

**USING INTEGRATED HISTORY AS A TOOL
TO IMPROVE COASTAL MANAGEMENT:
RHODE ISLAND'S SHELLFISHERY IN THE 1980S**



Harvest of Quahogs in Great Salt Pond, RI in 1998. (MacKenzie et al. 2000a)

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Major Paper
May 23, 2013

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INTRODUCTION

Predating European colonization and through our modern era, Rhode Island's history has long included an active shellfish¹ fishery that has supported the cultural practices, dietary requirements, and an economic base of Rhode Island's residents. However, as the population demographics have shifted and Rhode Island has become an increasingly populous state, shellfish resources have experienced fluctuations in abundance and distribution (Oviatt et al., 2003; Rice, 2006). As a result of impacts from habitat degradation, nutrient and bacteria loading, and heavy fishing pressure, landings and values of some shellfish species have been in decline (Brooks, 1994). As such the use and reliance on the shellfish fishery by the public has in turn fluctuated and includes times of large shellfish markets and profitability, and times of low prosperity for shellfishers. Despite management and a variety of strategies to protect the state's shellfish resources, the past two decades of the state's fisheries have been characterized by poor economic performance and economic contributions made by the industry to the state's economy (Hasbrouck et al., 2011).

Rhode Island Sea Grant is currently in the process of facilitating the development of a Shellfish Management Plan for the state's shellfish resources. As part of the development process of the management plan and to better understand the history and various fluctuations of this resource, I have been researching and developing a timeline of this resource in Rhode Island (Appendix 1). The timeline provides a graphical display of the socioeconomic uses of, policies, and environmental issues related to shellfish throughout time and may ultimately inform the management practices of the resource.

¹ For the purpose of this paper and the timeline, the term shellfish will refer to bivalves only, with specific emphasis on the Northern Quahog.

Over the course of multiple stakeholder meetings a consensus emerged that the 1980s was a particularly successful decade for shellfishers in Rhode Island (McCann and Cygler, personal communication, February 1, 2013). In order to better understand the unique circumstances that made this decade advantageous for shellfishers, I analyzed the various political, social, economic, and environmental factors that coincided during this time period, using the timeline as a foundation. Through this analysis I found that the shellfish industry in Rhode Island during the 1980s was driven by the harvest of northern quahogs (*Mercenaria mercenaria*) and, therefore, this analysis is primarily focused on this species (Fig. 1). This analysis will serve as an example of how after the organization of information into a timeline format, information can be extracted and used to understand the major events surrounding the history of a shared resource. Ultimately, this paper should elucidate the complexities of human and natural impacts that influence our natural resources over time in order to guide and inform managers and stakeholders actively engaged in developing a management plan for this invaluable resource.

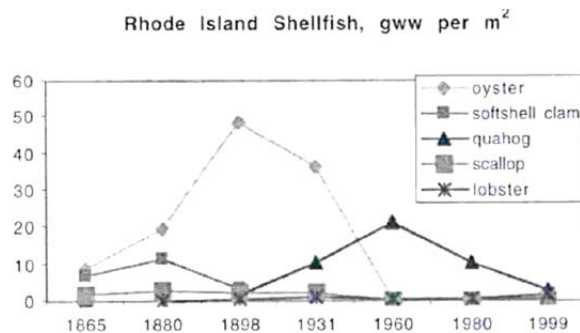


Figure 1. RI shellfish landings converted into biomass (grams wet weight per meter²), and showing trends in the dominant species landed from 1865-1999 (Oviatt et al., 2003).

METHODS

To develop the timeline I researched both primary and secondary literature in addition to newspaper and web sources, US Census Bureau and Bureau of Labor Statistics data, and state and national reports on stock sizes and trends. Each temporal event was then organized into a timeline format using Microsoft Excel (Appendix 1). I used the RI shellfish history timeline as a foundation for this analysis. I then conducted a primary and secondary literature review including a review of the *Proceedings of the Second and Third Annual Shellfish Conferences* held in Rhode Island, which provided a significant amount of information regarding the status and trends of the industry during the 1980s. Much of the information relevant to the following discussion of the state's shellfish industry during the 1980s was found in state generated reports, white papers, and University of Rhode Island, Sea Grant, and Coastal Resources Center reports. I then researched the current issues affecting the state's shellfish industry including user conflicts, climate change, and decreased landings in order to understand the differences between the current state of the fishery and that of 30 years ago. Finally, I spoke with several experts in the field who provided valuable insights into the state of the fishery during the 1980s and critical feedback to ensure that this analysis captured a robust picture of the industry and resource during the 1980s.

Timelines as a tool in Management

Timeline development is a process that is often used in a variety of disciplines to help organize and structure information, serving as a valuable tool and which provides a visual structure for data points that can otherwise become lost or confused (Adriansen, 2012; Malamed, 2013). In presenting data in this manner, one can begin to make links

and understand multiple relationships between certain events throughout periods of history. Timelines also provide a means to engage stakeholder and community members by providing opportunities to participate in the timeline's ongoing development (Adriansen, 2012; Malamed, 2013). As individuals share their own experiences and knowledge the timeline can also be a means of capturing institutional knowledge and linking events in time to broader social, political, economic and environmental framework (Adriansen, 2012). After a timeline has been developed, it can be used to isolate pivotal moments in time, and aid in the analysis of events that coincided around those periods. This type of analysis allows the audience to gain a better understanding of the time and the factors that contribute to making a particular period significant. This can be important in allowing us to move forward and manage our resource in a meaningful and intentional manner that is informed by the past.

