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2012 Washington State Herring Stock Status Report

by Kurt C. Stick, Adam Lindquist, and Dayv Lowry

Washington Department of
FISH AND WILDLIFE
Fish Program
Fish Management Division

FPA 14-09

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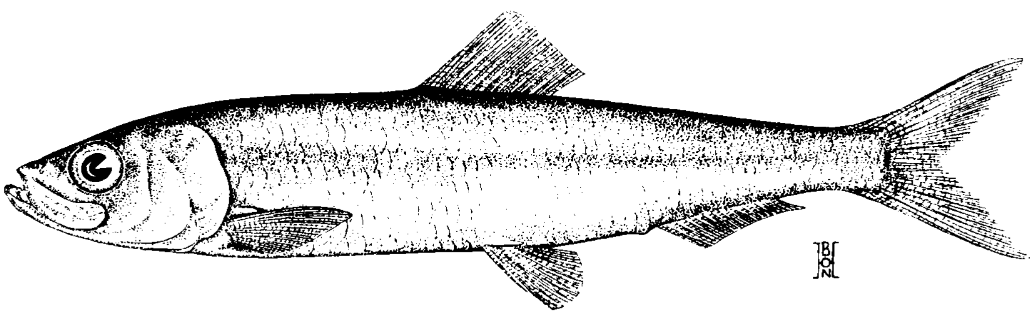

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Table of Contents

List of Figures

Executive Summary

This is the fifth edition of the Washington Department of Fish and Wildlife Pacific herring stock status report. Unlike previous editions, the scope of this report is limited to Puget Sound due to a lack of assessment of coastal herring stocks since the last stock status report published in 2009. Localized, documented herring spawning grounds in Washington waters are used to represent individual spawning stocks, and spawning biomass and other characteristics are reported at this scale. However, genetic studies to date have indicated that most Puget Sound herring stocks are not distinct from each other, or British Columbia herring stocks; the exceptions being the Cherry Point and Squaxin Pass stocks. These studies indicate that it may be more meaningful to examine abundance trends of Puget Sound herring on a larger scale than the individual spawning stock level presented in this report. An evaluation of Puget Sound herring biomass trends at various geographic aggregation levels is presented on page 63 of this report.

Individual stock status classifications since the 2009 status report have exhibited a decrease in the percentage classified as healthy or moderately healthy (Table E1) while cumulative abundance of all stocks, excluding Cherry Point stock, remained relatively stable (Figure E1) over the years. This report contains the first spawning abundance data for the newly identified Elliot Bay herring stock, which was first documented in April of 2012 by WDFW staff.

For the 2011-12 period the aggregate Puget Sound herring stock, excluding the Cherry Point and Squaxin Pass stocks, is considered moderately healthy. The overall abundance of south and central Puget Sound herring stocks since the previous stock status report has decreased, although the cumulative south/central stocks (excluding Squaxin Pass) are still classified as moderately healthy. Within this region, the Quilcene Bay and Holmes Harbor herring stocks are currently at high levels of abundance and have comprised an increasing portion of the south/central Puget Sound region's spawning biomass. The Cherry Point stock shows no signs of recovery from its critically low level of abundance. The cumulative north Puget Sound (excluding the Cherry Point stock) regional spawning biomass is classified as moderately healthy; the Strait of Juan de Fuca regional spawning biomass continues to be at a low level of abundance (critical status); and the Squaxin Pass stock is assessed as moderately healthy at this time.

Table E1. Describes a stock's current condition based primarily on recent (previous 2-year mean) abundance compared to long-term- previous 25-year (1988-2012) mean abundance. Stock criteria such as survival, recruitment, age composition, and spawning ground habitat condition are also considered.

Healthy - A stock with recent 2-year mean abundance above or within 10% of the 25-year mean.

Moderately Healthy - A stock with recent 2-year mean abundance within 30% of the 25-year mean, and/or with high dependence on recruitment.

Depressed - A stock with recent abundance well below the long-term mean, but not so low that permanent damage to the stock is likely (i.e., recruitment failure); typically 10-<70% of long-term mean.

Critical - A stock with recent abundance so low that permanent damage to the stock is likely or has already occurred (i.e., recruitment failure); typically less than 10% of long-term mean if survey coverage/methods are considered to be adequate.

Disappearance - A stock that can no longer be found in a formerly consistently utilized spawning ground.

Insufficient Data/Unknown- Insufficient assessment data to identify stock status with confidence.

Regional/genetic grouping	Stock	2012	2010	2008	2006	2004	2002	2000*	1998*	1996*	1994*
	Squaxin Pass	MOD. HEALTHY	MOD. HEALTHY	HEALTHY	MOD. HEALTHY	HEALTHY	HEALTHY	HEALTHY	MOD. HEALTHY	MOD. HEALTHY	MOD. HEALTHY
South-Central stocks exc. Squaxin Pass		MOD. HEALTHY	MOD. HEALTHY	MOD. HEALTHY	HEALTHY	HEALTHY	HEALTHY	HEALTHY	MOD. HEALTHY	HEALTHY	MOD.HEALTHY
	Purdy	UNKNOWN	UNKNOWN								
	Wollochet Bay	UNKNOWN	UNKNOWN	UNKNOWN	UNKNOWN	UNKNOWN	UNKNOWN				
	Quartermaster Harbor	DEPRESSED	DEPRESSED	DEPRESSED	MOD. HEALTHY	MOD. HEALTHY	MOD. HEALTHY	HEALTHY	HEALTHY	HEALTHY	HEALTHY
	Elliot Bay	UNKNOWN									
	Port Orchard-Madison	DEPRESSED	MOD. HEALTHY	HEALTHY	HEALTHY	MOD. HEALTHY	HEALTHY	HEALTHY	DEPRESSED	DEPRESSED	DEPRESSED
	South Hood Canal	HEALTHY	MOD. HEALTHY	MOD. HEALTHY	HEALTHY	MOD. HEALTHY	MOD. HEALTHY	HEALTHY	MOD. HEALTHY	UNKNOWN	UNKNOWN
	Quilcene Bay	HEALTHY	HEALTHY	HEALTHY	HEALTHY	HEALTHY	HEALTHY	HEALTHY	HEALTHY	HEALTHY	UNKNOWN
	Port Gamble	DEPRESSED	DEPRESSED	DEPRESSED	DEPRESSED	DEPRESSED	MOD. HEALTHY	HEALTHY	DEPRESSED	HEALTHY	HEALTHY
	Kilisut Harbor	DISSAPEARANCE	DISAPPEARANCE	DEPRESSED	DEPRESSED	MOD. HEALTHY	HEALTHY	HEALTHY	MOD. HEALTHY	UNKNOWN	HEALTHY
	Port Susan	DEPRESSED	DEPRESSED	MOD. HEALTHY	DEPRESSED	DEPRESSED	MOD. HEALTHY	MOD. HEALTHY	HEALTHY	DEPRESSED	MOD. HEALTHY
	Holmes Harbor	HEALTHY	HEALTHY	HEALTHY	HEALTHY	HEALTHY	HEALTHY	DEPRESSED	HEALTHY	UNKNOWN	UNKNOWN
	Skagit Bay	DEPRESSED	DEPRESSED	HEALTHY	HEALTHY	HEALTHY	HEALTHY	MOD. HEALTHY	MOD. HEALTHY	HEALTHY	UNKNOWN
North Puget Sound exc. Cherry Point		MOD.HEALTHY	DEPRESSED	DEPRESSED	DEPRESSED	DEPRESSED	HEALTHY	MOD.HEALTHY	MOD.HEALTHY	MOD.HEALTHY	HEALTHY
	Fidalgo Bay	DEPRESSED	DEPRESSED	DEPRESSED	DEPRESSED	DEPRESSED	HEALTHY	HEALTHY	HEALTHY	MOD. HEALTHY	MOD. HEALTHY
	Samish/Portage Bay	HEALTHY	HEALTHY	HEALTHY	HEALTHY	MOD. HEALTHY	HEALTHY	HEALTHY	HEALTHY	HEALTHY	MOD. HEALTHY
	Interior San Juan Is.	DEPRESSED	DEPRESSED	DEPRESSED	MOD. HEALTHY	DEPRESSED	MOD. HEALTHY	DEPRESSED	UNKNOWN	UNKNOWN	UNKNOWN
	N.W. San Juan Is.	DISAPPEARANCE	DISSAPEARANCE	DISAPPEARANCE	DEPRESSED	CRITICAL	DEPRESSED	UNKNOWN	DEPRESSED	UNKNOWN	UNKNOWN
	Semiahmoo Bay	HEALTHY	MOD. HEALTHY	MOD. HEALTHY	MOD. HEALTHY	DEPRESSED	MOD. HEALTHY	DEPRESSED	DEPRESSED	HEALTHY	HEALTHY
	Cherry Point	CRITICAL	CRITICAL	CRITICAL	CRITICAL	CRITICAL	CRITICAL	CRITICAL	CRITICAL	DEPRESSED	MOD. HEALTHY
Strait of Juan de Fuca		CRITICAL	CRITICAL	CRITICAL	DEPRESSED	CRITICAL	CRITICAL	CRITICAL	CRITICAL	CRITICAL	CRITICAL
	Discovery Bay	CRITICAL	CRITICAL	CRITICAL	DEPRESSED	CRITICAL	CRITICAL	CRITICAL	CRITICAL	CRITICAL	CRITICAL
	Dungeness/Sequim Bay	MOD. HEALTHY	DEPRESSED	DEPRESSED	DEPRESSED	DEPRESSED	MOD. HEALTHY	HEALTHY	HEALTHY	HEALTHY	UNKNOWN
All stocks combined exc. Squaxin Pass and Cherry Point		MOD.HEALTHY	MOD.HEALTHY	MOD.HEALTHY	HEALTHY	MOD.HEALTHY	HEALTHY	HEALTHY	MOD.HEALTHY	MOD.HEALTHY	MOD.HEALTHY
All Puget Sound stocks combined		MOD. HEALTHY	DEPRESSED	MOD. HEALTHY	HEALTHY	MOD. HEALTHY	HEALTHY	MOD. HEALTHY	DEPRESSED	MOD. HEALTHY	MOD.HEALTHY
Individual Stock Comparison		**2012**	**2010**	**2008**	**2006**	**2004**	**2002**	**2000**	**1998**	**1996**	**1994**
	HEALTHY	5 stocks	3 stocks	6 stocks	6 stocks	4 stocks	8 stocks	10 stocks	7 stocks	7 stocks	4 stocks
	MOD. HEALTHY	2 stocks	4 stocks	3 stocks	4 stocks	5 stocks	7 stocks	2 stocks	3 stocks	2 stocks	5 stocks
	DEPRESSED	7 stocks	7 stocks	6 stocks	7 stocks	6 stocks	1 stock	3 stocks	5 stocks	3 stocks	1 stock
	CRITICAL	2 stocks	2 stocks	2 stocks	1 stock	3 stocks	2 stocks	2 stocks	2 stocks	1 stock	1 stock
	DISAPPEARANCE	2 stocks	2 stocks	1 stock	0 stocks	0 stocks	0 stocks	0 stocks	0 stocks	0 stocks	0 stocks
	UNKNOWN	3 stocks	2 stocks	1 stock	1 stock	1 stock	1 stock	1 stock	1 stock	5 stocks	7 stocks
		39% Healthy or Mod. Healthy	39% Healthy or Mod. Healthy	50% Healthy or Mod. Healthy	56% Healthy or Mod. Healthy	50% Healthy or Mod. Healthy	83% Healthy or Mod. Healthy	71% Healthy or Mod. Healthy	59% Healthy or Mod. Healthy	69% Healthy or Mod. Healthy	82% Healthy or Mod. Healthy

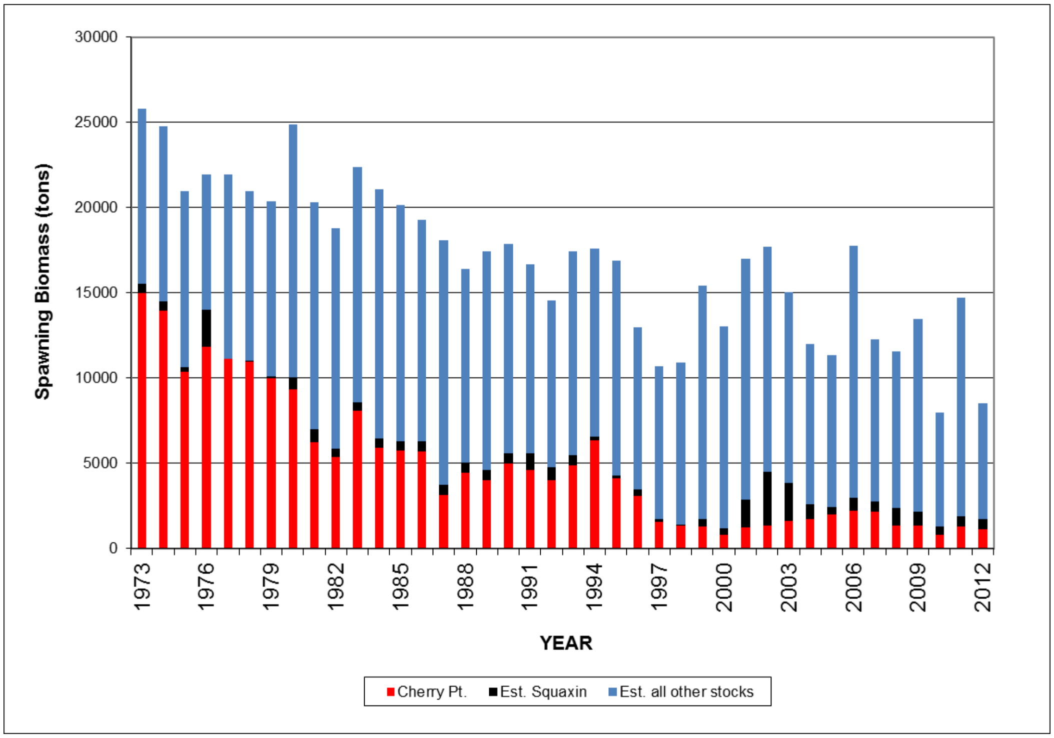


Figure E1. Estimated Puget Sound Herring Cumulative Spawning Biomass Estimates by Genetic Grouping, 1973-2012 (missing sample years estimated).

Introduction

The purpose of this report is to provide an evaluation of the current status of the Pacific herring (*Clupea pallasii* Valenciennes, 1847) resource in Washington based on available data through 2012. This report is the fifth edition published by the Washington Department of Fish and Wildlife (WDFW) that addresses the status of the herring resource in Washington waters. The previous editions are: *1994 Washington State Baitfish Stock Status Report* (WDFW 1995); *1996 Forage Fish Stock Status Report* (Lemberg et al. 1997); *2004 Washington State Herring Stock Status Report* (Stick 2005); and *2008 Washington State Herring Stock Status Report* (Stick and Lindquist 2009).

Forage fishes in general, and herring specifically, are vital components of the marine ecosystem and are a valuable indicator of the overall health of the marine environment. Many species of sea birds, marine mammals, and finfish, including lingcod (*Ophiodon elongatus*), Chinook (*Oncorhynchus tshawytscha*) and coho (*O. kisutch*) salmon, depend on herring as an important prey item (DFO 2001, Fresh et al. 1981). Significant predation occurs at each stage of the herring life cycle, starting with predation on deposited spawn by invertebrates, gulls and diving ducks. Reflecting the importance of herring in the Puget Sound ecosystem, the spawning biomass of Puget Sound herring was selected as a vital sign indicator of the health of Puget Sound by the Puget Sound Partnership in 2010.

Herring spawn for the first time at age two or three throughout Puget Sound at specific locations between early January and mid-June, depending on the stock. Eggs are deposited mainly on marine vegetation in the intertidal and shallow subtidal zone. Similar to previous editions, this document uses surveys of localized documented spawning grounds in Washington waters to represent Puget Sound herring stocks. While it is important to protect all documented herring spawning grounds, it may be more meaningful to examine abundance trends on a larger scale than the individual stock level.

No additional significant genetic studies have been published since the completion of the 2008 stock status report (Stick and Lindquist 2009). Between 2001 and 2008, several studies demonstrated that some Puget Sound herring stocks (e.g., Cherry Point and Squaxin Pass) are genetically distinct from other Puget Sound and British Columbia samples (Beacham et al. 2001, 2002, 2008, Small et al. 2005, Mitchell 2006). However, differentiation has not been demonstrated among other sampled Puget Sound herring stocks, in part due to a lack of sampling. The “Puget Sound Herring Stock Structure” section is largely a reiteration of the homologous section from Stick and Lindquist (2009), with mention of new spawning activity in Seattle’s Elliot Bay and continued activity by the Purdy stock in South Puget Sound.

The stock assessment methodologies and criteria for evaluating the status of herring stocks in this report are generally similar to previous editions. The current sampling design for Washington herring calls for annual assessment of each known stock in Puget Sound in order to provide an estimate of herring spawning biomass. Noteworthy, due to budget reductions, is the termination of acoustic/trawl assessment surveys following the 2009 season, which had been conducted on selected Puget Sound herring stocks by WDFW since the early 1970s. Current assessment is based solely on spawn deposition surveys via inspection of raked macrovegetation.

Stock profiles, which include spawning location and timing information, and annual run size estimates are presented for each known Washington herring stock. The definitions for stock profile criteria follow this section.

Following the Puget Sound stock status profiles, two-year stock status summaries for 1994 through 2012 are provided and are followed by a discussion and graph of cumulative herring spawning biomass estimates for the 1973-2012 period.

An updated summary of Puget Sound herring fisheries and landings through 2012 is provided in the next section. Herring were included in the 1974 "Boldt Decision" defining Native American fishing rights, and Washington stocks and fisheries are therefore jointly co-managed statewide by WDFW and locally by area Tribal governments. Currently, the only active commercial herring fishery in Washington waters is the sport bait fishery, which provides product primarily for recreational salmon fisheries.

Stock profiles for two coastal Washington stocks, Willapa Bay and Grays Harbor, were not included in this report as no assessment surveys have been conducted there since 2007. Information to date is included in the 2008 stock status report (Stick and Lindquist 2009).

An appendix containing herring age composition summaries through 2012 is included at the end of this report. Estimated spawning biomass (tons) and number of fish at age are reported. These estimates are calculated from herring biological data resulting from acoustic/trawl (A/T) surveys, which were annually conducted on 6-12 herring stocks from 1973-2009. As mentioned above, this project was terminated following the 2009 spawning season due to budget reductions. The only additional A/T survey data after 2009 consist of a single survey of the Cherry Point stock in 2011.

Puget Sound Herring Stock Structure

The importance of stock structure throughout the range of Pacific herring has been recognized since the onset of directed management efforts. The recognition of individual stocks within the Puget Sound herring resource has been utilized for management purposes for decades. Temporal and spatial specificity of observed spawn deposition and differences in biological data were the first characteristics used to support the independence of each spawning aggregation as a discrete stock.

Based largely on the fact that herring tend to return to spawn at about the same locations at about the same time year after year, Chapman et al. (1941) concluded that their hypothesis that each spawning population is independent from any other was strongly corroborated. Chapman et al. (1941) also suggested that the independence of spawning populations was demonstrated and that there was little, if any, intermixing between different spawning populations in Washington. This study formed the basis for considering each spawning aggregation as a discrete stock and was based primarily on mean vertebral counts and spawn timing and location. Williams (1959) reported that Chapman et al. demonstrated that stocks of herring in Puget Sound were largely independent of each other, with respect to population dynamics, and that depleted stocks receive very little recruitment from other stocks.

Based on differences in spawn timing and location, growth rates, patterns of annulus formation, and incidence of internal parasites, Trumble (1983) determined that several major discrete spawning herring populations existed in Puget Sound, and that several smaller stocks may also exist. Cherry Point (Strait of Georgia) and Case Inlet (Squaxin Pass) herring exhibited the most distinct characteristics that separated them from herring in other areas of Puget Sound. Trumble (1983) further stated that "spawning populations appear to maintain independence from other populations, and interbreeding between populations seems limited."

Early genetic work, based on allozyme variation (Grant and Utter 1984), did not support the existence of discrete populations of herring within Puget Sound. This study, which included samples from South Puget Sound (Hale Passage) and the Strait of Georgia (Cherry Point stock) observed genetic differentiation only over relatively large geographic areas, such as between Asian and eastern Pacific regions, and perhaps between the Gulf of Alaska and California herring samples. Later studies, using mitochondrial DNA variation (Schweigert and Withler 1990) and ribosomal DNA sequence variation (Domanico et al. 1996), also did not provide any evidence of local genetic differentiation of eastern Pacific herring, including those in Puget Sound.

The analysis of microsatellite DNA loci represented a landmark in the detection of genetic variation among populations in localized areas of the eastern Pacific Ocean, such as Puget Sound and Canadian Strait of Georgia. Analyses completed by O'Connell et al. (1998) of Alaskan herring were the first to suggest that microsatellite DNA loci could be used to detect subtle genetic differentiation not previously distinguished via other techniques.

The initial documentation of significant genetic differentiation for Washington state herring was reported by Beacham et al. (2001, 2002), who found that herring spawning at Cherry Point were distinct from sampled Canadian Strait of Georgia herring. However, these studies also found little genetic variation among British Columbia (B.C.) herring stocks. This finding was considered consistent with estimated straying rates from tagging studies among stocks that are sufficient to homogenize allele frequencies over large geographic areas.

Tagging studies of B.C. herring have indicated a high fidelity (i.e., repeat homing to a spawning location) rate of 75-96% of tagged fish at-large for one year, which also indicates a sizable straying rate of 4-25% (Ware et al. 2000). It should be noted that this is not a measure of natal homing but, rather, demonstration of a pattern of repeated use of a selected spawning area by an individual following first use of that site. Gustafson et al. (2006) concluded that the high fidelity rate provides the biological basis for existing B.C. herring stock management because most the adult herring return to the same region to spawn the following year, and that the observed straying rates reduce genetic divergence among the five major populations. In their analysis of the same tagging data, Hay et al. (2001) suggest a minimum area size of about 500 km^2 to support high fidelity. Ware et al. (2000) also concluded that their analysis suggests that the straying rate is density-dependent and appears to increase linearly with increased population size.

The dramatic one-year increase in spawning biomass observed for the Discovery Bay herring stock in Washington in 2006 may be an example of significant straying of adults to different spawning grounds. The estimated spawning biomass for this stock in 2006 was 1,325 tons. The presumed 2 to 5 year old adults that would have comprised most of the 2006 spawning biomass were spawned in years that had a mean spawning biomass of only 186 tons, and spawning biomass for the two years following 2006 was less than 250 tons. If the majority of the 2006 spawning biomass documented for this area was strays from another stock the identity of this stock is unknown.

Small et al. (2005) examined temporal and spatial genetic variation for herring, including samples of prespawning adult herring from Cherry Point, Semiahmoo Bay, Fidalgo Bay, Port Gamble, and Squaxin Pass collected over intervals of two to four years. They demonstrated consistent genetic differentiation between the Cherry Point, Squaxin Pass, and the other three Washington samples and considered the degree of genetic differentiation for these two stocks (Cherry Point and Squaxin Pass) to be "remarkable" given the small spatial scale involved. Late spawn timing (Cherry Point) and geographic isolation (Squaxin Pass) were suggested as the primary causes for the observed levels of genetic distinctiveness.

The genetic differentiation of the Cherry Point herring stock was further demonstrated by Mitchell (2006). Microsatellite DNA loci were examined for samples from Cherry Point, Semiahmoo Bay, Port Gamble, Quartermaster Harbor, and Squaxin Pass herring with an increased temporal scale of six years. Genetic differentiation was consistent over six years for the Cherry Point stock (samples from 1999, 2004, and 2005), but the genetic differentiation of Squaxin Pass (Case Inlet) fish observed in 1999 was not observed in 2005. However, 2007 samples again demonstrated differentiation (Lorenz Hauser, University of Washington, unpublished data). There was a lack of biologically meaningful genetic differentiation among the other area samples in this study.

First reported in 2008, continued spawning activity has since been documented annually for the Purdy herring stock at the north end of Carr Inlet in South Puget Sound. Sampling effort to collect age composition and genetic samples for this stock via an acoustic/trawl survey in 2009 was unsuccessful. However, pending results from genetic analyses of samples collected from research gill nets in 2013 from this spawning ground may shed light on this stock's status and/or discreteness.

Another "new" location for Puget Sound herring spawning is Seattle's Elliot Bay, where significant spawn deposition was documented in 2012 (see stock profile for more information) and 2013 (results not available for this report). These spawning events are unique due to the location and relatively late spawn timing (very late April-early May) for this region. While documentation of this spawning area/stock was first accomplished in 2012 and observed again in 2013, it is open to debate whether the area may have hosted spawning activity on a regular basis and was simply undetected due to a lack of sampling effort there. Deposited herring eggs collected from Elliot Bay are also part of a pending genetic study investigating Puget Sound herring stock structure.

The most recently completed genetic study involving samples from Washington herring again produced results showing genetic differentiation of Cherry Point herring (Beacham et al. 2008). Significant differentiation was observed between the Cherry Point stock and samples from the Kilisut Harbor (Port Townsend) and Skagit Bay prespawning fish in 2004, but no significant difference was observed between the Port Townsend and Skagit Bay samples. On average, the Washington herring were also distinct from those in other regions, particularly those in British Columbia. Similar to previous studies, the authors suggested that unique spawn timing has led to the observed genetic differentiation of the Cherry Point stock. Also noteworthy from this work based on summer mixed-stock samples is the indication that "resident" herring from the west side of the Strait of Georgia are predominantly derived from primary-timed spawning (i.e., "migratory") populations that did not migrate to offshore summer feeding grounds. Conversely, samples of "resident" herring from the east side of the strait had higher proportions of mainland inlet origin (i.e., "resident") fish.

In their study of the geographic distribution and magnitude of three perisistant organic pollutants (POPs) in herring West et al. (2008) suggest strong environmental segregation of herring samples from inner Puget Sound (Squaxin Pass, Quartermaster Harbor, Port Orchard) compared to the Strait of Georgia (Cherry Point, Semiahmoo Bay, Hornby/Denman Island, B.C.). They concluded the observed segregation likely resulted from differential exposure to contaminants related to the locations where populations reside and feed. All three "Strait of Georgia" samples were strongly isolated from the "Puget Sound" samples in multidimensional scaling (MDS) mapping of POPs.

It is most likely that Puget Sound herring consist of a combination of "migratory" and "resident" fish. It is also probable that many stocks in Puget Sound consist of migratory and resident individuals, as suggested by Penttila (1986). A review of genetic studies to date involving Puget Sound herring provides solid evidence of the genetic distinctness of the Cherry Point stock. It also appears that the Squaxin Pass (Case Inlet) stock may be genetically differentiated from other herring populations, although the results from 2005 samples (Mitchell 2006), presumed to be from the same prespawning aggregation as other years, does not support this.

The observed lack of genetic differentiation among other sampled herring stocks from Puget Sound (Quartermaster Harbor, Port Gamble, Kilisut Harbor, Skagit Bay, Fidalgo Bay, and Semiahmoo Bay) suggests sufficient gene flow between populations, particularly those with similar spawn timing, which would reduce genetic divergence. With the exception of Cherry Point, and possibly Squaxin Pass herring, Puget Sound herring stocks may be part of a metapopulation similar to the model assumed for B.C. herring. Though evidence is pending, the spring spawn timing of the Elliot Bay stock also suggests that genetic differentiation akin to that observed for the Cherry Point stock is plausible. The continued development of new methods to detect ever more subtle genetic differentiation raises the possibility that future technologies may demonstrate further population discreteness for Puget Sound herring.

