2006-2019 Catch, Effort, and Fishery Trends in the Rhode Island Whelk Fishery and Recent Stock Status

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"The mission of the Division of Marine Fisheries is to research and monitor marine species to support the effective management of finfish and shellfish of commercial and recreational importance."

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Introduction:

The channeled whelk (*Busycotypus canaliculatus* (Linnaeus, 1758)) and knobbed whelk (*Busycon carica* (Gmelin, 1791)) are two large marine neogastropod species occurring in Rhode Island state waters (0-3 miles) and near-shore coastal waters of southern New England belonging to the family Melongenidae. Both species occur along the eastern coast of the United States from Cape Cod, Massachusetts to central Florida, with members of the genus *Busycon* being the largest marine gastropods in this range (Abbott 1974, Ram 1977). These whelks have been harvested over the past 125 years in Rhode Island as a means to control predation on more economically-important clam and oyster populations (Shaw 1960, Walker 1988), for over 100 years as a food-source bycatch and economic supplement in southern New England lobster and finfish fisheries (DeKay 1843, Davis & Matthiessen 1978), and over the past approximately 35 years as a directed fishery as the economic viability of predominantly ethnic markets for whelks has increased (Davis & Sisson 1988).

In spite of this relatively long history of exploitation, little is known about the life history traits (growth rates, age-at-size, age-at-maturity, size-at-maturity) of these whelk species in the northern extent of their range, particularly for the channeled whelk which constitutes the vast majority of annual whelk landings in Rhode Island (2006-2019 mean = 95.74%, range of 93.37-99.48%) (ACCSP 2019) and southern New England. Due to the lack of information regarding these biological parameters, minimum size regulations may have been implemented (formerly 2.5" shell width (SW) or 4.5" shell length (SL) (2009-2011) and 2.75" SW or 4.75" SL (2012-2013)) that were not appropriate "*to support the effective management of finfish and shellfish of commercial and recreational importance.*" Both of these whelk species exhibit life history traits that make them vulnerable to overfishing that include a limited larval dispersal stage, slow growth and late maturation, low fecundity, low genetic diversity, and a relatively sedentary lifestyle (Hancock 1963, Berg & Olsen 1988, Gendron 1992, Shelmeradine et al. 2007).

Although the reliable landings and value data timeseries is somewhat limited (2006-2018), fishing effort directed on the RI whelk fishery resource increased substantially during years 2007-2011/2012 due to severe declines in the southern New England commercial lobster fishery and dramatic increases ex-vessel prices for whelks. As a result of these recent increases in fishing effort on the RI whelk resource, concerns have been raised by both RI whelk fishermen and RI Division of Marine fisheries (RIDMF) fishery scientists and managers regarding the ability of the resource to sustain itself (The Nature Conservancy 2017). To begin addressing these concerns, a whelk research project was initiated in April 2012 to collect the basic biological and fishery catch and effort data needed to advise RI fishery managers and the whelk fishing industry on the status of the whelk fishery resource and fishery management strategies that may be employed to accomplish this goal (Angell 2018; Castro et al. 2015). This report serves to supplement these previous efforts by synthesizing available information on the channeled and knobbed whelk populations in fisheries in Rhode Island state waters.

Fishery-Dependent Data:

Landings and Value:

Total reported RI whelk landings fluctuated with an overall increasing trend during the period of 2006-2012, increasing 110% from 368,028 pounds live weight (2006) to a peak of 773,885 pounds live weight (2012). During the period of 2012-2016, landings followed a generally decreasing trend with an overall decrease of 56% to 338,914 pounds live weight (2016) and fluctuated without trend during 2017-2019. Landings for 2019 totaled 443,852 pounds live weight, a 48% decrease over 2018 and were 25% above the timeseries mean (**Table 1, Figure 1**). Total ex-vessel value for whelk landings followed a generally increasing trend during 2006-2012 and increased 255% from $450,137 (2006) to a peak of $1,599,227 (2012). During the period of 2012-2016, ex-vessel value followed a generally decreasing trend and decreased 43% to $909,068 (2016). In 2017, ex-vessel value increased 45% from the 2016 value to $1,318,210. Total ex-vessel value for 2018 was $2,094,731, a 59% increase over 2017. In 2019, ex-vessel value was $1,440,940, a 31% decrease over 2018 and was 33% above the timeseries mean (**Table 1, Figure 2**). After an initial decrease of 24% from $1.22/pound (2006) to $0.93/pound (2007), a consistently increasing trend in the mean value per pound ($/pound) resulted in a 249% increase over time to $3.25/pound in 2019 (**Table 1, Figure 3**) (ACCSP 2019).

A breakdown of monthly whelk landings data (SAFIS 2019) shows two distinct seasonal peaks and troughs. Although whelk landings occur year-round, the majority of landings occur during May-December, which account for an average of 98.6% of total annual landings and the months of January-April accounting for an average of 1.4% of total annual landings. The first peak in whelk landings occurs in either May or June (except for July 2009, 2015, and 2017), with the second peak occurring in either October or November (except for December 2017). The larger seasonal peak varies from year to year, occurring during May in 2013; June in 2006, 2007, 2011, and 2019; July in 2009; October in 2012 and 2014-2018; and November in 2008 and 2010. Whelk landings decrease sharply during August and September, presumably due to reduced catchability as a result of reproductive activity combined with high water temperature. Whelk landings decrease sharply again during December-April presumably due to decreased water temperature and fishing effort. Mean monthly whelk landings, mean monthly number of transactions (sale of harvested whelk to a dealer), and mean whelk landings (pounds) per transaction follow the same monthly/seasonal trend (**Table 2, Figures 4-6**) (ACCSP 2019).

Fishing Effort:

Annual number of fishers reporting whelk landings during 2006-2011 fluctuated with an overall increasing trend and increased 84% from n=134 (2006) to a peak of n= 247 (2011). During 2012-2019, a consistently decreasing trend in the number of fishers reporting whelk landings resulted in a 55% decrease to n=110 in 2019. In 2019, a total of 110 fishers reported whelk landings, an 4% increase from 2018.

After an initial 40% decrease from 2,746 pounds/fisher (2006) to 1,965 pounds/fisher (2007), mean annual whelk landings (pounds) per fisher increased 80% to 3,544 pounds/fisher (2010). During 2010-2018, mean annual whelk landings per fisher fluctuated, showing a decreasing trend during 2010-2014 (20% decrease) and varied without trend during 2014-2019. Peak mean annual whelk landings per fisher occurred in 2018 at 6,400 pounds/fisher. Trends in number of fishers reporting whelk landings annually follow a similar pattern as total reported RI whelk landings (see **Figure 1**). For the entire timeseries (2006-2019), the overall trend is moderately decreasing for annual number of fishers reporting whelk landings (18% decrease), while mean annual whelk landings per fisher show an increasing trend (47% increase). Mean annual landings per fisher in 2019 were 37% lower than in 2018 (**Table 3, Figure 7**) (ACCSP 2019).

Number of fishing trips made that reported harvesting and landing whelks increased 139% from n=2050 (2006) to a peak of n=4897 (2012), then decreased consistently during 2013-2016, resulting in an 86% decrease to n=2629 (2016). This value increased in both 2017 and 2018, resulting in a 45% increase up to 3,822 whelk fishing trips made in 2018, followed by a slight 5% decrease in 2019. For the entire timeseries (2006-2019), the overall trend for number of fishing trips made is increasing, showing a 77% increase. Mean landings per fishing trip show an initial decrease of 27% from 180 pounds/trip (2006) to 131 pounds/trip (2007), followed by a 64% increase to a peak of 214 pounds/trip (2009). A generally decreasing trend in mean landings per fishing trip from 2009-2019 resulted in a 43% decrease for that period. Trends in number of fishing trips made that reported harvesting and landing whelks generally follow a similar pattern as total reported RI whelk landings (see **Figure 1**). For the entire timeseries (2006-2019), the overall trend for mean landings per fishing trip is decreasing, showing a 32% decrease (**Table 3, Figure 8**) (ACCSP 2019).

Although the number of fishers reporting whelk landings by month by year is somewhat variable within each month over time (**Figure 9**), the overall trends follow the same general monthly pattern as total whelk landings by month (see **Figure 4**), mean whelk landings by month, and mean number of transactions (sale of harvested whelk to a dealer) by month (see **Figure 5**). The mean number of fishers reporting whelk landings by month (**Table 3, Figure 10**) increases by 286% from a low of 21.4 fishers/month (February) to an initial peak of 82.8 fishers/month (June), decreases by 28% to 58.1 fishers/month (August), increases by 26% to a second peak of 73.2 fishers/month (October), then decreases steadily through January. Trends in mean number of fishers reporting whelk landings by month follow a similar pattern as total reported RI whelk landings by month (see **Figure 4**), mean whelk landings by month, and mean number of transactions (sale of harvested whelk to a dealer) by month (see **Figure 5**) (ACCSP 2019).

During 2006-2011/2012, fishing effort directed on the RI whelk fishery resource increased substantially in terms of reported whelk landings (110% increase) (**Table 1, Figure 1**), number of fishers reporting whelk landings (84% increase) (**Table 3, Figure 7**), and number of fishing trips made (139% increase) (**Table 3, Figure 8**), as severe declines in the southern New England commercial lobster fishery and dramatic increases in total value of whelk landings (255% increase) (**Table 1, Figure 2**) and mean ex-vessel prices for whelks (69% increase) (**Table 3, Figure 3**) have resulted in shifts in fishing effort. Effort trends for 2012-2019 show decreases in number of fishers reporting whelk landings (-55%) and number of fishing trips made (-26%). Since peaking in 2009, mean landings per fishing trip have been declining steadily through 2013 (-43%), but show an increase of 31% from 2013 to 2015, followed by a 19% decrease in 2016, a 38% increase through 2018, and a 5% decrease in 2019 (**Tables 2-3, Figures 7-8**) (ACCSP 2019). As a result of these recent increases in fishing effort on the RI whelk resource, concerns have been raised by both RI whelk fishermen and RI Division of Marine Fisheries (RIDMF) fishery managers regarding the ability of the resource to sustain itself. As the mission statement of the RIDMF is *"to research and monitor marine species to support the effective management of finfish and shellfish of commercial and recreational importance"*, RIDMF initiated a whelk research project in April 2012 to collect the basic biological and fishery catch and effort data needed to advise RI fishery managers and the whelk fishing industry on the status of the whelk fishery resource and fishery management strategies that may be employed to accomplish this goal.

Licensing Data:

There are three types of commercial fishing licenses issued – Multi-purpose (MPURP), Principal Effort (PEL), and Commercial Fishing (CFL). The multi-purpose license essentially allows for the harvest of all marine species occurring within RI state waters, including whelks, unless otherwise prohibited. PEL and CFL licenses are more restrictive regarding the fisheries the licensee can participate in. **Table 4** summarizes 2003-2019 commercial fishing license data. Until 2012, PEL and CFL license holders were not restricted in their ability to harvest whelks. However, starting in 2012 an endorsement to participate in the whelk fishery was required for PEL and CFL licenses in order to harvest whelks (at an additional cost ($25) to the licensee), which accounts for the significant decrease in the total number of eligible licenses able to harvest whelks from 2011 to 2012. MPURP and PEL licenses issued during 2003-2019 have experienced a consistently decreasing trend, resulting in a 13% and 20% decrease over that time period, respectively. During 2012-2019, PEL licenses endorsed for the whelk fishery have decreased by 62%. CFL licenses issued increased 71% during 2003-2007 but have fluctuated during 2008-2019, resulting in a 6% increase overall during that later time period. For the entire timeseries, CFL licenses issued exhibit an overall increasing trend, resulting in a 64% increase from 2003 to 2019. Since 2012, the number of CFL licenses endorsed to participate in the whelk fishery has decreased by 51% (**Table 4, Figure 11**) (OLIS 2019).

Fishery-Independent Data:

Rhode Island Division of Marine Fisheries (RIDMF) Trawl Surveys:

The RIDMF conducts seasonal (spring/April and fall/September) and monthly trawl survey sampling at a combination of random and fixed stations within RI state waters. These trawl surveys have been active since Y1979, but detailed collection of whelk data (species, shell length, shell width, and weight by species) was not initiated until 2009. Mean number and mean weight (kilograms (kg)) per tow are calculated to produce separate abundance indices for each whelk species and a species-combined abundance index. **Table 5** summarizes RIDMF spring, fall, and monthly trawl survey indices for both whelk species.

RIDMF Spring trawl survey abundance indices (mean #/tow and mean Kg/tow) for channeled whelk show an increasing trend from 2009-2012, a decreasing trend from 2012-2015, an increase in 2016, followed by a decreasing trend in 2017-2019. The #/tow index was below the timeseries mean in 7 of 11 years; the kg/tow index was below the timeseries mean in 8 of 11 years. Both indices have an overall slightly decreasing trend over the timeseries. Timeseries peak for both indices occurred in 2012; timeseries minimum for both indices occurred in 2009 and 2015. Both indices are currently below their timeseries means (**Figure 12**). RIDMF Spring trawl survey abundance indices for knobbed whelk are virtually constant and flat at zero from 2009-2019, with only 1 knobbed whelk being observed in 2018 (timeseries peak) (**Figure 13**). RIDMF Spring trawl survey abundance indices trends for species-combined are virtually identical to the trends for channeled whelk, as only 1 knobbed whelk was observed (2018) during the timeseries; both indices peaked in 2012 and are currently below their timeseries means (**Figure 14**).

