ASMFC Fishery Management Plan for American Eel.

Yellow eel survey in the Kennebec River watershed - From June to September each year, DMR scientists enumerate all yellow eels that migrate upstream at passageways installed at two hydropower facilities on the Sebasticook River and one facility on the Kennebec River. In addition, length and weight are measured on a subsample of eels. This survey provides an annual index of recruitment (multiple year classes) to the Kennebec River watershed.

Management, Habitat, and Monitoring

Penobscot River Diadromous Fishes Restoration Plan - DMR, cooperatively with the Department of Inland Fish and Wildlife developed a strategic plan with the goal of enhancing, restoring, diadromous fish populations and managing resident fish populations, aquatic resources and the ecosystems on which they depend, for their intrinsic, ecological, economic, recreational, scientific, and educational values for use by the people of the State. The plan recognizes that restoring ecosystem processes and integrated multi-species fish management will increase potential success. A five year operational plan is being developed.

HydropowerProject review – DMR staff review applications for federal licenses; provide written recommendations for fish passage, flow management protocols, and minimum flow requirements; and engage in comprehensive settlement discussions that often involve multiple projects within a watershed. Once a federal license has been issued, typically for 30 to 50 years, DMR staff review and comment on study plans and reports, make site visits, draft all or portions of annual reports, and participate in annual meetings.

Environmental review – DMR staff review applications for a variety of projects (point-source discharges, construction, road crossings, dredging, pipelines) and make recommendations to reduce project impacts on diadromous fishes.

Fish passage at nonhydropower dams - DMR staff work with various federal, state, and local partners to obtain funding for dam removals, fish passage, and maintenance of fish passage at more than 20 locations on Maine rivers.

Fishway monitoring - DMR staff monitors the upstream and downstream passage of American shad, alewife, and Atlantic salmon at the Brunswick and Lockwood fishways and conduct video studies of fish behavior at Brunswick to determine how to improve fish passage. Trapping facilities to intercept, count, and collect biological data from migrating adult Atlantic salmon are operated by DMR staff on the Narraguagus, Dennys, and Penobscot rivers. Atlantic salmon and other species are also captured and handled at fishway traps operated by cooperators (St. Croix Waterway Commission, or dam operators) on the Aroostook, Saco, St. Croix, Penobscot, and Union rivers.

Monitoring changes in fish communities after removal of Edwards Dam - A beach seine survey on the Kennebec River between Augusta and Waterville is conducted to monitor changes in fish communities over time with the removal of the Edwards Dam and to monitor the shad restoration program on the Kennebec River.

Evaluation of anadromous fish population restoration on the Sebasticook River - DMR scientists will use fish counters and PIT tagging to evaluate upstream passage efficiency, determine migration rates, and document life history traits (spawning escapement, percentage of repeat spawners) of anadromous fish populations that have been restored to the Sebasticook River.

Large wood additions to streams – Large wood was added to moderate sized streams in the East Machias, Machias, and Narraguagus drainages at a rate of approximately 12 pieces per 100m. Trees in the riparian zone were felled and their placement adjusted to achieve

either stability or geomorphologic effect. All large wood (existing and added) in the treatment sites was tagged with metal numeric tags and marked with spray paint. All sites were surveyed for fish populations immediately prior to the habitat work, and will be surveyed annually for wood movement and fish populations. The objectives of the study are to increase the complexity of habitat and test hypotheses about the links among habitat quality and salmon populations that will lead to habitat restoration prescriptions.

Co-evolved anadromous species - The question being addressed is whether survival of Atlantic salmon smolts emigrating from a river is greater in the presence of a significant alewife population. This project is intended to test the hypothesis that restoration of native alewives will benefit Atlantic salmon smolt emigration using several approaches: a retrospective review of salmon returns and alewife harvest within the DPS where data are available; identify and prioritize the 15 most important barriers to alewife passage in the DPS and facilitate removal of a minimum of three such barriers during the course of the contract period by partnering with other state agencies, federal agencies, towns and other affected parties; count returning alewives on one additional system within the DPS; and draft a study design to test whether the presence of a healthy alewife population serves as a predator buffer for migrating Atlantic salmon.