Potentially relevant to the discussion of stock structure and identification of Puget Sound herring is the fourth of a series of papers by Ware and Tovey (2004) outlining evidence that B.C. herring are spatially structured and interact as a metapopulation. They analyzed spawn time series between 1943 and 2002 for indications of "disappearance" and "recolonization" events at the spatial scale of "sections," which on average contain about 250 km (150 miles) of shoreline. A disappearance event was assumed to have occurred in a section when five consecutive years of no spawn appeared in the time series. A recolonization event was assumed to have occurred when spawning was documented after a disappearance event. The authors identified 82 spawn disappearance events for the sixty-year period examined and found that more than half (55%) of the sections had experienced one or more disappearance events. They found that sections with larger amounts of spawning habitat experienced fewer disappearance events than smaller sections and stated that the high degree of straying between nearby sections explains why herring spawning aggregations at the section spatial-scale are so dynamic. The authors also mention that their analysis may have overestimated the frequency of disappearance events in sections with very small spawn habitat indices (i.e., smaller spawning biomass) because it was not always known if a section had received survey effort.

If Puget Sound herring stocks, with the demonstrated exceptions of Cherry Point and Squaxin Pass, interact as a metapopulation similar to that attributed to B.C. herring, observed "disappearance" and/or dramatic decreases in abundance (e.g., N.W. San Juan Island, Kilisut Harbor, and Discovery Bay) of individual stocks may not be cause for major concern. Due to uncertainties regarding stock structure, annual sampling of all known spawning stocks in Puget Sound will continue. Additional collection of genetic samples involving as many spawning aggregations as possible will also be pursued.

Stock Profile Parameters

The parameters used to develop each stock-specific profile are described below. Status ratings for each stock consider all available information, but are mainly based on spawning biomass.

Stock Definition

Herring routinely spawn at specific sites or grounds throughout Washington waters each year. Documented Puget Sound spawning areas through the 2012 spawning season are shown in the map on page 11. For this report, localized spawning grounds are considered to represent distinct stocks. This assumption is based in part on early meristic studies, which concluded that heterogeneity exists among herring samples taken from various spawning areas throughout Puget Sound (Chapman et al. 1941). However, recent genetic studies have suggested that only the Cherry Point and Squaxin Pass herring stocks are genetically distinct from each other, and other Washington and British Columbia stocks (Beacham et al. 2001, 2002, 2008, Small et al. 2005, Mitchell 2006). Genetic distinction between other sampled Puget Sound stocks has not been demonstrated (Small et al. 2005, Mitchell 2006, Beacham et al. 2008). For fishery and ecosystem management purposes the total spawning biomass for all Puget Sound stocks, excluding the Cherry Point and Squaxin Pass stocks, is aggregated under the title "All Other Stocks."

Stock-based assessment data are very useful for localized fisheries management issues and plans. However, if straying rates among Puget Sound herring stocks are comparable to reported British Columbia herring behavior based on tagging results (Ware et al. 2000; Hay et al. 2001), it may be necessary to reconsider what represents a "stock" for Puget Sound herring. Further discussion of this topic is presented later in this document.

Overview

Overview provides any unique information about, or characteristics of, the stock.

Spawning Ground

The **Spawning Ground** map depicts the cumulative documented spawning ground (red) for each stock and the area where spawn deposition has been observed in the last five years (2008-2012; green). Herring deposit transparent, adhesive eggs primarily on lower intertidal and shallow subtidal eelgrass and marine algae. In Washington most spawning activity takes place between 0 and -10 feet MLLW in tidal elevation.

Prespawner Holding Area

Where known, the **Prespawner Holding Area** depicts the location (yellow), usually adjacent to the spawning ground in deeper waters, where ripening adult herring congregate and hold prior to spawning. Schools of prespawning adults typically begin concentrating three to four weeks, or more, before the first spawning event (Trumble et al. 1982).

Spawning Timing

Spawning Timing for herring in Washington typically lasts from mid-January through early June, with each stock generally spawning for approximately a 2-month period. The spawning timing figure for each stock indicates the occurrence of any documented spawning activity within the first or second half of a month. Observed peak spawning, based on the observed quantity of egg deposition, is indicated by red cross-hatched cells.

Spawning Biomass

Spawning Biomass is the term used to quantify the biomass (tonnage) of spawning herring. Two methods have traditionally been used to provide quantitative estimates of herring abundance: spawn deposition surveys (Stick 1994) and acoustic/trawl surveys (Burton 1991). Prior to 1996, the spawning biomass for the 10-12 larger Puget Sound stocks typically was assessed by both methods each year while the smaller 6-8 stocks were surveyed by spawn deposition surveys on a 3-year rotational basis (Stick 1994). The two assessment techniques have generally shown good correspondence (Burton 1991). The years when significant variance occurs are usually associated with sampling related problems such as survey timing, adverse weather, equipment malfunctions, etc. From 1996 to 2009, duplicate assessment coverage was reduced and assessment for all known herring stocks was attempted each year by either one or both methods (Stick and Lindquist 2009). Final spawning biomass estimates are combined with any directed fishery harvest of spawning fish to produce final run size estimates. If both methods are utilized, the spawn deposition estimate, combined with any relevant fishery harvest, is used as the **final run size estimate** if survey coverage is considered adequate.

Beginning in 2010, only spawn deposition surveys have been conducted to assess Washington herring stocks, with the exception of one acoustic/trawl survey of the Cherry Point stock in 2011.

Spawn Deposition Survey Estimates

Spawn Deposition Surveys provide a direct estimate of herring spawning biomass. Marine vegetation on spawning grounds is sampled via raking to determine the location and density of spawn deposition, and these data are converted to an estimate of spawning escapement (Stick 1994). These surveys are generally conducted weekly during a stock's spawning season to document cumulative spawn deposition.

Acoustic/Trawl Survey Estimates

Acoustic/Trawl Surveys are conducted on the prespawner holding areas early in, or prior to, the spawning season when prespawner abundance is peaking. This method utilizes computer interfaced echosounding equipment that produces real-time estimates of total fish abundance, which are apportioned to herring biomass based on concurrent trawl catch data (Lemberg et al.

1990). The weighted data from all trawl samples for each stock are pooled and extrapolated to the final spawning biomass estimate. The resulting data set represents the age composition for the stock's entire spawning run (Appendix A). Analyses of trawl-caught samples provide the basis for detailed stock indices such as biomass age composition, annual survival rates, and recruitment; recruitment is defined as the estimated biomass of age 2 fish in the current year's spawning run plus the biomass of age 3 fish that recruited in the current year. As previously mentioned, these surveys were discontinued following the 2009 season due to budget reductions.

Spawner Fishery

Spawner Fishery summarizes adult (spawner) herring harvests. Potential adult herring fisheries in recent years have been limited to the Cherry Point stock where the commercial product is roe. No harvest of this stock has been allowed since 1996 due to low spawning biomass abundance. Spawn-on-kelp (SOK) and sac-roe fisheries have been allowed when the Cherry Point stock size is considered appropriate for harvest (minimum of 3,200 tons). It should be noted that sport bait fisheries also occur in Puget Sound but that the fish targeted by these fisheries are juveniles originating from various stocks and, as such, their harvest is not factored in to the stock-specific harvest of spawning adults considered here.

Fish handling practices inherent to the SOK fishery result in predisposition of herring populations to epizootic mortality from viral hemorrhagic septicemia (VHS). These epizootics, characterized by high mortality and massive viral shedding among affected cohorts, frequently occur in herring impoundments used for SOK fisheries (Hershberger et al. 1999). In addition to creating localized epizootics inside the herring impoundments, shed waterborne virus can emanate from the net pens and represent a significant risk factor for initiating VHS epizootics in unconfined herring over a larger geographic area. SOK fishery management options exist that can decrease the probability of localized VHS epizootics within herring net pens (Hershberger et al. 2001), and should be considered if /when conditions warrant reopening of SOK fisheries.

Data Availability

Data availability - Determined by the relative amount of stock assessment data available.

- **Good** - A continuous time series of acoustic/trawl data and spawn deposition data.
- **Fair** - A continuous time series of spawn deposition or acoustic/trawl data only.
- **Poor** - An incomplete time series of either type of stock assessment data.

Recent Trend

Recent Trend - Slope of the regression for the most recent five years (2008-2012) of final spawning biomass estimates.

- **Increasing** - Statistically significant positive slope (90% confidence level).
- **No Significant Trend** - Slope not statistically significant from zero.
- **Decreasing** - Statistically significant negative slope (90% confidence level).

Stock Status

Describes a stock's current condition based primarily on most recent 2 years of abundance (spawning biomass) compared to long-term (25-year; 1988-2012) mean abundance. When available, stock criteria such as survival, recruitment, age composition, and spawning ground habitat condition are also considered.

Healthy - A stock with recent 2-year mean abundance above or within 10% of the 25-year mean.

Moderately Healthy - A stock with recent 2-year mean abundance within 30% of the 25-year mean, and/or with high dependence on recruitment.

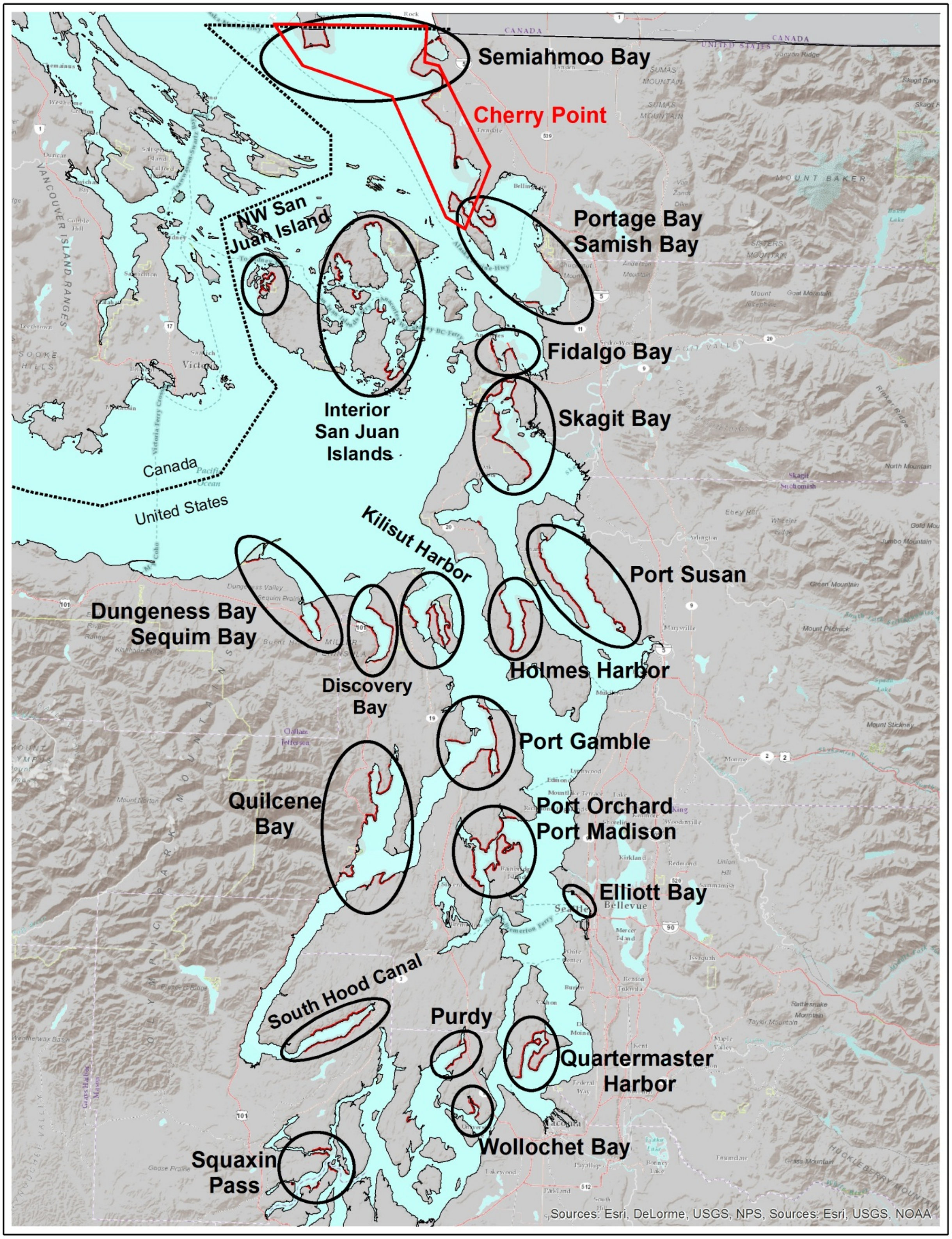
Depressed - A stock with recent abundance well below the long-term mean, but not so low that permanent damage to the stock is likely (i.e., recruitment failure); typically 10-<70% of long-term mean.

Critical - A stock with recent abundance so low that permanent damage to the stock is likely or has already occurred (i.e., recruitment failure); typically less than 10% of long-term mean if survey coverage/methods are considered to be adequate.

Disappearance - A stock that can no longer be found in a formerly consistently utilized spawning ground.

Insufficient Data/Unknown- Insufficient assessment data to identify stock status with confidence.

Documented Puget Sound Herring Spawning Grounds



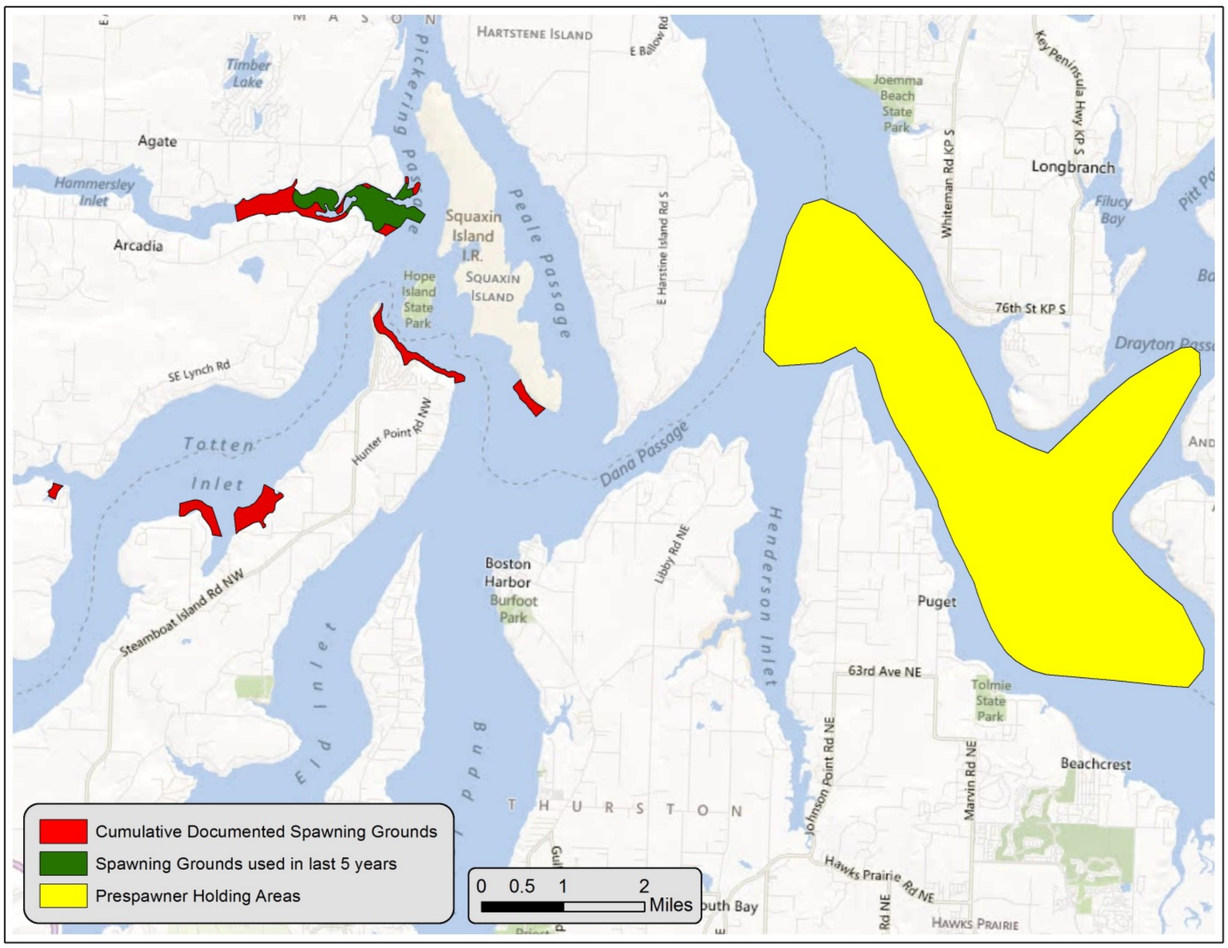
South/Central Puget Sound Herring Stock Profiles

Squaxin Pass Herring Stock

<u>OVERVIEW</u>

The southernmost stock within the Puget Sound basin, Squaxin Pass herring, exhibit unusual spawning behavior. Marine algae normally utilized for spawning substrate by herring are sparse in this area and spawn deposition often occurs on rocks and gravel, occasionally in relatively deep water (10-15 meters). Such behavior does not lend itself well to assessment from the spawn deposition survey method, which may explain the large disparity between spawn deposition and acoustic/trawl survey estimates for this stock. The Squaxin Pass herring stock has the slowest known growth rate in Washington. This stock is considered moderately healthy. Resumption of acoustic/trawl surveys to estimate abundance of this stock is being considered. Genetic analyses mentioned previously in this report have demonstrated differentiation of this stock from others in Puget Sound. Geographic isolation is suggested as the primary cause for the observed genetic divergence.

<u>SPAWNING GROUND</u>



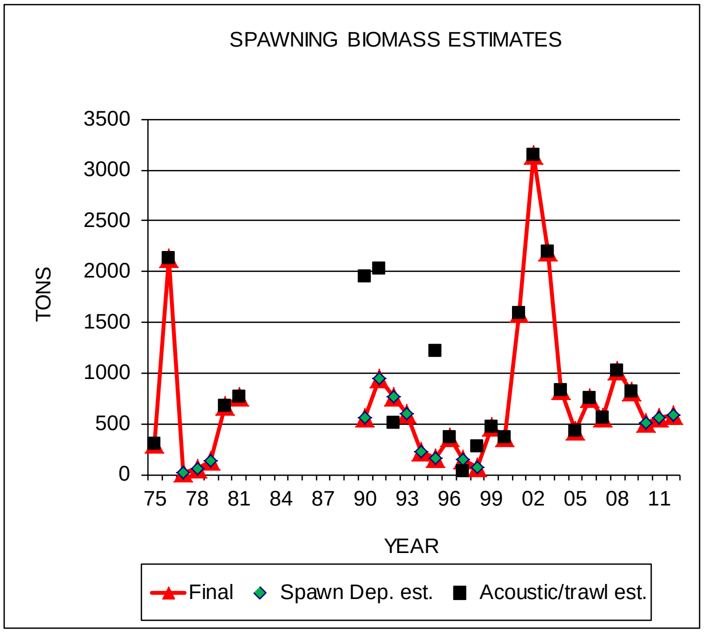
SPAWNING TIMING

Jan	Feb	March	April	May	June

STOCK STATUS PROFILE for Squaxin Pass Herring Stock

STOCK ASSESSMENT

YEAR	SPAWNING BIOMASS ESTIMATES (tons): SPAWN DEPOSITION SURVEYS	ACOUSTIC/ TRAWL SURVEYS	FINAL BIOMASS ESTIMATE	RECRUITMENT (tons)
1975		298	298	
1976		2138	2138	
1977	20		20	
1978	58		58	
1979	137		137	
1980		683	683	
1981		772	772	
1982				
1983				
1984				
1985				
1986				
1987				
1988				
1989				
1990	566	1950	566	
1991	943	2035	943	839
1992	771	507	771	0
1993	596		596	
1994	225		225	
1995	157	1219	157	
1996		374	374	315
1997	149	35	149	141
1998	68	275	68	25
1999		474	474	442
2000		371	371	360
2001		1597	1597	1120
2002		3150	3150	1301
2003		2201	2201	1159
2004		828	828	425
2005		436	436	259
2006		755	755	433
2007		557	557	260
2008		1025	1025	1025
2009		824	824	8
2010	510		510	
2011	565		565	
2012	589		589	
MEAN:				
25 year			771	
5 year			703	



STOCK SUMMARY

2012 SPAWNER FISHERY SUMMARY
no fishery

DATA QUALITY
fair

RECENT TREND (5 year)
decreasing

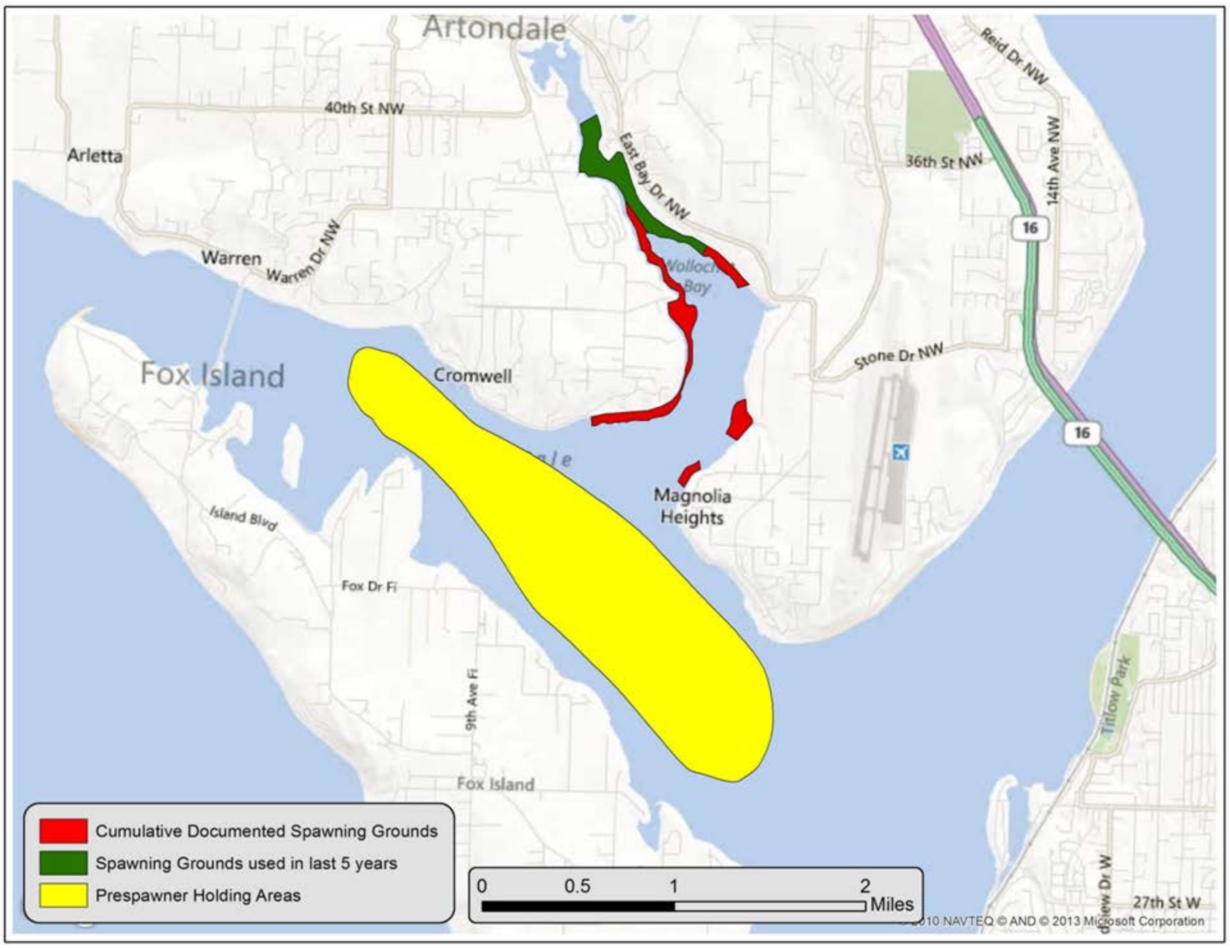
STOCK STATUS (2 year)
moderately healthy: 75% of 25 yr mean spawning biomass

Wollochet Bay Herring Stock

OVERVIEW

The Wollochet Bay stock's spawning grounds were initially documented during the 2000 season. This confirmed reported spawning activity from the late 1930s (Chapman et al. 1941) that had not been detected in the intervening years. Stock size appears to be small and estimated spawning biomass has been quite variable, with a high of 360 tons estimated in 2009 and a low of only 11 tons in 2011. Prespawning fish attributed to this spawning ground appear to congregate in Hale Passage. Spawn timing is early relative to other stocks with a peak in late January to early February. Timing of spawning activity here has been consistently earlier than that observed since 2008 in Carr Inlet (Purdy/Henderson Bay), suggesting that these stocks may be discrete.