RIDMF Fall trawl survey abundance indices for channeled whelk show a sharply decreasing trend from 2009-2011, followed by a generally increasing trend from 2011-2015, a sharp decrease again during 2016-2017, a sharp increase in 2018, and a sharp decrease in 2019. The #/tow index was below the timeseries mean in 7 of 11 years; the mean kg/tow index was below the timeseries mean in 8 of 11 years. Both indices have an overall decreasing trend for the timeseries. Timeseries peaks for both indices occurred in 2009; timeseries minimum for #/tow occurred in both 2017 and 2019, and in 2017 for kg/tow. Both indices are currently below their timeseries means (**Figure 12**). RIDMF Fall trawl survey abundance indices for knobbed whelk fluctuate, with an overall decreasing trend over the timeseries. The #/tow index was below the timeseries mean in 6 of 11 years; the kg/tow index was below the timeseries mean in 7 of 11 years. Timeseries peaks for both indices occurred in 2009. Timeseries minimum for #/tow occurred in 2013; timeseries minimum for kg/tow occurred in 2013; timeseries minimum for kg/tow occurred in 2019. Both indices are currently below their timeseries means (**Figure 13**). RIDMF Fall trawl survey abundance indices for species-combined show a sharply decreasing trend from 2009-2014, followed by a sharp increase in 2015, sharp decreases in 2016-2017, followed by a sharp increase again in 2018. Timeseries peak for #/tow and kg/tow for species-combined occurred in 2009. Timeseries minimum for #/tow occurred in 2017 and 2019; timeseries minimum for kg/tow occurred in 2019. The #/tow index was below the timeseries mean in 7 of 11 years; the kg/tow index was below the timeseries mean in 7 out of 11 years. Both indices have an overall decreasing trend for the timeseries. Both indices are currently above their timeseries means.

The RIDMF Monthly trawl survey abundance indices for channeled whelk, knobbed whelk, and species-combined fluctuate throughout the timeseries, all with an overall decreasing trend for both indices from 2009-2019. Timeseries peak in both indices for channeled whelk occurred in 2009; timeseries minimum in both indices occurred in 2017. The mean #/tow index for channeled whelk was below the timeseries mean in 8 of 11 years; the mean kg/tow index was below the timeseries mean in 6 of 11 years and both indices are currently below their timeseries means (**Figure 15**). For knobbed whelk, timeseries peak in #/tow occurred in 2009; timeseries peak in kg/tow occurred in 2011. Timeseries minimum for #/tow occurred in 2017; timeseries minimum for kg/tow occurred in 2016. The #/tow index was below the timeseries mean in 7 of 11 years; the mean kg/tow was below the timeseries mean in 7 out of 11 years. Both indices have an overall decreasing trend over the timeseries and both indices are currently below their timeseries means (**Figure 16**). For species-combined, timeseries peak in #/tow occurred in 2009; timeseries peak for kg/tow occurred in 2011. Timeseries minimums for both indices occurred in 2017. For species combined, timeseries minimum for both indices occurred in 2017 and both indices are currently below their timeseries means (**Figure 17**).

<u>University of Rhode Island/Graduate School of Oceanography (URI/GSO) Trawl Survey:</u>

The URI/GSO trawl survey conducts weekly survey tows at two fixed stations located within RI state waters (Fox Island and Whale Rock) and has been active since 1959. Mean number and mean weight (kg) per tow of these two whelk species combined is calculated to produce a species-combined index; mean Kg/tow data available for Y1994-2018 only. A detailed description of this trawl survey can be found in Collie, Wood, & Jeffries (2008).

The URI/GSO trawl survey abundance indices (#/tow and Kg/tow; species-combined) exhibit several periods of relatively low, moderate, and high abundance over time, are highly variable between the two survey stations, and appear to fluctuate without discernable trend or cycle.

The Fox Island survey station #/tow index shows relatively low whelk abundance during Y1959-1968, moderate abundance during Y1969-1982, relatively high abundance during Y1983-1988, relatively low abundance during Y1989-1996, moderate abundance during Y1997-1998, relatively high abundance during Y1999-2000, generally moderate abundance during 2001-2009 (except 2006 with relatively low abundance), relatively high abundance during 2010-2012, relatively low abundance during 2013-2014, relatively low abundance during 2015-2016, and relatively moderate abundance in 2017-2018. The Fox Island survey station #/tow abundance index was above the timeseries mean in 26 of 60 years, below in 34 of 60 years, and is currently below the timeseries mean by 22%. Timeseries peak for both indices occurred in Y1999; timeseries minimums for #/tow occurred in Y1967-1968 and for Kg/tow in Y1994 (NOTE: timeseries minimum for Kg/tow (0.000) would have also occurred in Y1967-1968). The Kg/tow index generally follows a similar pattern to the #/tow index for the years that the index is available (Y1994-2018). The Kg/tow index is relatively low during Y1994, low/moderate during Y1995-1998, relatively high during Y1999-2000, moderate during 2001-2005, low during 2006, moderate during 2007-2014, relatively low during 2015-2016, and moderate levels in 2017-2018. The 2018 Kg/tow index (0.577) is below the timeseries mean (1.113) by 48% (**Figure 18**).

The Whale Rock survey station shows relatively moderate/high abundance, but decreasing, during Y1959-1960, relatively low abundance during Y1962-1977 (except Y1964 with relatively moderate abundance), relatively moderate abundance during Y1978, relatively low abundance during Y1979-1982, relatively high abundance during Y1983-1984, relatively low abundance during Y1985-1995 (except for Y1988 with moderate abundance), a sharp peak of high abundance in Y1996, relatively low abundance during Y1997-2003, a peak of relatively high abundance in 2004, relatively low abundance during 2005-2010, relatively high abundance during 2011-2014, moderate abundance during 2015-2016, and relatively high abundance in 2017-2018. The Whale Rock survey station #/tow abundance index was above the timeseries mean in 16 of 60 years, below in 44 of 60 years, and is currently well above (101%) the timeseries mean. Timeseries peak for both indices occurred in Y1996; timeseries minimums for #/tow occurred in Y1963, Y1965-1968, Y1971-1973, Y1975-1977, Y1981-1982, Y1986, Y1989-1990, Y1994-1995, Y1998, 2001-2002, and 2009-2010 and for Kg/tow in Y1994-1995, Y1998, and 2009-2010 (NOTE: timeseries minimum for Kg/tow (0.000) would have also occurred in same years listed for #/tow minimum values. The Kg/tow index generally follows a similar pattern to the #/tow index for the years that the index is available (Y1994-2018). The Kg/tow index is relatively low during Y1994-1995, relatively high during Y1996, relatively low during Y1997-2003, relatively high during 2004, moderate during 2005, relatively low during 2006-2010, relatively moderate during 2011-2016, and relatively high in 2017-2018. The 2018 Kg/tow index (0.048) is currently well above (75%) the timeseries mean (0.027) (**Figure 19**).

The abundance indices for combined survey stations follow the trends for the Fox Island survey station, as the abundance index at the Fox Island survey station is an order of magnitude higher than the Whale Rock survey station and dominates the indices (**Figure 20)**.

Rhode Island Division of Marine Fisheries (RIDMF) Clam Dredge Survey:

Although the RIDMF clam dredge survey has been conducted since 1993, not all strata were surveyed in each year, making comparison between years problematic. The relative abundance index of whelk for this survey shows relatively low abundance during Y1993-2001 and relatively moderate to high abundance during 2002-2019, with an overall increasing trend for the timeseries. The 2019 whelk abundance index of 0.0335 whelk/meter^2 is 47% above the timeseries mean (0.0228 whelk/meter^2) but 32% below the 2018 index (0.0494 whelk/meter^2) (**Table 7, Figure 21**).

Rhode Island Division of Marine Fisheries (RIDMF) Lobster Ventless Trap Survey:

Since 2006, RIDMF has conducted an industry-assisted ventless trap survey primarily designed to monitor the relative abundance of sublegal-sized lobsters as part of information used to assess lobster stock status. Both species of whelk are caught as by-catch in this survey and a relative abundance index (catch-per-unit-effort (CPUE) index) is calculated simply as the number of whelks caught (species combined) divided by the number of traps sampled (hauled). Whelk relative abundance indices were calculated annually for each area (Narragansett Bay, RI Sound, and BI Sound) and both trap types (vented and unvented).

Narragansett Bay:

From 2006 to 2010, the relative abundance of whelks caught in **unvented** traps increased by 1312%, from 0.037 up to 0.523 whelk/trap-haul, the timeseries peak. After a 91% decrease in 2011 (0.048 whelk/trap-haul), the index increased 855% to 0.455 whelk/trap-haul in 2013. During 2013-2019, the index shows an overall decreasing trend with a 74% decrease during the timeframe. The 2019 unvented trap whelk abundance index of 0.118 whelk/trap-haul is 50% below the timeseries mean (0.238 whelk/trap-haul). Relative abundance of whelk caught in **vented** traps generally follows the trends for unvented traps. Both relative abundance indices have an overall slightly increasing trend for the entire timeseries (**Table 7, Figure 22**).

Rhode Island Sound:

From 2006 to 2008, the relative abundance of whelks caught in **unvented** traps decreased by 100%, from 0.046 down to 0.0 whelk/trap-haul. After a slight increase in 2009, the relative abundance increased 2717% to the timeseries peak of 0.174 whelk/trap-haul in 2010. The index dropped precipitously in 2011 to 0.0 whelk/trap-haul and stayed virtually flat until 2015 when it increased to 0.019 whelk/trap-haul, then dropped back to 0.0 whelk/trap-haul in 2016. The index increased again in 2017 up to 0.494 whelk/trap-haul, followed by an 87% decrease down to 0.0064 whelk/trap-haul in 2018 and 0.0 whelk/trap-haul in 2019. Relative abundance of whelk caught in **vented** traps generally follows the trends for unvented traps. Both relative abundance indices have an overall slightly decreasing trend for the entire timeseries (**Table 7, Figure 23**).

Block Island Sound:

After a 100% decrease from 2006 to 2007, the relative abundance index of whelks caught in **unvented traps** remained flat at 0.0 whelk/trap-haul until 2013 when it increased up to 0.0072 whelk/trap-haul, which persisted through 2014. The index dropped back down to 0.0 whelk/trap-haul and remained there during 2015-2017, followed by a huge increase up to 0.037 whelk/trap haul. Relative abundance of whelk caught in **vented** traps generally follows the trends for unvented traps but appears to lag the unvented trap relative abundance by a year. The relative abundance index for unvented traps has a slightly increasing trend; the relative abundance index for vented traps has a slightly decreasing trend (**Table 7, Figure 24**).

Brayton Point Power Station (Normandeau) Otter Trawl Surveys:

Since late 1971, the Brayton Point Power Station, Somerset, MA has conducted an otter trawl survey (standard trawl program) to monitor the effects of Brayton Point Power Station on the hydrography and biology in upper Mount Hope Bay. Sampling has occurred continuously at fixed stations using an otter trawl with 1.5-inch (38.1 mm) stretched mesh in the cod end. Beginning in 1997, the standard trawl program was augmented with additional sampling stations throughout Mount Hope Bay. Otter trawl sampling was modified in 1993 with the addition of sampling with a finer-mesh Wilcox trawl, using a 0.25-inch (6.4 mm) mesh liner in the cod end. Wilcox trawl tows have been conducted throughout Mount Hope Bay since 1996 and at two stations in Narragansett Bay since 1997. The primary objective of the standard and Wilcox trawl programs is to document finfish abundance and distribution throughout Mount Hope Bay and at two stations in Narragansett Bay. Beginning November 1, 2014, the biological monitoring program was revised, and the standard trawl program was eliminated. Two sampling stations located north of the Braga Bridge and two sampling stations in upper Narragansett Bay were also eliminated.

From 1995 to 1997, the relative abundance index of whelks increased 485%, from 0.33 whelk/tow (timeseries low) to 1.95 whelk/tow. The index then decreased annually from 1997 to 2001, resulting in an 86% decrease to 0.44 whelk/tow in 2001. Relative abundance fluctuated during 2001-2011, with an overall increasing trend which resulted in a 1080% increase from 0,44 whelk/tow (2001) to 5.195 whelk/tow (2011). From 2011 to 2014, the relative abundance index had an overall decreasing trend and decreased 90% from 5.193 whelk/tow to 0.518 whelk/tow. The entire timeseries has a slightly overall increasing trend and the 2014 whelk abundance index of 0.518 whelk/tow is 73% below the timeseries mean (1.93 whelk/tow) (**Table 8, Figure 25**). This survey has been discontinued after 2014 due to the shutdown of the power station.

FishPath Workshop and Conclusions:

A two-day workshop was held at the University of Rhode Island's Bay Campus from September 6-7, 2017. The workshop was organized by The Nature Conservancy and the Rhode Island Department of Environmental Management, Division of Marine Fisheries (RIDEM), convening fisheries scientists, managers and representatives from Rhode Island, Massachusetts, and the Conservancy. Members of the whelk fishery were invited but were unable to attend. The goals of the workshop were to review the current context of the whelk fishery in RI and MA and explore management options suited to the RI fishery. RIDEM provided several presentations and facilitated discussion on the current management and characteristics of the fishery. The team led an engaged discussion, walking through the Conservancy-developed FishPath software tool to determine the pros and cons of current and alternative management options for the fishery. At the outset of the workshop, the participants decided to focus on the largest component of the fishery in RI, channeled whelks caught in pots.