The draft timeline that I have developed on behalf of RI Sea Grant outlines many of the major environmental, social, economic, and legal events related to shellfish and their uses in Rhode Island. This timeline provides a foundation of the important events in the resource's history and will be expanded through public participation thus serving as a living document that may be presented at stakeholder meetings and available for revision. Additionally, the timeline may serve as a foundation for the analysis of various different periods in time that have been historically meaningful. For the purpose of my major paper, I have used the timeline as a guide in an analysis of the events and important political, social, economic, and environmental attributes of the 1980s that contributed to a highly successful decade of shellfishing in the state of Rhode Island.

AN ANALYSIS OF THE 1980s: THE GOLDEN AGE OF SHELLFISHING IN RHODE ISLAND

Many residents of Rhode Island have made use of the shellfish resource throughout the State's history, but there are some periods of time that have been more pivotal for the resource and advantageous its users. Certainly human impacts and uses as well as environmental disasters have resulted in some lasting impacts to the resource during various points in time, but political and socioeconomic issues resulting from nonrelated factors have contributed as well to changes in the shellfish resource in Rhode Island (Nixon, 1992; Rice, 1992, 2006). Shellfishers and resource managers alike have repeatedly referenced the decade of the 1980's as being something akin to a "golden age" for shellfishers in RI. While anecdotal evidence tells us that during the early 1980s Rhode Island had the largest outboard motor fleet in the world including 2,000 boats and quahoggers (Russo, 2013), more accurate estimates indicate that there were roughly 1,200 active quahoggers in the 1980s (Fig. 2) (RI DEM, 2008). Nonetheless, since then, the number of active fishermen engaged in the quahog industry has dropped to approximately 150 – 200 fishermen working on Narragansett Bay year round (Lazar, personal communication, May, 2 2013), leaving in its wake questions surrounding this decrease in fleet size and about the capacity of RI's shellfishery to support a prosperous industry.

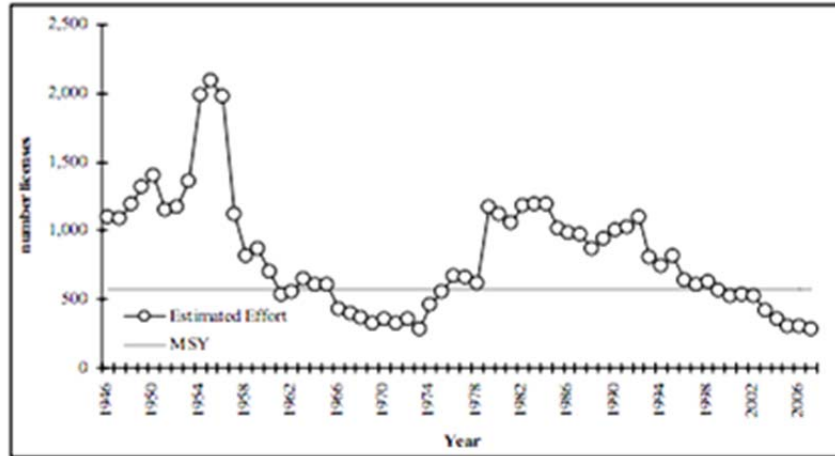


Figure 2. Estimated fishing effort in the Narragansett Bay quahog fishery relative to estimated level of Maximum sustainable yield (MSY) (RI DEM, 2008).

SHELLFISHING IN THE 1980s: THE RISE OF THE QUAHOG

Rhode Island's shellfishery has gone through many cycles and changes in the dominantly harvested species. Beginning with Native Americans, eastern oysters (*Crassostrea virginica*) were among the most intensively harvested species as evidenced by the midden data (Lee, 1980; Pfeiffer-Herbert, 2007), although quahogs played an important role both in the diet of Native Americans and as Wampum for both Native Americans and colonists (Mackenzie, 2002; Scozzari, 2012). The installation of the breachway in Point Judith Pond in 1910 and the installation of the breachways in the remaining major south shore salt ponds in RI in the 1950s and 1960s changed the nature of the ponds from intermittently breached brackish estuaries to systems that were highly saline and tidally flushed (Lee, 1980). As a result, the once prolific eastern oyster populations, which require salinities of 14-28 parts per thousand (ppt) (Shumway, 1996) and are susceptible to saltwater predators (Lee, 1980), declined while more saline-tolerant species such as the bay scallop (*Argopecten irradians*) and northern quahog

which tolerate slightly more saline waters ranging from 18-32 ppt in salinity (Rice, 1992a) expanded throughout the ponds (Lee 1980, Pfeiffer-Herbert 2007). In addition to the decline of oyster populations because of changes in the salt pond ecology, the 1938 hurricane decimated many of the processing facilities that supported the oyster industry and facilitated the ultimate collapse of the state's oyster industry shortly thereafter (Rice, 2006). The economic void created by the loss of the oyster allowed for the expansion of bay scallops as well as for quahogs to become the state's largest and most important commercial and recreational shellfish species (Fig. 1) (Lee, 1980; Twombly and Goldsmith, 1994; Pfeiffer-Herbert, 2007).