SPAWNING GROUND



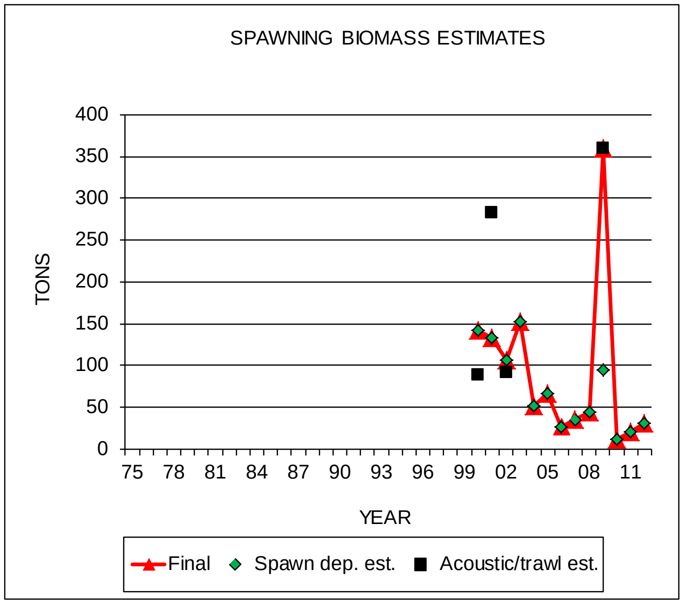
SPAWNING TIMING

Jan	Feb	March	April	May	June

STOCK STATUS PROFILE for Wollochet Bay Herring Stock

STOCK ASSESSMENT

YEAR	SPAWNING BIOMASS ESTIMATES (tons) SPAWN DEPOSITION SURVEYS	ACOUSTIC/ TRAWL SURVEYS	FINAL BIOMASS ESTIMATE	RECRUITMENT (tons)
1975				
1976				
1977				
1978				
1979				
1980				
1981				
1982				
1983				
1984				
1985				
1986				
1987				
1988				
1989				
1990				
1991				
1992				
1993				
1994				
1995				
1996				
1997				
1998				
1999				
2000	142	89	142	
2001	133	282	133	101
2002	106	92	106	57
2003	152		152	
2004	52		52	
2005	67		67	
2006	27		27	
2007	35		35	
2008	45		45	
2009	95	360	360	
2010	11		11	
2011	21		21	
2012	31		31	
MEAN:				
25 year			91	
5 year	41		94	



STOCK SUMMARY

2012 SPAWNER FISHERY SUMMARY
no fishery

DATA QUALITY
poor

RECENT TREND (5 year)
no significant trend

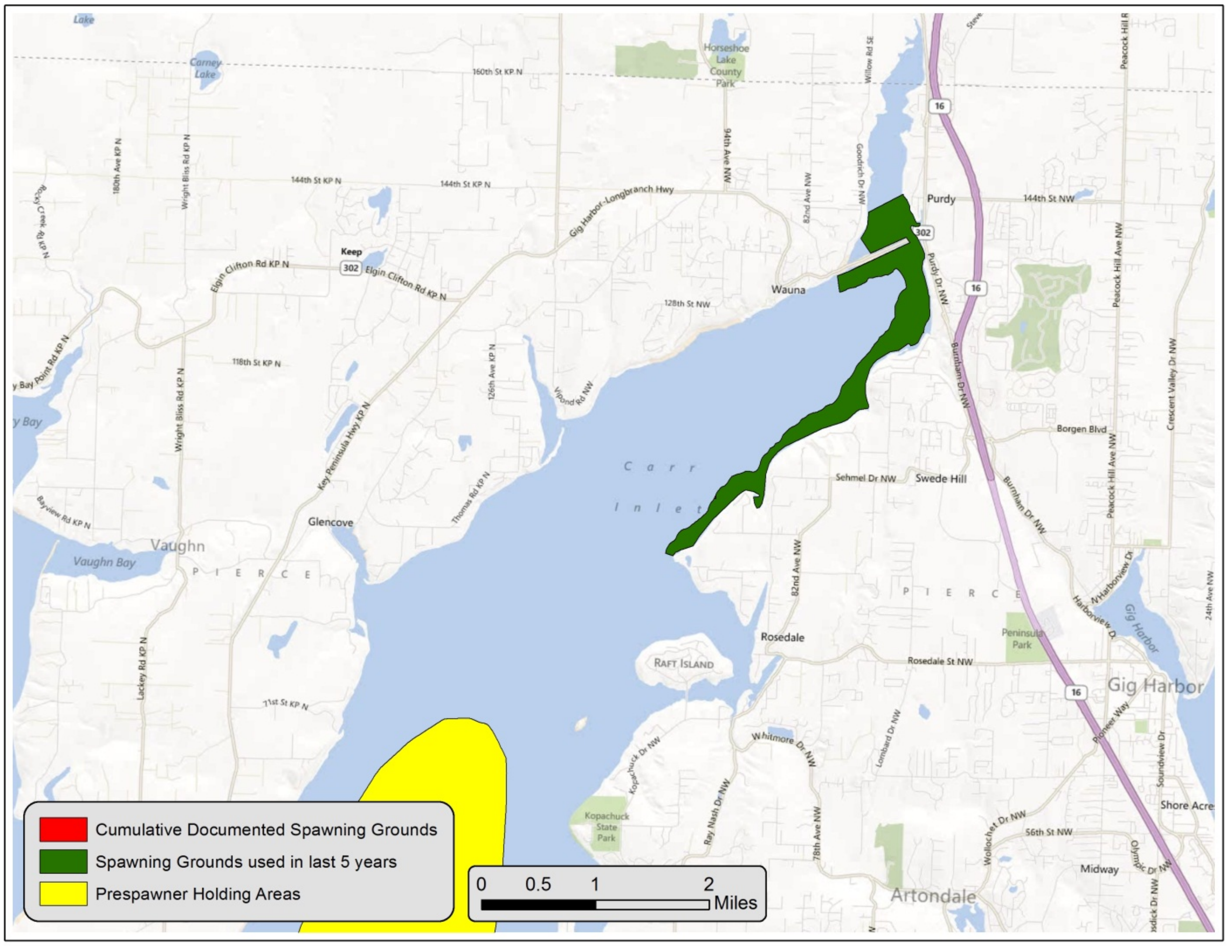
STOCK STATUS (2 year)
insufficient data

Purdy Herring Stock

OVERVIEW

The Purdy stock's spawning grounds were first documented during the 2008 season and spawning activity has occurred annually since that time. Although unconfirmed, a prespawner holding area for this stock is assumed to be in lower Carr Inlet. Spawn timing is relatively late compared to other south Puget Sound stocks, with spawn dates as late as April 14. Samples of spawning herring collected in 2013 for genetic comparison to other Puget Sound stocks may shed further light on the stock structure of South Puget Sound herring.

SPAWNING GROUND



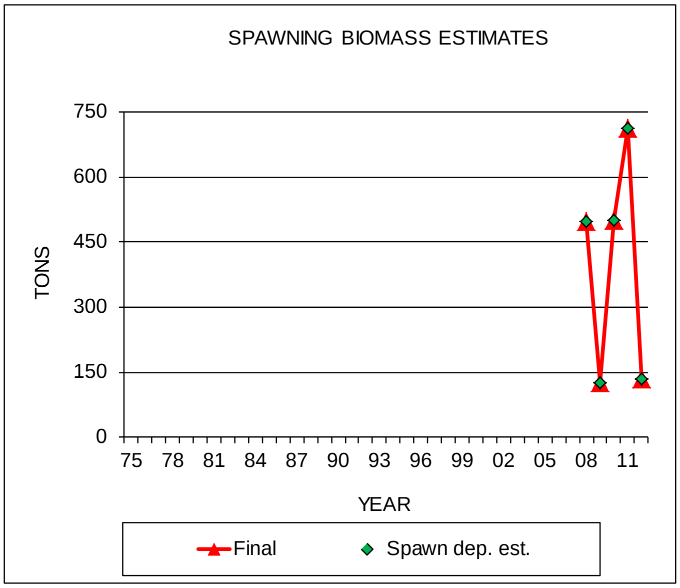
SPAWNING TIMING

Jan	Feb	March	April	May	June

STOCK STATUS PROFILE for Purdy Herring Stock

STOCK ASSESSMENT

YEAR	SPAWNING BIOMASS ESTIMATES (tons) SPAWN DEPOSITION SURVEYS	ACOUSTIC/ TRAWL SURVEYS	FINAL BIOMASS ESTIMATE	RECRUITMENT (tons)
1975				
1976				
1977				
1978				
1979				
1980				
1981				
1982				
1983				
1984				
1985				
1986				
1987				
1988				
1989				
1990				
1991				
1992				
1993				
1994				
1995				
1996				
1997				
1998				
1999				
2000				
2001				
2002				
2003				
2004				
2005				
2006				
2007				
2008	496		496	
2009	125		125	
2010	500		500	
2011	711		711	
2012	135		135	
MEAN:				
25 year			393	
5 year	393		393	



STOCK SUMMARY

2012 SPAWNER FISHERY SUMMARY
no fishery

DATA QUALITY
poor

RECENT TREND (5 year)
no significant trend

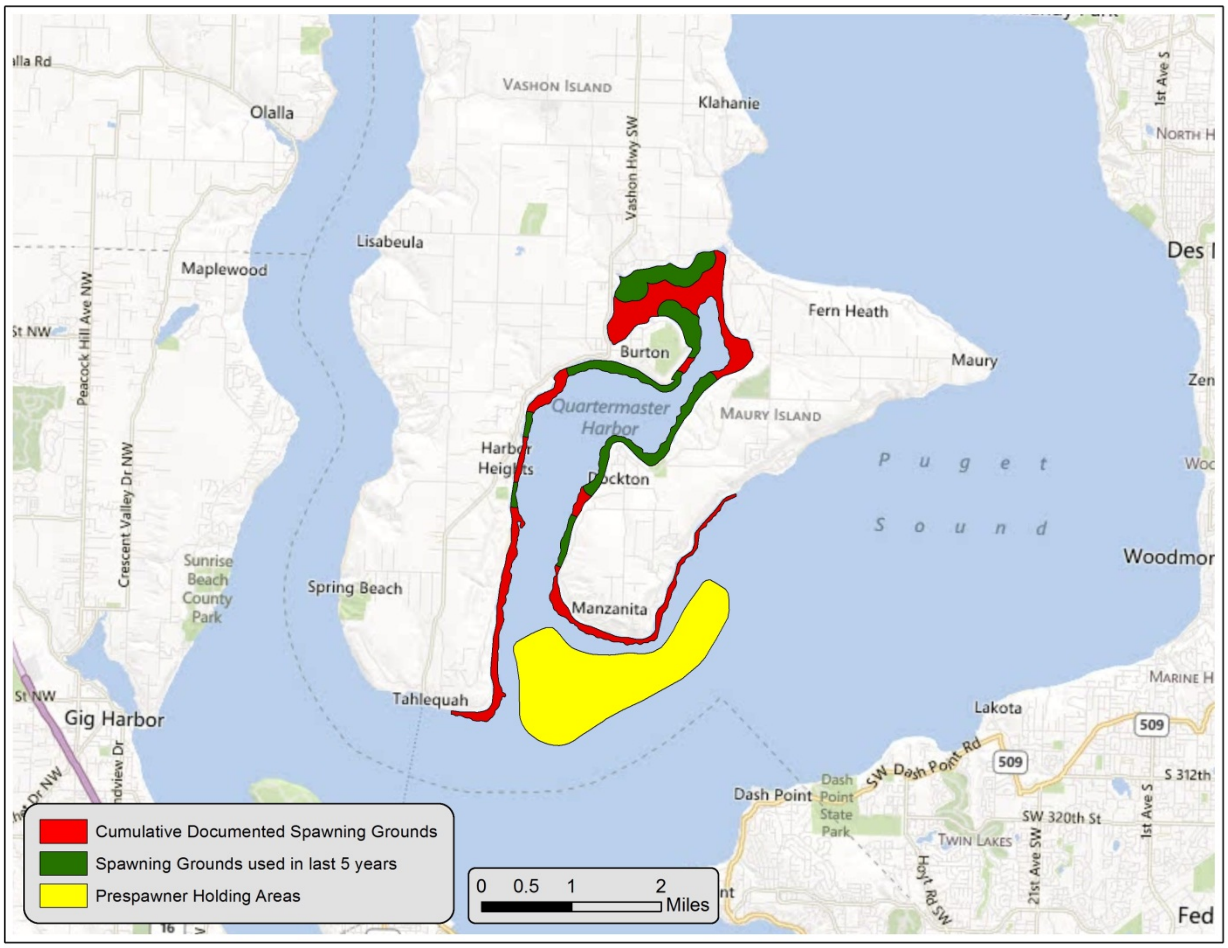
STOCK STATUS (2 year)
insufficient data to compare to long-term mean abundance

Quartermaster Harbor Herring Stock

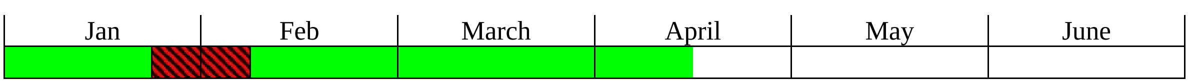
OVERVIEW

The Quartermaster Harbor herring stock spawning activity occurs relatively early in the year, with spawning often beginning in early January. Spawn deposition is typically centered near Dockton on Maury Island. Growth and spawning behavior characteristics for this stock are considered to be average for central/south Puget Sound. Spawning biomass peaked in 1995 at 2,001 tons, followed by a general decrease through 2008 and record low levels since 2010. One genetic study (Mitchell 2006) that included a sample from this stock did not demonstrate genetic differentiation between it and other Puget Sound samples, with the exception of Squaxin Pass and Cherry Point herring.

SPAWNING GROUND



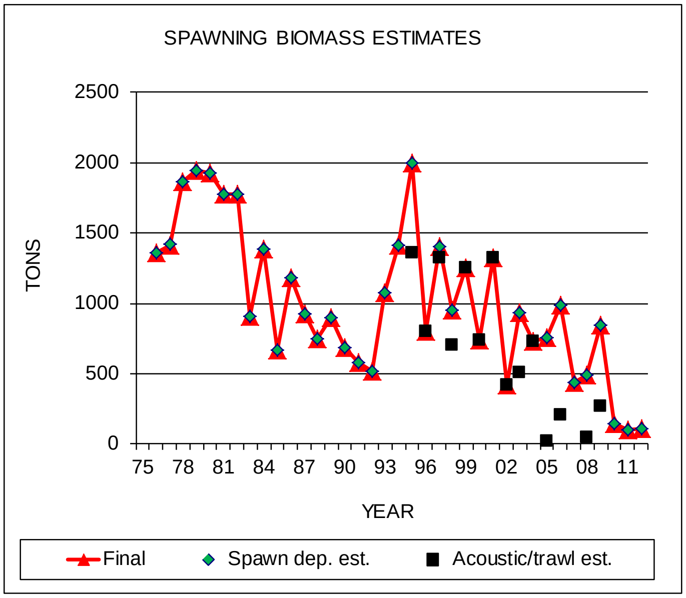
SPAWNING TIMING



STOCK STATUS PROFILE for Quartermaster Harbor Herring Stock

STOCK ASSESSMENT

YEAR	SPAWNING BIOMASS ESTIMATES (tons): SPAWN DEPOSITION SURVEYS	ACOUSTIC/ TRAWL SURVEYS	FINAL BIOMASS ESTIMATE	RECRUITMENT (tons)
1975				
1976	1357		1357	
1977	1423		1413	
1978	1860		1860	
1979	1941		1941	
1980	1930		1930	
1981	1777		1777	
1982	1778		1778	
1983	909		909	
1984	1386		1386	
1985	667		667	
1986	1181		1181	
1987	924		924	
1988	750		750	
1989	898		898	
1990	681		681	
1991	580		580	
1992	518		518	
1993	1075		1075	
1994	1412		1412	
1995	2001	1362	2001	
1996		805	805	757
1997	1402	1321	1402	438
1998	947	701	947	0
1999		1257	1257	1200
2000		743	743	562
2001		1320	1320	1224
2002		416	416	213
2003	930	506	930	655
2004		727	727	136
2005	756	18	756	534
2006	987	209	987	846
2007	441		441	
2008	491	46	491	
2009	843	272	843	441
2010	143		143	
2011	96		96	
2012	108		108	
MEAN:				
25 year			813	
5 year	336		336	



STOCK SUMMARY

2012 SPAWNER FISHERY SUMMARY
no fishery

DATA QUALITY
fair

RECENT TREND (5 year)
no significant trend

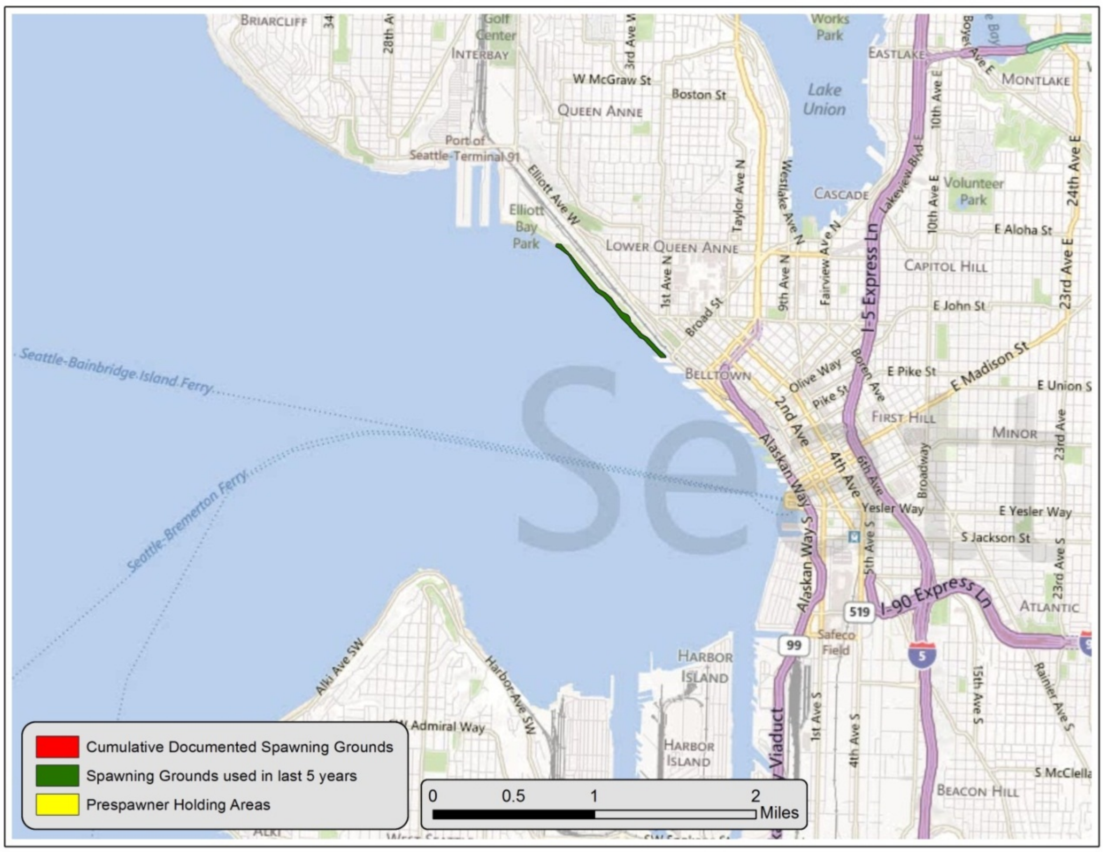
STOCK STATUS (2 year)
depressed: 13% of 25 yr mean spawning biomass

Elliot Bay Herring Stock

OVERVIEW

Herring spawn deposition was documented for the first time in Elliot Bay in late April of 2012. The spawning location was primarily on restored/enhanced substrate created in 2008, primarily to benefit the migration of juvenile salmonids (Olympic Sculpture Park Habitat Rehabilitation). Spawn timing is also unusually late in the year for the region, with a spawn date of April 30 in 2012. The only other stock in Puget Sound with consistently documented spawning occurring this late in the season is the Cherry Point herring stock, though spawning occurs into late April in the Holmes Harbor and Interior San Juan Islands stocks. Similar to the situation for the Purdy stock in 2008, this area had not been previously sampled for herring spawn deposition, so it is possible spawning activity in Elliot Bay could have been occurring undetected. Egg samples from Elliot Bay are included in ongoing research related to stock structure of Puget Sound herring and should provide information about the genetic composition of this stock.

SPAWNING GROUND



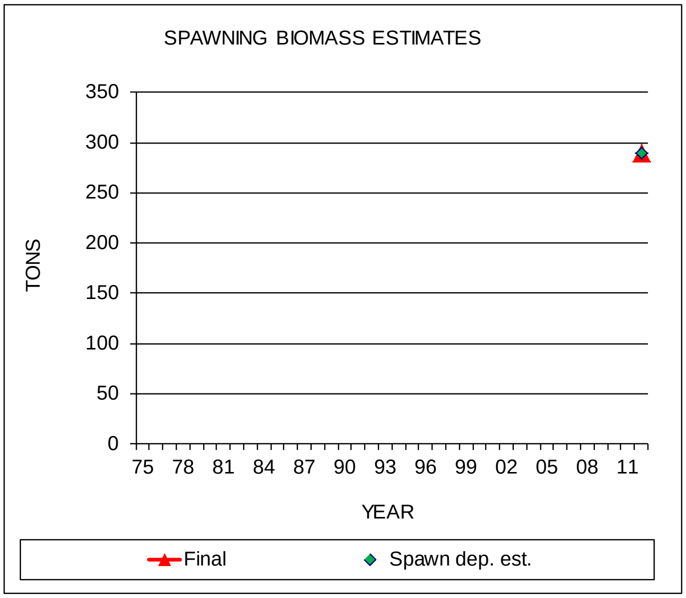
SPAWNING TIMING

Jan	Feb	March	April	May	June

STOCK STATUS PROFILE for Elliot Bay Herring Stock

STOCK ASSESSMENT

YEAR	SPAWNING BIOMASS ESTIMATES (tons)			RECRUITMENT (tons)
	SPAWN DEPOSITION SURVEYS	ACOUSTIC/ TRAWL SURVEYS	FINAL BIOMASS ESTIMATE	
1975				
1976				
1977				
1978				
1979				
1980				
1981				
1982				
1983				
1984				
1985				
1986				
1987				
1988				
1989				
1990				
1991				
1992				
1993				
1994				
1995				
1996				
1997				
1998				
1999				
2000				
2001				
2002				
2003				
2004				
2005				
2006				
2007				
2008				
2009				
2010				
2011				
2012	290		290	
MEAN:				
25 year			290	
5 year			290	



STOCK SUMMARY

2012 SPAWNER FISHERY SUMMARY
no fishery

DATA QUALITY
poor

RECENT TREND (5 year)
insufficient data

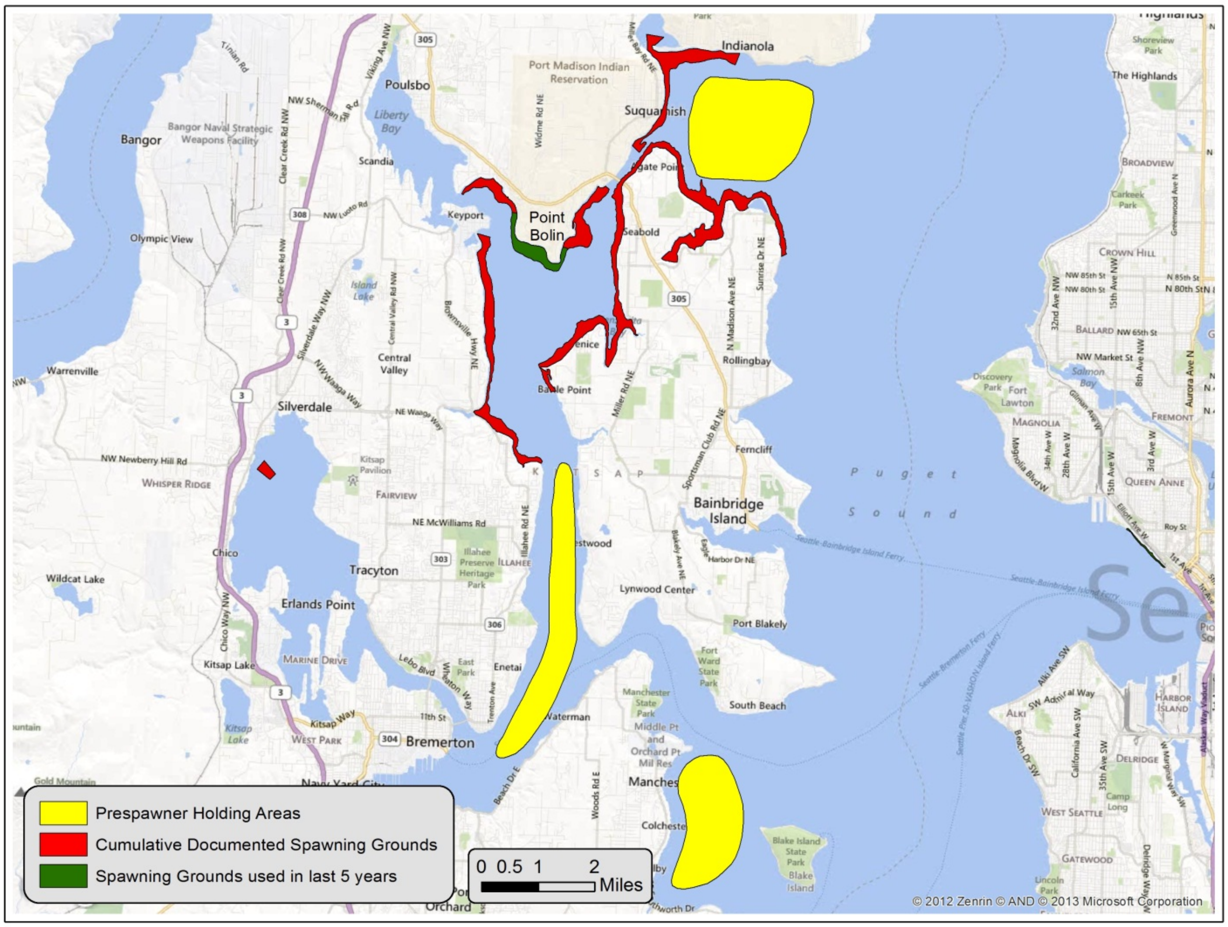
STOCK STATUS (2 year)
unknown/insufficient data

Port Orchard/Madison Herring Stock

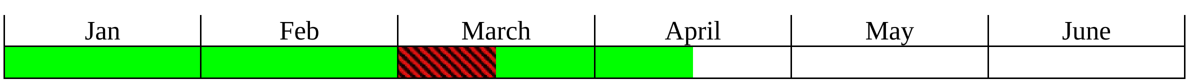
OVERVIEW

The Port Orchard/Madison herring stock abundance has apparently decreased dramatically (although not statistically significant) since 2009. This trend is likely confounded by a change in sampling methodology. Estimated spawning biomass, as measured primarily by acoustic/trawl survey, has fluctuated significantly with a low point in the early 1990s, followed by a general increase. Since 2010, however, assessment of this stock has relied on spawn deposition surveys, resulting in an order of magnitude decrease in estimated spawning biomass. Prior to their cessation, acoustic/trawl surveys noted an increase in abundance of the Yukon Harbor prespawner holding area east of Blake Island, providing some doubt regarding the spawning location of those fish. Virtually all observed spawn deposition in recent years has been in the vicinity of Point Bolin (southeast of Poulsbo).