The FishPath process provided a list of potential options for monitoring, assessing the stock, and management rules, along with the potential pros and cons of each method. These results focused on the whelk pot fishery in Rhode Island, which is largely composed of channeled whelks (The Nature Conservancy 2017). The complete workshop report can be found at: http://www.dem.ri.gov/programs/bnatres/marine/pdf/Whelk_FishPath.pdf

Monitoring:

FishPath identified almost every monitoring option as possible in the fishery except for the fishery independent surveys conducted by fishers. Fishery independent surveys are an excellent monitoring option that are currently being conducted by the State. Workshop participants indicated, however, that a more focused whelk survey could be valuable and potentially could be run as a collaboration between the industry and RIDEM. In addition, specific studies such as a dedicated port and/or sea sampling program could also benefit from broader engagement with the industry and potentially sampling with commercial boats. While all options were possible, discussion during the questionnaire/results indicated that there were few new types of monitoring that would add a tremendous amount of value to the current data collection program.

Discussion did suggest that additional sampling or specific studies could be useful to better inform distribution and life history parameters. Currently, the von Bertalanffy growth parameters are poorly estimated because there are almost no samples at the smallest and largest size classes. Additional work to target collections of these size classes could improve parameter estimates that are in turn used in stock assessments. Additionally, there is little information on the finer scale distribution of whelks within Narragansett Bay or in relation to spawning and nursery areas. Certain management options are not possible (rotational closures, no-take zones) because of the lack of this information. A more focused whelk survey could improve this information.

Stock Assessments:

Given the large amount of information on the RI whelk fishery there are a range of potential assessment options available. With the available data, potential categories of assessment techniques range from indicator-based frameworks, to proxy reference points, to stock status-based reference points, or a combination of a number of these. The specific techniques utilized will depend on a thorough examination of the different types of data available, the caveats of the different methods, and the capacity RIDEM has to undertake these methods.

Management Rules:

The RI whelk fishery has a wide range of available options for decision rules, with varying levels of caveats provided by FishPath. Participants ranked the potential options to determine which decision rules would be most viable in Rhode Island. Long lived, late maturing, sedentary individuals with dimorphic growth and limited dispersal present serious challenges for fisheries management. The options were divided into three general categories: viable and/or currently in place decision rules; decision rules that could potentially work; and nonviable decisions rules. The combination of whelk life history and whelk fishing impacts determined the nonviable decision rules and they were removed/down weighted. Potential decision rules were options that were not currently in use but were potentially viable in Rhode Island. The majority of these tied an effort or catch limit to the status of whelk. These include a range of options, such as linking the number of allowable pots, length of the open season, daily catch limit, or seasonal catch limit to a measure of the stock such as CPUE-, catch-, or a model-based assessment.

Conclusions:

The FishPath process generally reaffirmed that the current decision rules in place were likely the most viable. These included a size limit, limited entry, an effort control in limiting the number of pots, a daily trip limit, and temporal restrictions (no hauling gear at night). This package of regulations provides a reasonable management framework; however, the stock is currently declining. While the fishery is considered limited entry because participants need a license, as stated previously, there is a large amount of latent effort in the fishery. The size limit also allows immature females to be harvested. Maintaining the current situation, therefore is not tenable.

A few additional options were also identified that have previously not been considered. Rotational closures provide a means to manage sedentary species with limited dispersal. This type of framework would require a large enough distribution of the species that areas could be closed, but still allow fishing. Spatially explicit data throughout the Bay would be required to determine when to open and close areas, as well as a willingness for industry to move to different areas. Tiered licensing was also discussed as a possible option. This could reduce the latent effort by ensuring individuals who actively fish could have a given number of pots, daily trip limit, or an alternative control, while those moving into the fishery would only be allowed a smaller amount. One other option mentioned to reduce the mortality on older females was to move the season to a fall only fishery. The idea would be to close the fishery in the spring, allowing females on the edge of maturity to grow and breed in the summer before being caught.

Recent Stock Status and Research:

Recent Stock Status:

An initial stock assessment of the RI whelk and fishery was performed by Gibson (2010) using a biomass dynamic model (BDM) and an overfishing reference point of F_{msy}=0.33 was calculated. The BDM clearly showed that whelk abundance is strongly influenced by fishing mortality rate (F). High F rates above the F_{msy}=0.33 level result in low biomass; high whelk abundance occurs when the F is less than F_{msy}. Based on the available data at that time, it was concluded that F_{msy}=0.33 was an appropriate overfishing reference point and a fishing mortality rate target equal to 75% of F_{msy} (F=0.25) would provide a buffer between the overfishing threshold. Based on this initial stock assessment, F rate was at or below this level, indicating that overfishing was not occurring. Also, biomass was estimated to be near the B_{msy} reference level, so an overfished condition was not likely (Gibson 2010).

The whelk stock assessment was updated in 2014 to include data through 2013 and resulted in re-estimation of F_{msy}=0.40. As with the initial stock assessment, high fishing mortality rates above F_{msy}=0.40 resulted in low biomass; high whelk abundance occurred when the F was less than F_{msy}. The updated target F rate was 0.30. F had risen and was now estimated to be at or above F_{msy}, so overfishing was likely. Biomass remained at or above B_{msy}, however projections indicated that biomass would fall below B_{msy} if overfishing continued.

The whelk stock assessment was updated again in 2017 to include data through 2016 and resulted in re-estimation of F_{msy}=0.53. As with the previous assessments, high fishing mortality rates above F_{msy}=0.53 result in low biomass; high whelk abundance occurs when the F is less than F_{msy} (**Figure 26**). The updated target F rate is 0.39. F has risen and is now estimated to be at or above F_{msy} (**Figure 27**), so overfishing is likely. Biomass is now below B_{msy} (**Figure 28**) and projections indicate that biomass will continue to fall if overfishing continues (Gibson 2017).

Research:

Since 2012, RIDMF has collected basic biological and fishery catch and effort data needed to advise RI fishery managers and the whelk fishing industry on the status of the whelk fishery resource and fishery management strategies that may be employed. In 2020, the Division was awarded a U.S. Fish and Wildlife Service State Wildlife Grant to conduct a histological study of female channeled whelk gonad maturity during 2021-2022. The objectives of this research are to develop more accurate estimates of size at maturity for female channeled whelk using microscopic, histological methodologies; compare size at maturity estimates from histological gonad examination with estimates generated from macroscopic, visual gonad examination (Angell 2018); and to provide better information for guiding whelk fishery management in RI state waters.

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Table 1 – 2006-2019 total Rhode Island whelk landings, total value, and mean value/pound (see Figure 1).

Year	Total Landings (pounds)	Total Value ($)	Mean $/pound
2006	368,028	$450,137	$1.22
2007	361,486	$336,486	$0.93
2008	423,952	$407,997	$0.96
2009	716,386	$742,412	$1.04
2010	659,204	$973,404	$1.48
2011	746,469	$1,312,837	$1.76
2012	773,885	$1,599,227	$2.07
2013	584,896	$1,268,156	$2.17
2014	446,154	$1,036,116	$2.32
2015	493,166	$1,279,091	$2.59
2016	338,914	$909,068	$2.68
2017	458,765	$1,318,210	$2.87
2018	678,432	$2,094,731	$3.09
2019	443,852	$1,440,940	$3.25

Table 2 – 2006-2019 Mean monthly whelk landings, mean monthly number of fishers reporting whelk landings, mean monthly number of dealer transactions (see Figures 5 & 10).

Month	Mean monthly landings (pounds)	Mean monthly # of fishermen reporting whelk landings	Mean monthly # of dealer transactions
January	947	27.6	72.1
February	319	24.6	69.3
March	481	26.8	87.7
April	5,035	38.2	115.2
May	72,366	95.7	398.0
June	104,038	122.4	544.1
July	56,557	109.7	391.1
August	14,327	73.5	229.1
September	28,280	87.0	273.5
October	124,130	141.4	555.3
November	111,076	105.0	459.2
December	24,731	68.8	191.5

Table 3 – 2006-2019 Annual number of fishers reporting whelk landings, mean landings/fisher, number of fishing trips, and mean landings/fishing trip (see Figures 7, 8, and 10).

Year	# of Fishers reporting whelk landings	Mean landings/fisher (pounds)	# of fishing trips (landing days)	Mean landings (pounds)/fishing trip
2006	134	2,746	2,050	180
2007	184	1,965	2,770	131
2008	163	2,601	2,560	166
2009	210	3,411	3,340	214
2010	186	3,544	3,317	199
2011	247	3,022	4,390	170
2012	242	3,198	4,897	158
2013	220	2,659	4,845	121
2014	158	2,824	3,172	141
2015	151	3,266	3,098	159
2016	137	2,474	2,629	129
2017	98	4,681	3,226	142
2018	106	6,400	3,822	178
2019	110	4,035	3,628	122

Table 4 – 2003-2019 Number of licenses eligible to harvest whelk and number of licenses reporting whelk landings.

Year	Total Eligible Licenses	# of Multi-Purpose (MPURP) Licenses	# of Commercial Fishing (CFL) and Principal Effort (PEL) Licenses w/endorsement	# of licenses reporting landings
2003	2787	1191	1596	
2004	2566	1135	1431	
2005	2389	1075	1314	
2006	2346	1019	1327	131
2007	2299	973	1326	183
2008	2170	939	1231	160
2009	2126	917	1209	211
2010	2078	891	1187	190
2011	1979	868	1111	253
2012	1108	853	255	245
2013	1039	829	210	223
2014	970	816	154	161
2015	931	804	127	153
2016	913	802	111	140
2017	908	789	119	101
2018	884	771	113	109
2019	856	751	105	113

Table 5 – RIDMF Spring, Fall, and Monthly Trawl Survey indices for channeled whelk, knobbed whelk, and species combined, 2009-2019 (see Figures 12-17).

	Spring Survey – Channeled Whelk		**Spring Survey – Knobbed Whelk**		**Spring Survey – Species Combined**	
Year	#/tow	Kg/tow	#/tow	Kg/tow	#/tow	Kg/tow
2009	0.000	0.000	0.000	0.000	0.000	0.000
2010	0.140	0.015	0.000	0.000	0.140	0.015
2011	0.163	0.014	0.000	0.000	0.163	0.014
2012	0.409	0.062	0.000	0.000	0.409	0.062
2013	0.091	0.016	0.000	0.000	0.091	0.016
2014	0.023	0.001	0.000	0.000	0.023	0.001
2015	0.000	0.000	0.000	0.000	0.000	0.000
2016	0.136	0.023	0.000	0.000	0.136	0.023
2017	0.068	0.010	0.000	0.000	0.068	0.010
2018	0.045	0.002	0.023	0.00041	0.068	0.0026
2019	0.023	0.002	0.000	0.000	0.023	0.002
Timeseries Mean	0.108	0.015	0.00227	0.000041	0.1098	0.0145
	Fall Survey – Channeled Whelk		**Fall Survey – Knobbed Whelk**		**Fall Survey – Species Combined**	
Year	#/tow	Kg/tow	#/tow	Kg/tow	#/tow	Kg/tow
2009	1.048	0.174	0.524	0.066	1.571	0.240
2010	0.762	0.118	0.214	0.043	0.976	0.161
2011	0.140	0.025	0.279	0.071	0.419	0.097
2012	0.227	0.045	0.295	0.063	0.523	0.108
2013	0.273	0.048	0.023	0.004	0.295	0.052
2014	0.114	0.024	0.114	0.033	0.227	0.057
2015	0.442	0.085	0.256	0.064	0.698	0.149
2016	0.136	0.021	0.159	0.040	0.295	0.061
2017	0.091	0.011	0.045	0.013	0.136	0.024
2018	0.455	0.057	0.318	0.042	0.773	0.098
2019	0.091	0.019	0.045	0.001	0.136	0.020
Timeseries Mean	0.343	0.057	0.207	0.040	0.550	0.097

Table 5 (cont.) – RIDMF Spring, Fall, and Monthly Trawl Survey indices for channeled whelk, knobbed whelk, and species combined, 2009-2019 (see Figures 12-17).

	Monthly Survey – Channeled Whelk		**Monthly Survey – Knobbed Whelk**		**Monthly Survey – Species Combined**	
Year	#/tow	Kg/tow	#/tow	Kg/tow	#/tow	Kg/tow
2009	0.651	0.098	0.428	0.050	1.079	0.148
2010	0.586	0.090	0.217	0.027	0.803	0.117
2011	0.600	0.095	0.303	0.057	0.903	0.152
2012	0.306	0.061	0.163	0.041	0.469	0.102
2013	0.333	0.060	0.083	0.015	0.417	0.075
2014	0.250	0.043	0.132	0.027	0.382	0.070
2015	0.321	0.048	0.114	0.028	0.436	0.076
2016	0.209	0.036	0.033	0.006	0.242	0.042
2017	0.096	0.016	0.032	0.009	0.128	0.025
2018	0.229	0.032	0.104	0.019	0.333	0.051
2019	0.238	0.038	0.056	0.013	0.294	0.051
Timeseries Mean	0.347	0.056	0.151	0.027	0.499	0.083

Table 6 – URI/GSO Trawl Survey abundance indices for combined whelk species, 1959-2019 (see Figures 18-20).