During the 1980s, quahogs were the primary species harvested, and wild harvest was the primary harvest type (Twombly and Goldsmith, 1994; Oviatt et al., 2003). While shellfishing for this species was relatively lucrative during this decade, the shellfish resource began to experience a variety of impacts during the 1980s that have contributed to the declines in the wild harvest over time. In fact, many of the impacts that seem to have contributed to losses in the quahog fishery since the mid 1980s were already affecting other species found throughout the salt ponds and Narragansett Bay. Virginia Lee's *The Elusive Compromise, RI Coastal Ponds and their People* (1980) provided evidence from fishermen that the salt ponds which were previously highly productive for oysters, fish, and other shellfish species (Olson and Lee, 1991) were at risk of losing the capacity to support a diversity of species due to impacts including development, nutrient loading, sedimentation, overfishing, and the further breaching and widening of the ponds. Other studies highlighted the narrow and limited distribution of oysters in the surface waters of oxygen-depleted coves throughout the salt ponds as a result of eutrophication

(Lee and Olson, 1985). While the northern quahog remains the most important commercial shellfish species in the state, the late 1980s marked a shift in the industry as landings and values began to depreciate and today the shellfish industry in Rhode Island is characteristically different than it was during the 1980s. The following sections describe the various biophysical, socioeconomic, and regulatory events that have led to the difference between the industry now and in the 1980s.

SHELLFISHING IN THE 1980s: URBANIZATION OF RI & ASSOCIATED WATER QUALITY

In the 30 years leading up to the 1980s, the housing market in Rhode Island began to boom as Rhode Islanders moved away from the urban center of Providence and disbursed throughout the state (Olson and Lee, 1991). Much of this disbursement led to development in the watersheds containing the state's salt ponds and Narragansett Bay, the centers of the state's shellfish industry (Lee, 1980; RI DEM, 2000). Archetto and Wang (2012) documented the changes in land cover throughout Rhode Island between 1972 and 2010 and found a 24% increase in urban lands between 1972 and 1985. A primary result of this increase in urbanization was the input of point and non-point sources of metals, bacteria, and nutrients from wastewater treatment facilities, combined sewer overflows, failing septic systems, the discharge of human waster from boats, and storm drains all of which contributed to the degradation of the waters overlying shellfish grounds (Nixon, 1982; Olson and Lee, 1991; RI DEM, 2000). A study from 1984-1996, found that up to two days following a rainfall event, water quality station readings showed bacterial contamination levels between Providence and Upper Narragansett Bay that exceeded the levels acceptable for shellfish harvesting (Doall et al., 2008). As a

result of these types of water quality impacts Olson and Lee (1991) found that if development continued on a similar trajectory, the salt ponds would become highly contaminated leading to the closure of many previously fishable areas. Nevertheless, the state's population continued to grow from 947,154 in 1980 to 1,003,464 residents in 1990 (US Census Bureau) and shift away from urban centers placing additional burdens on Rhode Island's natural environment (Olson et al., 1980; Lee and Olson, 1985). Between 1978 and 2010, developed lands in Rhode Island increased by 83% from 41,681 hectares to 76,418 hectares, while forested lands decreased by 18% (Archetto and Wang, 2012). The bacterial contamination and nutrient loading resulting from this development led the state regulating agency, the Department of Environmental Management (RI DEM), jointly tasked with the Department of Health to enforce the National Shellfish Sanitation Program (NSSP) standards and laws regulating shellfish harvesting (Holst, 1992), to close shellfish grounds to harvest and establish limitations on shellfish harvests. While efforts during the past 25 years have led to substantial progress on improving water quality, as of 2000, the bacterial contamination of shellfish beds had caused the permanent or conditional closure of 25% of potentially fishable waters (Fig. 3) (RI DEM, 2000).

**Impairments to Rhode Island Coastal Waters
(Major / Moderate Causes - Sq Miles Impaired)**

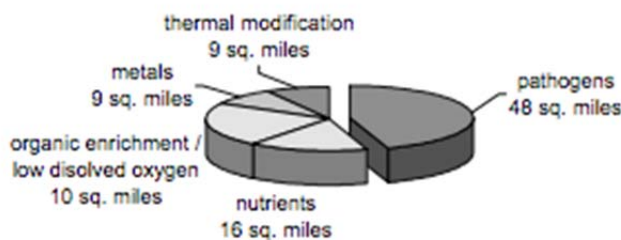


Figure 3. Breakdown of impairments to Rhode Island’s coastal waters by square mile (RIDEM, 2000).

In 1981, the habitat and waters of Greenwich Bay, considered one of the most productive areas for quahogs in the state (Rice, 1992), had already become significantly degraded and overfished and was closed to shellfishing (Fig. 4) (Lazar et al., 1994). In an effort to restore Greenwich Bay it was reseeded with transplanted shellfish from uncertified waters and was later reopened in 1982-1983 with an imposed reduced fishing effort (Lazar et al., 1994). The restoration effort in the early part of the decade proved successful and provided harvests up to 1 million pounds in shell weight each year and contributed to the successes of quahoggers in the states during the 1980s. However, increases in residential development around Greenwich Bay, in the surrounding watershed, and in recreational boating facility development on the Bay led to significant bacteria and nutrient loading which forced a closure of the Bay’s shellfish grounds in 1992. These ongoing water quality impairments prevented Greenwich Bay from meeting NSSP standards and forced the Bay to remain closed to shellfishing for 1.5 years (Lazar et al., 1994). By the early 1990s, it was determined that the majority (59%) of quahogs in Greenwich Bay were found in waters classified as polluted (Lazar et al., 1994).