SPAWNING GROUND



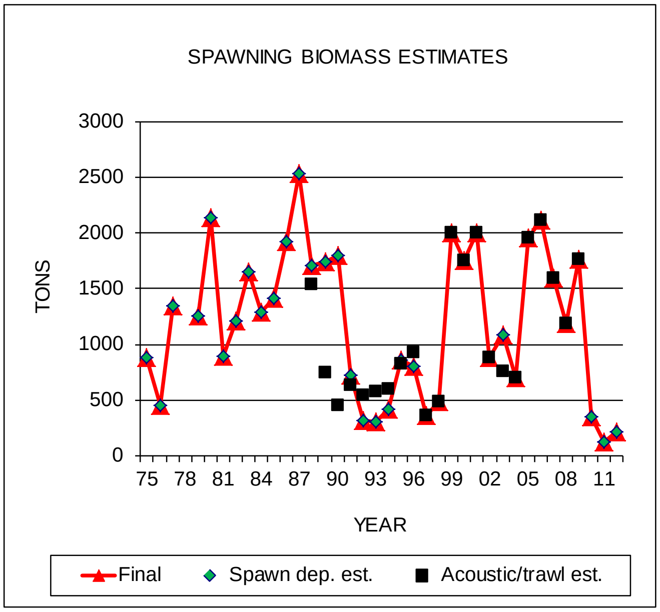
SPAWNING TIMING



STOCK STATUS PROFILE for Port Orchard/Madison Herring Stock

STOCK ASSESSMENT

YEAR	SPAWNING BIOMASS ESTIMATES (tons) SPAWN DEPOSITION SURVEYS	ACOUSTIC/ TRAWL SURVEYS	FINAL BIOMASS ESTIMATE	RECRUITMENT (tons)
1975	887		887	
1976	447		447	
1977	1348		1348	
1978				
1979	1255		1255	
1980	2133		2133	
1981	891		891	
1982	1214		1214	
1983	1651		1651	
1984	1293		1293	
1985	1415		1415	
1986	1926		1926	
1987	2538		2538	
1988	1705	1537	1705	
1989	1739	743	1739	853
1990	1795	456	1795	1123
1991	722	630	722	339
1992	314	544	314	223
1993	304	582	304	256
1994	424	596	424	104
1995	863	831	863	708
1996	806	932	806	517
1997		360	360	325
1998		489	489	439
1999		2006	2006	1809
2000		1756	1756	1139
2001		2007	2007	1770
2002		878	878	648
2003	1085	755	1085	673
2004		700	700	398
2005		1958	1958	1176
2006		2112	2112	1647
2007		1589	1589	1089
2008		1186	1186	963
2009		1768	1768	770
2010	350		350	
2011	123		123	
2012	217		217	
MEAN:				
25 year			1090	
5 year			729	



STOCK SUMMARY

2012 SPAWNER FISHERY SUMMARY
no fishery

DATA QUALITY
fair

RECENT TREND (5 year)
no significant trend

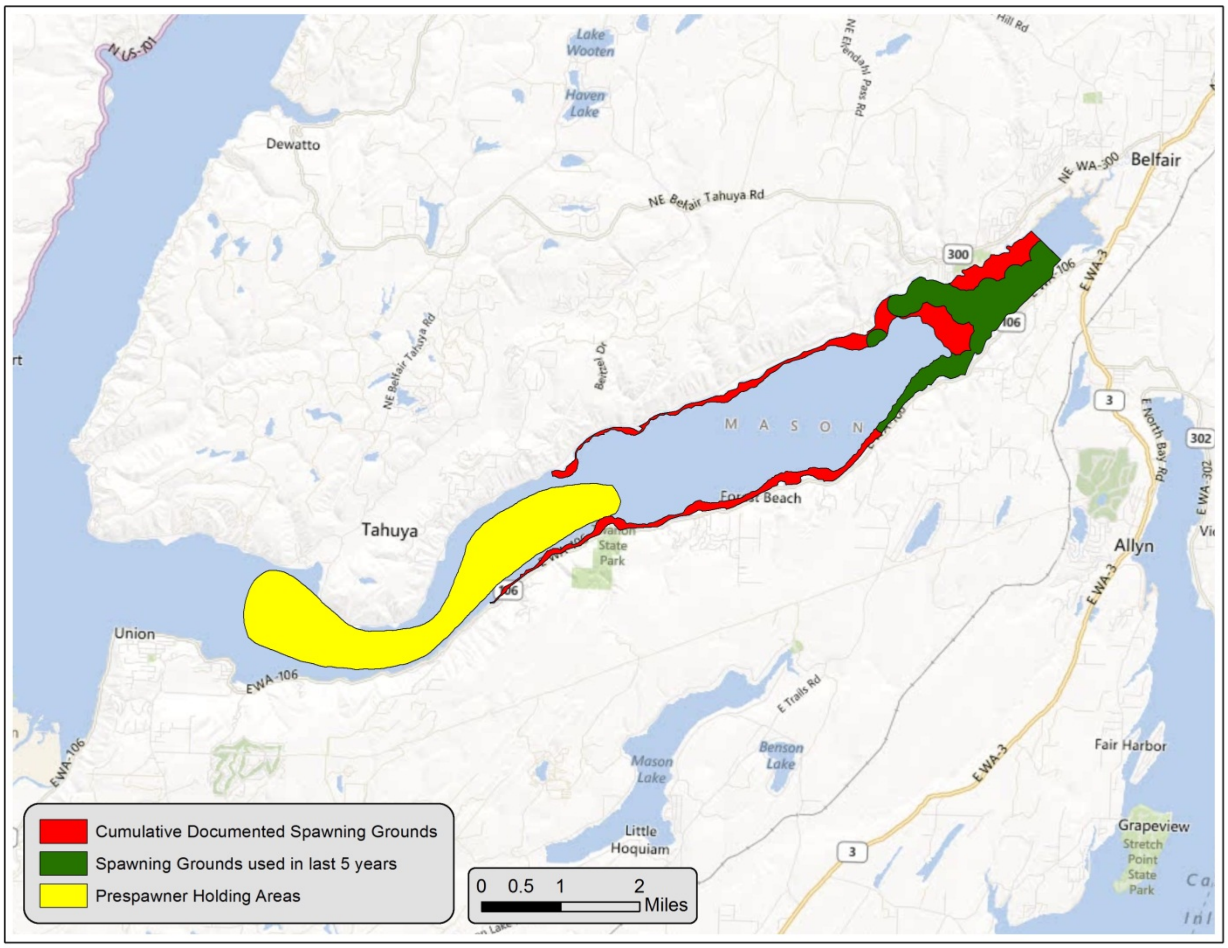
STOCK STATUS (2 year)
depressed: 16% of previous 25 yr mean spawning biomass (note survey note methodology change since 2010)

South Hood Canal Herring Stock

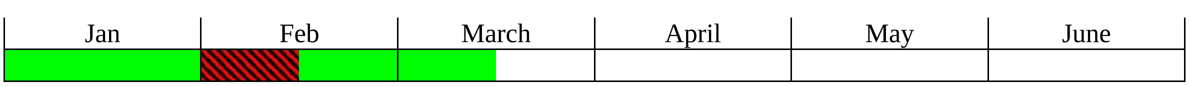
OVERVIEW

Spawning activity by this small herring stock is generally confined to Lynch Cove at the head of south Hood Canal. Spawning starts relatively early (by mid-January) and typically is finished by early March. Estimated spawning biomass averages slightly over 200 tons, with a high of 516 tons observed in 1999, and a low of 70 tons estimated in 2007. Effects of low dissolved oxygen levels in mainstem Hood Canal on the abundance of this stock are unknown. However, other than the mentioned decrease in 2007, estimated spawning biomass has been fairly stable since 2000. The location of this stock’s spawning grounds at the end of Hood Canal could contribute to genetic differentiation similar to that observed for Squaxin Pass and remote inlet “resident” herring populations in British Columbia, although stock samples have not been included in any study to date.

SPAWNING GROUND



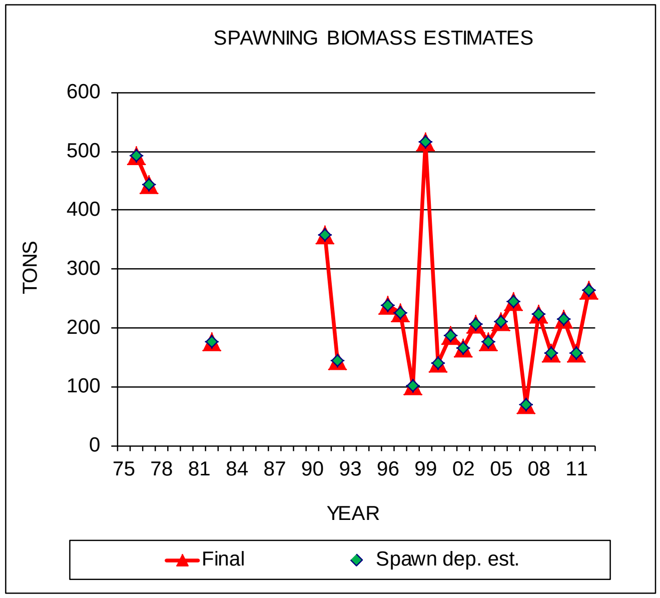
SPAWNING TIMING



STOCK STATUS PROFILE for South Hood Canal Herring Stock

STOCK ASSESSMENT

YEAR	SPAWNING BIOMASS ESTIMATES (tons): SPAWN DEPOSITION SURVEYS	ACOUSTIC/ TRAWL SURVEYS	FINAL BIOMASS ESTIMATE	RECRUITMENT (tons)
1975				
1976	492		492	
1977	444		444	
1978				
1979				
1980				
1981				
1982	177		177	
1983				
1984				
1985				
1986				
1987				
1988				
1989				
1990				
1991	357		357	
1992	144		144	
1993				
1994				
1995				
1996	239		239	
1997	226		226	
1998	101		101	
1999	516		516	
2000	140		140	
2001	187		187	
2002	166		166	
2003	207		207	
2004	176		176	
2005	210		210	
2006	244		244	
2007	70		70	
2008	223		223	
2009	156		156	
2010	214		214	
2011	156		156	
2012	264		264	
MEAN:				
25 year			210	
5 year	203		203	



STOCK SUMMARY

2012 SPAWNER FISHERY SUMMARY
no fishery

DATA QUALITY
poor

RECENT TREND (5 year)
no significant trend

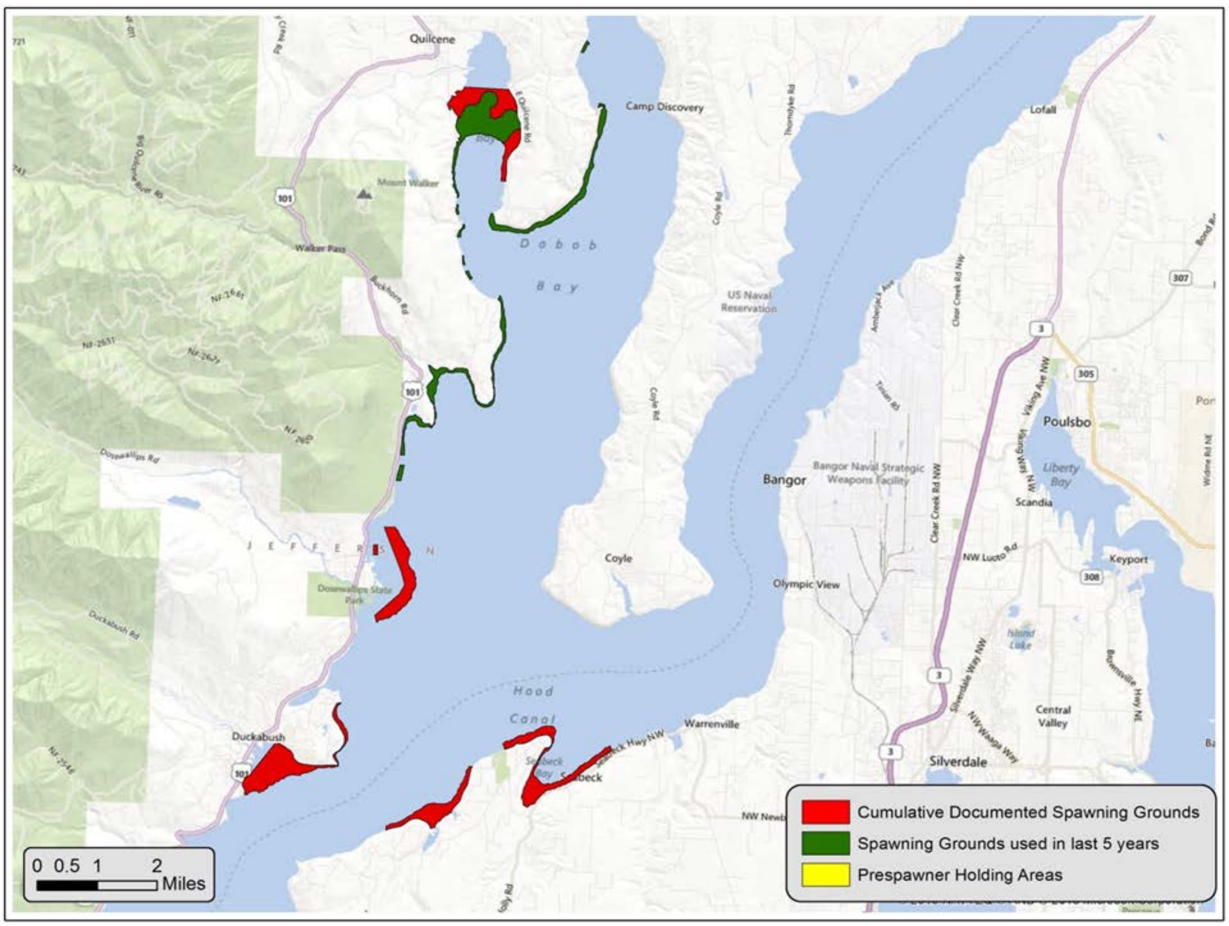
STOCK STATUS (2 year)
healthy: 100% of 25 yr mean spawning biomass

Quilcene Bay Herring Stock

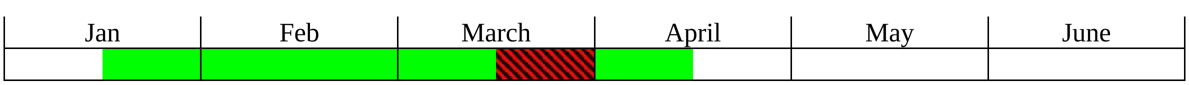
OVERVIEW

The Quilcene Bay herring stock is currently the largest in Puget Sound, with mean annual spawning biomass of almost 2,400 tons in the last ten years; 833 tons more than next largest stock in that time frame (Cherry Point). Estimated spawning biomass was particularly high in 2011 at 4,443 tons. Based primarily on fishery landings, this stock was considered to be one of the largest herring stocks in Washington waters in the 1930s through the 1950s (Chapman et al. 1941, Williams 1959), followed by a significant decrease in abundance from that time to the mid-1990s. Documented spawning grounds have been significantly expanded since 1998. Most spawn deposition in recent years has occurred at the south end of the Bolton Peninsula and the shoreline from Jackson Cove to Point Whitney. An observed inverse abundance relationship with the Port Gamble herring stock may indicate spawning stock linkage, with intermixing and straying between spawning grounds probable. Limited tagging recoveries suggest that this stock is “migratory,” with migration to summer offshore feeding grounds.

SPAWNING GROUND



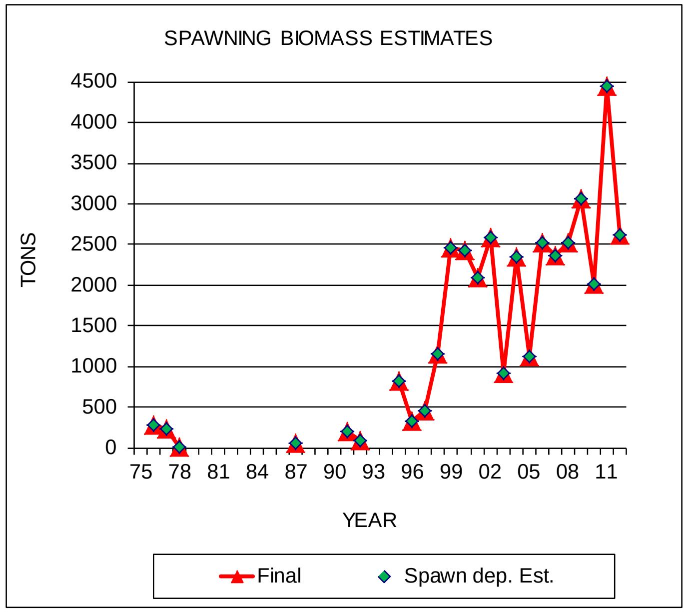
SPAWNING TIMING



STOCK STATUS PROFILE for Quilcene Bay Herring Stock

STOCK ASSESSMENT

YEAR	SPAWNING BIOMASS ESTIMATES (tons)			RECRUITMENT (tons)
	SPAWN DEPOSITION SURVEYS	ACOUSTIC TRAWL SURVEYS	FINAL BIOMASS ESTIMATE	
1975				
1976	279		279	
1977	232		232	
1978	14		14	
1979				
1980				
1981				
1982				
1983				
1984				
1985				
1986				
1987	68		68	
1988				
1989				
1990				
1991	204		204	
1992	97		97	
1993				
1994				
1995	817		817	
1996	328		328	
1997	465		465	
1998	1152		1152	
1999	2464		2464	
2000	2426		2426	
2001	2091		2091	
2002	2585		2585	
2003	916		916	
2004	2342		2342	
2005	1125		1125	
2006	2530		2530	
2007	2372		2372	
2008	2531		2531	
2009	3064		3064	
2010	2012		2012	
2011	4443		4443	
2012	2626		2626	
MEAN:				
25 year			1830	
5 year	2935		2935	



STOCK SUMMARY

2012 SPAWNER FISHERY SUMMARY
no fishery

DATA QUALITY
fair/poor

RECENT TREND (5 year)
no significant trend

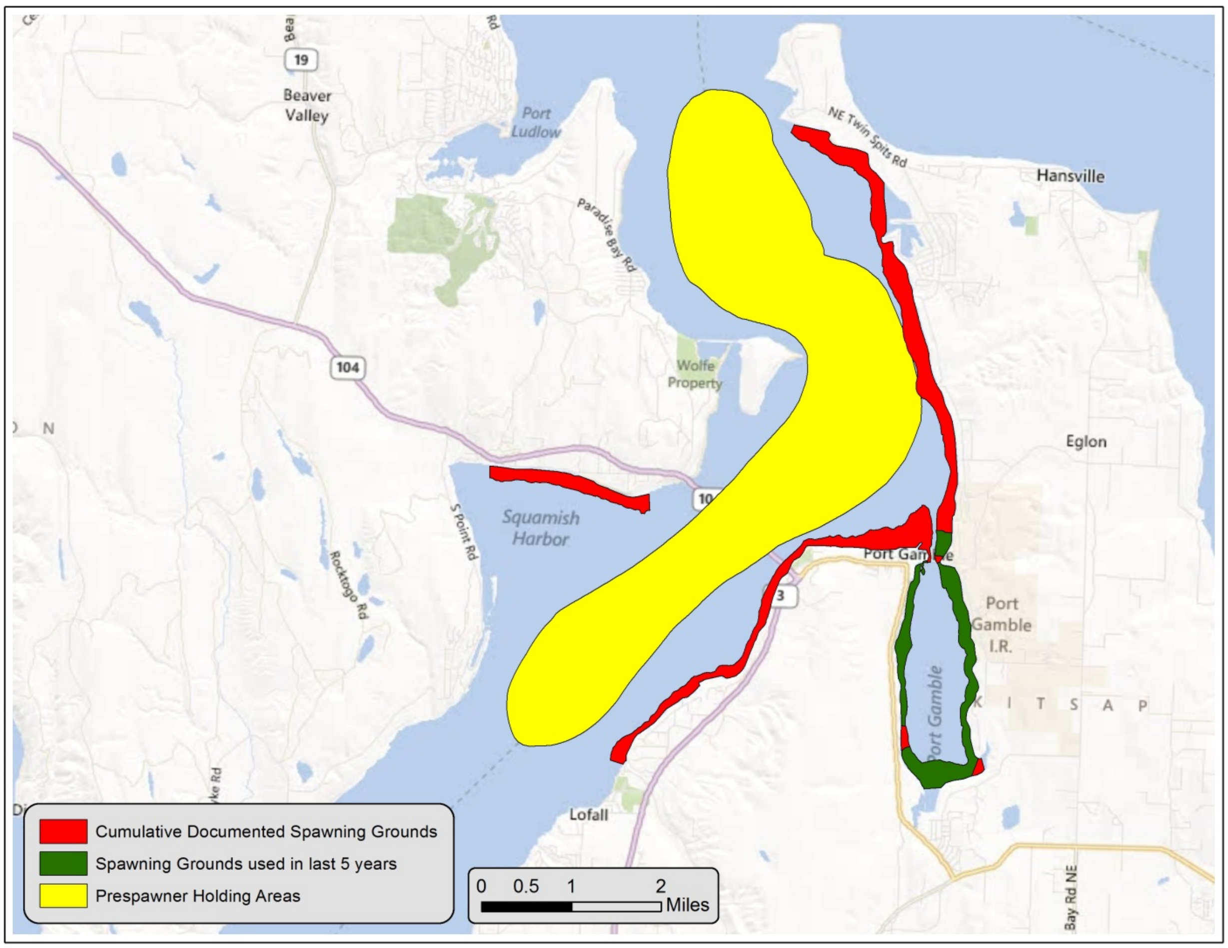
STOCK STATUS (2 year)
healthy: 193% of 25 yr mean spawning biomass

Port Gamble Herring Stock

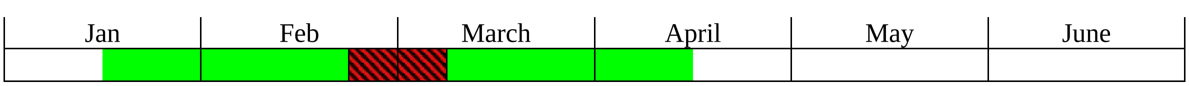
OVERVIEW

The Port Gamble herring stock has been considered one of the larger stocks in Puget Sound since quantitative survey effort began in the late 1970's. However, it has followed a decreasing trend since 2000, when the spawning biomass estimate was almost 2,500 tons. A record low of only 208 tons was estimated in 2008, but a mild upswing in abundance has followed, with a high of 1,464 tons in 2011. Spawning activity is centered in Port Gamble Bay. Abundance trends compared to Quilcene Bay stock indicate a potential linkage between the two stocks. Genetic samples from this stock have not been shown to be distinct from other Puget Sound populations (Small 2005, Mitchell 2006). Higher than average embryo mortalities of deposited herring eggs have been observed from inside Port Gamble Bay.

SPAWNING GROUND



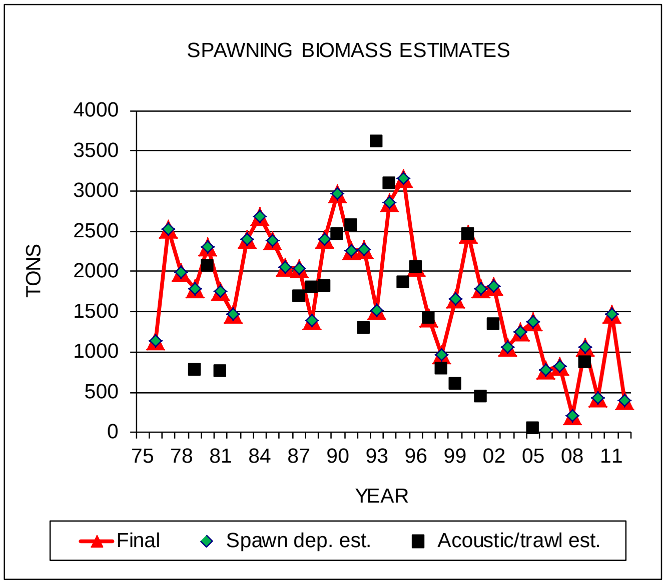
SPAWNING TIMING



STOCK STATUS PROFILE for Port Gamble Herring Stock

STOCK ASSESSMENT

YEAR	SPAWNING BIOMASS ESTIMATES (tons) SPAWN DEPOSITION SURVEYS	ACOUSTIC TRAWL SURVEYS	FINAL BIOMASS ESTIMATE	RECRUITMENT (tons)
1975				
1976	1142		1142	
1977	2525		2525	
1978	1984		1984	
1979	1790	772	1790	
1980	2309	2077	2309	
1981	1753	761	1753	
1982	1463		1463	
1983	2407		2407	
1984	2685		2685	
1985	2387		2387	
1986	2050		2050	
1987	2046	1688	2046	
1988	1390	1808	1390	980
1989	2395	1824	2395	1567
1990	2969	2470	2969	811
1991	2259	2579	2259	655
1992	2270	1291	2270	1569
1993	1521	3614	1521	1225
1994	2857	3099	2857	327
1995	3158	1862	3158	2402
1996		2058	2058	947
1997		1419	1419	1250
1998	971	792	971	346
1999	1664	608	1664	1429
2000		2459	2459	1916
2001	1779	444	1779	1526
2002	1812	1342	1812	1133
2003	1064		1064	
2004	1257		1257	
2005	1372	44	1372	
2006	774		774	
2007	826		826	
2008	208		208	
2009	1064	873	1064	
2010	433		433	
2011	1464		1464	
2012	404		404	
MEAN:				
25 year			1594	
5 year	715		715	



STOCK SUMMARY

2012 SPAWNER FISHERY SUMMARY
no fishery

DATA QUALITY
fair

RECENT TREND (5 year)
no significant trend

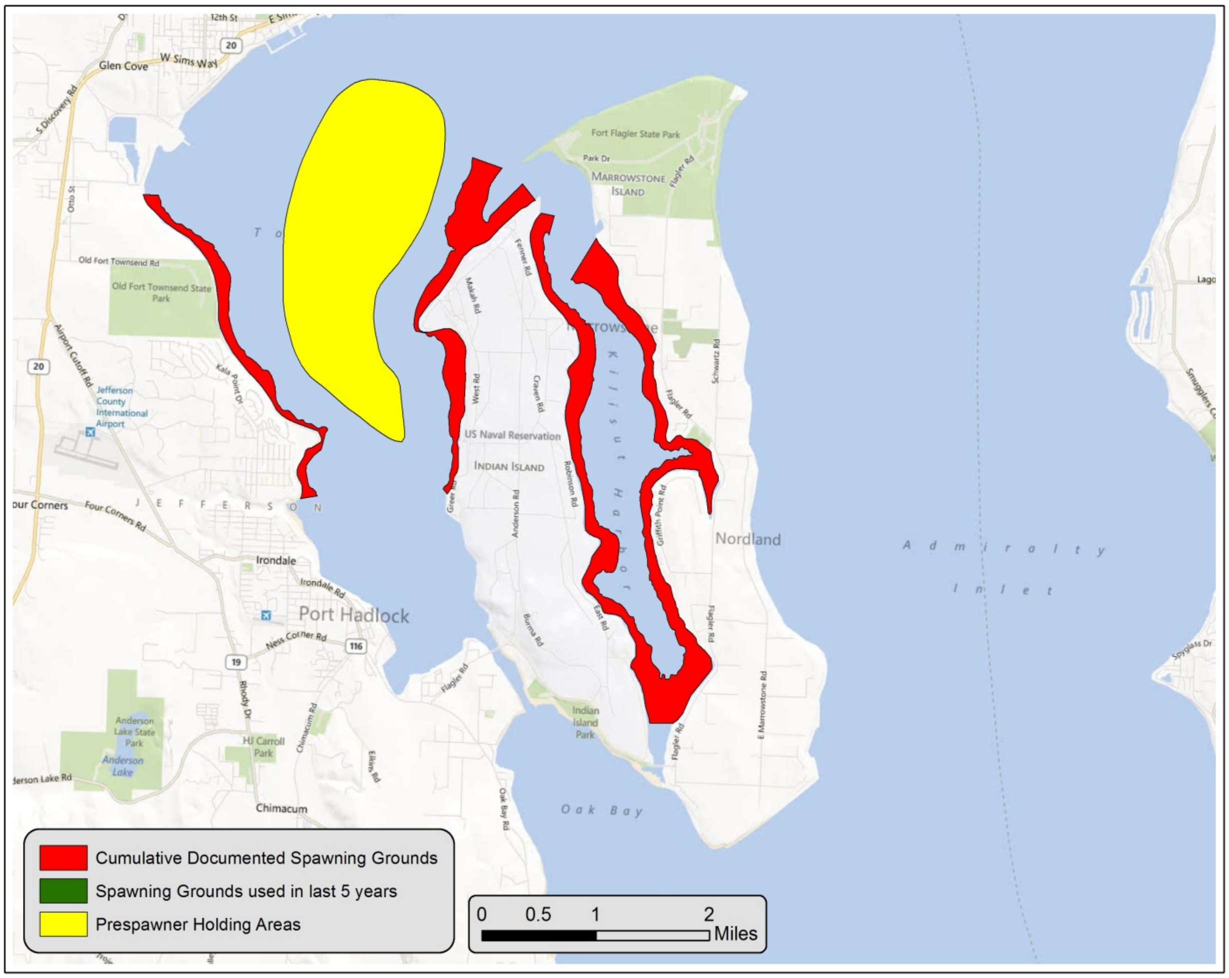
STOCK STATUS (2 year)
depressed: 59% of 25 yr mean spawning biomass

Kilisut Harbor Herring Stock

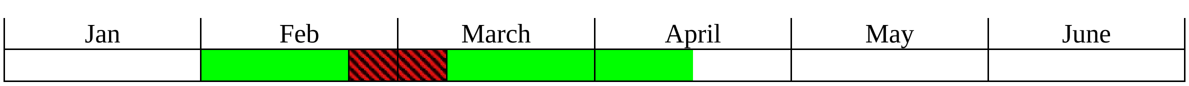
OVERVIEW

No spawning activity has been documented for the Kilisut Harbor stock since 2007. Traditionally spawning for this stock ran from early February to early April, with peak spawning in March. Growth characteristics are average for Puget Sound. Estimated spawning biomass for this stock quickly decreased since 2002. A sample from this stock was included in one genetic study (Beacham et al. 2008) and significant genetic differentiation was observed between this stock and the Cherry Point stock, with no significant difference compared to the Skagit Bay stock. This finding suggests gene flow between this stock and others in Puget Sound.