	Fox Island station			Whale Rock station			Stations combined		
Year	#/tow	Kg/tow	# tows	#/tow	Kg/tow	# tows	#/tow	Kg/tow	# tows
1959	1.521		55	0.353		55	0.937		110
1960	0.975		54	0.213		54	0.594		108
1961	2.238		53	0.063		53	1.150		106
1962	1.257		54	0.028		54	0.642		108
1963	2.621		52	0		52	1.310		104
1964	0.617		51	0.063		51	0.340		102
1965	0.271		53	0		53	0.135		106
1966	0.567		49	0		49	0.283		98
1967	0		45	0		45	0		90
1968	0		41	0		41	0		82
1969	4.029		48	0.028		48	2.028		96
1970	3.181		49	0.028		49	1.604		98
1971	5.592		47	0		47	2.796		94
1972	7.488		43	0		43	3.744		86
1973	6.422		44	0		44	3.211		88
1974	4.324		46	0.021		46	2.172		92
1975	7.410		48	0		48	3.705		96
1976	5.822		43	0		43	2.911		86
1977	6.765		42	0		42	3.383		84
1978	5.163		53	0.111		53	2.637		106
1979	5.723		57	0.028		57	2.875		114
1980	6.196		54	0.042		54	3.119		108
1981	7.932		44	0		44	3.966		88
1982	7.090		43	0		43	3.545		86
1983	15.167		42	0.375		42	7.771		84
1984	16.797		48	0.156		48	8.476		96
1985	9.839		52	0.021		52	4.930		104
1986	3.310		48	0		48	1.655		96
1987	9.728		52	0.021		52	4.874		104
1988	9.338		51	0.100		51	4.719		102
1989	2.729		52	0		52	1.365		104
1990	0.567		50	0		50	0.283		100
1991	3.032		47	0.021		47	1.526		94
1992	2.004		52	0.021		52	1.013		104
1993	0.721		52	0.038		52	0.379		104
1994	1.596	0.213	52	0	0	52	0.798	0.017	104
1995	6.858	1.207	52	0	0	52	3.429	0.603	104
1996	2.917	0.504	53	1.138	0.179	53	2.027	0.254	106
1997	4.954	0.771	52	0.021	0.006	52	2.488	0.386	104
1998	7.233	1.508	52	0	0	52	3.617	0.754	104

Table 6 (cont.) – URIGSO Trawl Survey abundance indices for combined whelk species, 1959-2019 (see Figures 18-20).

	Fox Island station			Whale Rock station			Stations combined		
Year	#/tow	Kg/tow	# tows	#/tow	Kg/tow	# tows	#/tow	Kg/tow	# tows
1999	27.899	3.513	48	0.042	0.002	48	13.970	1.757	96
2000	11.704	2.086	51	0.021	0.011	51	5.863	1.043	102
2001	5.046	1.092	53	0	0.012	53	2.523	0.546	106
2002	6.217	1.398	49	0	0.004	49	3.108	0.699	98
2003	5.347	1.259	51	0.017	0.005	50	2.682	0.636	101
2004	7.644	1.480	51	0.313	0.110	51	3.987	0.741	102
2005	4.225	0.989	51	0.050	0.018	51	2.138	0.495	102
2006	1.944	0.357	50	0.028	0.005	50	0.986	0.179	100
2007	4.692	1.003	51	0.058	0.012	51	2.375	0.517	102
2008	6.676	1.269	51	0.021	0.002	51	3.349	0.635	102
2009	4.971	0.758	43	0	0	42	2.486	0.384	85
2010	9.954	1.603	52	0	0	52	4.977	0.801	104
2011	12.822	1.403	51	0.417	0.025	51	6.619	0.702	102
2012	8.190	1.129	51	0.330	0.021	51	4.260	0.565	102
2013	6.642	0.868	53	0.173	0.043	52	3.407	0.439	105
2014	7.333	0.845	51	0.184	0.030	49	3.759	0.431	100
2015	2.824	0.300	51	0.157	0.030	51	1.490	0.150	102
2016	3.569	0.407	51	0.098	0.014	51	1.833	0.203	102
2017	9.135	1.267	52	0.333	0.081	51	4.734	0.641	103
2018	4.435	0.577	47	0.178	0.048	47	2.306	0.292	94
2019	4.170	0.452	47	0.213	0.090	47	2.191	0.271	94
Mean	5.663	1.088	49.7	0.090	0.029	49.6	2.877	0.559	99.2

Table 7 – RIDMF lobster ventless trap (2006-2019) and clam dredge survey (1993-2019) whelk abundance index (see Figures 21 & 22).

Year	Lobster Ventless Trap – Narragansett Bay only (#/unvented trap-haul)	Clam Dredge – All Strata (#/tow)
1993		0.0028
1994		0.0121
1995		0.0200
1996		0
1997		0.0052
1998		0.0038
1999		0.0099
2000		0
2001		0.0115
2002		0.0200
2003		0.0176
2004		0.0200
2005		0.0393
2006	0.037	0.0408
2007	0.160	0.0194
2008	0.028	0.0150
2009	0.222	
2010	0.523	0.0186
2011	0.048	
2012	0.186	0.0260
2013	0.454	0.0237
2014	0.424	0.0191
2015	0.429	0.0290
2016	0.347	0.0423
2017	0.230	0.0455
2018	0.125	0.0494
2019	0.118	0.0335
Timeseries Mean	0.238	0.0228

Table 8 – Brayton Point Power Station whelk abundance index for combined standard and Wilcox trawl program tows, 1995-2014 (see Figure 23).

Year	Mean # whelk/tow
1995	0.333
1996	1.950
1997	3.180
1998	2.120
1999	1.720
2000	1.590
2001	0.440
2002	1.670
2003	1.270
2004	0.880
2005	0.970
2006	2.650
2007	1.400
2008	2.920
2009	2.264
2010	2.790
2011	5.193
2012	2.134
2013	2.672
2014	0.518
Timeseries Mean	1.933

Figure 1 – 2006-2019 total RI whelk landings (pounds) by year, species combined.

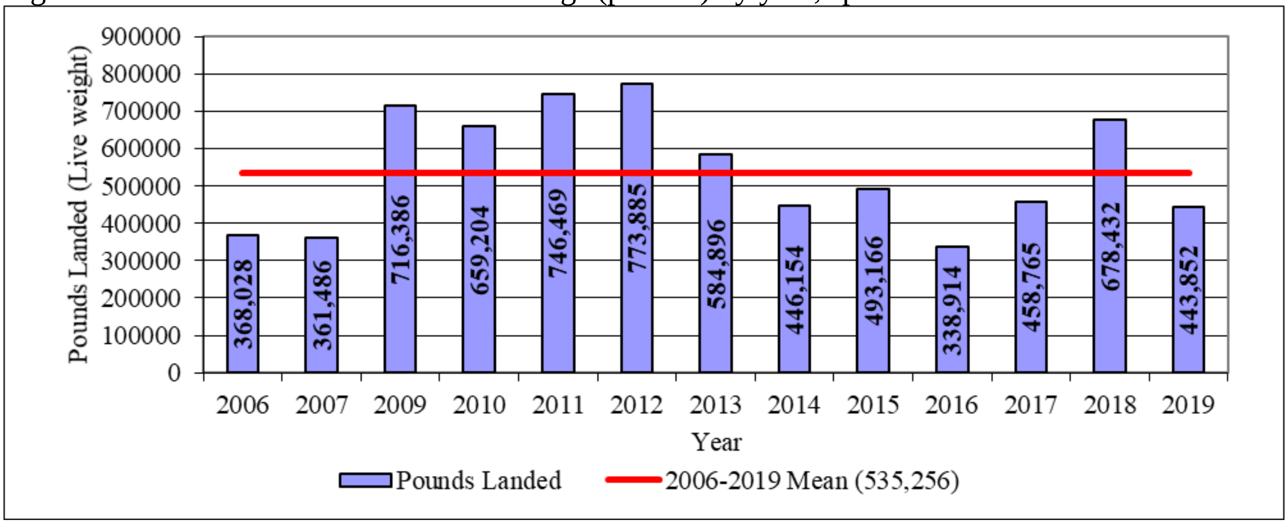

Figure 2 – 2006-2019 total RI whelk landings value ($) by year.

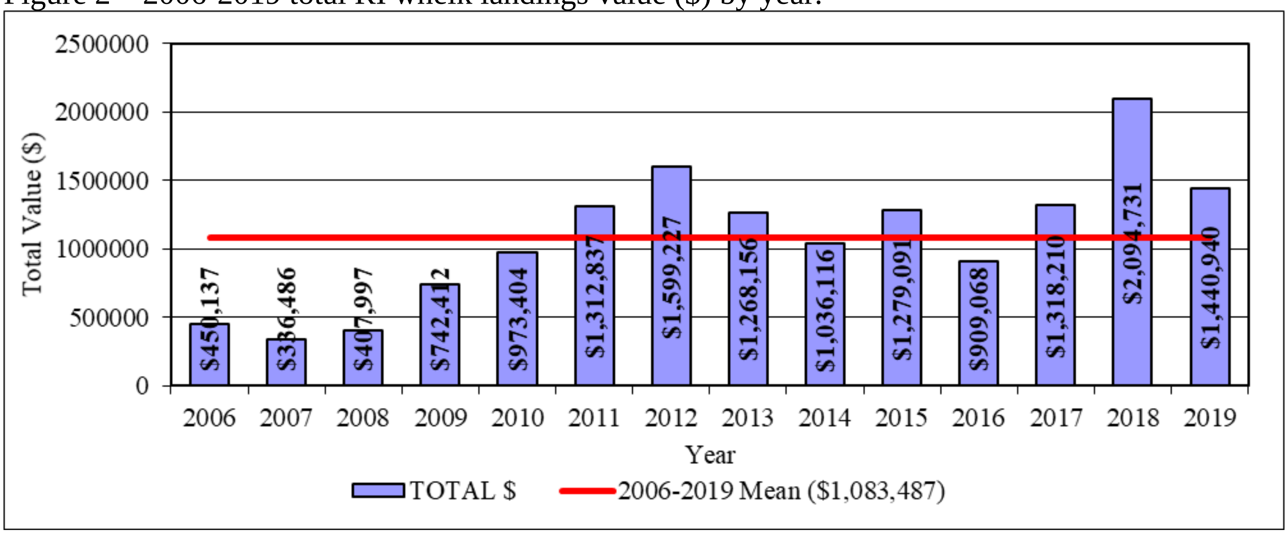

Figure 3 – 2006-2019 Mean landings value per pound ($/pound) by species by year.

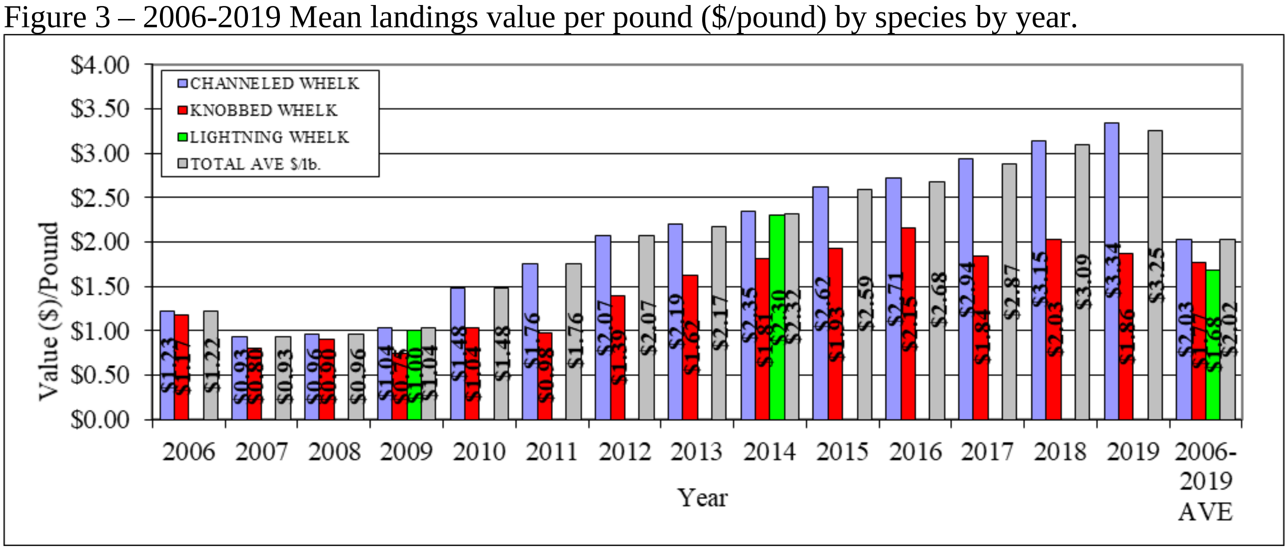

Figure 4 – 2006-2019 total commercial whelk landings (pounds) by month.

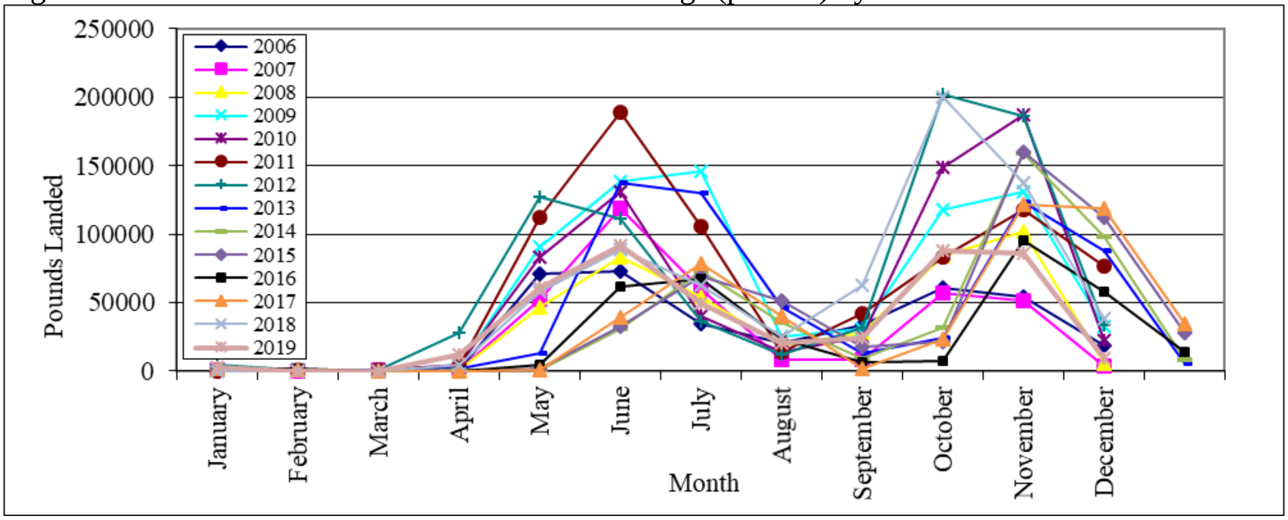

Figure 5 – 2006-2019 Mean monthly landings (pounds) and number of transactions.