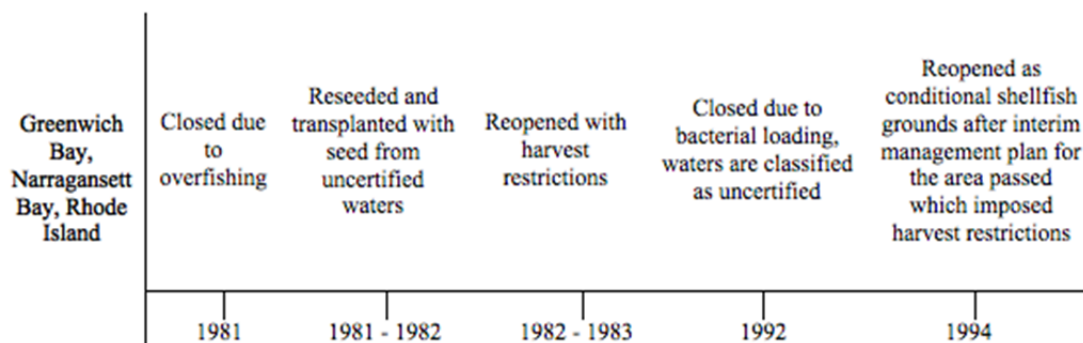


Figure 4. Timeline of openings and closures of Greenwich Bay, one of the most productive quahog areas in Rhode Island from 1981-1994 (Lazar et al., 1994).

In addition to the impacts of development, suburbanization, population growth, and nutrient and bacteria loading on local shellfish resources, negative media attention related to shellfish consumption throughout the country began to impact the national shellfish industry beginning in the 1980s. Throughout the US's shellfish producing states there are various state, and local regulatory and enforcement agencies with similar missions that include the enforcement of shellfish closures to protect consumers and stocks (Holst, 1992). However, even in a small state such as Rhode Island, DEM's capacity to enforce and supervise all of the shellfish grounds throughout the state is nearly impossible (Holst, 1992). As a result of these enforcement challenges a relatively small, but potentially lethal, number of food poisoning cases occur annually throughout the US, and began garnering wide media coverage and provoking consumer fears related to the human impacts of contaminated shellfish on a national level (Brooks, 1994). Wild caught seafood and shellfish became a particular concern for many Americans and contributed to a decline in consumer demand for wild caught shellfish and a drop in values of shellfish during the late 1980s (Brooks, 1994). By 1990, the national consumption of shellfish in the US had declined by 15% because of decreased consumer confidence after a series of illnesses including an incident in 1982 in which 471 people became sick after eating oysters that were contaminated by sewage (Remmer, 1998). As Rhode Island produces shellfish both for local consumption as well as for export and the public is highly sensitive to reports of contaminated shellfish, the RI shellfish industry remains is vulnerable to a drop in demand stemming from public fears of shellfish contamination.

SHELLFISHING IN THE 1980s: FISHERMEN

Unlike some other fisheries that require highly specialized gear and expensive equipment, quahogging requires relatively little capital investment. As a result it is widely believed that the number of active quahoggers fluctuates with trends in the economy; increasing as people seek to supplement their incomes during times of economic weakness then decreasing when the fishery becomes less profitable (Nixon, 1992; Rice, 1992a). This characteristic of the fishery coupled with the fact that the quahog fishery was open to anyone wishing to purchase a license during the 1980s provides insight into one of the reasons that there were such high numbers of active fishermen during this time period (N. Lazar, personal communication, May, 2 2013).

In 1982 the United States was in the midst of a deep economic recession leading to an unemployment rate in Rhode Island of 9.5% (BLS US DOL) and likely preempting an increase in shellfishing to supplement incomes. Anecdotal reports indicated that during the 1980s, Rhode Island had the largest outboard motor fleet in the world, an assertion generally supported by the license and effort data presented in figure 3 and partially explained by the economic climate of the 1980s as well. As unemployment steadily climbed into the 1980s and advancements in bullrake technology allowed for increased harvest throughout the Bay, fishing pressure by both tong and bullrake for quahogs in the middle and upper parts of Narragansett Bay intensified. While there have been relatively few surveys of shellfishermen, two surveys that provide shellfishermen population statistics from 1962-1963 and 1978-1979 show an increase from 21% in the 1960s to 36% in the late 1970s of shellfishers who earned more than 75% of their income from quahogging (Nixon, 1992). The unemployment rates had increased steadily up to

1979 then decreased slightly before beginning to climb steadily again into the 1980s. This general upward trend in unemployment corresponds with the increase in quahoggers from the 1960s to the late 1970s. While further information from the 1980s is not available regarding the percentage of income generated by quahogging, other statistics, such as licenses (Fig. 2), show an increasing trend in licenses that corresponds with the unemployment rate, which peaked in 1982 (BLS US DOL). Reports from the 1980s indicate that based on the number of boat registers and issued licenses, approximately 1,000 to 1,200 full time shellfishermen were working throughout Rhode Island (Nixon, 1992). The number and types of licenses issued indicate increases in investment in new boats and gear and a transition of quahoggers into different licenses categories suggesting increased profitability of quahogs (Korny, 1981). During the early part of the decade, the value of littlenecks (a size class of the northern quahog) grew from \$0.80 per pound in 1979 to \$0.90 to \$1.00 per pound in 1980 thereby offsetting the costs of investment in new gear and fostering a reliance on the quahog industry to support household incomes (Korny, 1981).