HABITAT, ENVIRONMENT, AND MANAGEMENT

Low Tide Aerial Photography – Intertidal and shallow subtidal habitats are photographed about once every 10 years. Their value in providing managers with a record of change over time has been especially useful in determining the extent of impacts from human development and resource harvest activities. They have also been key in documenting habitat conditions prior to oil spills (see next) so that the State can accurately assess damage. This photographic series has been especially valuable toward understanding and tracking changes in eelgrass habitat. Eelgrass habitat is critical for a number juvenile finfish species and blue mussels. In 2009, aerial photography is planned for the region from Schoodic to Eastport.

Natural Resource Damage Assessment - DMR staff responds to oil and hazardous waste spills in the marine and estuarine environment as needed to assist with assessment of damages to natural resources. These assessments are the basis for compensating the State for natural resource losses. The DMR is funded and participates in conducting research into prevention techniques and impact assessment.

Long-term Physical Environmental Monitoring - Observations of air temperature, barometric pressure, precipitation, sea surface and bottom temperature, solar radiation, relative humidity, tide height, wind speed and wind direction are recorded at hourly, and daily intervals. Monthly and yearly summaries of the first six observations listed above are compiled and distributed. Near real-time data can be accessed at: <http://www.maine.gov/dmr/rm/environmentaldata.html> and <http://www.gomoos.org/dmr/>.

Invasive Species - DMR staff participates in the Maine Invasive Species Task Force and the Northeast Aquatic Nuisance Species Panel and monitors activities and reports of invasive species in the state.

Environmental Reviews of Coastal Alteration Projects - DMR reviews environmental permit applications for coastal alterations, energy development, dredging, docks, and marina projects. Technology and practices have evolved greatly over the past decade to the point where some rules and guidelines may no longer be appropriate. In 2009 staff will begin testing the efficacy of specific practices for particular activities and impacts.

Aquaculture Research - The effect of aquaculture on seabirds and vice versa have been identified as research priorities for 2007 through 2010. A science advisory committee led by DMR consists of seabird biologists from Inland Fisheries and Wildlife, US Fish and Wildlife

Service, and Army Corps of Engineers to advance understanding of seabird interaction with aquaculture. The University of Maine's Cooperative Wildlife Research Unit has been contracted to conduct the study. In 2008, investigations to develop field protocols for monitoring seabird behavior were initiated. In 2009, this work will continue.

Taunton Bay Resource Management Plan – A comprehensive resource management plan for Taunton Bay was developed and passed by the Legislature in 2007. This plan is a novel management experiment. A Taunton Bay Advisory Committee advises the Commissioner on implementing a science-based comprehensive resource management plan for Taunton Bay. The plan addresses principal resource user groups in the context of sustaining ecological processes, functions, and values of Taunton Bay. In 2008, new harvest regulations on urchins, mussels, scallops, and kelp went into effect. In 2009, focus will be on refining the harvest regulations and beginning work on some of the ecological issue outlined in the plan. A report to the Legislature on this experiment will be prepared early in 2010.

Education and Outreach – DMR's research and monitoring efforts are very much directed toward solving and preventing problems and improving management. Key to the success is making sure results are known and available, especially to managers, policy and decision makers. Disseminating research and monitoring findings are key to results being useful. DMR operates the Marine Resources Aquarium in West Boothbay Harbor and the Burnt Island Lighthouse Live History Program to provide visitors with an opportunity to learn about Maine's marine fisheries. A collection of regional fish, invertebrates, and interactive exhibits are maintained to allow for quality interactive learning. Both these facilities and education staff draw on research and monitoring results of the Department. Research and education staff conducts seminars and lectures on a variety of topics to Maine's school children, the public, and media. The Education Program provides teacher recertification training courses.

RESEARCH NEEDS

The research programs described above illustrate DMR's focus on long-term monitoring programs that are essential to protect public health, and assess and restore populations of marine, estuarine, and diadromous species, their environments, and fisheries. There are many additional research and monitoring needs that cannot be addressed due to lack of funding and personnel. In addition, there are a number projects such as the Maine-New Hampshire inshore trawl survey for which DMR has not identified a stable source of long-term support.