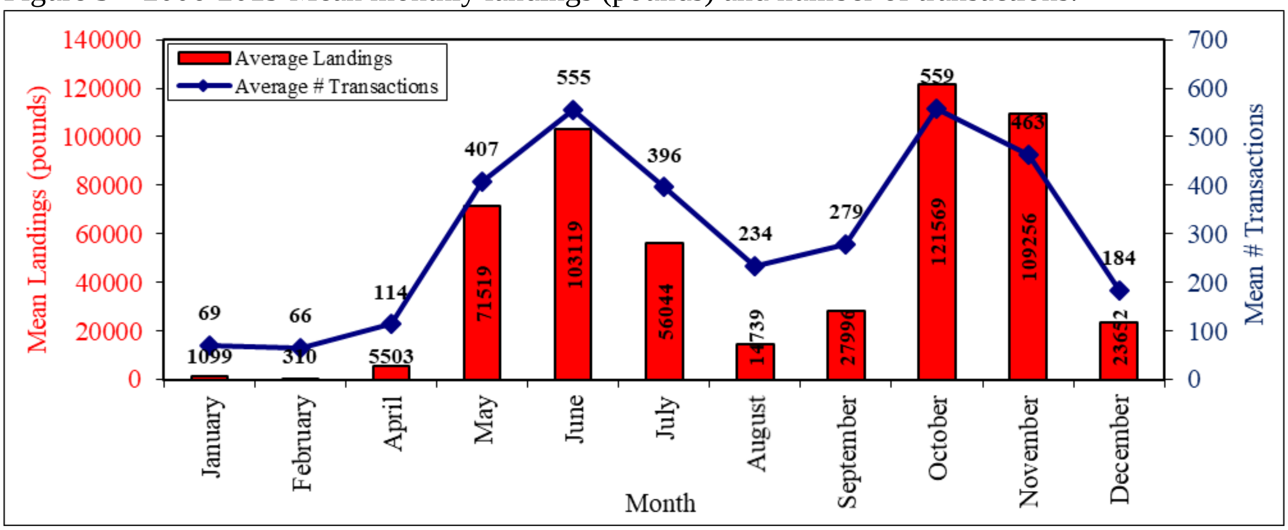

Figure 6 – 2006-2019 mean whelk landings (pounds) per transaction by month (±se).

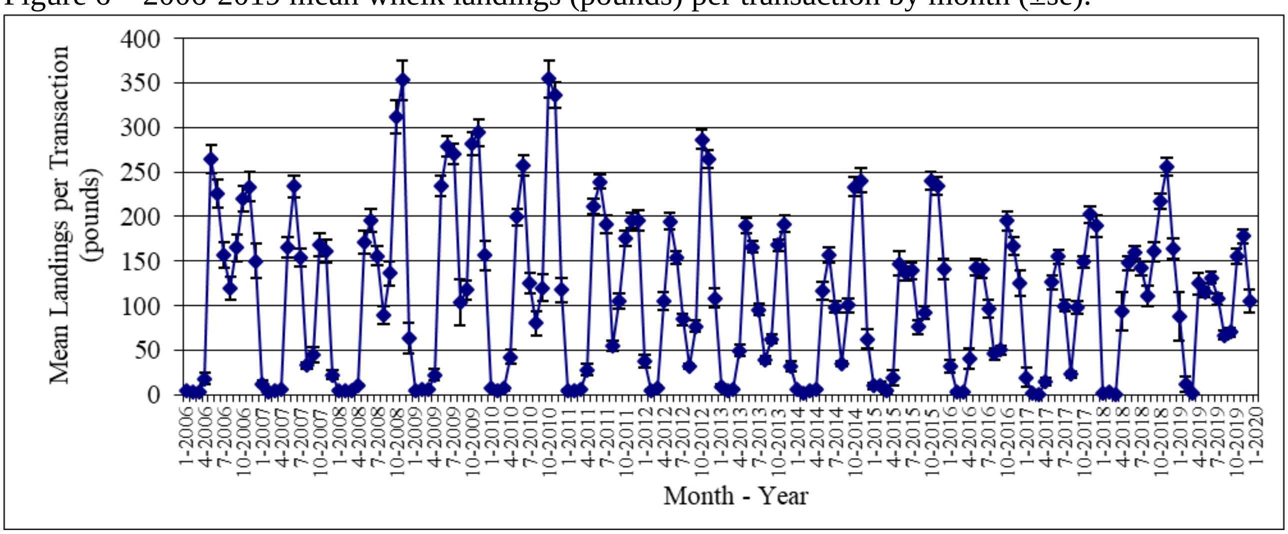

Figure 7 – 2006-2019 number of fishers reporting whelk landings and mean landings per fisher.

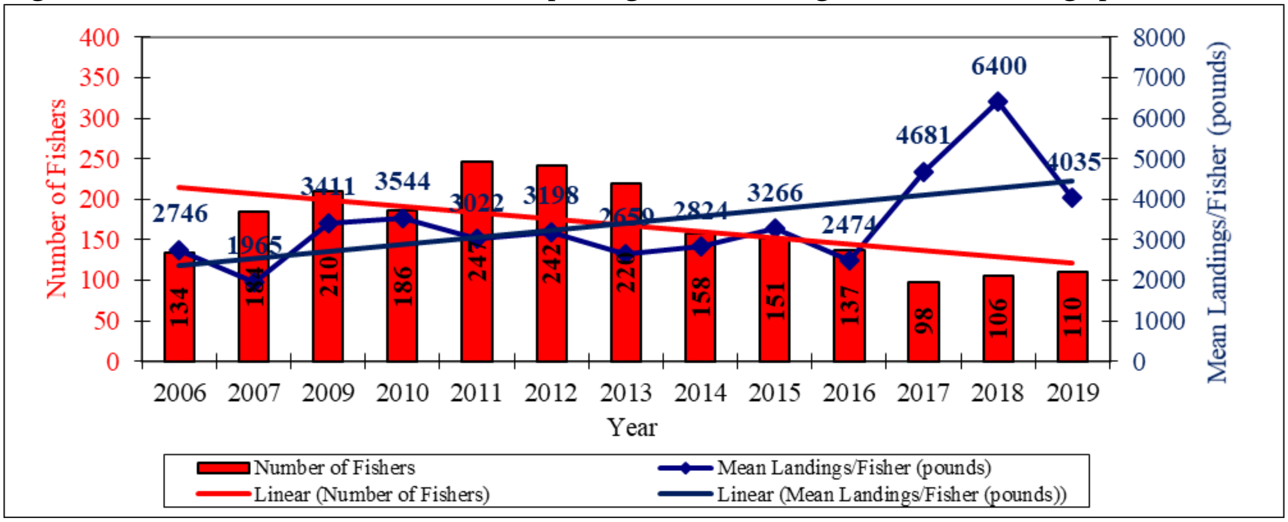

Figure 8 – 2006-2019 Number of fishing trips (landing days) and mean landings per fishing trip.

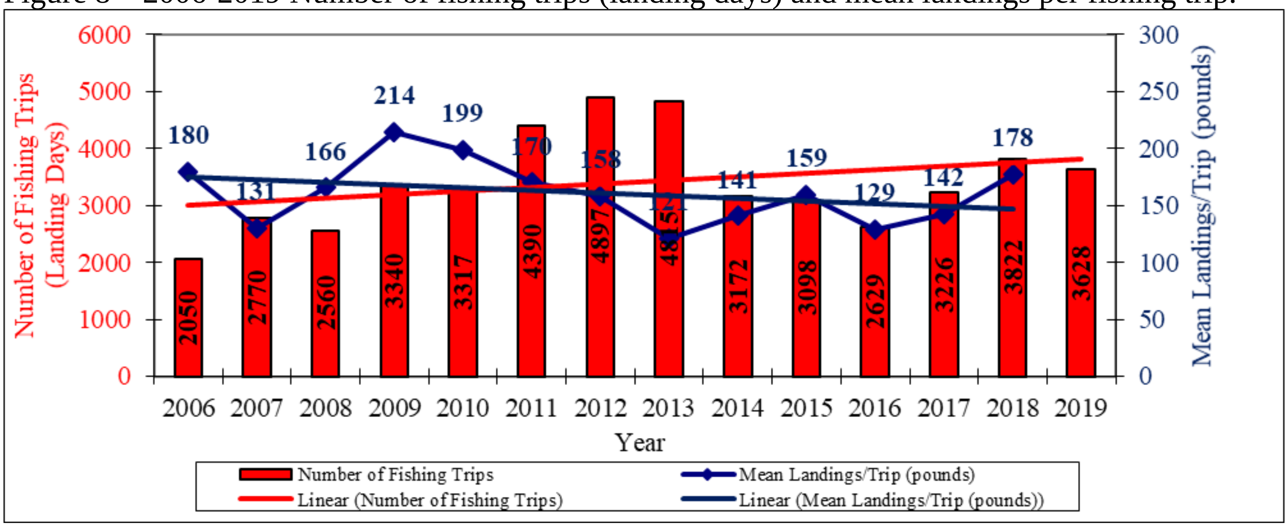

Figure 9 – 2006-2019 number of fishermen reporting whelk landings by month by year.

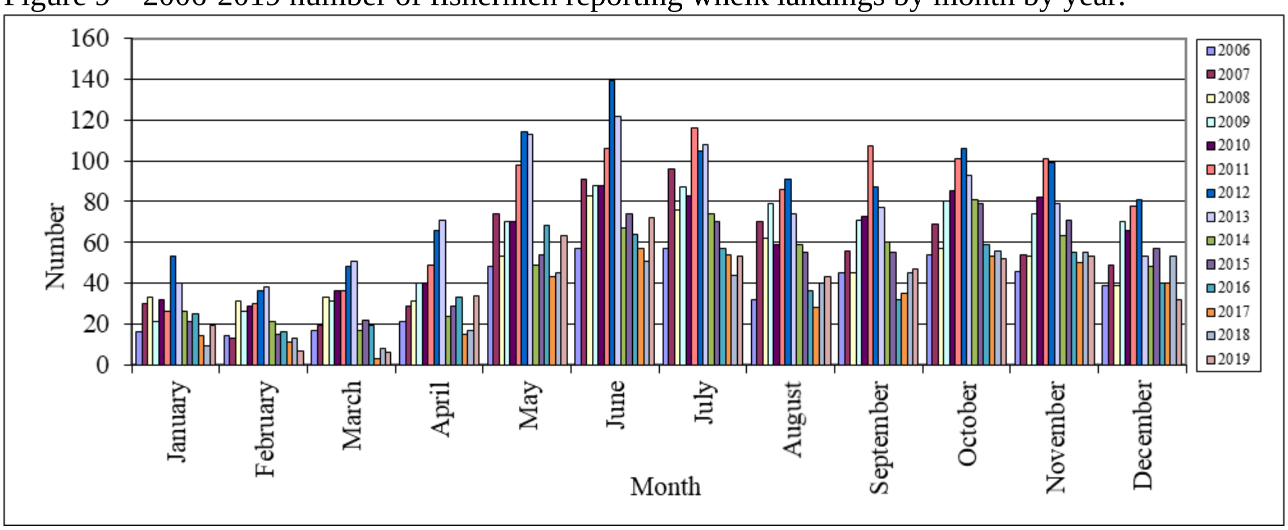

Figure 10 – 2006-2019 Mean number of fishermen reporting whelk landings by month (±se).

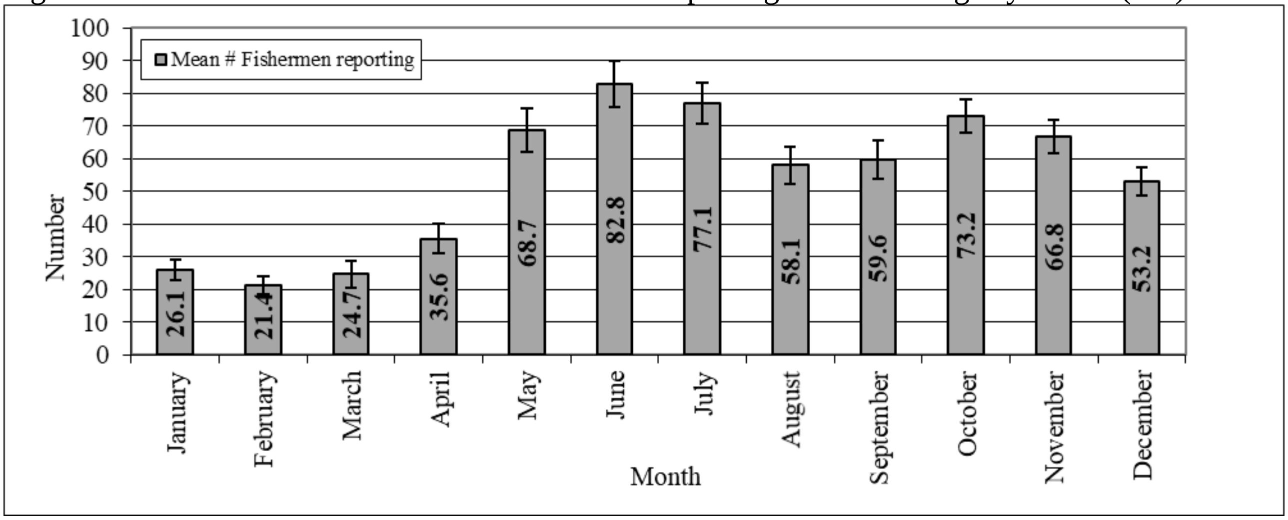

Figure 11 – 2003-2019 Number of licenses eligible to harvest whelk, number of licenses reporting whelk landings, number of multi-purpose licenses (MPURP), and number of commercial fishing licenses (CFL) and principal effort licenses (PEL) endorsed to harvest whelk.