SPAWNING GROUND



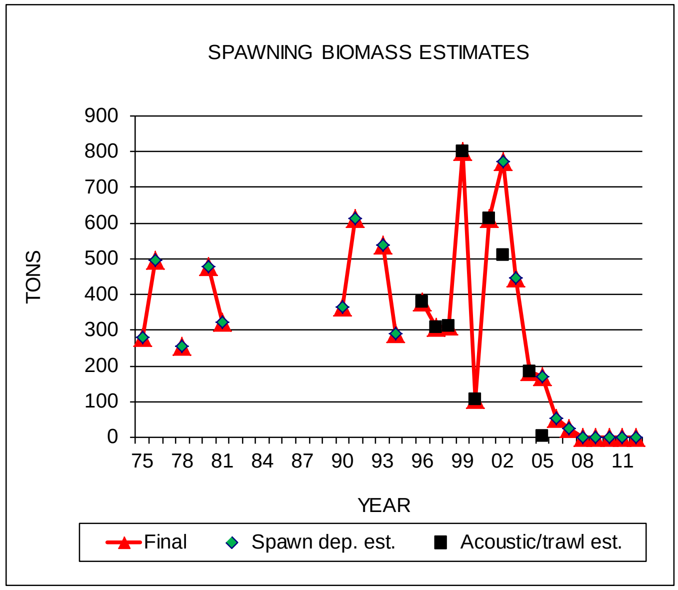
SPAWNING TIMING



STOCK STATUS PROFILE for Kilisut Harbor Herring Stock

STOCK ASSESSMENT

YEAR	SPAWNING BIOMASS ESTIMATES (tons) SPAWN DEPOSITION SURVEYS	ACOUSTIC/ TRAWL SURVEYS	FINAL BIOMASS ESTIMATE	RECRUITMENT (tons)
1975	279		279	
1976	495		495	
1977				
1978	254		254	
1979				
1980	477		477	
1981	324		324	
1982				
1983				
1984				
1985				
1986				
1987				
1988				
1989				
1990	364		364	
1991	613		613	
1992				
1993	538		538	
1994	292		292	
1995				
1996		380	380	
1997		307	307	0
1998		311	311	170
1999		802	802	792
2000		107	107	107
2001		612	612	393
2002	774	510	774	629
2003	448		448	
2004		184	184	
2005	170	5	170	120
2006	54		54	
2007	24		24	
2008	0		0	
2009	0		0	
2010	0		0	
2011	0		0	
2012	0		0	
MEAN:				
25 year			285	
5 year	0		0	



STOCK SUMMARY

2012 SPAWNER FISHERY SUMMARY
no fishery

DATA QUALITY
fair/poor

RECENT TREND (5 year)
no observed spawning escapement

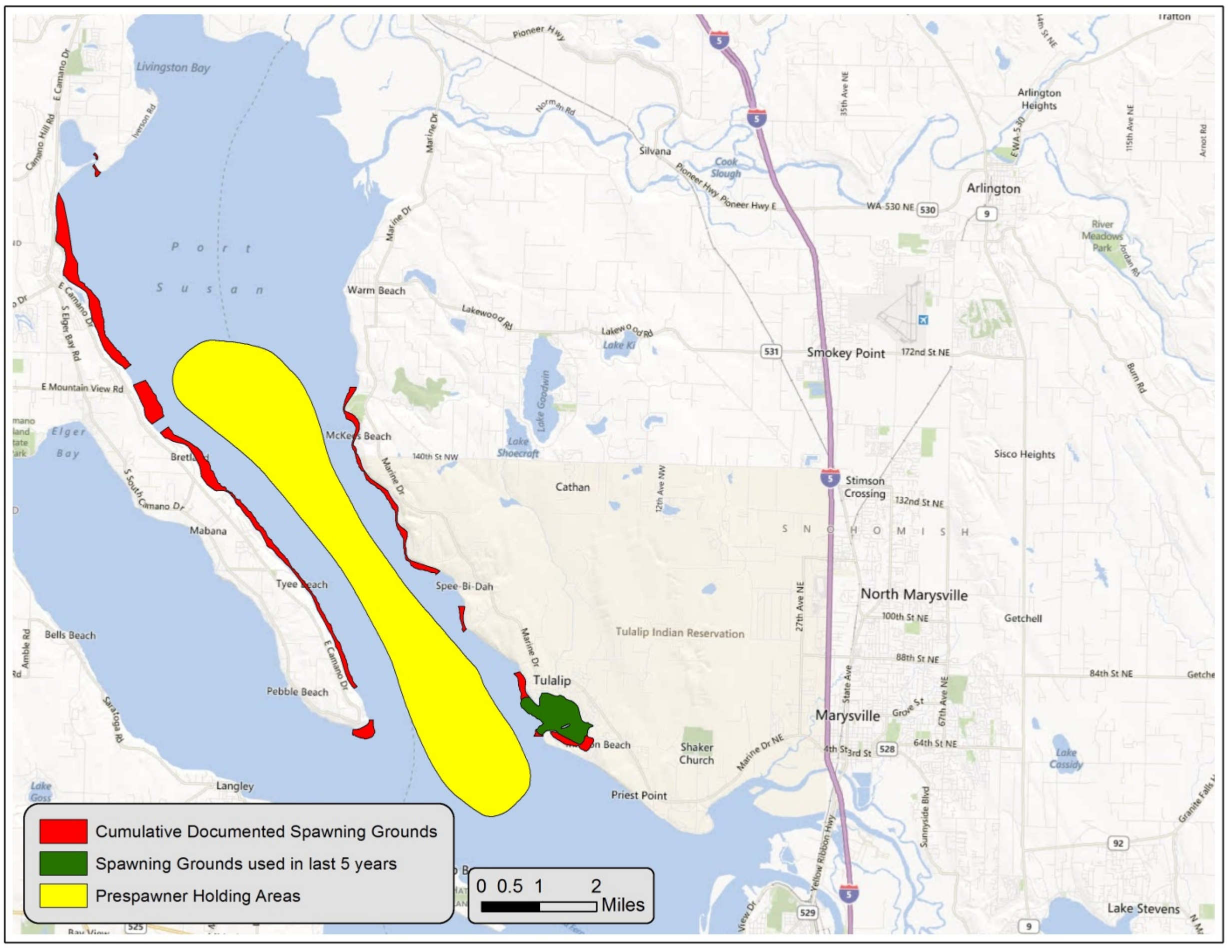
STOCK STATUS (2 year)
disappearance: 0% of 25 yr mean spawning biomass

Port Susan Herring Stock

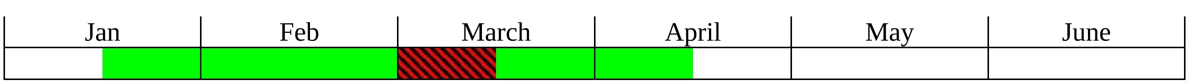
OVERVIEW

The Port Susan herring stock often deposits significant spawn on rocks and gravel. Outside of Tulalip Bay, where most observed spawn deposition has been located, marine algae normally used by herring as spawning substrate are sparse. This behavior makes acoustic/trawl survey assessment the method of choice for this stock, although successful location of prespawner aggregations has been sporadic. Estimated spawning biomass, via spawn deposition surveys, was a record low in 2012 and current stock classification is depressed. All observed spawn deposition in recent years has been in/near Tulalip Bay.

SPAWNING GROUND



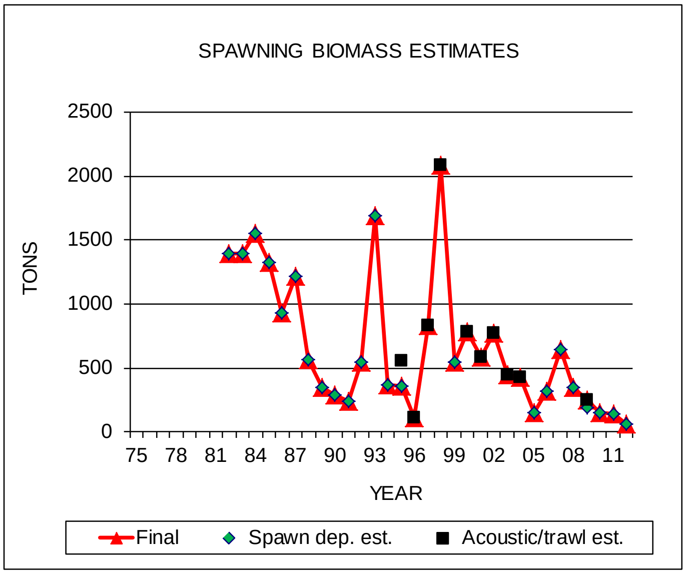
SPAWNING TIMING



STOCK STATUS PROFILE for Port Susan Herring Stock

STOCK ASSESSMENT

YEAR	SPAWNING BIOMASS ESTIMATES (tons) SPAWN DEPOSITION SURVEYS	ACOUSTIC/ TRAWL SURVEYS	FINAL BIOMASS ESTIMATE	RECRUITMENT (tons)
1975				
1976				
1977				
1978				
1979				
1980				
1981				
1982	1391		1391	
1983	1398		1398	
1984	1555		1555	
1985	1321		1321	
1986	934		934	
1987	1216		1216	
1988	570		570	
1989	345		345	
1990	291		291	
1991	245		245	
1992	545		545	
1993	1693		1693	
1994	365		365	
1995	363	557	363	
1996		110	110	75
1997		828	828	670
1998		2084	2084	1276
1999	545		545	
2000		785	785	
2001		587	587	557
2002		775	775	72
2003		450	450	374
2004		429	429	154
2005	157		157	
2006	321		321	
2007	643		643	
2008	345		345	
2009	193	252	252	
2010	152		152	
2011	138		138	
2012	61		61	
MEAN:				
25 year			523	
5 year	178		190	



STOCK SUMMARY

2012 SPAWNER FISHERY SUMMARY
no fishery

DATA QUALITY
fair

RECENT TREND (5 year)
decreasing

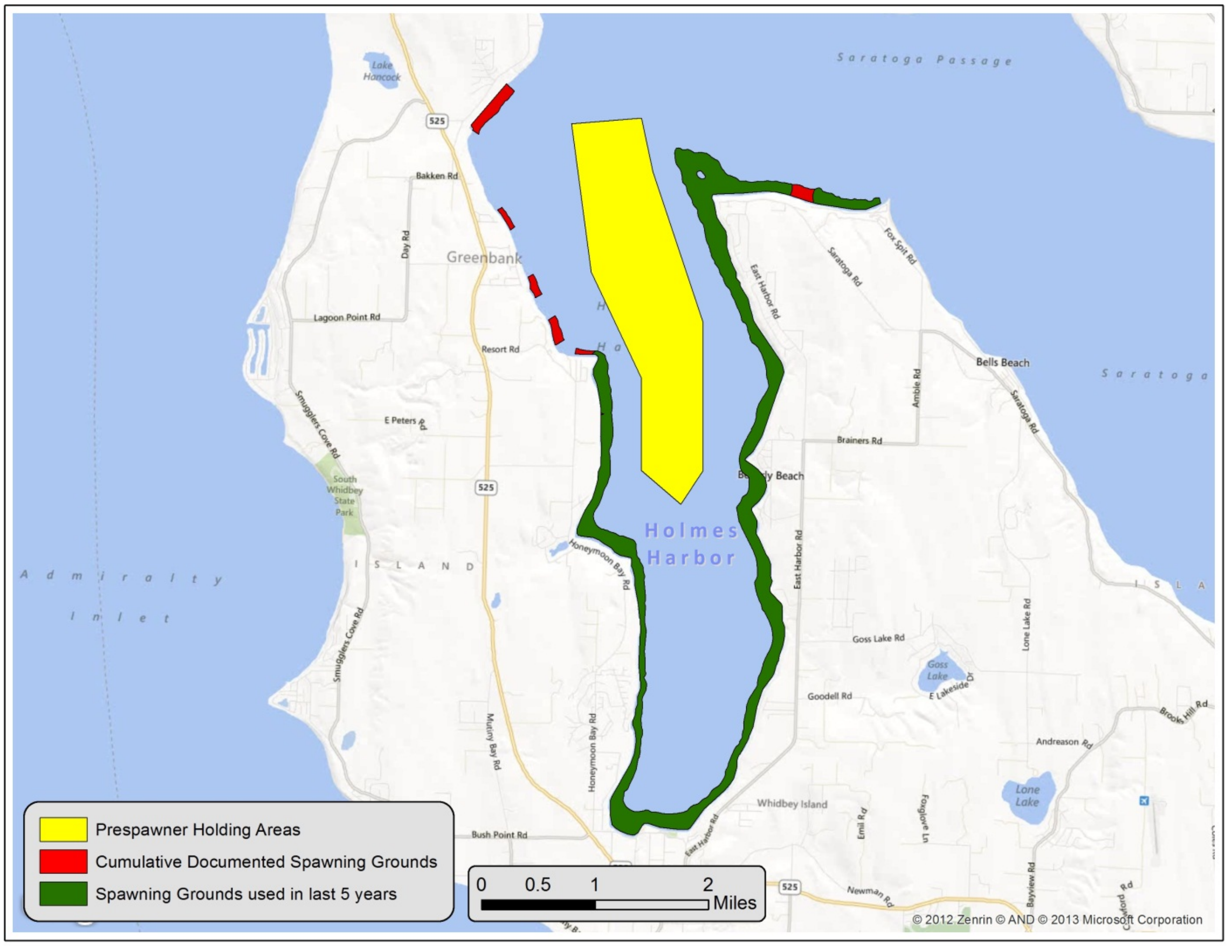
STOCK STATUS (2 year)
depressed: 19% of 25 yr mean spawning biomass

Holmes Harbor Herring Stock

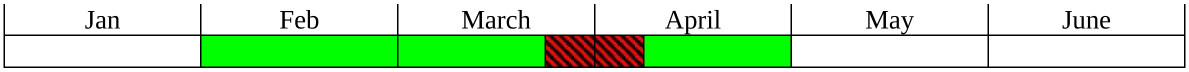
OVERVIEW

Currently one of the largest Puget Sound herring stocks, estimated spawning biomass for the Holmes Harbor stock has been relatively high since the early 2000s. The peak of more than 3,000 tons in 2011 is an order of magnitude larger than the mean spawning biomass of 343 tons between 1976 and 2001. Along with the Quilcene Bay stock, this stock was considered to be the largest in Washington waters prior to the start of quantitative surveys in the 1970s, as reported by Chapman et al. (1941), Cleaver and Franett (1946), and Williams (1959). This conclusion was based mainly on fishery observations and landings (brush weir/trap) that reached as high as 358 tons in 1937. Limited tag recoveries of adult fish at Swiftsure Bank off the southwest tip of Vancouver Island in the summer and in early winter reduction fisheries in the southeast Vancouver Island region, suggests that the Holmes Harbor stock is migratory.

SPAWNING GROUND



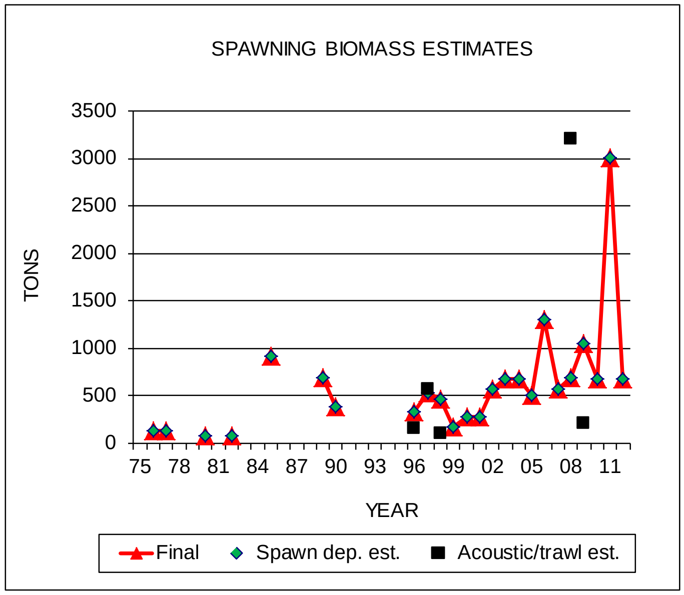
SPAWNING TIMING



STOCK STATUS PROFILE for Holmes Harbor Herring Stock

STOCK ASSESSMENT

YEAR	SPAWNING BIOMASS ESTIMATES (tons) SPAWN DEPOSITION SURVEYS	ACOUSTIC/ TRAWL SURVEYS	FINAL BIOMASS ESTIMATE	RECRUITMENT (tons)
1975				
1976	126		126	
1977	135		135	
1978				
1979				
1980	78		78	
1981				
1982	78		78	
1983				
1984				
1985	914		914	
1986				
1987				
1988				
1989	693		693	
1990	380		380	
1991				
1992				
1993				
1994				
1995				
1996	336	160	336	
1997	530	571	530	328
1998	464	97	464	141
1999	175		175	
2000	281		281	
2001	275		275	
2002	573		573	
2003	678		678	
2004	673		673	
2005	498		498	
2006	1297		1297	
2007	572		572	
2008	686	3213	686	
2009	1045	211	1045	
2010	673		673	
2011	3003		3003	
2012	678		678	
MEAN:				
25 year			711	
5 year	1217		1217	



STOCK SUMMARY

2012 SPAWNER FISHERY SUMMARY
no fishery

DATA QUALITY
fair

RECENT TREND (5 year)
no significant trend

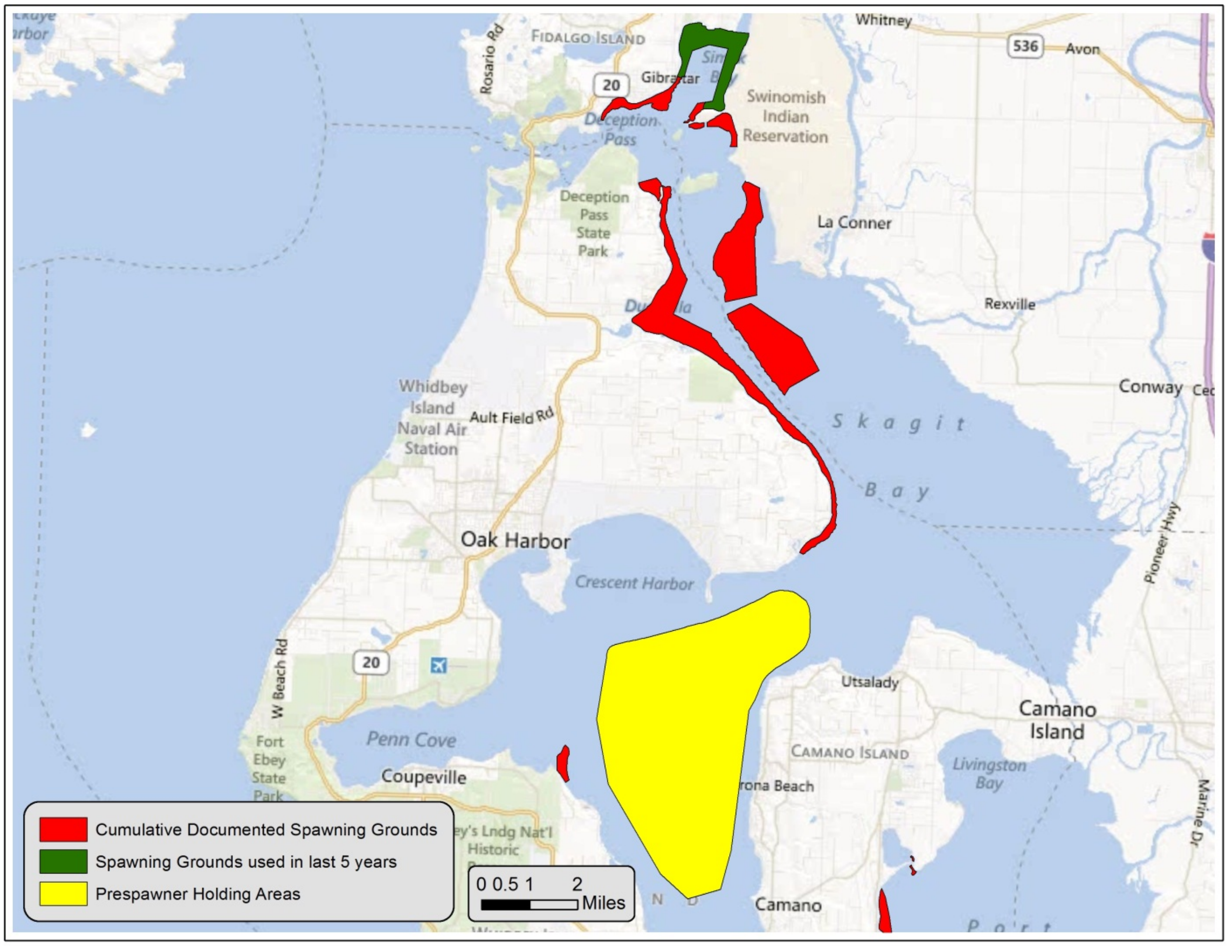
STOCK STATUS (2 year)
healthy: 259% of 25 yr mean spawning biomass

Skagit Bay Herring Stock

<u>OVERVIEW</u>

Estimated spawning biomass for the Skagit Bay stock since 2009 (i.e., the last season an acoustic/trawl survey was conducted) has dropped by over 50% to less than 500 tons. This apparent decrease is likely the result of a change in assessment methodology and may not reflect an actual change in stock abundance. Observed spawn deposition in recent years has been confined to Similk Bay. The close proximity to the prespawner holding area and spawning grounds of the Holmes Harbor stock, and reasonably similar spawn timing make it likely that intermixing of these two stocks occurs, although spawn timing is typically earlier for the Skagit Bay stock.

<u>SPAWNING GROUND</u>



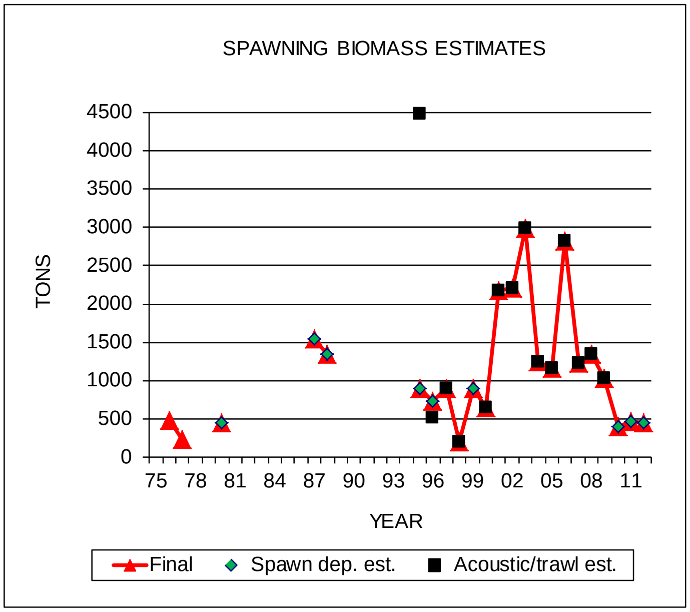
<u>SPAWNING TIMING</u>

Jan	Feb	March	April	May	June

STOCK STATUS PROFILE for Skagit Bay Herring Stock

STOCK ASSESSMENT

YEAR	SPAWNING BIOMASS ESTIMATES (tons): SPAWN DEPOSITION SURVEYS	ACOUSTIC/ TRAWL SURVEYS	FINAL BIOMASS ESTIMATE	RECRUITMENT (tons)
1975				
1976			478	
1977			227	
1978				
1979				
1980	453		453	
1981				
1982				
1983				
1984				
1985				
1986				
1987	1552		1552	
1988	1340		1340	
1989				
1990				
1991				
1992				
1993				
1994				
1995	891	4480	891	
1996	736	521	736	736
1997		893	893	892
1998		209	209	31
1999	905		905	
2000		646	646	
2001		2170	2170	1309
2002		2215	2215	1212
2003		2983	2983	2517
2004		1245	1245	692
2005		1169	1169	462
2006		2826	2826	2275
2007		1236	1236	556
2008		1342	1342	1047
2009		1036	1036	747
2010	402		402	
2011	469		469	
2012	443		443	
MEAN:				
25 year			1219	
5 year			738	



STOCK SUMMARY

2012 SPAWNER FISHERY SUMMARY
no fishery

DATA QUALITY
fair

RECENT TREND (5 year)
no significant trend

STOCK STATUS (2 year)
depressed: 37% of 25 yr mean spawning biomass (note survey note methodology change since 2010)

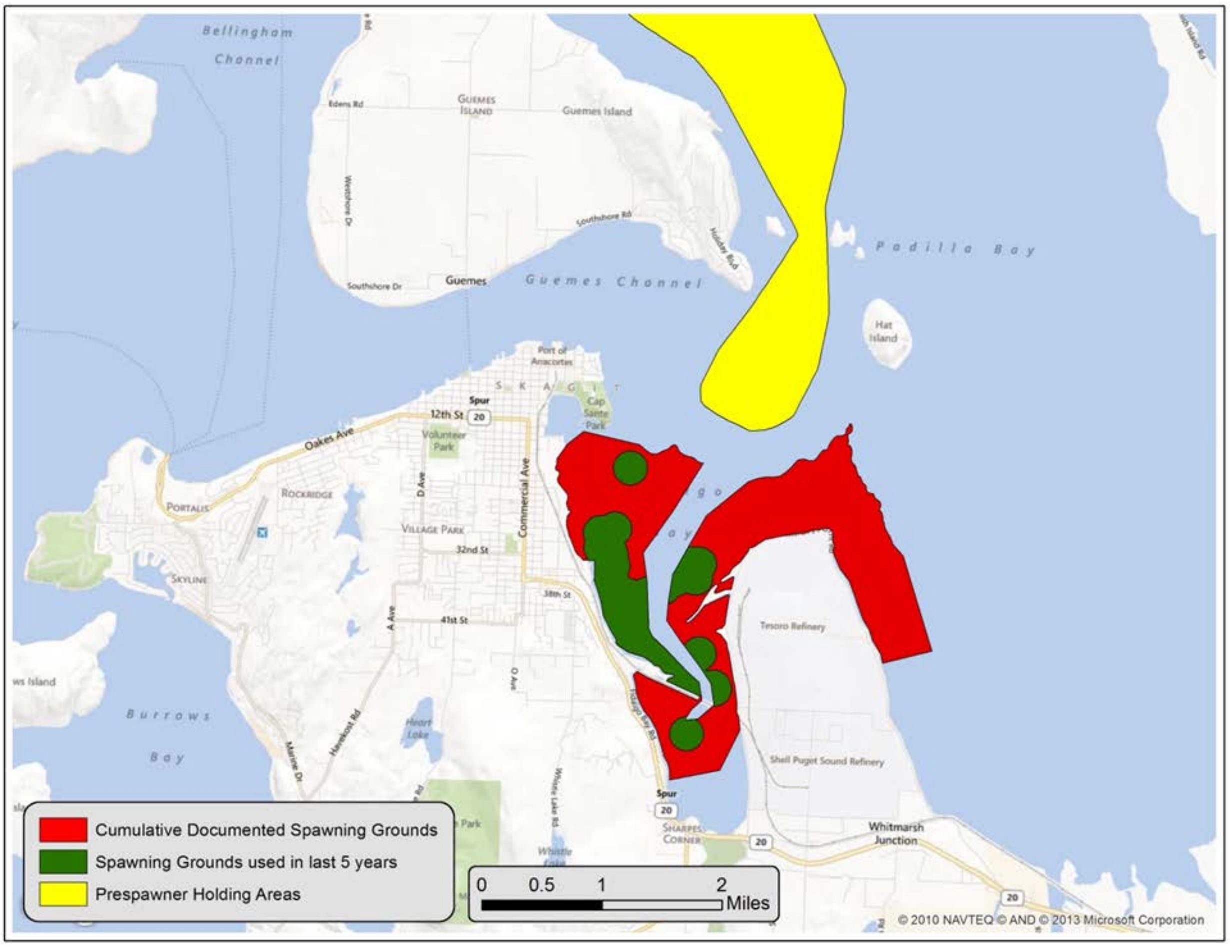
North Puget Sound Herring Stock Profiles

Fidalgo Bay Herring Stock

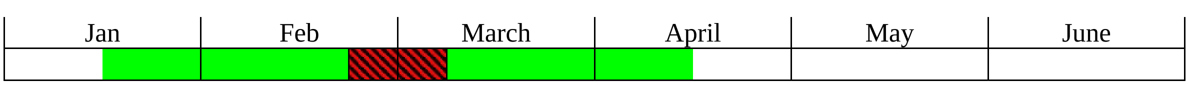
OVERVIEW

Formerly considered to be a medium-sized north Puget Sound herring stock, the Fidalgo Bay stock has decreased substantially in recent years. Annual spawning biomass estimates have generally decreased each year since 2001, and dropped below 100 tons twice. Compared to the previous 25 year mean spawning biomass, the 2012 status is very depressed. The proximity of its spawning grounds to oil refinery activities at March Point make its status of particular interest. Spawn deposition takes place at very low densities over the large shallow eelgrass flats that encompass much of the bay. One sample of Fidalgo Bay herring from 1999 was not genetically differentiated from other Puget Sound stocks, except the Cherry Point and Squaxin Pass stocks (Small 2005).

