**Aquaculture Fact Sheet**

**Page 1**

**Importance of Aquaculture in the Gulf of Maine**

Aquaculture has been practiced in the Gulf of Maine for many decades with oyster sites cultivated in Nova Scotia for nearly a century. The aquaculture industry as currently known began in the 1970s. Despite its importance in local economies and perceived impacts to the environment, it is difficult to fully understand the numerous agencies that monitor sites and the true density of aquaculture in the region. The most dominant species in the region are listed in the table below.

|  |  |  |
| --- | --- | --- |
| **Common Name** | **Scientific Name** | **State or Province** |
| Atlantic Salmon | *Salmo salar* | Maine, New Brunswick, Nova Scotia |
| Eastern/American oyster | *Crassostrea virginica* | Massachusetts , New Hampshire, Maine, Nova Scotia |
| Blue Mussel | *Mytilus edulis* | Massachusetts, New Hampshire , Maine, New Brunswick |
| Giant Sea Scallop/Sea scallops | *Placopecten magellanicus* | Massachusetts, New Brunswick, Nova Scotia |
| Quahogs | *Mercenaria mercenaria* | Massachusetts |
| Soft shell clam | *Mya arenaria* | Massachusetts, New Brunswick |
| Surf clam | *Spisula solidissimia* | Massachusetts |
| Bay scallops | *Aequipecten irradians* | Massachusetts |
| Urchins | *Strongylocentrotus droebachiensis* | New Hampshire |
| Rainbow Trout | *Salmo gairdneri kamloops* | Nova Scotia |
| European oysters | *Ostrea edulis* | Nova Scotia |

Regulations are distinctly different in the various States and Provinces and have greatly shaped the growth of the aquaculture industry. Consequently aquaculture has emerged as a dominant industry in parts of the Bay of Fundy while some more southern locations have seen more modest growth.

**Focus Box: Why Indicators?**

Simply put, indicators are one of the best tools for understanding the complexities of the Gulf of Maine. Like the dashboard of a vehicle, indicators can work in concert with each other to provide an essential look at the larger system. Indicators can be quite complex, like the Dow Jones Index, or very simple. Simple indicators themselves are often driven by complicated pressures and responses. The two indicators that ESIP has chosen for aquaculture in the Gulf of Maine are:

1. The economic value of aquaculture

2. Number of acres leased for aquaculture.

**Page 2 Indicator: Economic value of aquaculture**

Aquaculture in the Gulf of Maine is a productive and valuable sector of the economy. In 2008, total finfish and shellfish economic value was placed at over $83,000,000 USD or $88,000,000 CAD. The relative importance of aquaculture varies between the various States or Provinces and is displayed in the table below. Three State or Provinces have records that are of sufficient length to look at changes over time. New Brunswick's aquaculture leases have been recorded from 1999 through to present and represent salmon production only. The economic value of salmon aquaculture during that time has nearly doubled. In contrast, Maine's aquaculture values have decreased from a high of $90,725,385 USD ($134,745,560 CAD) in 2000 to a low of approximately $20,000,000 USD ($25,000,000 CAD) in 2007. The proportion of total economic value based on shellfish as opposed to finfish also varies between State and Province. For example, Massachusetts' aquaculture sector in the Gulf of Maine relies upon shellfish whereas Maine, New Brunswick, and Nova Scotia have a larger portion of aquaculture value derived from finfish with salmon being the dominant species. No single indicator can fully assess the value and presence of aquaculture in the Gulf of Maine. Despite this, economic indicators such as the one presented here do allow for better understanding of the impact of aquaculture on the communities that surround the Gulf of Maine. It is expected that if fisheries income continues to decline more and more individuals used to working on the Gulf of Maine will turn to aquaculture as a means of support.