SHELLFISHING IN THE 1980s: FISHERIES LANDINGS DATA

As previously stated, after the collapse of the oyster aquaculture industry in the late 1930s and early 1940s (Rice, 2006), bay scallops and quahogs expanded as the dominant fisheries throughout Rhode Island (Pfeiffer-Herbert, 2007). Despite relatively robust landings of shellfish from the late 1970s through the mid 1980s, there has been a general downward trend in the values and landings of various shellfish species since the late 1980s likely attributed to a variety of factors (Olson et al., 1980). The bay scallop,

which experienced a number of peaks and lows in production levels, provided the largest landings in the 1970s before being impacted by two consecutive years of brown algae blooms in the mid 1980s and the loss of important eelgrass habitats due to nutrient loading, which the species has yet to recover from (RI DEM, 2000; Pfeiffer-Herbert, 2007). The collapse of the bay scallop left the quahog as the primary harvested species in the state's shellfish industry until the more recent returns of oyster aquaculture.

The large landings of quahogs of the 1980s followed by the downward trend in landings presents an interesting phenomenon, which highlights the complexity of the quahog fishery during the 1980s (Fig. 5). Research by Henry and Nixon (2008) suggests that nutrient loading of Narragansett Bay may have led to blooms of phytoplankton communities, which allowed for significantly increased adult quahog growth rates during the 1960s-1970s and the 1980s-1990s. The same changes in phytoplankton, however, may have also contributed to significant decreases in juvenile growth rates, which are sensitive to the hypoxic conditions created by the phytoplankton blooms and likely suffered from increased predation during that time period (Henry and Nixon, 2006; Mercer, personal communication, May 6, 2013). These changes may have led to faster maturing quahog sets that were rapidly available to harvest during the 1980s as well as decreased growth rates in juveniles that were thus unavailable for harvest (Mercer, personal communication, May 6, 2013). In effect this created a bifurcated population of quahogs in which adults were removed from the population through harvest and the young were unable to grow quickly enough to keep up with those rates of harvest. This abundance of fast growing quahogs represents an additional factor that led to the large landings experienced during the 1980s and subsequent downturn in landings.

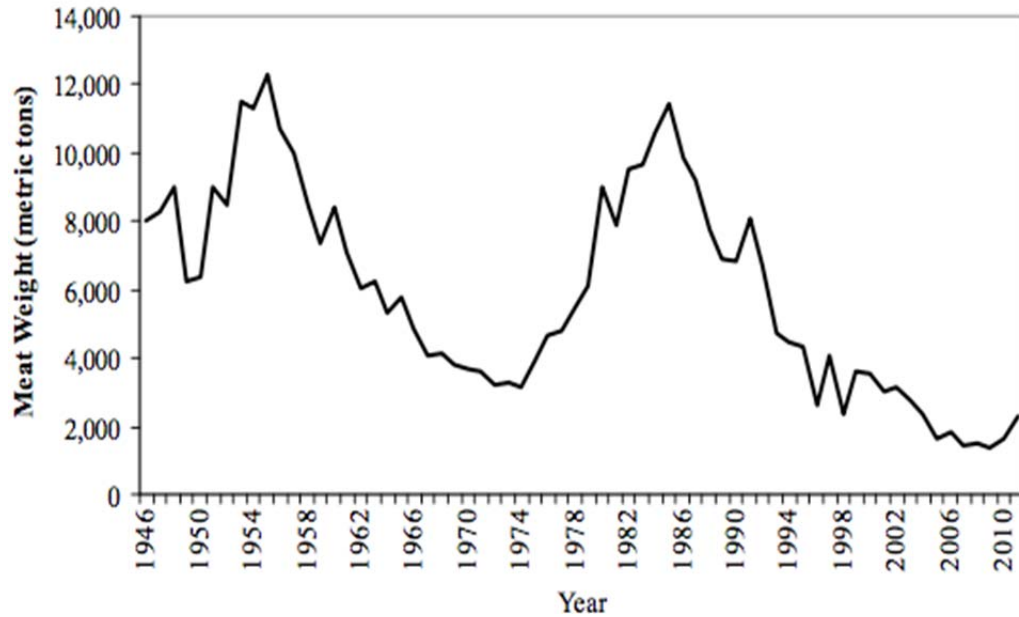


Figure 5. Meat weight in metric tons of quahogs landed commercially in RI from 1946-2011 (RI DEM, 2012).

In addition to the increased effort because of the weak economy and sets of fast growing mature quahogs, the opening of the Upper Narragansett Bay conditional areas in 1984 opened quahog stocks, which had not previously been available to shellfishers and also contributed to increased landings during the 1980s (Mercer, personal communication, May 6, 2013). This conditional opening led to heavy concentrated effort, generating substantial yields and which contributed to the peak in landings beginning in 1984 and culminating in 1986-1987 (RI DEM, 1999; Mercer, personal communication, May 6, 2013). Additionally, advances in bullrake technology provided access to areas of the Bay that were previously unavailable to shellfishermen further increasing potential yields (Beutel and Leavitt, personal communication, April 29, 2013). Since the late 1980s, however, reported values of the quahog fishery have trended downwards from a peak of \$16 million in 1986-1987 to \$8.3 million in 1993 (Fig. 6) (Brooks, 1994), with

landings also trending downwards from 11,500 metric tons in 1983 to approximately 2,000 metric tons in 2010 (Fig. 5) (RI DEM, 2000).