The DMR will continue to seek funding opportunities to address priority issues identified in interstate and federal fishery management plans; "Coastal Fisheries Research Priorities for the State of Maine" (http://www.maine.gov/dmr/research/table_of_contents.htm); issues related to freshwater habitat identified in state, regional, federal, and international management, conservation, and recovery plans for Atlantic salmon; and other issues as they are identified. DMR scientists will continue to work collaboratively with other scientists in the region and with the fishing industry to conduct research to improve the management of Maine's marine and diadromous fish resources and DMR's programs will continue to be an important avenue of communication with fishermen and the public.

The following is a list of other areas of concern for the DMR that are not currently being addressed and for which additional new funding will be required.

Public Health

DMR's Growing Area Program component of the National Shellfish Sanitation Program underwent an external peer review in 2007 that made a number of recommendations for program improvements that have been implemented. Additional research is needed on the following:

- Monitoring for biotoxins other than Paralytic Shellfish Poisoning
- Water quality studies to address the length of rainfall closures and closures around sewage treatment plant outfalls

- Studies to determine shellfish meats vs. water quality, especially in colder, winter periods
- Hydrographic/drogue studies of river systems; Kennebec River, etc. (this would be good for PSP and WQ)
- Study of the feasibility of "automatic reopening" of rainfall closures based on historical data and shellfish meat vs. water quality studies
- Study to determine which areas of the coast are never, least, moderately or most impacted by FLOOD rainfall to determine closing/reopening sequence
- Hydrographic studies and alternative technologies to determine mixing of rivers and runoff with estuaries and bays
- Determining levels of *Vibrio parahaemolyticus* (pathogenic and nonpathogenic) in Maine coastal waters and the risk to shellfish industry
- Evaluate the risk of contamination of shellfish in wet storage units by *Campylobacter jejuni* from seabirds.

Resource Assessment

Stock assessment includes all of the activities carried out to describe the conditions or status of a stock. This can be separated into fishery dependent information such as numbers of fishermen by gear type, amount of fish caught and fishing effort expended by individual harvesters over time, times and areas of fishing, and value. Biological data that is needed from the catches include the age structure of the population by each type of gear, age at first spawning, fecundity, sex ratios, growth rates, natural and fishing mortality, spawning time and location, habitats, migratory habits, and food habits. Fishery independent information describes the information collected by scientists from their own sampling programs such as from the Maine-New Hampshire Trawl Survey and the scallop and sea urchin surveys. Table 1 summarizes the information collected by DMR research programs and indicates where research is needed.

Diadromous Fish Restoration

The DMR (e.g. Atlantic Salmon Commission), USFWS, and NOAA Fisheries have a long history of working cooperatively for the conservation of Atlantic salmon. Cooperation and coordination among federal and state agencies is critical to ensuring that available resources are used in the most efficient and effective manner to further the protection and recovery of Atlantic salmon in Maine. Even the combined resources of the DMR (then the Atlantic salmon Commission), NOAA, and USFWS, cannot accomplish all of the important research and management activities for Atlantic salmon. In 2005, these agencies developed the following joint priorities for Maine Atlantic Salmon Recovery and Restoration.

Investigate Potential Causes and Magnitude of Early Marine Survival

Monitoring and assessing early marine survival is a core responsibility of the National Marine Fisheries Service. Ongoing activities include documenting and describing the distribution of post smolts. Efforts are being expanded to monitor the coastal environment more broadly including reviewing and analyzing data sets on environmental variables, food availability, and changes in ecosystem structure and dynamics. Accomplishing this requires cooperation and collaboration with other personnel within NOAA and with state, federal and international resource agencies and academia, as well as non-traditional parties such as NGO's and the commercial industry. Future program areas include testing hypothesis that fish, bird or marine mammal predation reduces survival of smolts leaving rivers and passing through estuaries.