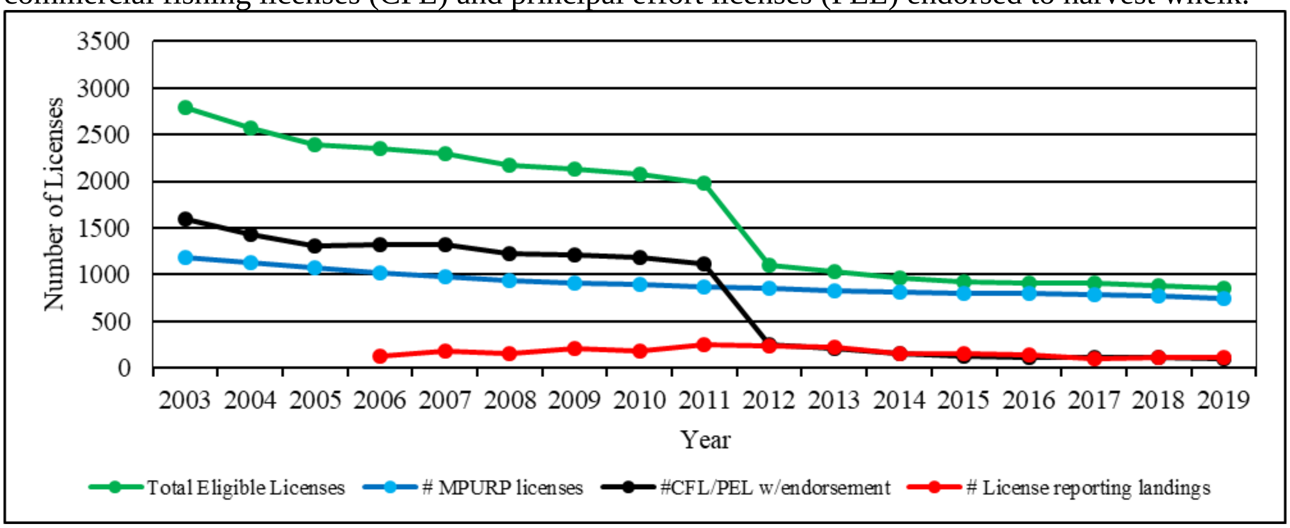

Figure 12 – 2009-2019 RIDMF Spring & Fall trawl survey channeled whelk abundance indices.

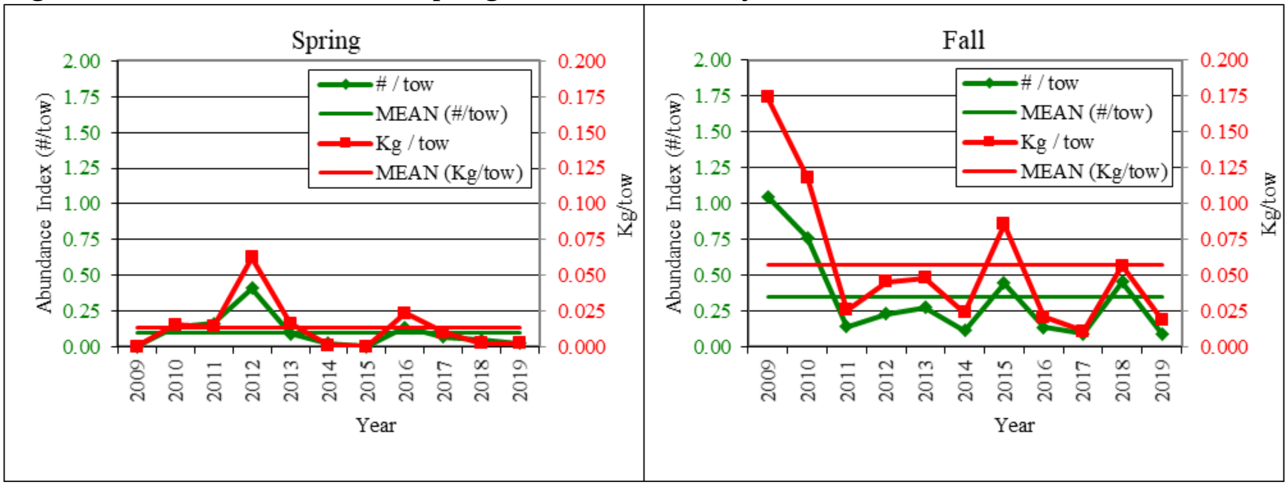

Figure 13 – 2009-2019 RIDMF Spring & Fall trawl survey knobbed whelk abundance indices.

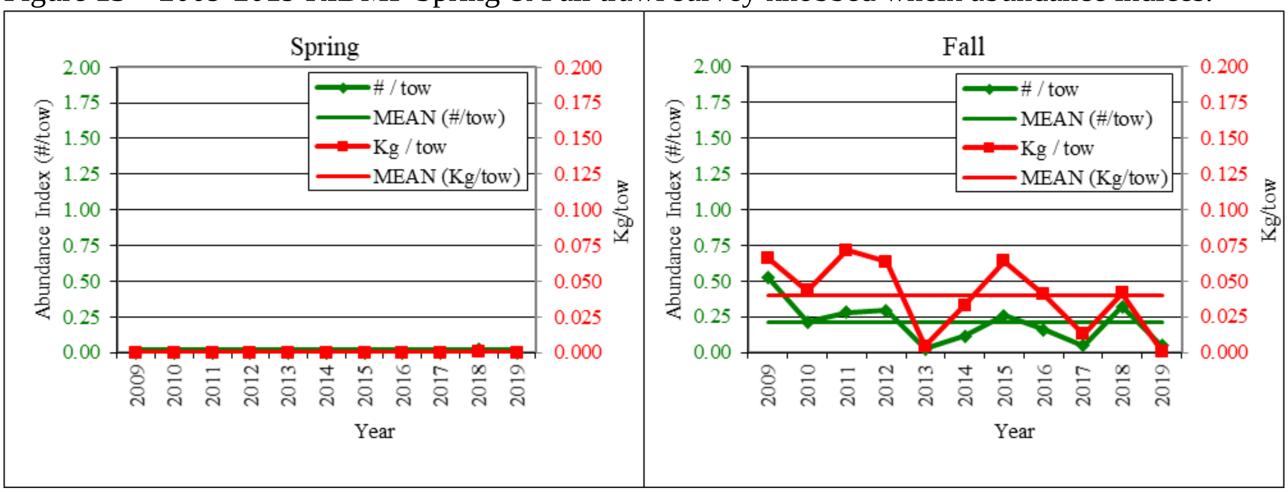

Figure 14 – 2009-2019 RIDMF Spring & Fall trawl survey; combined whelk abundance indices.

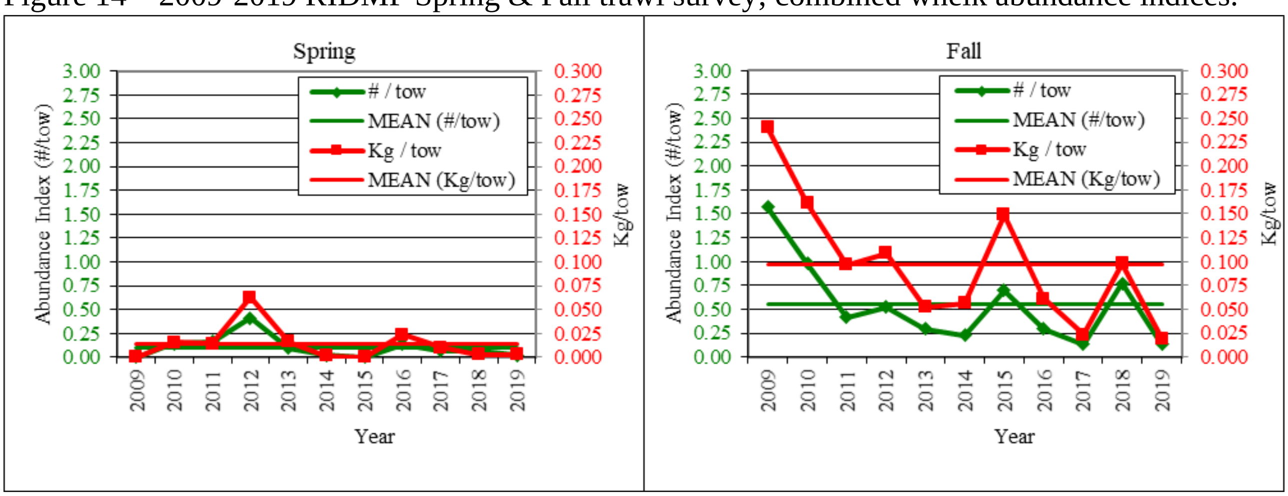

Figure 15 – 2009-2019 RIDMF Monthly trawl survey channeled whelk abundance indices.

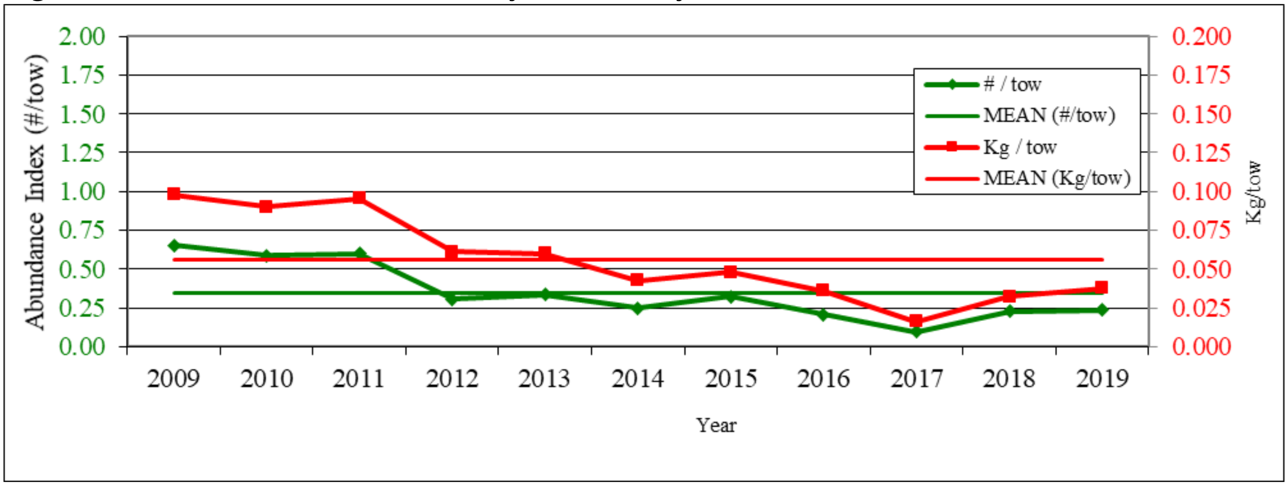

Figure 16 – 2009-2019 RIDMF Monthly trawl survey knobbed whelk abundance indices.

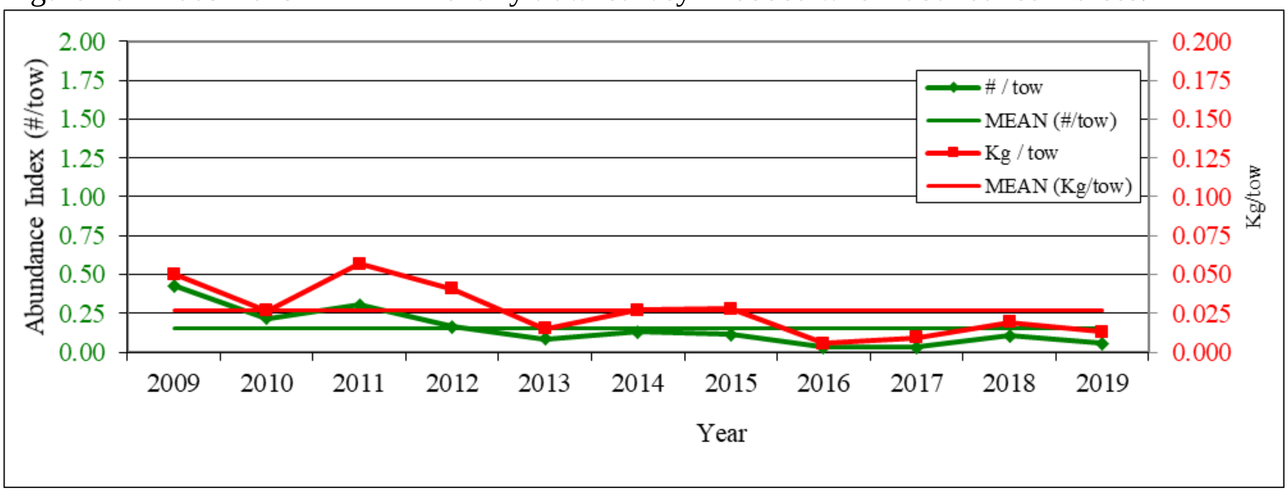

Figure 17 – 2009-2019 RIDMF Monthly trawl survey whelk species-combined abundance indices.