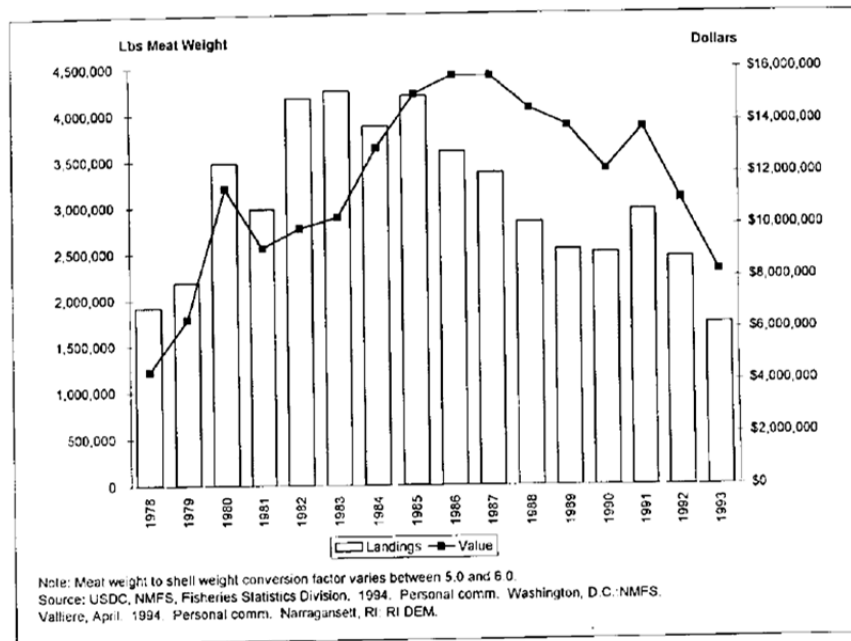


Figure 6. Rhode Island quahog landings and harvest value between 1978 and 1993 (Brooks, 1994).

In addition to bacteria and nutrient loading and habitat degradation, leading to a slowed juvenile growth and the closure of important shellfish grounds, another potential cause of landing declines includes issues related to heavy fishing pressure, which made fishing more challenging and less profitable. Although overexploitation can be challenging to document, a study by Lazar et al. (1994) showed a correlation between increased fishing effort and decreased catch per unit effort believed to be indicative of resource overexploitation (Fig. 7) (Lazar et al., 1994). Additionally, during the 1980s, various species were harvested despite being undersized with one study reporting that 50% of quahogs, 75% of soft-shelled clams, and 90% oysters harvested were undersized (Olson and Lee, 1991). The proportion of undersized and young shellfish in harvests provided evidence that mature and adequately sized individuals had already been

removed from the accessible population, thereby implying that the stocks in certified and easily accessible waters had been overfished (Olson and Lee, 1991). Furthermore, while many fishermen cease fishing when it becomes unprofitable due to decreased landings of adequately sized quahogs (Olson and Lee 1991), there was an incentive to continue harvesting undersized individuals during the 1980s because of a difference in the legally harvestable size between Pennsylvania and Rhode Island (Beutel, personal communication, April 29, 2013). This may have led to the removal of undersized individuals from Rhode Island for sale in Pennsylvania and which may have potentially impacted some of the local stocks. It is important to note however, that the while quahog stocks may have been locally depleted in important fishing grounds, simply looking at landings data does not represent a full picture of the resource throughout the Bay. It is likely that quahogs were not generally overharvested throughout all of Narragansett Bay as over half of the biomass still remains behind closed waters and may be stable or increasing (Leavitt, personal communication, April 29, 2013; Mercer, personal communication, May 6, 2013).

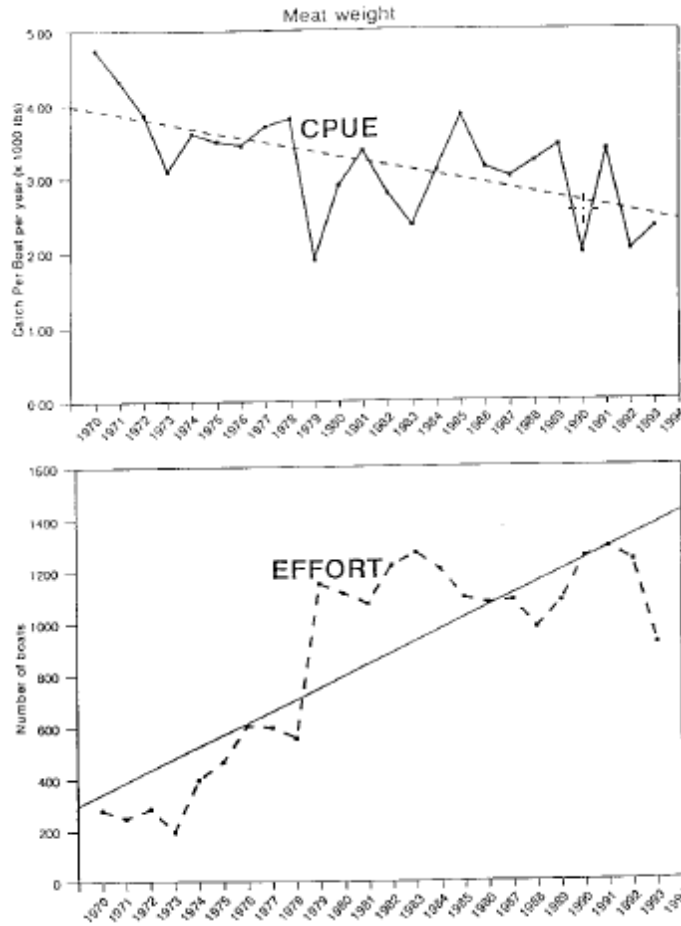


Figure 7. Catch per unit effort (top) and total effort measured by the number of boats (bottom) of Northern Quahogs from 1970 to 1994 (Lazar et al., 1994)