Operate and Evaluate Conservation Hatchery Programs for DPS and Penobscot River

Operating federal fish rearing facilities needed for recovery of the DPS and Penobscot are part of the core responsibilities of FWS. A broodstock management plan will be completed by the end of the 2005 calendar year. Annual stocking plans will also be available by January 2006 that include explanations and justifications for each life stage stocking approach/methodology, identify stocking locations, and describe assessments. An independent review of hatchery goals and objectives, production practices, the use of river

specific facilities and demographic effects of stocking for the DPS and the Penobscot River will be conducted. Existing data will be used to review hatchery practices. The primary goal is to develop adaptive management approaches to hatchery production and stocking.

Habitat

Activities associated with habitat assessment, protection, restoration and enhancement were the most diffuse across the agencies as well as conservation organizations, and private individuals. Greater technical assistance is needed to guide habitat efforts, coordination to ensure priority habitat issues are addressed, and evaluation of habitat restoration and enhancement projects.

Physical Habitat: Greater attention will be focused on improving our understanding of how current physical habitat characteristics (hydrology, substrate, embeddedness and permeability) affect salmon production. We will work with USGS to (a) determine the sediment budget of streams and rivers; (b) assess the impacts of large-scale landscape change on watershed processes; and (c) determine “natural” channel of streams prior to historic alterations.

The primary agencies will continue to work with the recovery team and other agencies (e.g. NRCS) to seek opportunities to reconnect habitat through the removal of barriers and improved passage. This includes getting involved early in DOT and Maine Forest Service planning processes to prioritize critical crossings for bottomless arches. Finally, a working group/team will be created to facilitate adaptive habitat management experiment(s) addressing one or more of the following: (a) experimentally manipulate embeddedness levels; (b) adding large woody debris to streams; and/or (c) restore a stream to a natural channel.

Water Quality and Quantity: Identifying water quality issues that have the potential to cause over-winter mortality is a high priority and EPA’s expertise and involvement will be sought. The TAC habitat working group and Recovery Team habitat working group will be asked to determine effective/efficient methods to increase productivity and manipulate river productivity. A commitment by USGS to maintain stream gages at points along the rivers within the DPS is a recovery priority.

Biological Communities: Restoration of diadromous species assemblages that co-evolved with salmon is a priority so that they can serve as predator buffers and improve nutrient exchange. Working with IFW to promote aggressive management practices against populations of exotic fish species in salmon rivers is also necessary. The new TAC habitat working group will be requested to identify what is known about optimal habitat conditions (physical habitat, water quality, food) that can serve as background for the design of experiment(s) to create and evaluate optimal habitat. The new TAC habitat working group will also be asked to facilitate adaptive management experiment(s) that manipulates predators and evaluates the effect of this on salmon.

Aquaculture

Marine aquaculture is a valuable industry in Maine and includes the culture of Atlantic salmon, trout, oysters, and mussels. The finfish aquaculture industry has undergone a period of consolidation, while the number of shellfish growers has increased. As of 2008, there are 69 standard shellfish leases, totaling 639.82 acres, 28 finfish leases, totaling 632.14 acres, and nine experimental leases totaling 15.85 acres, located in marine and estuarine waters along the Maine coast.

- Use of Aquaculture for habitat protection and water quality improvement (e.g., polyculture)
- Development of husbandry techniques to minimize benthic impacts to low energy sites
- Inventory of endemic disease organisms to form the basis for biosecurity zones

- Determine the severity of aquaculture operations on disturbance to nesting seabirds (work in progress)
- Development of storm resistant sea cages
- Assess extent to which mussel rafts contribute to local mussel sets

Life History

Much is still unknown about the basic biology and life history of most of our marine resources. The following priorities for lobster, shrimp, scallops, and sea urchins were identified in a series of meetings with fishermen and scientists in 2000

(http://www.maine.gov/dmr/research/table_of_contents.htm):

- Improve the understanding of lobster growth rates, particularly of juveniles, in order to be able to link strength of post settlement year classes to future catch.
- Understand migration and movement of lobster post larvae, juveniles, and especially broodstock.
- What are the key factors in shrimp larval survival? Can environmental conditions at the time of larval release be used as a predictor of shrimp year class strength?
- Describe shrimp juvenile life history, especially its duration, to provide better assumptions for stock assessment models.
- What factors regulate timing of juvenile shrimp migrations, sexual transformation (male to female) and female inshore/offshore migration?
- What factors such as density dependence are operating to determine shrimp sexual maturation (male)?
- What triggers scallop spawning? Is it density dependent?
- Document and understand scallop growth rates in different areas.
- Study predation on scallops at larval and juvenile life stages.
- Understand urchin spawning, settlement survival, size/age ratio, and other biological measures in a local context to support local management.