SPAWNING GROUND



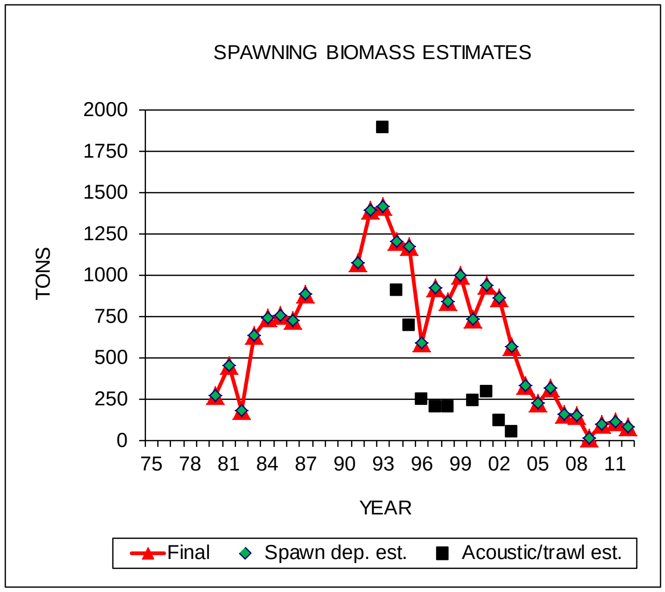
SPAWNING TIMING



STOCK STATUS PROFILE for Fidalgo Bay Herring Stock

STOCK ASSESSMENT

YEAR	SPAWNING BIOMASS ESTIMATES (tons) SPAWN DEPOSITION SURVEYS	ACOUSTIC/ TRAWL SURVEYS	FINAL BIOMASS ESTIMATE	RECRUITMENT (tons)
1975				
1976				
1977				
1978				
1979				
1980	276		276	
1981	456		456	
1982	182		182	
1983	640		640	
1984	742		742	
1985	761		761	
1986	731		731	
1987	887		887	
1988				
1989				
1990				
1991	1079		1079	
1992	1399		1399	
1993	1417	1896	1417	1206
1994	1207	912	1207	590
1995	1173	702	1173	882
1996	590	255	590	273
1997	929	208	929	800
1998	844	206	844	680
1999	1005		1005	
2000	737	246	737	
2001	944	296	944	500
2002	865	124	865	737
2003	569	55	569	49
2004	339		339	
2005	231		231	
2006	323		323	
2007	159		159	
2008	156		156	
2009	15		15	
2010	103		103	
2011	119		119	
2012	89		89	
MEAN:				
25 year			777	
5 year	242		242	



STOCK SUMMARY

2012 SPAWNER FISHERY SUMMARY
no fishery

DATA QUALITY
fair

RECENT TREND (5 year)
no significant trend

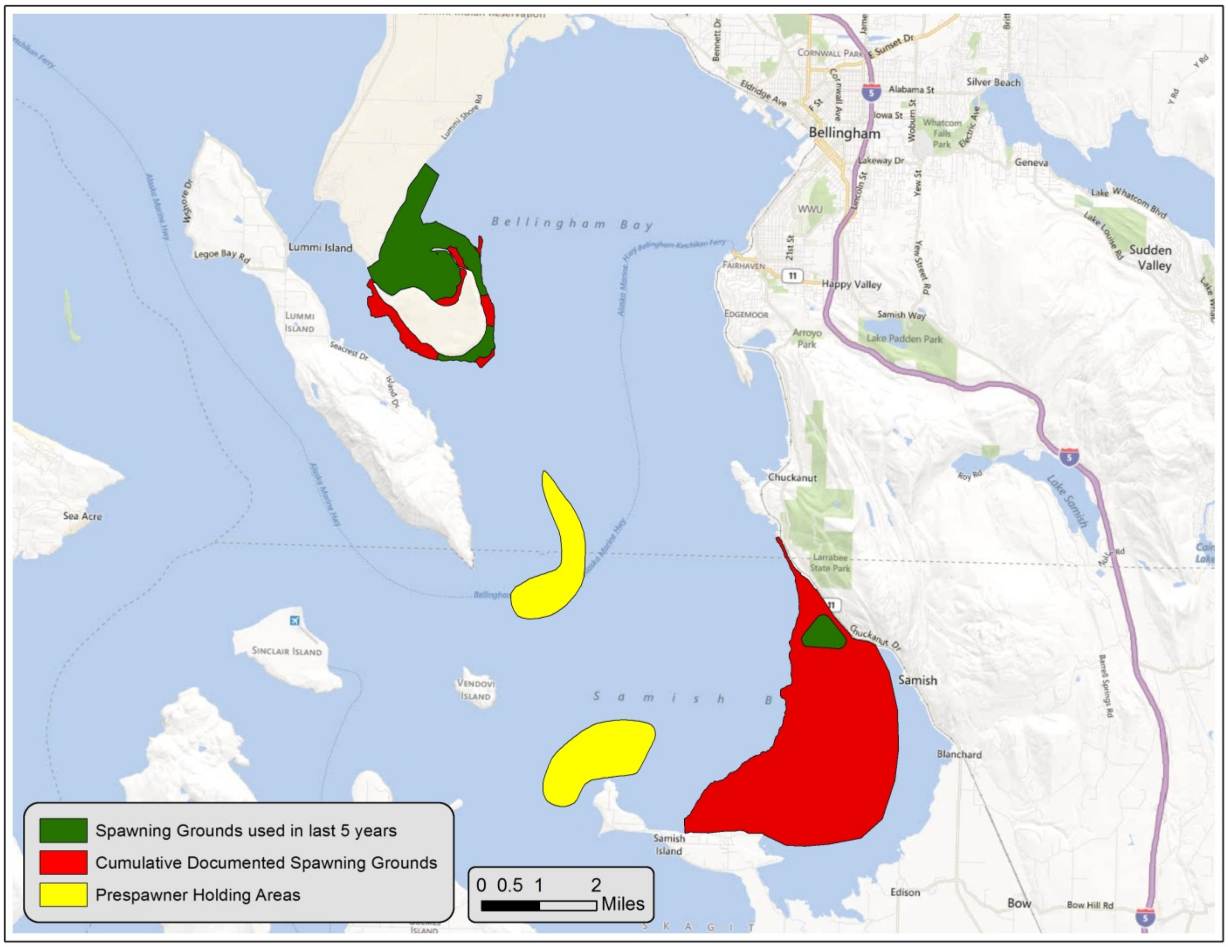
STOCK STATUS (2 year)
depressed: 16% of previous 25 yr mean spawning biomass

Samish/Portage Bay Herring Stock

OVERVIEW

Spawning by this north Puget Sound stock occurs in both Samish Bay and Portage Bay, though almost all spawning activity in recent years has been observed in the Portage Bay portion of its documented spawning grounds. Spawning activity typically occurs from early February to late March. Some of this stock's spawning grounds overlap with those of the later spawning Cherry Point stock on the east side of Hale Passage. This stock has been considered moderately healthy or healthy since stock status classification began in 1994, and continues to be classified as healthy today.

SPAWNING GROUND



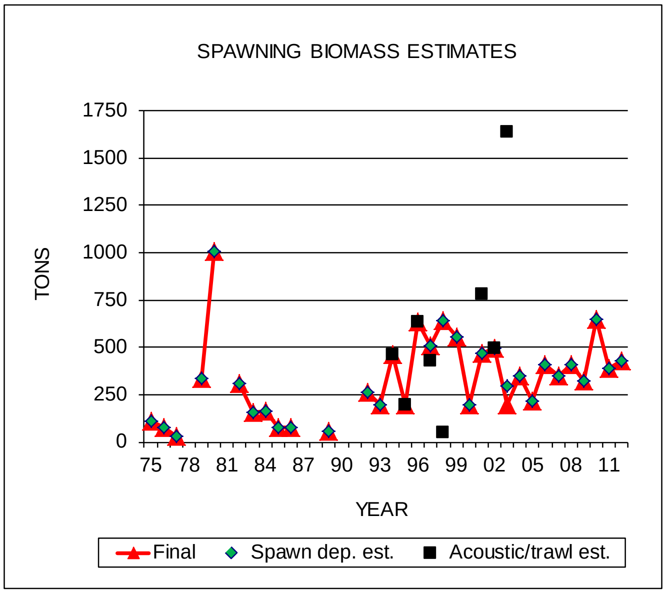
SPAWNING TIMING

Jan	Feb	March	April	May	June

STOCK STATUS PROFILE for Samish/Portage Bay Herring Stock

STOCK ASSESSMENT

YEAR	SPAWNING BIOMASS ESTIMATES (tons) SPAWN DEPOSITION SURVEYS	ACOUSTIC/ TRAWL SURVEYS	FINAL BIOMASS ESTIMATE	RECRUITMENT (tons)
1975	109		109	
1976	77		77	
1977	32		32	
1978				
1979	333		333	
1980	1008		1008	
1981				
1982	310		310	
1983	159		159	
1984	160		160	
1985	78		78	
1986	79		79	
1987				
1988				
1989	58		58	
1990				
1991				
1992	262		262	
1993	198		198	
1994		459	459	
1995		194	194	66
1996		636	636	487
1997	509	431	509	452
1998	643	48	643	419
1999	555		555	
2000	196		196	
2001	470	778	470	
2002	496	497	496	283
2003	299	1638	199	20
2004	351		351	
2005	218		218	
2006	412		412	
2007	348		348	
2008	409		409	
2009	320		320	
2010	649		649	
2011	387		387	
2012	430		430	
MEAN:				
25 year			382	
5 year	439		439	



STOCK SUMMARY

2012 SPAWNER FISHERY SUMMARY
no fishery

DATA QUALITY
fair

RECENT TREND (5 year)
no significant trend

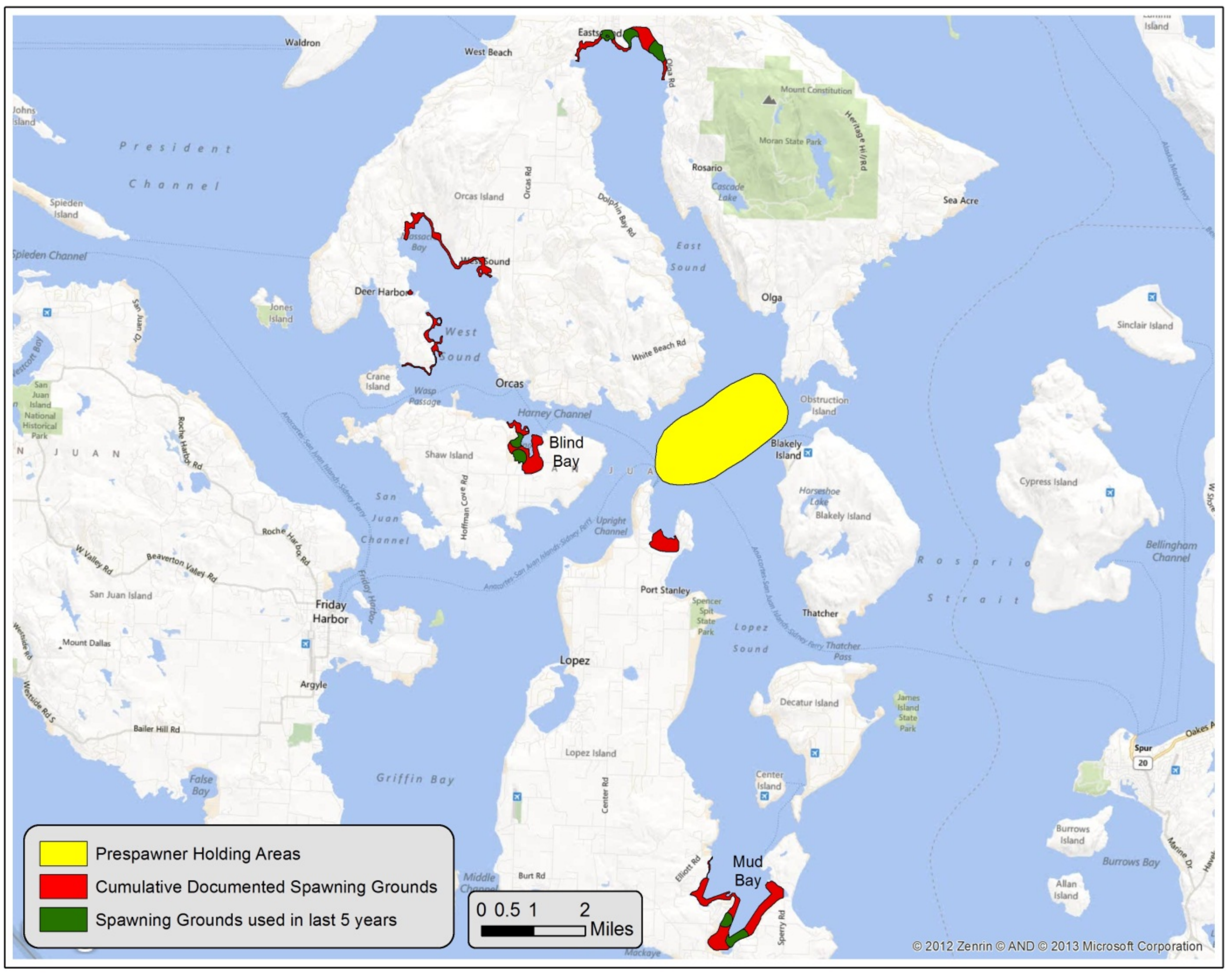
STOCK STATUS (2 year)
healthy: 107% of 25 yr mean spawning biomass

Interior San Juan Islands Herring Stock

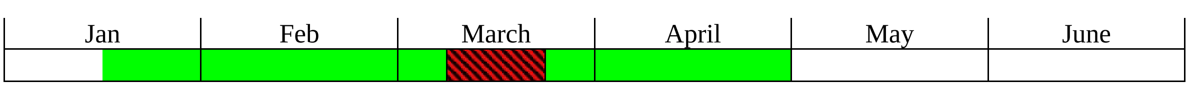
OVERVIEW

The Interior San Juan Islands herring stock is small with spawning grounds in several separate areas and one known prespawner holding area near Harney Channel. Documented spawning grounds include West Sound and East Sound (Orcas Island), Mud Bay (Lopez Island), and Blind Bay (Shaw Island) with most spawn deposition observed in East Sound in recent years. Spawning activity for this stock appears to be somewhat intermittent and does appear to necessarily occur annually. Significant portions of eelgrass beds in Blind Bay previously used for spawning have disappeared. Spawning activity has been documented into late April. Current spawning biomass currently appears to be low, although it should be noted that sampling effort has been sporadic for this stock's spawning grounds.

SPAWNING GROUND



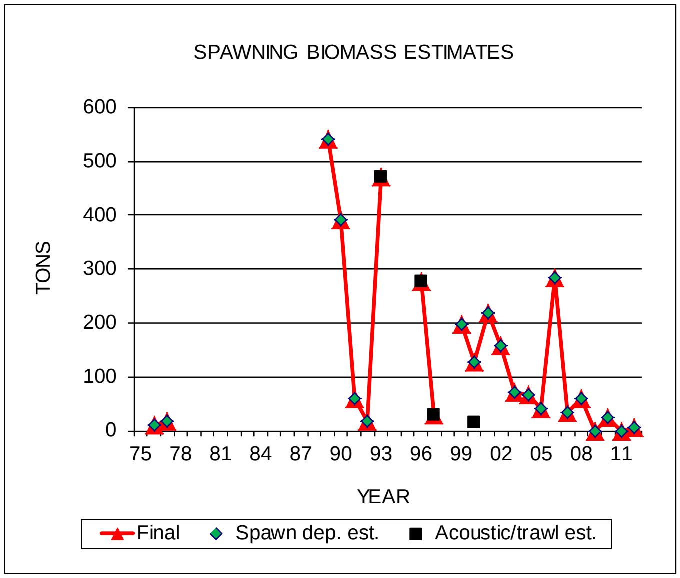
SPAWNING TIMING



STOCK STATUS PROFILE for Interior San Juan Islands Herring Stock

STOCK ASSESSMENT

YEAR	SPAWNING BIOMASS ESTIMATES (tons) SPAWN DEPOSITION SURVEYS	ACOUSTIC/ TRAWL SURVEYS	FINAL BIOMASS ESTIMATE	RECRUITMENT (tons)
1975				
1976	10		10	
1977	18		18	
1978				
1979				
1980				
1981				
1982				
1983				
1984				
1985				
1986				
1987				
1988				
1989	541		541	
1990	391		391	
1991	60		60	
1992	17		17	
1993		472	472	
1994				
1995				
1996		277	277	
1997		30	30	30
1998				
1999	197		197	
2000	128	16	128	
2001	218		219	
2002	158		158	
2003	72		72	
2004	67		67	
2005	41		41	
2006	285		285	
2007	33		33	
2008	60		60	
2009	0		0	
2010	24		24	
2011	0		0	
2012	5		5	
MEAN:				
25 year			147	
5 year	97		97	



STOCK SUMMARY

2012 SPAWNER FISHERY SUMMARY
no fishery

DATA QUALITY
poor

RECENT TREND (5 year)
no significant trend

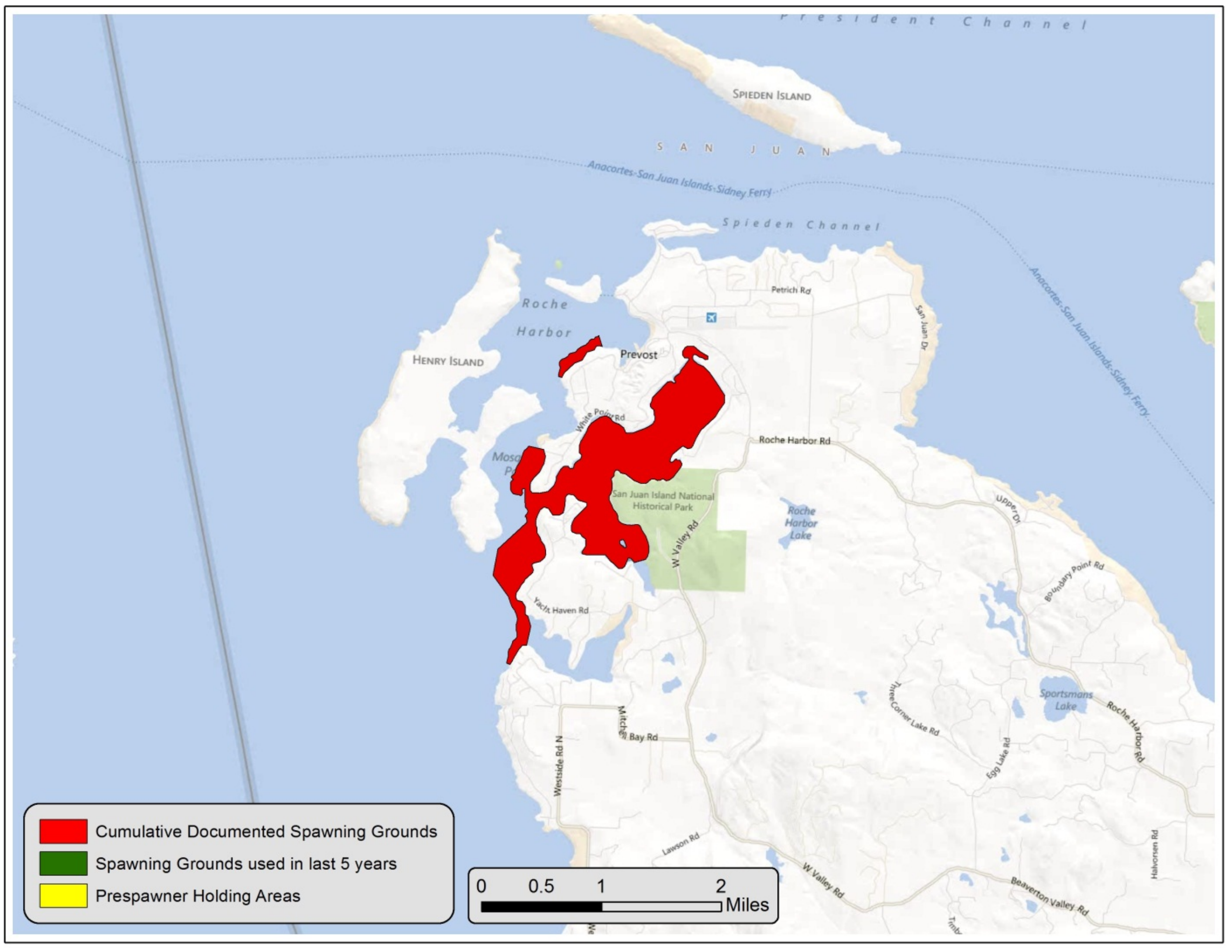
STOCK STATUS (2 year)
depressed: 2% of 25 yr mean spawning biomass

Northwest San Juan Island Herring Stock

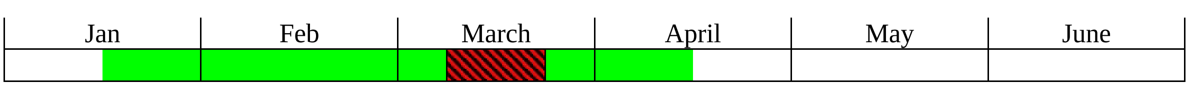
OVERVIEW

Historically, the Northwest San Juan Island stock is a small stock with spawning grounds primarily in Westcott Bay and Garrison Bay on San Juan Island. Stock distinction from the Interior San Juan Islands stock is based only on geographical separation. A disappearance of extensive eelgrass beds for unknown reasons in Westcott and Garrison Bay that was first reported in 2001 has not shown significant improvement. A shift in spawning location to other suitable locations in the vicinity (outside of Westcott and Garrison Bays) has not been documented. Limited spawn deposition survey effort has not documented any spawning activity here since 2003, thus this stock's status is categorized as "disappeared".

SPAWNING GROUND



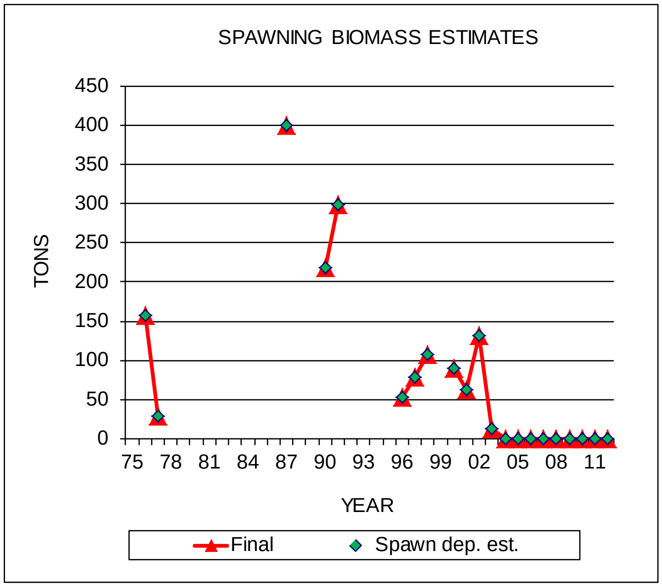
SPAWNING TIMING



STOCK STATUS PROFILE for NW San Juan Island Herring Stock

STOCK ASSESSMENT

YEAR	SPAWNING BIOMASS ESTIMATES (tons) SPAWN DEPOSITION SURVEYS	ACOUSTIC/ TRAWL SURVEYS	FINAL BIOMASS ESTIMATE	RECRUITMENT (tons)
1975				
1976	157		157	
1977	29		29	
1978				
1979				
1980				
1981				
1982				
1983				
1984				
1985				
1986				
1987	400		400	
1988				
1989				
1990	218		218	
1991	298		298	
1992				
1993				
1994				
1995				
1996	53		53	
1997	79		79	
1998	107		107	
1999				
2000	90		90	
2001	62		62	
2002	131		131	
2003	13		13	
2004	0		0	
2005	0		0	
2006	0		0	
2007	0		0	
2008	0		0	
2009	0		0	
2010	0		0	
2011	0		0	
2012	0		0	
MEAN:				
25 year			97	
5 year	0		0	



STOCK SUMMARY

2012 SPAWNER FISHERY SUMMARY
no fishery

DATA QUALITY
poor

RECENT TREND (5 year)
no observed spawning escapement

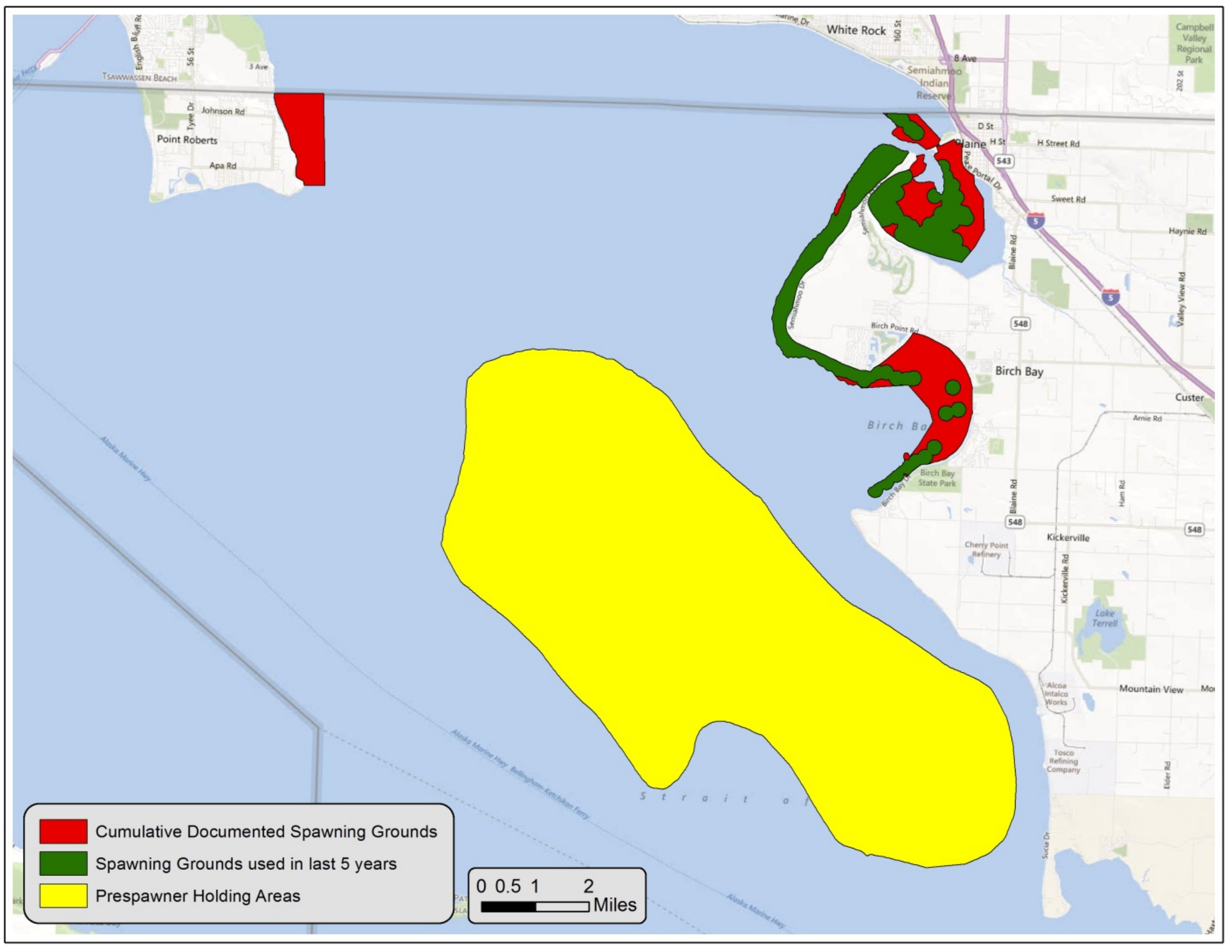
STOCK STATUS (2 year)
disappearance: 0% of 25 yr mean spawning biomass

Semiahmoo Bay Herring Stock

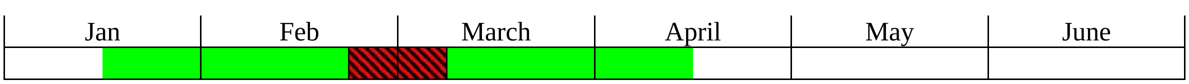
OVERVIEW

The Semiahmoo Bay herring stock's documented spawning grounds overlap with those of the spring-spawning Cherry Point stock, with most spawning activity taking place between early February and mid-March. Biological characteristics such as growth rates, and spawning behavior such as time of spawning, differ markedly between the two stocks on a consistent basis. Additionally, two studies (Small et al. 2005, Mitchell 2006) examining DNA microsatellites concluded that this stock is genetically differentiated from Cherry Point herring without significant observed genetic divergence from other sampled Puget Sound stocks. Spawning biomass for the last two years has averaged 1,242 tons and the stock is considered to be healthy, contrary to the long term critical status of the Cherry Point stock.