LOOKING AHEAD: THE CURRENT STATE OF THE SHELLFISHERY

The shellfish industry of the 1980s saw an increase in the number of shellfishermen under the age of 65 (Hasbrouck et al., 2011). Today, however, the fishing industry is characterized by an aging population of fishermen and limited opportunities for newcomers as the industry landings continue to decline (Hasbrouck et al., 2011). As early as 1993, it was believed that the number of active fulltime fishermen participating in the quahog fishery was likely half the number of fulltime commercial quahoggers working Narragansett Bay during the 1980s (Rice, 1993). The 1993 estimate of active

shellfishermen working Narragansett Bay year round was roughly 320 (Lazar, personal communication, May, 2 2013) despite there being 900 licenses allowing the harvest of quahogs in some capacity, down from 1,200 licenses in 1983 (Fig. 2) (Lazar et al., 1994). Today, there are roughly 700 licensed fishermen in the quahog fishery of which 1/3 is active year round, ranging in size from 150-200 fishermen (Lazar, personal communication, May, 2 2013).

In addition to the drop in the number of active commercial quahoggers, market prices for quahogs had stagnated at 1970s prices forcing quahoggers to spend more time fishing while earning less (Rice, 1993; Hasbrouck et al., 2011). Forced closures of important shellfishing grounds related to habitat degradation, nutrient loading and bacterial contamination during the 1980s also created increased fishing pressure in the remaining open waters (Lazar et al., 1994). Because of the increased harvest pressure in smaller areas, fishermen that were once able to make \$500 per hour, were relegated to overfished but certified shellfish grounds leading to significantly lower landings that ranged \$30 and \$200 per day (Korny, 1981). The lack of sufficient income generation began to force previously fulltime shellfishers out of the industry in search of other sources of income to supplement their quahogging income, a reversal of the trend during the 1960s and 1970s that created such a large commercial quahog shellfishery (Lazar et al., 1994). New employment opportunities associated with the strengthened economy that emerged in the 1990s also contributed to shellfishermen leaving the industry for more stable work on land (Mackenzie et al., 2002a). A recent survey of fishermen in Rhode Island found that none of the polled bullrakers earned 100% of their wages from shellfishing, and used additional sources of income including other means of

employment, savings, or pension benefits to make up the remainder of their income (Hasbrouck et al., 2011).

However it is important to note that although many quahoggers left the fishery as it became less profitable at the end of the 1980s, a distinguishing feature of the current quahog fishery is the strict limit on the number of new licenses granted, whereas there was no limit to the number of quahog licenses issued in the 1980s (RI DEM 2008; Leavitt, personal communication, April 29, 2013). While the fishery was likely overfished between 1979 and 1995 and the industry suffered from closures related to poor water quality, the ongoing decline in the number of active shellfishermen pursuing quahogs is also in part due to license and harvest restrictions (RI DEM, 2008). The industry entrance limitations were implemented by DEM in 2001 in order to protect the quahog resource and fishermen and to maintain effort below that the estimated maximum sustainable yield level (RI DEM, 2008).

LOOKING AHEAD: PRIMARY HARVEST TYPES

During the early part of the 1980s the Coastal Resources Management Council undertook an effort to redesign the State's aquaculture laws in order to increase what had become a stagnant industry (Rice, 2006). Over the last 20 years Rhode Island's aquaculture industry has undergone a large expansion, growing from a \$300,000 to a \$1.6 million industry from 2001-2007 (Byron, 2010). Ninety-nine percent of the state's aquaculture industry is comprised of oyster aquaculture (Byron et al., 2011) making the oyster resource an important part of the state's economy. A recent study by Byron et al. (2011) showed that oyster aquaculture could continue to increase up to 625 times

throughout Narragansett Bay and not exceed the ecological carrying capacity as the Bay has very high levels of primary productivity which can support a healthy and growing oyster population (Byron et al., 2011). The study also found that other species throughout the Bay would not suffer adverse impacts because of expanded oyster aquaculture (Byron et al., 2011). However, there have long been conflicts between resource user groups including wild harvesters, aquaculturists, and recreational harvesters (Olson and Lee, 1991), which presents challenges as the industry continues to expand. During the 1980s aquaculture in Rhode Island was just being reimagined after having slowed considerably with few leases being issued over the course of the previous 40 years. In fact a moratorium was placed on aquaculture permits after quahoggers objected to a 60-acre lease in 1980 and the first actual lease under the revised aquaculture laws of 1981 wasn't granted until 1990 (Rice, 2006). Today, however, the continued expansion of aquaculture means that shellfish resources and the space needed to pursue those resources will need to be shared and partitioned among user groups, marking one fundamental difference between the current conditions of the shellfish industry and those in the 1980s.

LOOKING AHEAD: CLIMATE CHANGE

The acidification of our oceans as a result of climate change presents potential challenges to marine species such as clams, oysters and mussels that require calcium carbonate to produce their shells (Smith, 2007). Ocean acidification is the increase of CO₂ and decrease of pH in our oceans and can potentially disrupt the ability of calcifying organisms such as shellfish to produce their shells and skeletons (Cooley and Doney, 2009). One study examining the effects of ocean acidification on quahogs found that

individuals exposed to current levels of CO₂ produced less robust shells, were slower growing, and experienced lower survival rates than those at preindustrial CO₂ levels (Talmage and Gobler, 2010). Furthermore, individuals exposed to levels of CO₂ that are predicted to occur later this century were deformed and eroded (Talmage and Gobler, 2010). Climate change related threats facing the shellfish resources in Rhode Island are undoubtedly complex and unlike any challenges faced by the industry in the 1980s. Tackling the impacts related to this issue will require a much broader scale management and mitigation approach than simple stock management. Nonetheless, unchecked impacts on shellfish populations from ocean acidification could result in massive losses of the shellfish species currently found in Rhode Island, which in turn would have far reaching ecological and economic consequences (Smith, 2007).