**Table: Economic Value of Aquaculture - Total Finfish + Shellfish**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **State/Province** | **1999** | **2000** | **2001** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** |
| **Nova Scotia 1** |  |  |  |  |  |  |  |  |  | $ 8,159,494 USD | $14,388,509 USD |
|  |  |  |  |  |  |  |  |  |  | $ 8,698,137 CAD | $16,431,351 CAD |
| **New Brunswick2** | $94,222,781 USD | $150,147,886 USD | $161,455,285 USD | $171,935,124 USD | $151,270,629 USD | $153,820,120 USD | $185,699,887 USD | $251,302,008 USD | $196,319,015 USD | $158,534,460 USD | $169,005,112 USD |
| $140,000,000 CAD | $223,000,000 CAD | $250,000,000 CAD | $270,000,000 CAD | $212,000,000 CAD | $200,200,000 CAD | $225,000,000 CAD | $285,000,000 CAD | $211,000,000 CAD | $169,000,000 CAD | $193,000,000 CAD |
| **Maine3** | $67,496,007 USD | $90,725,385 USD | $72,763,840 USD | $37,469,592 USD | $33,108,547 USD | $46, 932,595 USD | $30,805,697 USD | $28,126,057 USD | $23,380,090 USD | $52,348,904 USD |  |
| $100,288,283 CAD | $134,745,560  CAD | $112,668,718  CAD | $58,840,740 CAD | $46,400,362 CAD | $61,083,722 CAD | $37,325,181 CAD | $31,897,581 CAD | $25,021,004 CAD | $55,804,679 CAD |  |
| **New Hampshire4** |  |  |  |  |  |  | $255,848  USD | $380,014  USD | $334,345 USD | $329,300  USD | $371,690  USD |
|  |  |  |  |  |  | $309,994  CAD | $430,972  CAD | $359,348 CAD | $351,039  CAD | $424,462  CAD |
| **Massachusetts5** |  | $3,522,736  USD | $2,660,801  USD | $2,915,393  USD | $2,896,825  USD | $2,807,072  USD | $4,191,643  USD | $5,035,244  USD | $4,508,644  USD | $6,552,487  USD |  |
|  | $5,231,976  CAD | $4,120,027  CAD | $4,578,216 CAD | $4,059,789 CAD | $3,653,460 CAD | $5,078,731 CAD | $5,710,438  CAD | $4,845,806 CAD | $6,985,045 CAD |  |

Data represent Gulf of Maine only. Average annual exchange rate utilized for calculating USD:CAD.

1 Nova Scotia values from NS Department of Fisheries and Aquaculture

2New Brunswick values from NB Dept. of Agriculture & Aquaculture and represent salmon production only. Remainder of species determined to not be significant in the Bay of Fundy.

3 Maine values from Maine Department of Marine Resources and calculated utilizing data from lease holders. Data pre-2005 not included for shellfish as data deemed unreliable.

4New Hampshire values from NH Fish and Game utilizing reported sales of product.

5Massachusetts values from Massachusetts Division of Marine Fisheries utilizing data reported by lease holders.

**Focus Box: What is IMTA?**

Fulfilling aquaculture’s growth potential requires responsible technologies and practices. Sustainable aquaculture should be ecologically efficient, environmentally benign, product-diversified, profitable and beneficial to society. Integrated multi-trophic aquaculture (IMTA) has the potential to achieve these objectives by cultivating a primary crop species (e.g. finfish fed sustainable commercial diets) with extractive species, which utilize the inorganic nutrients (e.g. seaweeds) and organic particles (e.g. suspension- and deposit-feeders) excess nutrients from aquaculture for their growth.

By using IMTA systems, extractive aquaculture produces additional valuable biomass, while simultaneously rendering biomitigative services. Through IMTA, some of the food, nutrients and by-products considered “lost” from the fed component are recaptured and converted into harvestable and healthy seafood of commercial value, while biomitigation takes place (partial removal of nutrients and CO2, and supplying of oxygen). In this way, some of the externalities of fed monoculture are internalized, hence increasing the overall sustainability, profitability and resilience of aquaculture farms.

IMTA is an emerging aquaculture practice in the Western World and will certainly evolve as experience is gained. Several areas in the Gulf of Maine are on the leading edge of research, development and commercialization of this concept, with IMTA systems permitted and implemented.

**Page 3 Indicator: Acres of permitted aquaculture**

The amount of acreage leased for aquaculture varies by State and Province in the Gulf of Maine. Some states have more acres under permit for shellfish production such as Massachusetts and Nova Scotia. The majority of leased areas in New Brunswick is in finfish aquaculture. Maine has acres evenly divided between the two. For the length of records obtained there has been relatively little change in the amount of acreage leased.