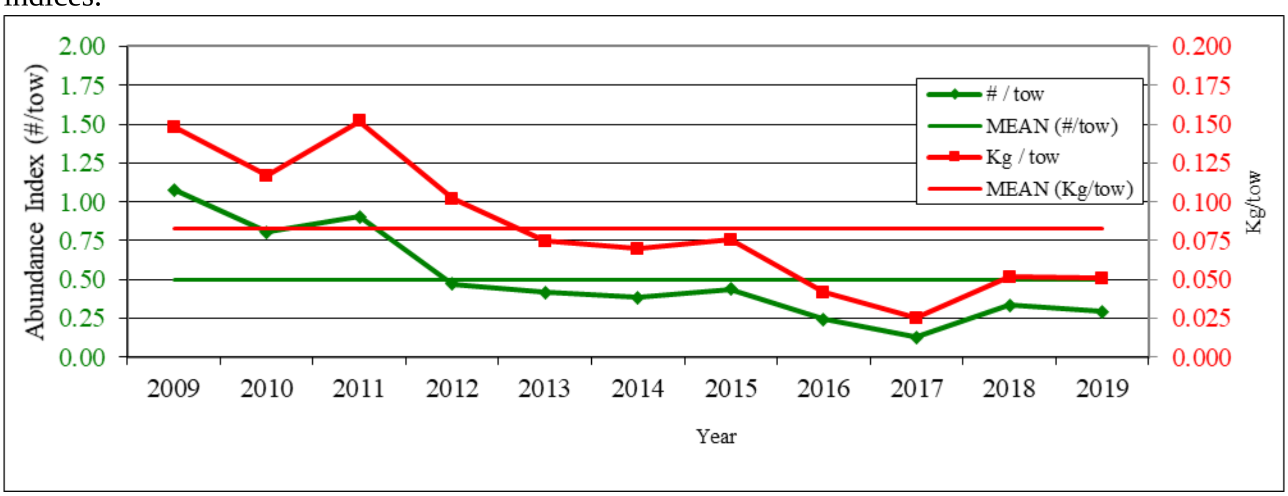

Figure 18 – 1959-2019 URI/GSO trawl survey whelk species-combined abundance indices, Fox Island.

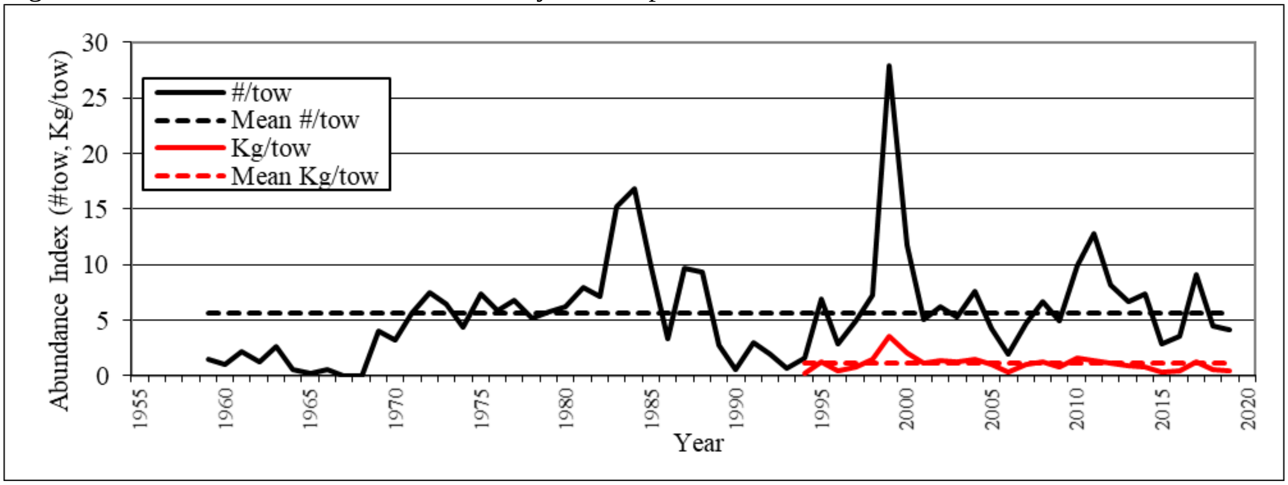

Figure 19 – 1959-2019 URI/GSO trawl survey whelk species-combined abundance indices, Whale Rock.

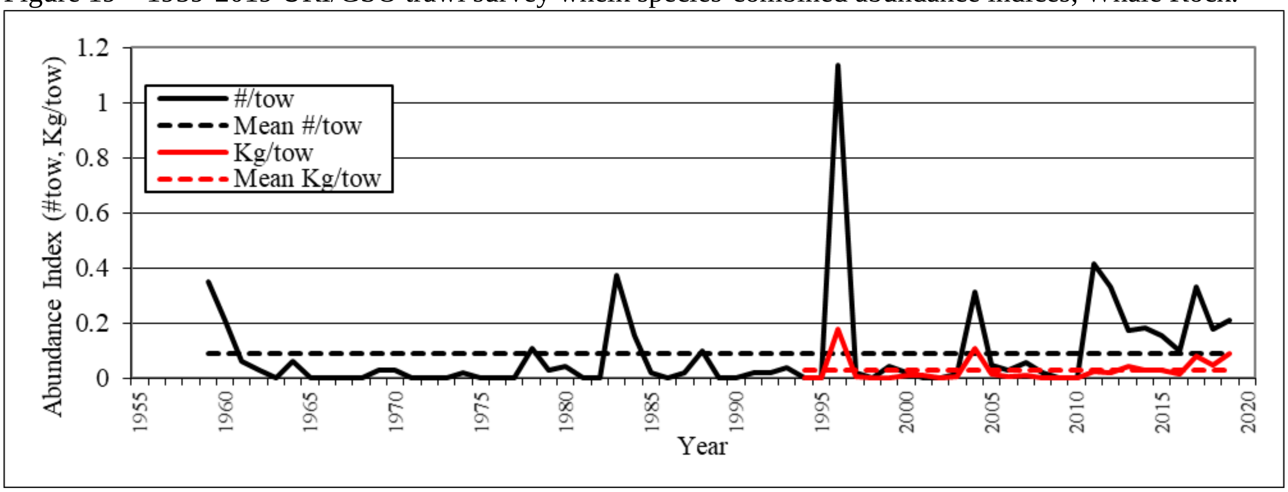

Figure 20 – 1959-2019 URI/GSO combined trawl survey stations and whelk species abundance indices.

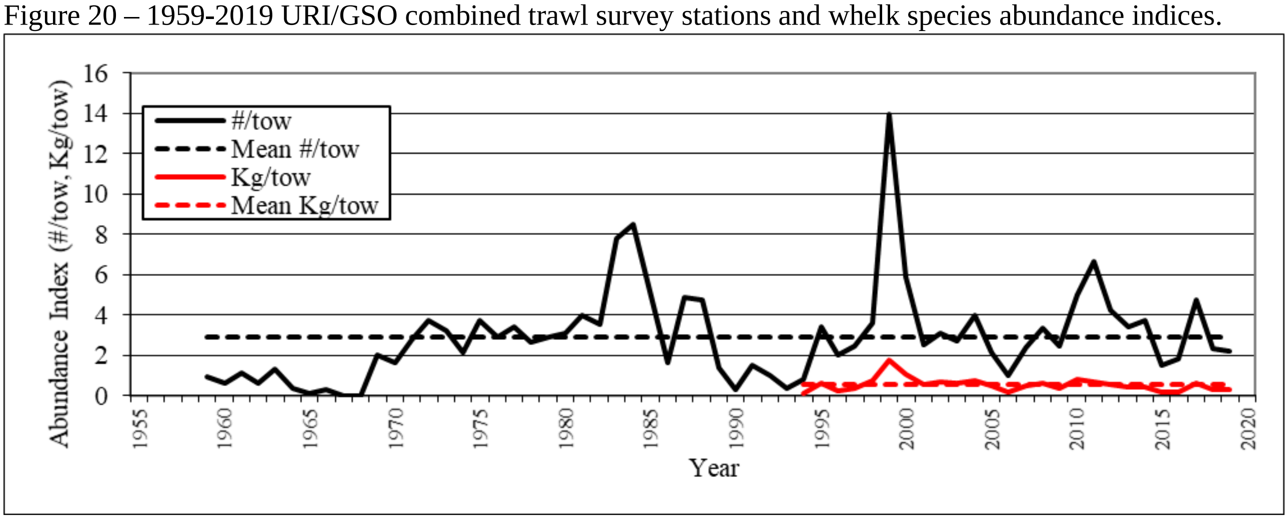

Figure 21 – 1993-2019 RIDMF Clam Dredge Survey whelk relative abundance index, all strata combined.

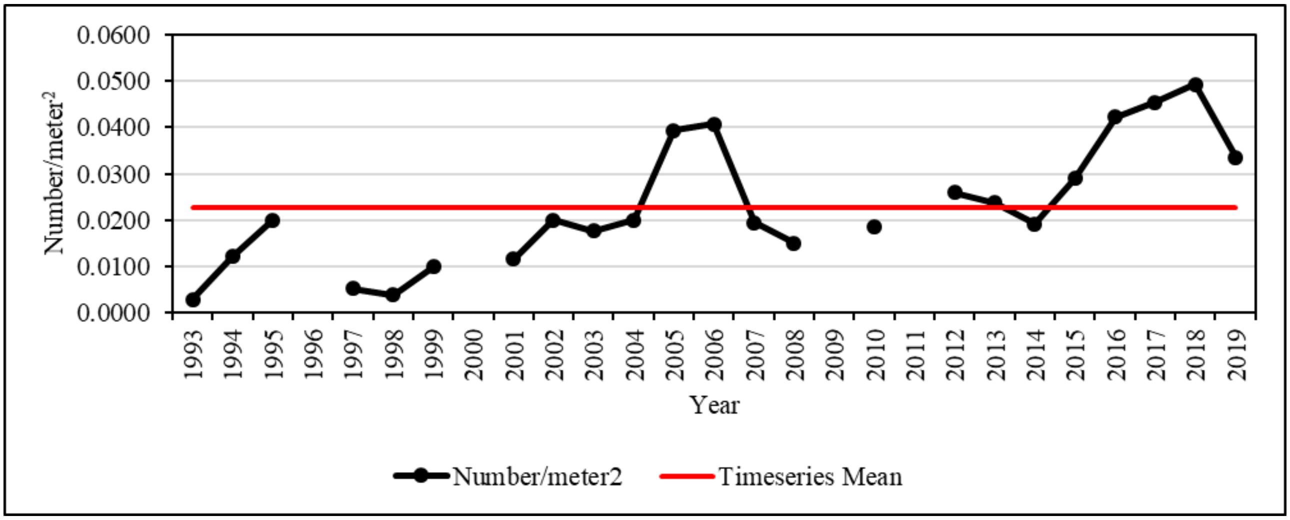

Figure 22 – 2006-2019 RIDMF Lobster Ventless Trap Survey whelk relative abundance indices for vented (V) and unvented (UV) traps, Narragansett Bay only.

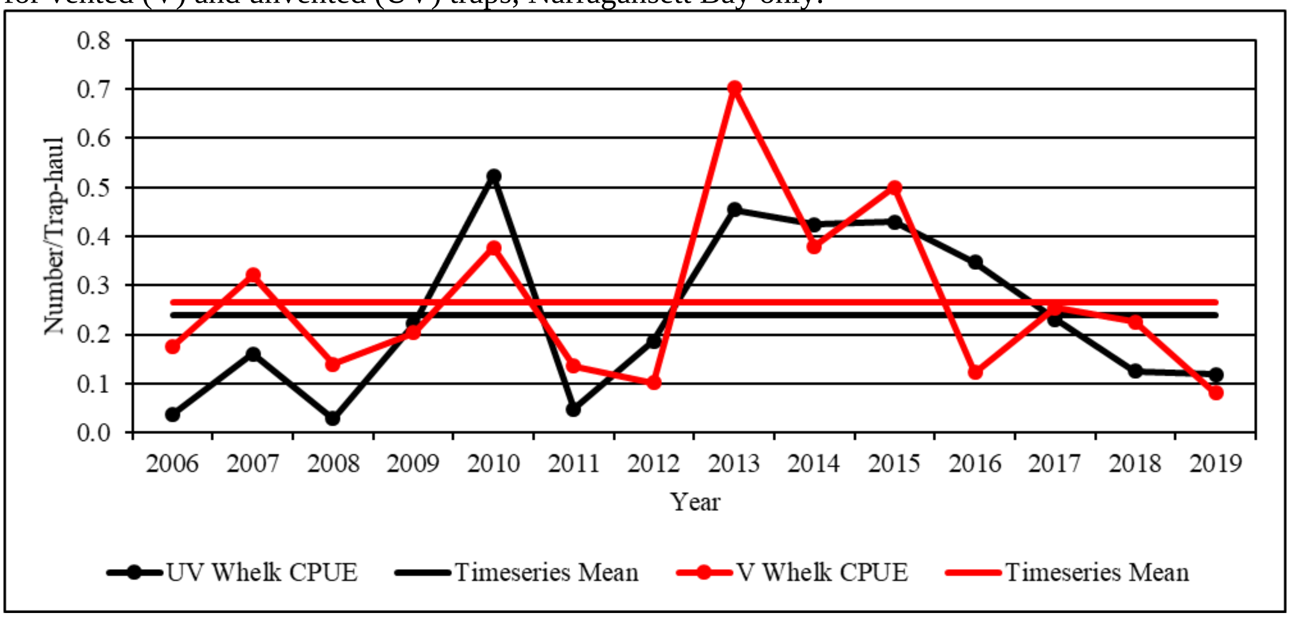

Figure 23 – 2006-2019 RIDMF Lobster Ventless Trap Survey whelk relative abundance indices for vented and unvented traps, Rhode Island Sound only.