SPAWNING GROUND



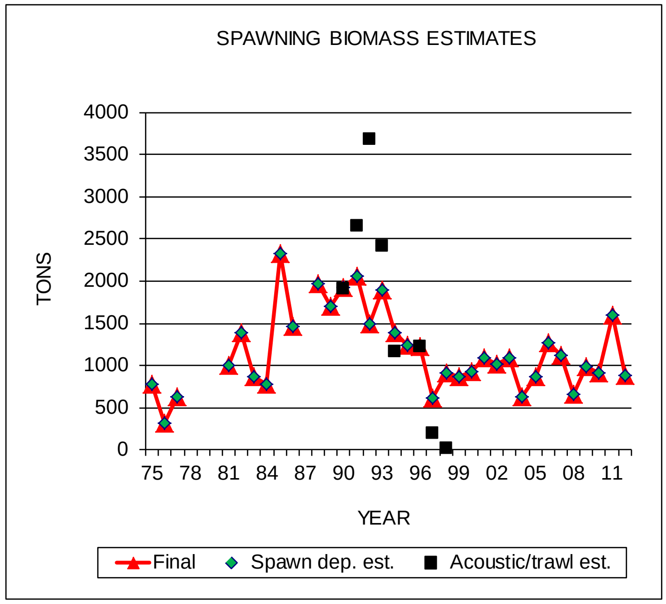
SPAWNING TIMING



STOCK STATUS PROFILE for Semiahmoo Bay Herring Stock

STOCK ASSESSMENT

YEAR	SPAWNING BIOMASS ESTIMATES (tons) SPAWN DEPOSITION SURVEYS	ACOUSTIC/ TRAWL SURVEYS	FINAL BIOMASS ESTIMATE	RECRUITMENT (tons)
1975	772		772	
1976	321		321	
1977	634		634	
1978				
1979				
1980				
1981	1008		1008	
1982	1389		1389	
1983	874		874	
1984	772		772	
1985	2325		2325	
1986	1464		1464	
1987				
1988	1965		1965	
1989	1701		1701	978
1990	1930	1909	1930	1573
1991	2061	2655	2061	860
1992	1501	3689	1501	636
1993	1902	2416	1902	1554
1994	1389	1166	1389	676
1995	1245		1245	
1996		1219	1219	
1997	621	196	621	465
1998	919	12	919	731
1999	868		868	
2000	926		926	
2001	1098		1098	
2002	1012		1012	
2003	1087		1087	
2004	629		629	
2005	870		870	
2006	1277		1277	
2007	1124		1124	
2008	662		662	
2009	990		990	
2010	909		909	
2011	1605		1605	
2012	879		879	
MEAN:				
25 year			1216	
5 year	1009		1009	



STOCK SUMMARY

2012 SPAWNER FISHERY SUMMARY
no fishery

DATA QUALITY
fair

RECENT TREND (5 year)
no significant trend

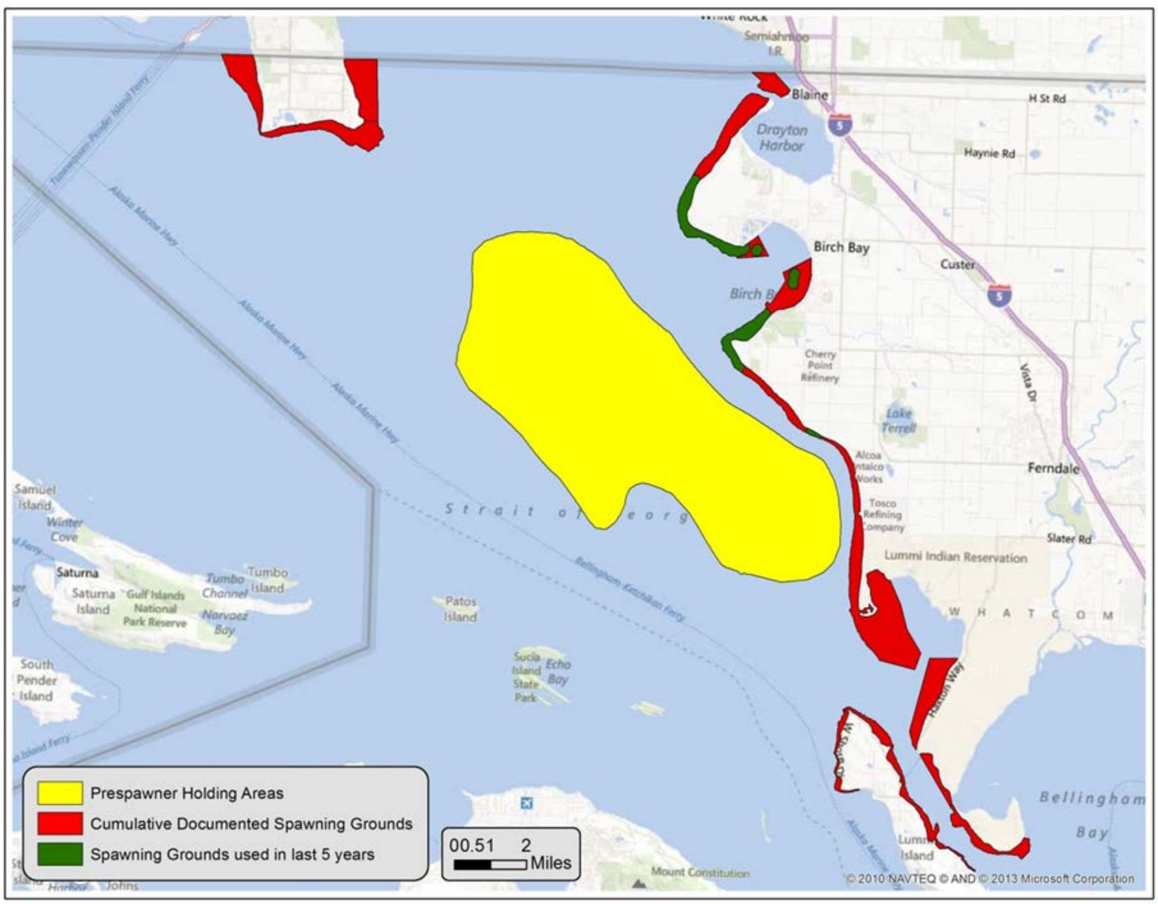
STOCK STATUS (2 year)
healthy: 102% of 25 yr mean spawning biomass

Cherry Point Herring Stock

OVERVIEW

The Cherry Point herring stock is unusual in Washington State because of its late “spring” spawning timing. Washington’s largest herring stock from the 1970s until the mid-1990s, its abundance has decreased dramatically and it continues to be in critical condition, showing no signs of increased abundance. As discussed previously in this report, several genetic studies (Beacham et al 2001, 2002, 2008; Small et al 2005; Mitchell 2006) examining DNA microsatellites have identified the Cherry Point stock as being genetically distinct from British Columbia and other Puget Sound stocks sampled to date, justifying its management as a discrete stock. The location of spawning activity has shifted northward in recent years and the majority of spawn deposition is currently near Birch Point, A decrease in available spawning habitat has not been documented for this stock’s spawning grounds. Potential causes for the stock’s precipitous decline and lack of recovery include pollution, climate change, changes in predator/prey abundance, and disease.

SPAWNING GROUND



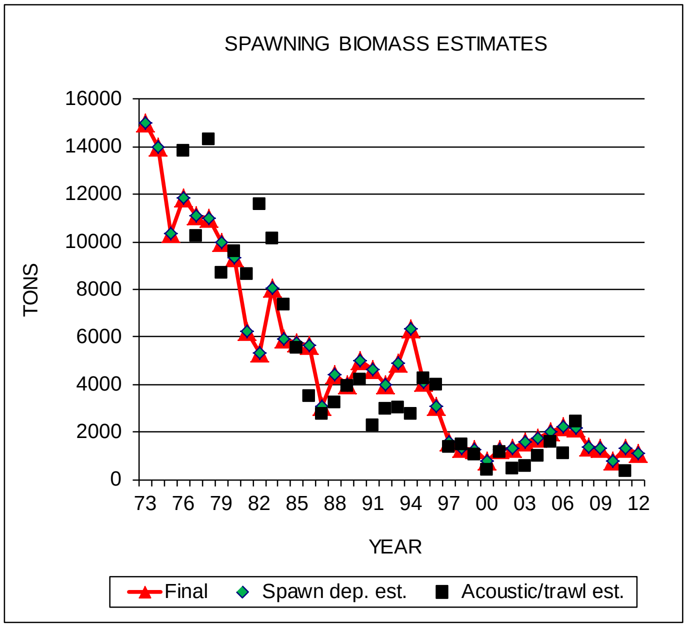
SPAWNING TIMING

Jan	Feb	March	April	May	June

STOCK STATUS PROFILE for Cherry Point Herring Stock

STOCK ASSESSMENT

YEAR	SPAWNING BIOMASS ESTIMATES (tons) SPAWN DEPOSITION SURVEYS	ACOUSTIC/ TRAWL SURVEYS	FINAL BIOMASS ESTIMATE	RECRUITMENT (tons)
1973	14998		14998	
1974	13963		13963	
1975	10337		10337	1910
1976	11844	13832	11844	1159
1977	11097	10270	11097	3009
1978	10973	14314	10973	3541
1979	9957	8684	9957	1129
1980	9329	9589	9329	3675
1981	6219	8637	6219	397
1982	5342	11562	5342	2043
1983	8063	10142	8063	1385
1984	5901	7347	5901	1001
1985	5760	5519	5760	2928
1986	5671	3528	5671	3295
1987	3108	2775	3108	1155
1988	4428	3236	4428	2080
1989	4003	3963	4003	2497
1990	4998	4215	4998	1901
1991	4624	2278	4624	1141
1992	4009	2998	4009	1991
1993	4894	3055	4894	3434
1994	6324	2777	6324	4076
1995	4105	4251	4105	1204
1996	3095	3971	3095	772
1997	1574	1400	1574	645
1998	1322	1502	1322	984
1999	1266	1052	1266	890
2000	808	436	808	560
2001	1241	1146	1241	680
2002	1330	450	1330	974
2003	1611	555	1611	998
2004	1734	981	1734	22
2005	2010	1565	2010	1784
2006	2216	1102	2216	2029
2007	2169	2434	2169	1515
2008	1352		1352	952
2009	1341		1341	
2010	774		774	
2011	1301	335	1301	
2012	1120		1120	
MEAN:				
25 year	2546		2546	
5 year	1178		1178	



STOCK SUMMARY

2012 SPAWNER FISHERY SUMMARY
no fishery

DATA QUALITY
good

RECENT TREND (5 year)
no significant trend

STOCK STATUS (2 year)
critical: 48% of 25 yr mean spawning biomass; <10% of 1970s spawning biomass

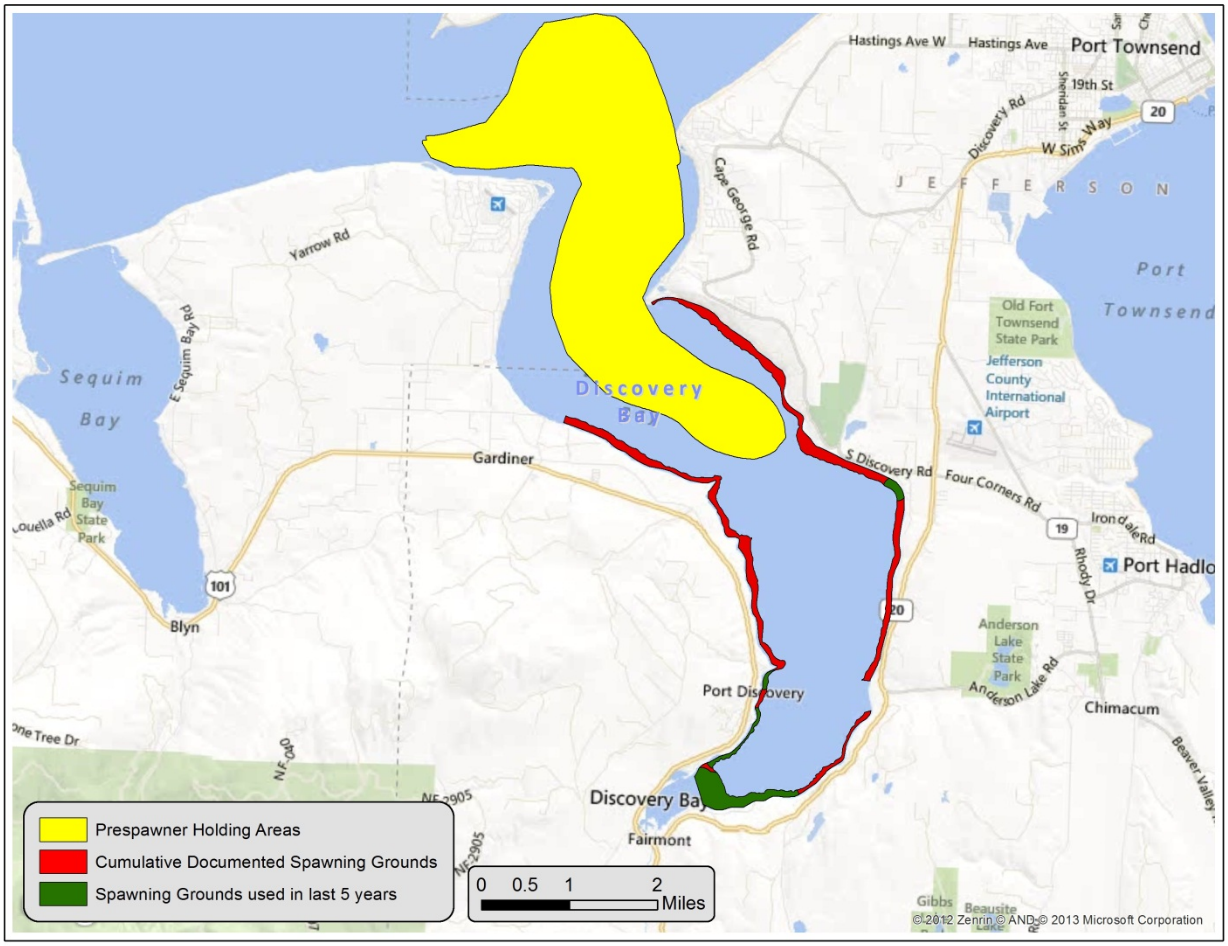
Strait of Juan De Fuca Herring Stock Profiles

Discovery Bay Herring Stock

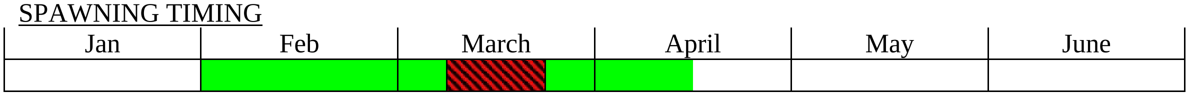
OVERVIEW

The Discovery Bay herring stock is traditionally the major Strait of Juan de Fuca stock. Its abundance has fluctuated dramatically since the early 1900s, when significant fishery landings suggested sizable spawning biomass. This period was followed by decreased fishery activity and assumed abundance decline in the 1930s, a return to "relatively high" abundance levels during the 1940s and 1950s (Williams 1959), documented high abundance (peak of 3,220 tons in 1980) in the early 1980s, and generally very low abundance since 1990. The stock has no known fishery interceptions and its spawning grounds are considered to be among the most pristine in Washington. Increased pinniped predation and/or movement to other spawning grounds with similar spawn timing are potential causes for biomass decline. As described previously in the stock structure section, extreme fluctuations in year-to-year spawning activity create doubt about natal and/or spawning site fidelity for this stock.

SPAWNING GROUND



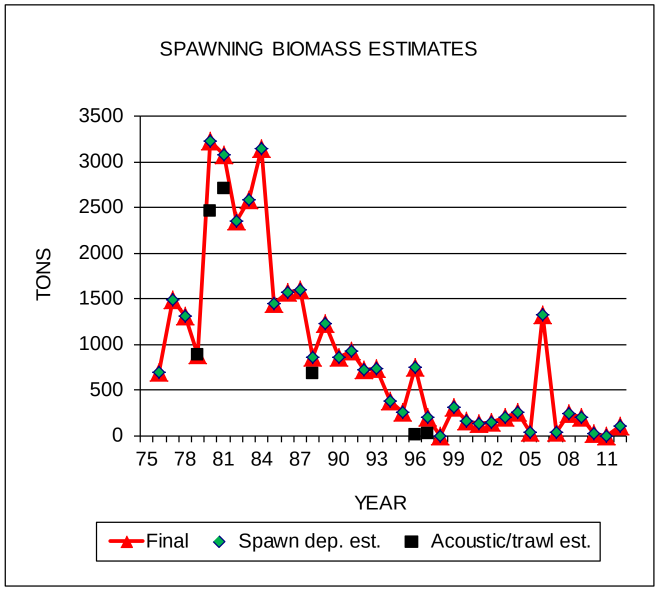
SPAWNING TIMING



STOCK STATUS PROFILE for Discovery Bay Herring Stock

STOCK ASSESSMENT

YEAR	SPAWNING BIOMASS ESTIMATES (tons) SPAWN DEPOSITION SURVEYS	ACOUSTIC/ TRAWL SURVEYS	FINAL BIOMASS ESTIMATE	RECRUITMENT (tons)
1975				
1976	697		697	
1977	1488		1488	
1978	1305		1305	
1979		882	882	
1980	3220	2458	3220	
1981	3070	2712	3070	
1982	2356		2356	
1983	2578		2578	
1984	3144		3144	
1985	1447		1447	
1986	1566		1566	
1987	1593		1593	
1988	853	687	853	
1989	1225		1225	
1990	855		855	
1991	925		925	
1992	727		727	
1993	737		737	
1994	375		375	
1995	261		261	
1996	747	5	747	
1997	199	19	199	
1998	0		0	
1999	307		307	
2000	159		159	
2001	137		137	
2002	148		148	
2003	207		207	
2004	252		252	
2005	33		33	
2006	1325		1325	
2007	42		42	
2008	248		248	
2009	205		205	
2010	26		26	
2011	0		0	
2012	105		105	
MEAN:				
25 year	404		404	
5 year	117		117	



STOCK SUMMARY

2012 SPAWNER FISHERY SUMMARY
no fishery

DATA QUALITY
fair

RECENT TREND (5 year)
no significant trend

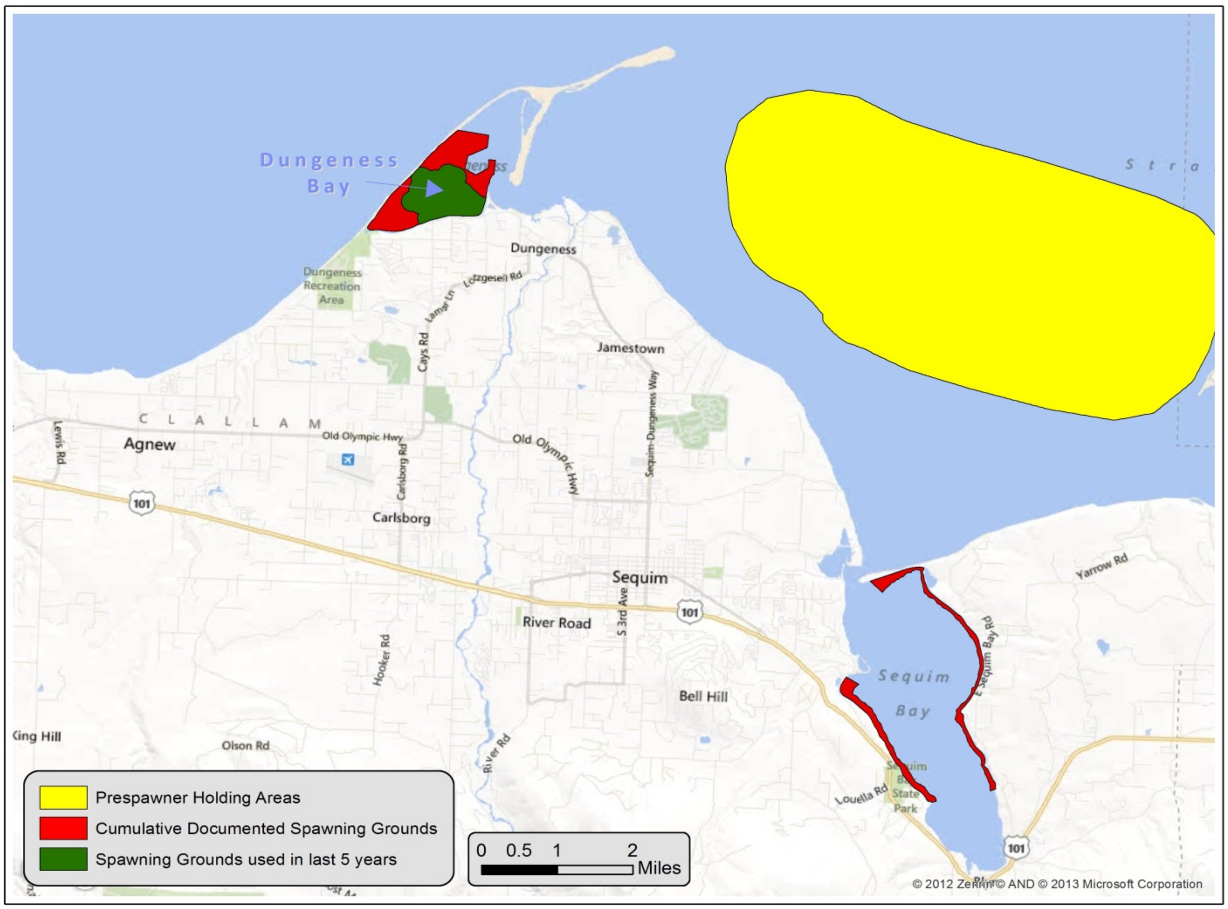
STOCK STATUS (2 year)
critical: 13% of 25 yr mean spawning biomass; <10% of historic highs in the 1980s

Dungeness/Sequim Bay Herring Stock

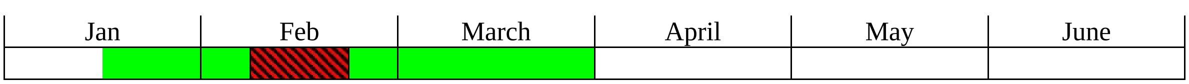
OVERVIEW

The Dungeness Bay portion of this small stock's spawning grounds has hosted virtually all of its spawning activity in recent years. These spawning grounds are the westernmost documented grounds for any Puget Sound herring stock. Despite the presence of abundant marine vegetation preferred for spawning in Sequim Bay, only one small spawning event has been documented there since 1994. Observed spawning activity in Sequim Bay was highest in the early 1980s when peak spawning biomass was documented for the nearby Discovery Bay stock, suggesting a "spillover" effect to Sequim Bay when the Discovery Bay population is at high abundance. Documented spawn timing is slightly earlier for Dungeness Bay compared to Sequim Bay and Discovery Bay, again suggesting a link between those two spawning grounds. A decrease in available spawning substrate has been observed in parts of Dungeness Bay in recent years, but is not considered to be limiting abundance.

SPAWNING GROUND



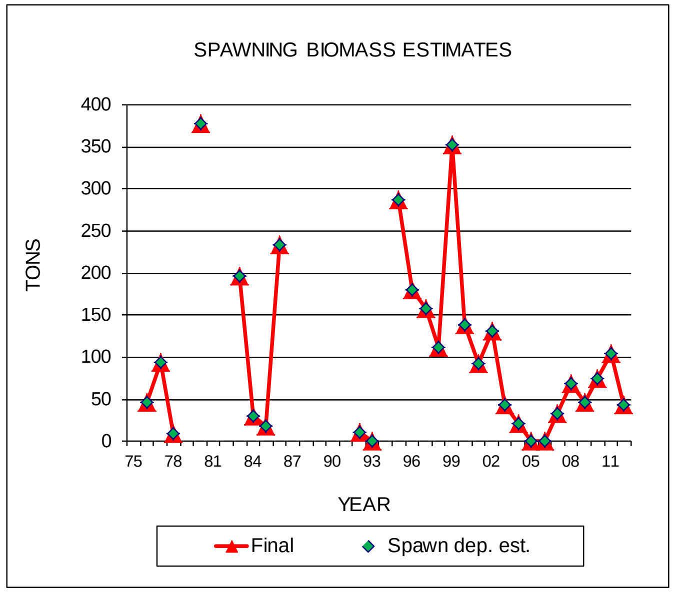
SPAWNING TIMING



STOCK STATUS PROFILE for Dungeness/Sequim Bay Herring Stock

STOCK ASSESSMENT

YEAR	SPAWNING BIOMASS ESTIMATES (tons) SPAWN DEPOSITION SURVEYS	ACOUSTIC/ TRAWL SURVEYS	FINAL BIOMASS ESTIMATE	RECRUITMENT (tons)
1975				
1976	47		47	
1977	94		94	
1978	10		10	
1979				
1980	378		378	
1981				
1982				
1983	197		197	
1984	31		31	
1985	18		18	
1986	234		234	
1987				
1988				
1989				
1990				
1991				
1992	11		11	
1993	0	(partial survey	0	
1994		coverage)		
1995	287		287	
1996	180		180	
1997	158		158	
1998	112		112	
1999	352		352	
2000	138		138	
2001	93		93	
2002	131		131	
2003	44		44	
2004	22		22	
2005	0		0	
2006	0		0	
2007	34		34	
2008	69		69	
2009	46		46	
2010	75		75	
2011	104		104	
2012	43		43	
MEAN:				
25 year			95	
5 year	67		67	



STOCK SUMMARY

2012 SPAWNER FISHERY SUMMARY
no fishery

DATA QUALITY
poor

RECENT TREND (5 year)
no significant trend

STOCK STATUS (2 year)
moderately healthy: 77% of 25 yr mean spawning biomass

Puget Sound Herring Stock Status Summary

The following table includes individual, regional, and Puget Sound cumulative stock status summaries since 1994 based on two-year and previous 25-year mean spawning biomass estimates, and status classification criteria described on page 10 of this report. Obviously, the value of a stock-by-stock evaluation is affected greatly by stock discreteness.