It is important to note that while the scale of aquaculture relative to the overall area of the Gulf of Maine is quite small (less than 0.02% of Bay of Fundy is leased for aquaculture) impacts at the local level may be significantly larger. For example, there are 130 acres leased for shellfish production in Maine's upper Damariscotta River alone. Along with the private permitted growers in the Damariscotta River, there is an interesting program underway on the river that allows residents to participate in growing oysters in a community "garden" run through the University of Maine, Maine Sea Grant Program, and Maine Aquaculture Innovation Center. This program helps to transfer knowledge and understanding of the different aspects of aquaculture and the river ecosystem to the recreational community.

**Acres leased for Aquaculture - Finfish**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **State/Province** | **1999** | **2000** | **2001** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** |
| **Nova Scotia 1** |  |  |  |  |  |  |  |  |  | 249 | 249 |
| **New Brunswick2** |  |  |  | 3766 | 3773 | 3868 | 3805 | 3800 | 3870 | 3539 |  |
| **Maine3** | 738 | 750 | 250 | 745 | 745 | 759 | 708 | 604 | 615 | 636 | 650 |
| **New Hampshire4** |  |  |  |  |  |  | 30 | 30 | 30 | 30 | 0 |
| **Massachusetts5** | 0 |  |  | 0 | 0 | 0 | 0 | 0 | 0 |  |  |

*1 Nova Scotia values from NS Department of Fisheries and Aquaculture.*

*2New Brunswick values from NB Dept. of Agriculture & Aquaculture.*

*3 Maine values from Maine Department of Marine Resources.*

*4New Hampshire values from NH Fish and Game. Data for urchins also available and equal to 2 acres from 2005-2009.*

*5Massachusetts values from Massachusetts Division of Marine Fisheries.*

**Acres leased for Aquaculture - Shellfish**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **State/Province** | **1999** | **2000** | **2001** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** |
| **Nova Scotia 1** |  |  |  |  |  |  |  |  |  | 4796 | 4796 |
| **New Brunswick2** |  |  |  |  | 32 | 32 | 32 | 32 | 32 | 32 |  |
| **Maine3** | 401 | 477 | 521 | 542 | 582 | 650 | 659 | 669 | 713 | 656 | 651 |
| **New Hampshire4** |  |  |  |  |  |  | 11 | 13 | 13 | 13 | 13 |
| **Massachusetts5** | 482 |  |  | 539 | 557 | 591 | 571 | 582 | 287 |  |  |

*1 Nova Scotia values from NS Department of Fisheries and Aquaculture. Value does not include soft shell clams.*

*2New Brunswick values from NB Dept. of Agriculture & Aquaculture.*

*3 Maine values from Maine Department of Marine Resources.*

*4New Hampshire values from NH Fish and Game. Data for urchins also available and equal to 2 acres from 2005-2009.*

*5Massachusetts values from Massachusetts Division of Marine Fisheries.*

**Focus Box: Climate Change**

Climate change impacts in the Gulf of Maine range from air and sea temperature changes and sea level rise to increased frequency of intense storms and heavy precipitation. All of these impacts can play a role in what species may be chosen for aquaculture, where aquaculture can take place and what adaptations may be required to keep aquaculture production successful.

Temperature changes have both direct and indirect impacts. Most directly are projected increases in sea surface temperature (SST) across the Gulf over the next 50 to 100 years. As SST increases, species type and viability will be impacted. Some species thrive at warmer temperatures while others may have too narrow a “temperature threshold” for productivity. More indirectly, warmer air temperatures leading to earlier springs and low river flows by summer may impact production along estuaries.

|  |  |  |
| --- | --- | --- |
| **Common Name** | **Scientific Name** | **Optimal Temperature\*** |
| Atlantic Salmon | *Salmo salar* | 42 to 60 ◦F or 5.6 to 15.6◦C |
| Eastern Oyster/American Oyster | *Crassostrea virginica* | 64 to 81 ◦F or 18 to 28 ◦C |
| Blue Mussel | *Mytilus edulis* | 41 to 68◦F or 5 to 20◦C |
| Quahogs/Bay Quahogs | *Mercenaria mercenaria* | 64.4 to 77◦F or 18 to 25◦C |
| Soft shell clam | *Mya arenaria* | 60.8 to 68◦F or 16 to 20◦C |
| Giant sea scallops/sea scallops | *Placopecten magellanicus* | 43.7 to 60.8◦F or 6.5 to 16◦C |
| Surf clam | *Spisula solidissimia* | 57.2 to 86◦F with optimal at 71.6 ◦F or 14 to 30◦C with optimal at 22◦C |