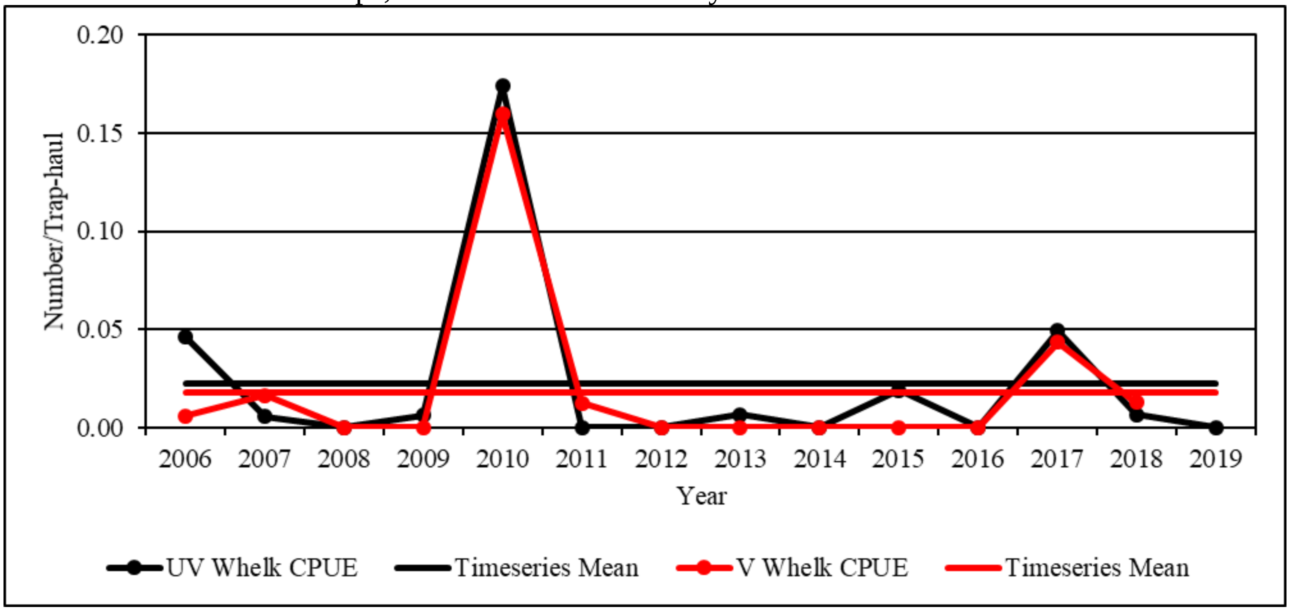

Figure 24 – 2006-2019 RIDMF Lobster Ventless Trap Survey whelk relative abundance indices for vented and unvented traps, Block Island Sound only.

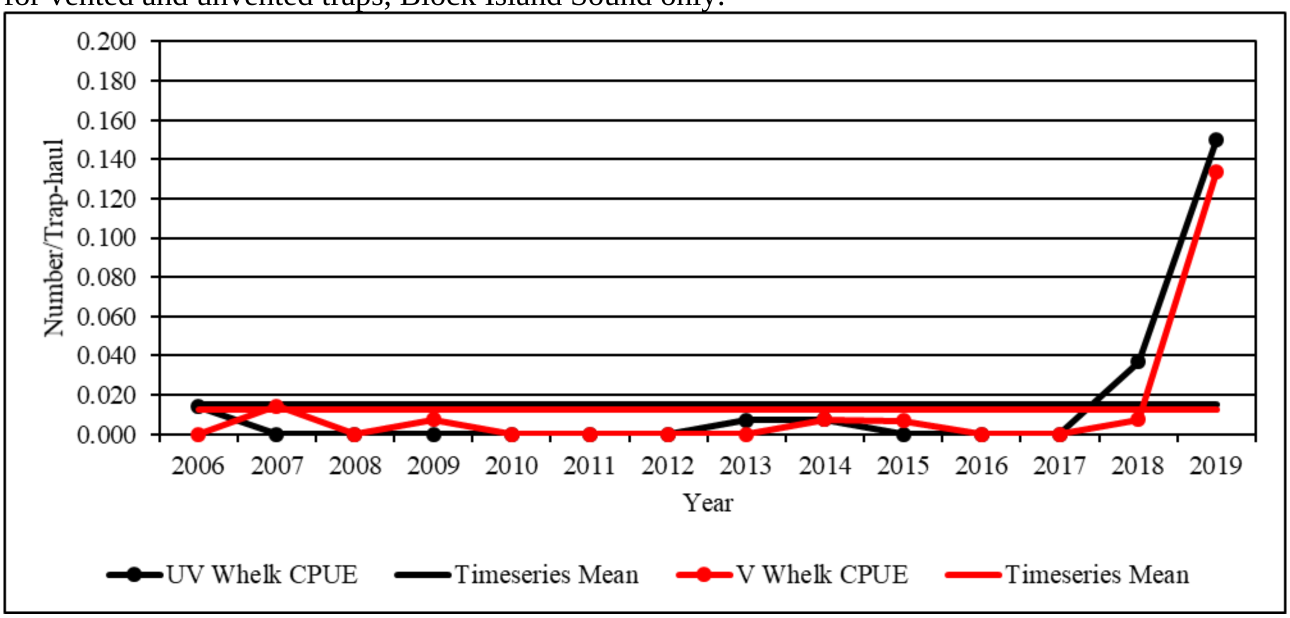

Figure 25 – 1995-2014 Brayton Point Power Station whelk abundance index (mean # whelk/tow) for combined standard and Wilcox otter trawl program sampling station.

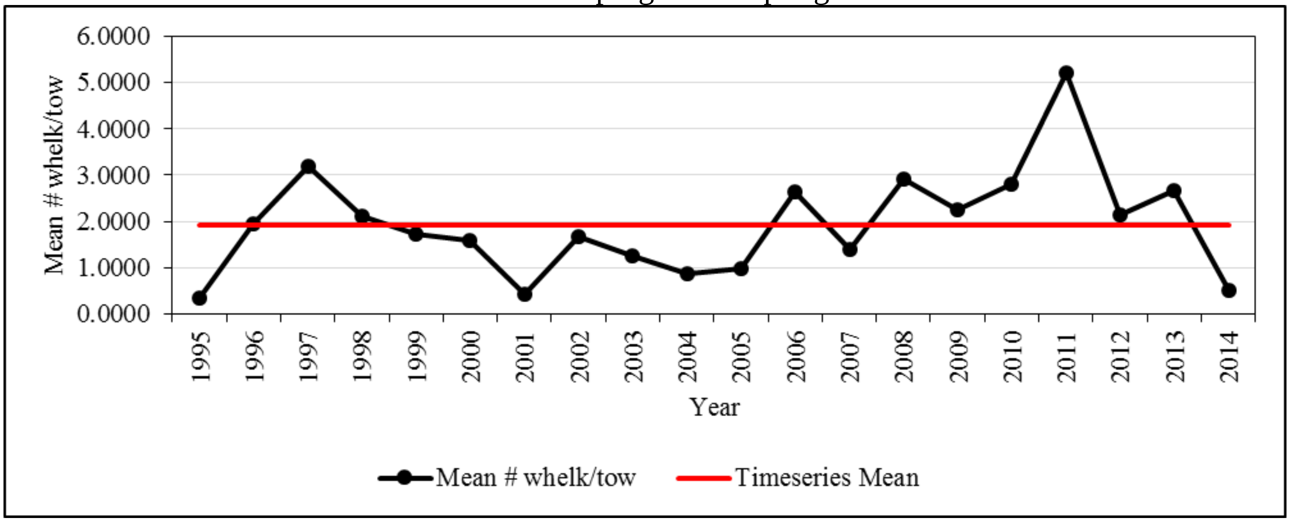

Figure 26 – Phase plot for fishing mortality rate (F) and stock biomass.

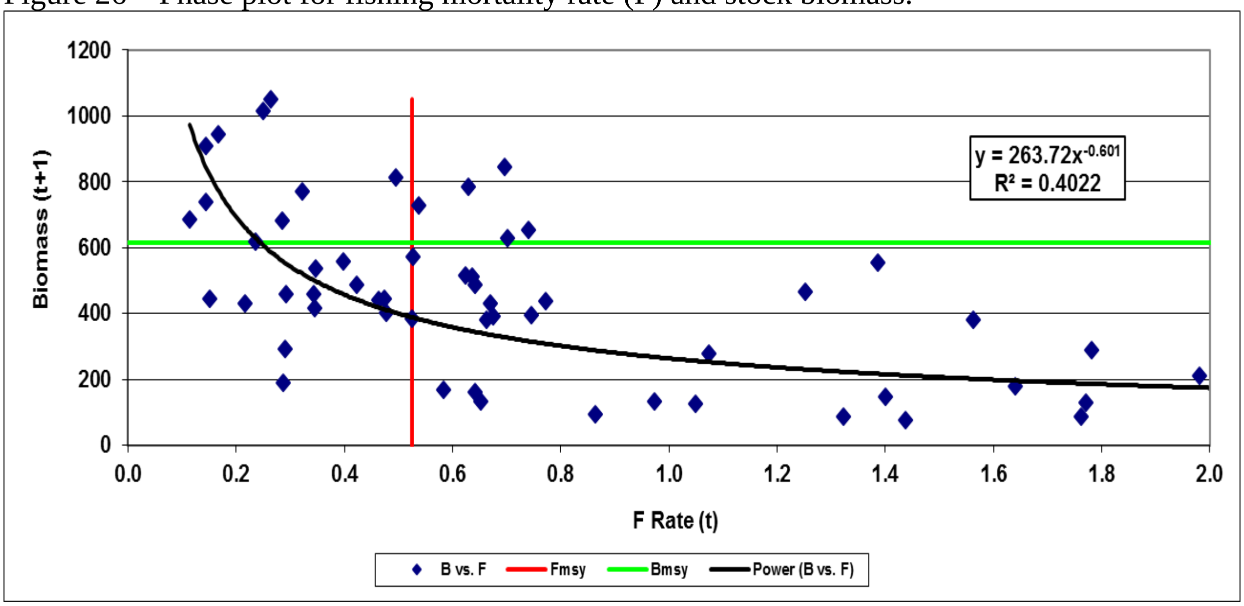

Figure 27 – Estimated whelk fishing mortality rate compared to F_{msy}.

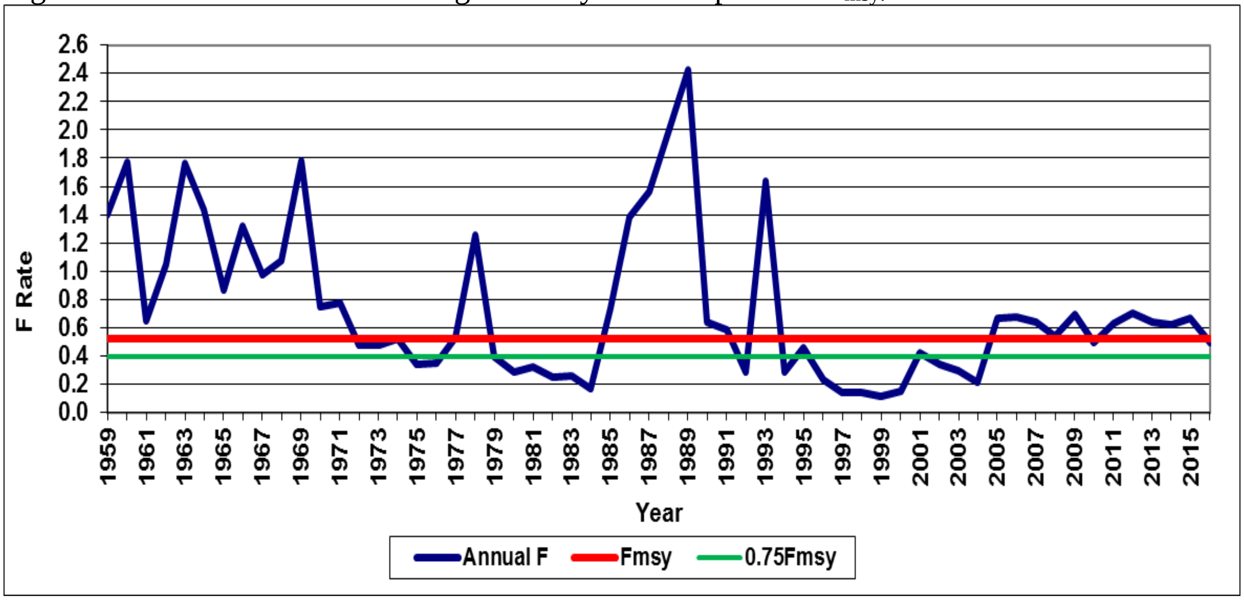

Figure 28 – Estimated absolute abundance and landings compared to B_{msy}.