Habitat Characterization, Ecology, Monitoring, and Mapping

- Eelgrass studies for BMP development to determine and minimize impact of fishing activities
- Conduct seafloor mapping of nearshore Gulf of Maine waters
- Effects of inter-tidal mussel dragging on benthic organisms
- What is the role of the clam flat in coastal ecology and the environment?
- What is the impact of harvesting methods on the ecology of the clam flat: pulling, turning over mud, clam digging, worm digging, nearshore dragging?
- What is impact of water quality, toxics, and exotics such as enteromorpha on clam flat health?
- What are the specific habitat needs of clams?
- Mechanisms that control clam settlement, survival, and growth.
- Effect of water quality on lobster reproduction, growth, and health including chlorine, herbicides and pesticides, and nutrients.

Oceanographic Influences on Fisheries

The influence of oceanographic currents and nearshore circulation on the delivery of larval stages of most marine resources are not well understood and have important implications for area-specific management and enhancement efforts. Specific areas of research have been identified for lobster, shrimp, scallops, sea urchins, and clams.

- Determine the lobster broodstock source for larval settlement and harvest areas and the relationship and relative contributions of the inshore and offshore broodstock.
- Study nearshore oceanography to understand its impact on larval transport and settlement for lobsters.

- Are there large-scale oceanographic or climatic influences that have caused the reduced lobster larval settlement in certain years? If so, through what factors or mechanisms are those influences operating?
- Refine our understanding of the effects of large-scale oceanographic events such as the North Atlantic Oscillation, El Nino, and global warming on the Gulf of Maine.
- Evaluate the physical and biological effects of oceanographic events relative to the shrimp population.
- Fine scale research and current modeling to determine scallop larval dispersion patterns.
- Where is the effective broodstock for each scallop area?
- What are the mechanisms that determine the relationship between adult scallop biomass and recruitment success?
- Do adult scallops or scallop larvae move inshore and/or offshore?
- What is the broodstock source for the clam larvae that settle in a specific cove?
- What are the oceanographic and sediment conditions that result in successful growth of clams after spat fall or reseeded?
- Document and explain local variability in clam growth rates, particularly the slow growth in eastern Maine.
- Study nearshore oceanography to understand its impact on urchin larval transport and the relationship between larval source and urchin settlement.

Impacts of Climate Change on Marine Resources, Habitats, and Fisheries

While specific measurements, causes, and consequences of climate change continue to be debated, there is now nearly universal consensus that we are experiencing significant changes in global climate and that human activities are contributing to these changes. We do not understand definitively how fisheries will be impacted, but we can be certain that changes in temperature and circulation will impact the patterns of distribution and migration of species, their life history, their habitats, and the fisheries. DMR's long-term monitoring programs will be useful for tracking these changes.

Ecosystem-based Management

Ecosystem-based management (EBM) is an integrated approach to management that considers the entire ecosystem, including humans. Approaches to implementing EBM in coastal and marine ecosystems focus on protecting their structure and function in order to sustain the services that humans want and need (food and livelihoods from fishing, storm protection, pollution mitigation, recreations, etc.). DMR has successfully carried out an EBM approach in Taunton Bay; however, the resources are not available to maintain or expand this approach. A critical need to support EBM is:

- Develop a human use inventory (i.e., mapping where people use the resource)

Large Whales

Entanglement risk in Maine coastal fishing habitats - All of the work done by the Large Whale Conservation Program arm of the Protected Species Division stems from needs identified at the Atlantic Large Whale Take Reduction Team level. This may include questions directly addressed by the team or areas of concern identified by the DMR delegation as relevant and vital to management discussions. First and foremost in these discussions is the definition of entanglement risk, how it is identified, calculated, and reduced through the use of management regulations on certain commercial fisheries. These questions are of the utmost importance because they define the federal regulations put into place to reduce the risk that the Maine lobster and gillnet fisheries pose to endangered and threatened large whales.