*\*Optimal temperatures cover the various life stages of the species in question.*

Sea level rise (SLR) may not impact “at sea” production facilities directly but coastal infrastructure that supports aquaculture may be at risk. SLR indicates a permanent loss of land. It also exposes more coastline to inundation and erosion.

More intense storms have several characteristics that put aquaculture at risk to damage and loss. Wind and wave damage to farming infrastructure can be highly detrimental to overall production. This includes coastal as well as “at sea” structures. Such wind and wave action may also increase the risk of loss of farmed species to the open ocean.

Heavy precipitation, typically associated with these more intense storms, will increase runoff into small embayments, increasing silt and material contamination as well as the potential for an increase in toxics in nearshore environments.

Adaptation strategies related to these impacts may include appropriate species choice, flexibility in siting, flexibility in farming structures and appropriate decisions related to prevention of land runoff and contamination of nearshore environment. Links to more information are available through the ESIP Indicator Reporting Tool (www2.gulfofmaine.org/esip/reporting).

One, often over looked, issue in climate change is the change in pathogens that will occur under a warming regime. Like fish and shellfish the pathogens these animals support can also have an optimum environment that ensures the survival of live stages when they are not infecting the host. For example cold water Vibriosis would be likely to disappear from the Gulf of Maine under a rising temperature regime. While sea lice (*Lepeophtheirus salmonis*) would likely benefit from a warmer environment the earlier spring and later autumn would give them a longer reproductive season. New pathogens may also appear in the Gulf of Maine as new species and intermediate hosts colonize the warmer conditions of the Gulf of Maine under a rising temperature regime.

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**Environmental Effects of Bivalve Shellfish Culture**

Bivalve aquaculture is very different from the culture of other aquatic animals such as finfish in that cultured shellfish use the phytoplankton naturally occurring in the water, thus avoiding the need to external feed. No net nutrients are added to the water body as a result of shellfish aquaculture, but rather nutrients are either transferred through phytoplankton to feces and pseudofeces which are deposited to benthic sediments, or incorporated to the shell and soft tissues. When shellfish are harvested, a net removal of nutrients from the water body is achieved.

Commonly cultured bivalves such as oysters, clams and mussels are filter feeders. They ingest not only phytoplankton and other living particles as food, but also detritus. The non-food particles are then deposited to the bottom as pseudofeces. In most cases, water clarity and thus light penetration is improved due to bivalve aquaculture activities. In addition to water clarity, other water quality parameters such as dissolved oxygen, nutrients and particulate matters can change due to bivalve aquaculture activities.

Ecological services of bivalve shellfish aquaculture include providing additional habitats for other species, as a result of complicated three dimensional cultural structures such as long lines and floating cages. Local species abundance and diversity of fish and invertebrates are usually increased. Another ecological benefit of bivalve shellfish aquaculture is helping eelgrass recover due to improved light penetration.

Harvesting of shellfish with dredges can cause changes in sediment structure and benthic communities. However, with proper management, bivalve shellfish activities can minimize the environmental impacts and provide positive benefit to the surrounding ecosystem.

**Focus Box: Indicator Reporting Tool**

All data used for the two indicators discussed in this fact sheet are available for graphing and downloading via ESIP's Indicator Reporting Tool. The tool (available at www2.gulfofmaine.org/esip/reporting) uses familiar mapping programs to enable users to locate aquaculture data in the region and build graphs for the time periods of interest. Snapshots such as those provided by the tool can provide critical information in a timely fashion for those faced with making decisions quickly. Questions such as the following can be answered using the tool:

1. How has the economic value of aquaculture varied over time as compared to extreme precipitation trends?

2. Where do blue mussels used in the Gulfwatch program contain high levels of lead in their tissues?

3. Where is eelgrass present that might be affected by an aquaculture site?