CONCLUSIONS

As evidenced by this report, the Rhode Island shellfish industry has changed greatly since the 1980s in various ways and for numerous reasons. The massive yields of the 1980s can be attributed to multiple factors including increased efforts as a result of a poor economy on shore and newly opened fishing areas including the Upper Narragansett Bay which presented opportunities for easy harvest with substantial returns on investment, both of which helped bolster landings of shellfish (Fig. 5) (Mercer, personal communication, May 6, 2013). However, some of the same factors that may have contributed to the high yields of the 1980s may have also resulted in negative impacts on the fishery over time.

As of 1992, Rhode Island's shellfish resource managers still lacked a clear understanding of the degree to which the resource was being harvested as the number of fishermen engaged in the fishery fluctuated rapidly and with the prevailing economy and state of the fishery (Dealteris et al., 1992). This lack of understanding may have contributed to localized overharvesting and an inaccurate definition of the maximum sustainable yield set at 12 bushels per day, which may have been insufficient to protect the resource (Dealteris et al., 1992). As such, quahogs were landed in large volumes potentially at an unsustainable level and the harvesting of undersized individuals may have resulted in the localized overexploitation of the resource with residual impacts (Olson and Lee, 1991; Lazar et al., 1994). The state's population growth and the continued suburbanization had begun to cause high levels of nutrient loading and bacterial contamination of shellfish grounds in the 1980s leading to heavy pressure on abundant fast-growing adult quahogs that left stocks of slow-growing and undersized juvenile quahogs (Henry and Nixon, 2006; Mercer, personal communication, May 6, 2013). As early as 1992, just a few short years from the heralded "golden years" of shellfishing in Rhode Island, the panelist discussion during the 2nd Annual Shellfish Conference discussed the need to improve the management of the shellfish resources or risk a collapse of quahog industry (Dealteris et al., 1992). As the 1980s ended widespread poor publicity surrounding shellfish coupled with a depressed economy contributed to stagnant quahog prices (Dealteris et al., 1992). That price stagnation likely further contributed to overharvesting and a reduction in full time quahoggers.

Although many of the same issues as well as emerging threats including ocean acidification and user conflicts trouble the industry today, Rhode Island's shellfishery

remains an important livelihood industry and economic driver as well as an important part of the history and heritage of Rhode Island and its peoples. As a result the resource is in high demand from a variety of user groups but also occupies an important niche in the ecosystem as it helps to not only filter and clean water but also serves as an important food source for many species in the food web (Olson and Lee, 1991). While improved management of the shellfish resource was called for in 1992 (Dealteris et al., 1992), there continues to be an ongoing need to review and improve management practices through stakeholder input as well as regulatory intervention to ensure its continued viability. The northern quahog remains the most important species of shellfish for Rhode Island and was among the top ten highest valued fish species in 2010, bringing in \$3,280,986 to the state (Hasbrouck et al., 2011). However, these values are down from the 2000 landings values of \$7,990,838 (Hasbrouck et al., 2011) indicating potential issues associated with the fishery. Additionally, the expanding aquaculture industry has brought increased economic revenues, totaling \$3 million in 2012 (Beutel, personal communication, April 29, 2013), to the state and created important revenue sources for many commercial fishermen. Finally, the recreational sector remains an important part of the state's history and cultural heritage and must be considered when moving forward with a management strategy. Despite many successful years for some user groups throughout various points in the state's history, Rhode Island's marine resources including the relatively small area available to pursue both wild harvested and cultured shellfish must now be shared among these user groups. Because of these conflicting uses, the management of the shellfish and marine resources and the establishment of a legal framework has required significant revisionary efforts from a variety of angles in order to develop an acceptable solution that

is beneficial to both the people of Rhode Island and yet still supports a healthy shellfish fishery. In order to properly manage the harvest and stock levels, a comprehensive stock assessment is needed in order to determine if the 12-bushel limit is sufficient to protect the resource. In addition to the need for the management of stocks, there is an ongoing need for research that identifies price trends of shellfish and looks at the economics of shellfish in the state (Hasbrouck et al., 2011). While progress has been made to regulate the shellfish industry and establish legal mechanisms that ensure safe shellfish products are put into the markets, gaps in the current system still exist. For these reasons, Rhode Island is embarking on a fundamental shift in its approach to management through the drafting of its first ever state-wide shellfish management plan and we can anticipate continued changes and ongoing evolution of the management of the shellfish fishery in Rhode Island.

While the purpose of this paper was to provide information regarding the factors that contributed to the successes of the industry during the 1980s, the reality is that there are fundamental differences among the shellfishery of today and that of 20 or 30 years ago. The factors that contributed to a productive quahog shellfishery during the 1980s are complex and not necessarily indicative of a healthy and sustainable fishery. The need for a comprehensive management plan, however, has endured. In order for the state's shellfish resources to remain viable, cooperative effort from all user-groups including aquaculturists and wild harvesters as well as resource managers and the public will be required to ensure that the management plan that is developed will support and serve both Rhode Island's shellfish industry and the resource itself.

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