- Determine the risk of entanglement due to different gear types in Maine coastal fishing habitats

- Document baseline gear densities and configurations. How do those change seasonally and with the enforcement of new regulations regarding gear types and use?
- What are the seasonal abundances and distributions of large whale species, specifically right, humpback and fin whales, in Maine near-shore habitats?
- What is an acceptable level of entanglement risk? What reductions in gear densities are needed to achieve those levels?
- Are there gear modifications or changes in fishing practices that can be done to decrease the level of entanglement risk without removing gear from the water?
- How can the effect of new gear regulations on the entanglement rate be measured and monitored?
 - How high is fishing industry compliance?
 - What is the baseline entanglement scarification rate on humpbacks in the Gulf of Maine and how has that changed after regulations were in place?
 - Can a method of documenting entanglement rate be developed for fin and right whales?

Whale Habitat - There is little known about large whale habitat use and needs along the rocky coastline of Maine. How this area of their range is used, how often and what the differences are between Gulf of Maine habitats and critical habitats that are well studied in other locations are all important parts of the discussion when regulating fisheries to reduce a perceived or proven risk in this area.

- What parts of the coast and in what seasons are habitats conducive to large whale abundance
 - What are the defining characteristics (oceanographic variables, prey occurrence) of those habitats and what are the inter-annual fluctuations associated with them?
 - Can these characteristics be used to construct a near-shore predictive model for the occurrence of right and other large whales?
- What parts of the water column are whales using during feeding? Do they go to the bottom and if so what is the nature of these dives (exploratory, feeding)?

Whale Behavior

Large whale behavior while in Maine coastal waters is also of concern because certain behaviors put the whale more at risk for entanglement than others. Most research on right whales has been completed in their critical habitats of the Bay of Fundy, Cape Cod Bay, and the Great South Channel. Little is known about how they use the coastal parts of the Gulf of Maine and how the behaviors they exhibit here may influence their risk for entanglement in trap/pot or gillnet gear. Some work with humpback whales has occurred in Maine but that is mostly exclusive to Jeffery's Ledge in the south and Downeast. Little information is known about their feeding and diving behaviors in these regions. Fin whales are probably the least studied species because they are faster and harder to work with.

- What are the diving depths of right, humpback and fin whales in Maine's rocky coastal habitat and how close to the bottom do these dives take them?
- What are the feeding patterns and behaviors of right, fin and humpback whales in Maine?
- Is there an offshore winter/breeding ground for right whales in the Gulf of Maine?

Table 1. Status of DMR research on Maine's marine resources.

	SPECIES																									
	American eel	American lobster	American shad	Atlantic halibut	Atlantic herring	Atlantic sturgeon	Blue mussel	Crabs, Jonah & rock	Green crab	Groundfish	Hagfish	Horseshoe crab	Marine worms	Monkfish	Northern shrimp	Ocean quahog	River herring	Sea cucumber	Sea scallop	Sea urchin	Seaweed	Smelt	Soft-shell clam	Striped bass		
RESEARCH TOPICS																										
Commercial & recreational statistics																										
Commercial landings						NA																		NA		
Catch by harvester						NA																				
Recreational harvest						NA																				
Resource assessment:																										
Fishing effort by gear type						NA																				
Bycatch by gear																										
Age and growth																										
Maturity																										
Fecundity																										
Sex ratio																										
Spawning time & location																										
Natural mortality																										
Fishing mortality																										
Habitat by life history stage																										
Migratory habits																										
Food habits																										
Stock assessment models																										
Fish health monitoring																										
Stock structure																										
Fishery independent surveys																										
Gear research to reduce bycatch of undersized target species and of non-target species																										
Impacts of fishing gear on habitat and development of BMPs																										
Key:		No ongoing research		Some research		Fairly complete research																				
NA	Not applicable																									