A discussion of stock structure of Puget Sound herring was included in the previous Washington stock status report (Stick and Lindquist 2009). No relevant additional studies related to Puget Sound herring stock identification have been conducted since the completion of that report. As suggested in the last stock status report, additional genetic studies are recommended to attempt to further clarify the stock structure of Puget Sound herring, and at least two such studies are currently in progress.

If considerable intermixing/gene flow occurs among most Puget Sound herring stocks, the individual stock statuses presented below may be of limited importance. It may be more useful to examine abundance levels and trends on a regional or sub-regional basis and also to consider genetic findings to date (e.g., separate the Cherry Point and Squaxin Pass stocks from their respective regions).

Noteworthy since the last status report is continued annual spawning activity in northern Carr Inlet (Purdy stock) of South Puget Sound. Initially documented in 2008, spawn deposition has been observed there each year since that time. Another "new" area that hosted documented herring spawning activity in 2012 for the first time was Elliot Bay in Seattle. Both the location and spawn timing (late April/early May) are unusual for this region. Both of these spawning locations are thought to be new occurrences, but it is also possible that spawning activity for both areas had simply avoided detection until recently due to a lack of survey coverage.

For the 2011-12 period, there was a continued drop in Puget Sound herring stocks classified as healthy or moderately healthy to 39% (7 of 18; 3 stocks with status considered to be unknown). Two herring stocks, N.W. San Juan Island and Kilisut Harbor, have not had detectable spawning activity since 2008 and have a "disappearance" classification. Sampling effort will continue in these areas to determine if/when a "recolonization" of spawning herring, similar to that described in British Columbia areas (Ware and Tovey 2004), occurs in the future.

The Cherry Point herring stock has shown no signs of improving from its critical status and the stock's smallest estimated spawning biomass to date was documented in 2010. This followed a moderate increase in abundance from 2000 through 2006. Spawning activity has shifted northward in recent years, with most observed spawn deposition located near Birch Point. Annual acoustic/trawl surveys of this stock, which provided age composition data, were discontinued due to budget cuts after 2009 but a relative lack of older fish likely continues to be the case for this population.

The other Puget Sound herring stock that appears to be genetically differentiated, Squaxin Pass, has been assessed as moderately healthy at this time although it has exhibited a significant decrease in abundance in the last five years. The spawn timing of the Purdy stock has consistently been significantly later than the Squaxin Pass stock, which does not suggest the two stocks are connected genetically. Further genetic sampling will hopefully clarify this issue.

The spawning biomass for all Puget Sound herring stocks combined, excluding the two stocks that are considered to be genetically distinct (Cherry Point and Squaxin Pass) is classified as moderately healthy compared to the previous 25-year sum of mean spawning biomasses, at 9,824 tons (82% of 25 year mean).

Regionally, south/central Puget Sound stocks combined, excluding Squaxin Pass, are considered moderately healthy for 2011-12, following a healthy classification in 2008. North Puget Sound stocks, excluding the Cherry Point stock, are moderately healthy (72% of 25 year mean), which is a change from the table classification for north Puget Sound, primarily due to increased abundance for the Semiahmoo Bay and Portage/Samish Bay stocks.

The Strait of Juan de Fuca region's stock status has been primarily classified as critical since 1994, with the exception of 2006 when a significant one-year increase in the estimated spawning biomass of the Discovery Bay stock was documented. The condition and spawning biomass of the Discovery Bay stock has been considered an enigma since assessment surveys were started there in 1976. Estimated spawning biomass was over 3,000 tons in the 1980s followed by an unexplained steady decrease to little or no documented spawning activity since 2000, other than the mentioned spawning biomass in 2006. No recent direct fishery harvest, relatively undisturbed spawning grounds, and good water quality add to the mystery of this stock's recent spawning biomass history. However, reports by Chapman et al (1941) and Williams (1959) indicate similar trends in abundance for Discovery Bay herring between the early 1900s and the 1950s; ranging from high levels of abundance early, followed by a decrease in the 1930s, and a return to "relatively high" levels by the 1950s. Again, this scenario brings up the question of stock structure of Puget Sound herring and the concepts of "disappearance" and "recolonization" events and a metapopulation model described previously in this document.

STOCK STATUS - Describes a stock's current condition based primarily on recent (previous 2-year mean) abundance compared to long-term- previous 25-year (1988-2012) mean abundance. Stock criteria such as survival, recruitment, age composition, and spawning ground habitat condition are also considered.

Healthy - A stock with recent 2-year mean abundance above or within 10% of the 25-year mean.

Moderately Healthy - A stock with recent 2-year mean abundance within 30% of the 25-year mean, and/or with high dependence on recruitment.

Depressed - A stock with recent abundance well below the long-term mean, but not so low that permanent damage to the stock is likely (i.e., recruitment failure); typically 10-<70% of long-term mean.

Critical - A stock with recent abundance so low that permanent damage to the stock is likely or has already occurred (i.e., recruitment failure); typically less than 10% of long-term mean if survey coverage/methods are considered to be adequate.

Disappearance - A stock that can no longer be found in a formerly consistently utilized spawning ground.

Insufficient Data/Unknown- Insufficient assessment data to identify stock status with confidence.

Regional/genetic grouping	**Stock**	**2012**	**2010**	**2008**	**2006**	**2004**	**2002**	**2000***	**1998***	**1996***	**1994***
	Squaxin Pass	MOD. HEALTHY	MOD. HEALTHY	HEALTHY	MOD. HEALTHY	HEALTHY	HEALTHY	HEALTHY	MOD. HEALTHY	MOD. HEALTHY	MOD. HEALTHY
South-Central stocks exc. Squaxin Pass		MOD. HEALTHY	MOD. HEALTHY	MOD. HEALTHY	HEALTHY	HEALTHY	HEALTHY	HEALTHY	MOD. HEALTHY	HEALTHY	MOD.HEALTHY
	Purdy	UNKNOWN	UNKNOWN								
	Wollochet Bay	UNKNOWN	UNKNOWN	UNKNOWN	UNKNOWN	UNKNOWN	UNKNOWN				
	Quartermaster Harbor	DEPRESSED	DEPRESSED	DEPRESSED	MOD. HEALTHY	MOD. HEALTHY	MOD. HEALTHY	HEALTHY	HEALTHY	HEALTHY	HEALTHY
	Elliot Bay	UNKNOWN									
	Port Orchard-Madison	DEPRESSED	MOD. HEALTHY	HEALTHY	HEALTHY	MOD. HEALTHY	HEALTHY	HEALTHY	DEPRESSED	DEPRESSED	DEPRESSED
	South Hood Canal	HEALTHY	MOD. HEALTHY	MOD. HEALTHY	HEALTHY	MOD. HEALTHY	MOD. HEALTHY	HEALTHY	MOD. HEALTHY	UNKNOWN	UNKNOWN
	Quilcene Bay	HEALTHY	HEALTHY	HEALTHY	HEALTHY	HEALTHY	HEALTHY	HEALTHY	HEALTHY	HEALTHY	UNKNOWN
	Port Gamble	DEPRESSED	DEPRESSED	DEPRESSED	DEPRESSED	DEPRESSED	MOD. HEALTHY	HEALTHY	DEPRESSED	HEALTHY	HEALTHY
	Kilisut Harbor	DISSAPEARANCE	DISAPPEARANCE	DEPRESSED	DEPRESSED	MOD. HEALTHY	HEALTHY	HEALTHY	MOD. HEALTHY	UNKNOWN	HEALTHY
	Port Susan	DEPRESSED	DEPRESSED	MOD. HEALTHY	DEPRESSED	DEPRESSED	MOD. HEALTHY	MOD. HEALTHY	HEALTHY	DEPRESSED	MOD. HEALTHY
	Holmes Harbor	HEALTHY	HEALTHY	HEALTHY	HEALTHY	HEALTHY	HEALTHY	DEPRESSED	HEALTHY	UNKNOWN	UNKNOWN
	Skagit Bay	DEPRESSED	DEPRESSED	HEALTHY	HEALTHY	HEALTHY	HEALTHY	MOD. HEALTHY	MOD. HEALTHY	HEALTHY	UNKNOWN
North Puget Sound exc. Cherry Point		MOD.HEALTHY	DEPRESSED	DEPRESSED	DEPRESSED	DEPRESSED	HEALTHY	MOD.HEALTHY	MOD.HEALTHY	MOD.HEALTHY	HEALTHY
	Fidalgo Bay	DEPRESSED	DEPRESSED	DEPRESSED	DEPRESSED	DEPRESSED	HEALTHY	HEALTHY	HEALTHY	MOD. HEALTHY	MOD. HEALTHY
	Samish/Portage Bay	HEALTHY	HEALTHY	HEALTHY	HEALTHY	MOD. HEALTHY	HEALTHY	HEALTHY	HEALTHY	HEALTHY	MOD. HEALTHY
	Interior San Juan Is.	DEPRESSED	DEPRESSED	DEPRESSED	MOD. HEALTHY	DEPRESSED	MOD. HEALTHY	DEPRESSED	UNKNOWN	UNKNOWN	UNKNOWN
	N.W. San Juan Is.	DISAPPEARANCE	DISSAPEARANCE	DISAPPEARANCE	DEPRESSED	CRITICAL	DEPRESSED	UNKNOWN	DEPRESSED	UNKNOWN	UNKNOWN
	Semiahmoo Bay	HEALTHY	MOD. HEALTHY	MOD. HEALTHY	MOD. HEALTHY	DEPRESSED	MOD. HEALTHY	DEPRESSED	DEPRESSED	HEALTHY	HEALTHY
	Cherry Point	CRITICAL	CRITICAL	CRITICAL	CRITICAL	CRITICAL	CRITICAL	CRITICAL	CRITICAL	DEPRESSED	MOD. HEALTHY
Strait of Juan de Fuca		CRITICAL	CRITICAL	CRITICAL	DEPRESSED	CRITICAL	CRITICAL	CRITICAL	CRITICAL	CRITICAL	CRITICAL
	Discovery Bay	CRITICAL	CRITICAL	CRITICAL	DEPRESSED	CRITICAL	CRITICAL	CRITICAL	CRITICAL	CRITICAL	CRITICAL
	Dungeness/Sequim Bay	MOD. HEALTHY	DEPRESSED	DEPRESSED	DEPRESSED	DEPRESSED	MOD. HEALTHY	HEALTHY	HEALTHY	HEALTHY	UNKNOWN
All stocks combined exc. Squaxin Pass and Cherry Point		MOD.HEALTHY	MOD.HEALTHY	MOD.HEALTHY	HEALTHY	MOD.HEALTHY	HEALTHY	HEALTHY	MOD.HEALTHY	MOD.HEALTHY	MOD.HEALTHY
All Puget Sound stocks combined		MOD. HEALTHY	DEPRESSED	MOD. HEALTHY	HEALTHY	MOD. HEALTHY	HEALTHY	MOD. HEALTHY	DEPRESSED	MOD. HEALTHY	MOD.HEALTHY
Individual Stock Comparison		**2012**	**2010**	**2008**	**2006**	**2004**	**2002**	**2000**	**1998**	**1996**	**1994**
	HEALTHY	5 stocks	3 stocks	6 stocks	6 stocks	4 stocks	8 stocks	10 stocks	7 stocks	7 stocks	4 stocks
	MOD. HEALTHY	2 stocks	4 stocks	3 stocks	4 stocks	5 stocks	7 stocks	2 stocks	3 stocks	2 stocks	5 stocks
	DEPRESSED	7 stocks	7 stocks	6 stocks	7 stocks	6 stocks	1 stock	3 stocks	5 stocks	3 stocks	1 stock
	CRITICAL	2 stocks	2 stocks	2 stocks	1 stock	3 stocks	2 stocks	2 stocks	2 stocks	1 stock	1 stock
	DISAPPEARANCE	2 stocks	2 stocks	1 stock	0 stocks	0 stocks	0 stocks	0 stocks	0 stocks	0 stocks	0 stocks
	UNKNOWN	3 stocks	2 stocks	1 stock	1 stock	1 stock	1 stock	1 stock	1 stock	5 stocks	7 stocks
		39%	39%	50%	56%	50%	83%	71%	59%	69%	82%
		Healthy or Mod. Healthy	Healthy or Mod. Healthy	Healthy or Mod. Healthy	Healthy or Mod. Healthy	Healthy or Mod. Healthy	Healthy or Mod. Healthy	Healthy or Mod. Healthy	Healthy or Mod. Healthy	Healthy or Mod. Healthy	Healthy or Mod. Healthy

Puget Sound Herring Spawning Biomass Estimates, 1973-2012

Pacific herring abundance, as well as that of other forage fishes, has a tendency to fluctuate greatly (Bargmann 1998),as reflected in large annual changes in spawning biomass estimates of individual stock profiles previously presented. As discussed in Stick and Lindquist (2009), it is likely that there is considerable gene flow among various Puget Sound herring stocks.

To date, genetic divergence has been demonstrated, or at least suggested, only for the Cherry Point and Squaxin Pass herring stocks with a lack of differentiation among other sampled stocks from Puget Sound, including Quartermaster Harbor, Port Gamble, Kilisut Harbor, Skagit Bay, Fidalgo Bay, and Semiahmoo Bay (Beacham et al. 2001, 2002, 2008; Small et al. 2005; Mitchell 2006). These studies suggest sufficient gene flow occurs among most Puget Sound herring stocks, particularly those with similar spawn timing, which would overshadow any emerging genetic divergence.

Therefore, the most meaningful way to attempt to determine abundance trends and comparisons for the Puget Sound herring resource using spawning biomass estimates is to group stocks that have not demonstrated genetic divergence Puget Sound-wide or by region. Thus, the Cherry Point and Squaxin Pass stocks can be examined individually with all others stocks grouped together or by region.

The spawning biomass of the Cherry Point herring stock has been estimated annually since 1973 but very few other Puget Sound herring stocks were assessed prior to 1976. Between 1976 and 1996, the spawning biomass for only the 10-12 larger Puget Sound stocks was estimated annually, with the remaining smaller stocks surveyed on a rotational basis. Beginning in 1996, annual estimates of all known herring stocks in Puget Sound have been attempted (Appendix B).

To account for this lack of consistent sampling effort prior to 1996, ”missing” sample years can be filled in using most recent available years’ estimates. The most recent sampled years around a missing cell were used to fill it; adjacent years were used if available, then five year intervals, and then decadal averages if needed.

The obvious decline of the Cherry Point herring stock has been well documented in previous herring stock status reports (Stick 2005, Stick and Lindquist 2009). Estimated spawning biomass for this stock has ranged from a high of almost 15,000 tons in 1973 to a low of less than 800 tons in 2008 (Figs. 1-3).

Using only sampled stocks, the cumulative spawning biomass of all other Puget Sound herring stocks combined has not exhibited a decrease similar to the Cherry Point stock, fluctuating between about 10,000 and 16,000 tons (Fig. 1 and Appendix B). If sampling effort is not considered, the south/central Puget Sound combined stock spawning biomass suggests a general increasing trend since 1997 (Fig. 1). Conversely, the Strait of Juan de Fuca region cumulative spawning biomass had a peak in abundance in the 1980s followed by very low levels to date, and the north Puget Sound cumulative (excluding Cherry Point stock) was highest in the early 1990s (Fig. 1).

To account for the lack of sampling effort in a given year an estimated spawning biomass was used based on most recent years' estimates if a stock was not sampled as described above. The primary impact of ignoring sampling effort is an underestimate of the cumulative spawning biomass of the Central/South Puget Sound region prior to 1996. The south/central Puget Sound region's estimated cumulative spawning biomass has fluctuated between about 6,000 and 11,000 tons since 1973. The highest level for this region was in 2002 with a low estimated in 2010 (Fig. 2).

Spawning biomass abundance for the south/central region in recent years has been dominated by the Quilcene Bay and Holmes Harbor stocks. Both stocks experienced record highs in 2011. Interestingly, both of these stocks were considered to be relatively small stocks when quantitative assessments began in the 1970s, until the late 1990s when both stocks exhibited a dramatic increase in abundance. As mentioned previously in their stock profiles, the Quilcene Bay and Holmes Harbor herring stocks were considered to be the state's largest through the 1950s. Meanwhile, several other of the south/central Puget Sound region's stocks are at record low levels since 2010 (e.g. Quartermaster Harbor, Port Orchard/Madison, and Port Susan).

Recent spawning biomass abundance for the north Puget Sound region, excluding the Cherry Point stock, is lower than a cumulative peak observed in the 1990s (Fig. 2). Spawning biomass for the Semiahmoo Bay and Portage Bay/Samish Bay stocks has been comparable to historic levels in recent years but the other stocks in this region (Fidalgo Bay, Interior San Juan Islands, N.W. San Juan Islands) have been at low levels for a number of years.

The cumulative estimated herring spawning biomass for the herring stocks in the Strait of Juan de Fuca region (Discovery Bay, Dungeness/Sequim Bay) continues to be very low compared to the peak period observed in the early 1980s. Extreme fluctuation in the estimated abundance of the Discovery Bay stock, exemplified by a significant one-year increase in 2006, has casted doubt on the amount of natal homing and fidelity for this stock.

As previously mentioned, genetic studies have suggested that the Squaxin Pass herring stock is also genetically discrete from other populations. The estimated spawning biomass for the Squaxin Pass stock has fluctuated drastically but has generally been between 500-1,000 tons (Fig. 2). Current estimates are based on spawn deposition surveys, which underestimate spawning biomass for this stock and call into question recent assessments of biomass relative to historic values derived from A/T surveys.

The aggregate approach to evaluating herring stock status mentioned above has been used by the Puget Sound Partnership to develop one of their Dashboard Indicators of Puget Sound health (Puget Sound Partnership Vital Signs). The resultant three groups based on genetic sampling are: Cherry Point; Squaxin Pass; and all other stocks combined. Abundance trends for these groupings are essentially the same as described above with the inescapable decline of the Cherry Point stock, the same trend for Squaxin Pass, and a slight decline for all other stocks combined with low cumulative numbers in 2010 and 2012 (Fig. 3).

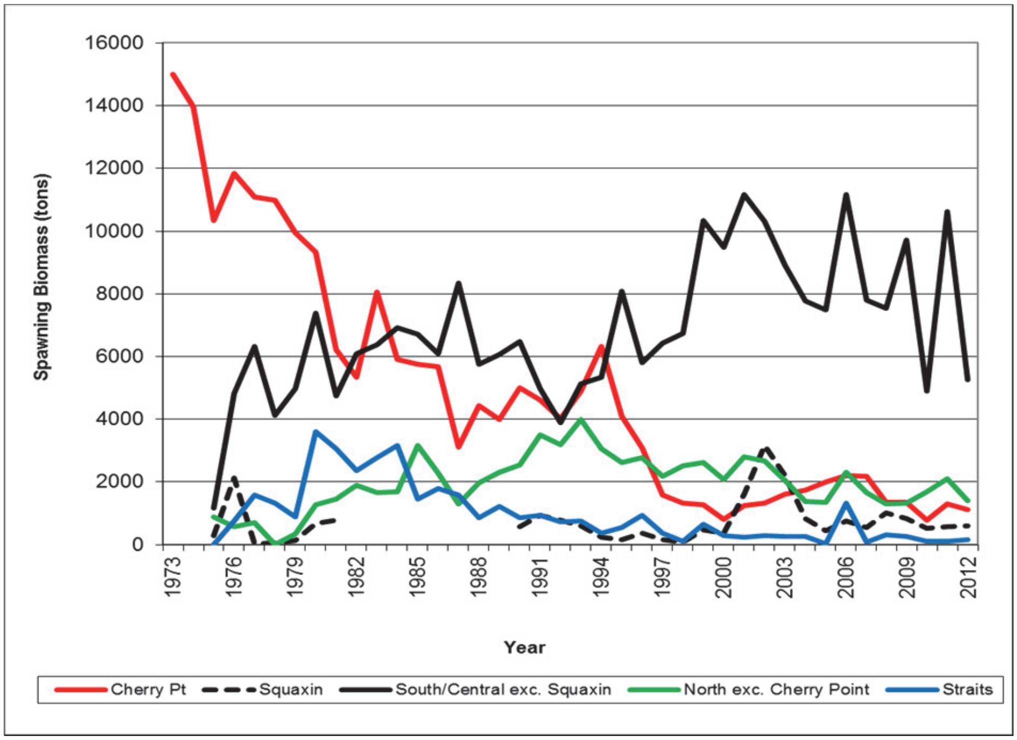


Figure 1. Puget Sound Herring Cumulative Spawning Biomass Estimates by Region with Cherry Point and Squaxin Pass stocks separated, 1973-2012 (only sampled stocks included in figure).

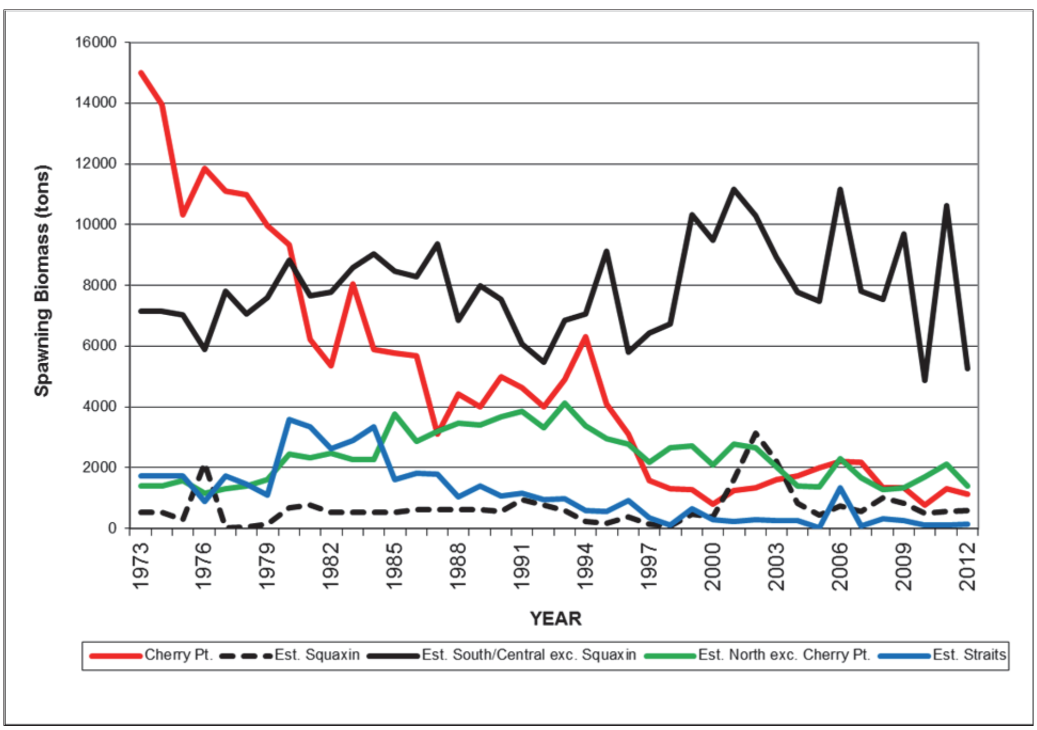


Figure 2. Estimated Puget Sound Herring Cumulative Spawning Biomass Estimates by Region with Cherry Point and Squaxin Pass stocks separated, 1973-2012 (missing sample years estimated).

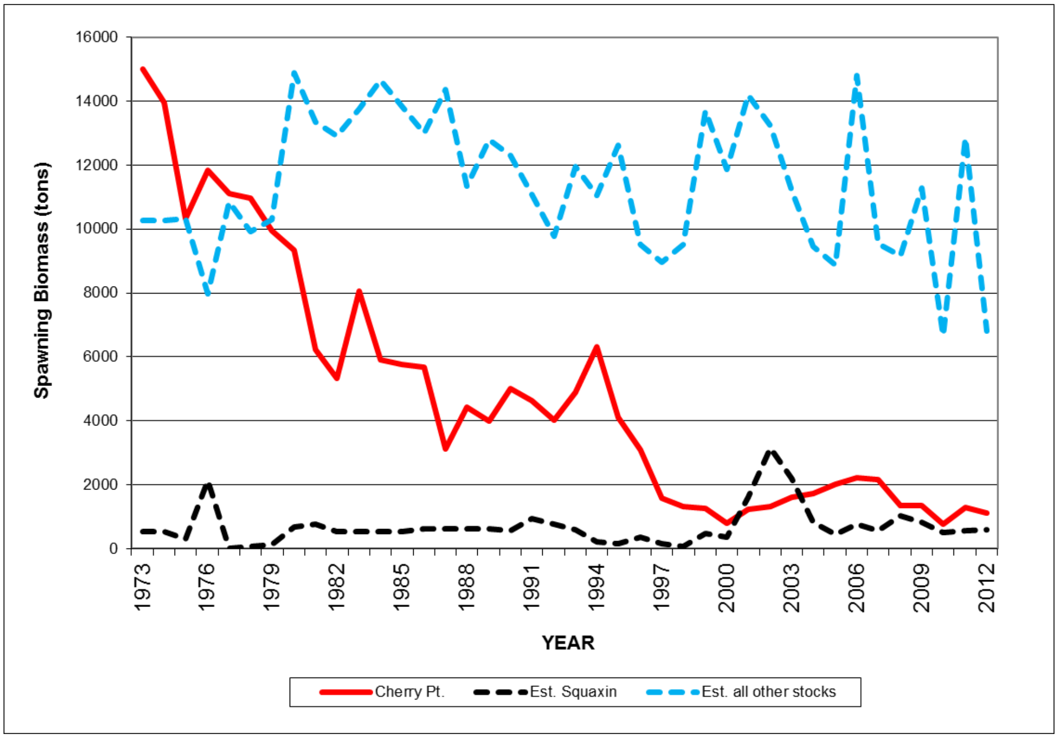


Figure 3. Estimated Puget Sound Herring Cumulative Spawning Biomass Estimates by Genetic Grouping, 1973-2012 (missing sample years estimated).

Summary of Puget Sound Herring Fisheries

Commercial herring fisheries in Puget Sound have experienced several major shifts since the start of the last century, as described in detail by Trumble (1983) and Williams (1959), and summarized in the previous Washington state stock status report (Stick and Lindquist 2009). This section largely restates these fishery trends with an update since 2008 (Figure 4).

Commercial herring fisheries in the early 1900s harvested herring mainly for export, a market that collapsed soon after World War I. From the 1920s through the 1940s the major portion of herring landings were used as bait for commercial halibut, crab, and shark fisheries. Herring traps accounted for much of the landings beginning in the 1920s. Traps were typically located adjacent to or near spawning grounds to intercept adult fish migrating to and from spawning areas. The most successful trap sites were in Holmes Harbor and at Point Whitney and Jackson Cove near Quilcene Bay in Hood Canal. Total reported herring landings through the 1940s ranged from a low of 36 tons in 1942 to a high of 1,311 tons in 1926 (Chapman et al. 1941 and Williams 1959).

Commercial herring fishing emphasis in Puget Sound shifted again in the early 1950s to primarily supply bait to growing recreational salmon fisheries. Changing market conditions and trap location restrictions in 1937 decreased the number of operational herring traps to one (in Holmes Harbor) by 1947 and led to a gradual reduction in trap landings, the last of which occurred in 1971.

The next shift in the Puget Sound herring fishery occurred in 1957 when the reduction of herring to oil and meal was authorized; landings were also used for commercial crab bait. This “general purpose” fishery with most of the fishing effort occurring in Bellingham Bay, resulted in annual landings of 1,500 to 3,500 tons. This fishery was phased out, by regulation, in the early 1980s due to concerns about potential effects on local herring stock abundance, particularly the Cherry Point stock.

In 1972, a sac-roe fishery targeting the Cherry Point herring stock began. Landings in this treaty and non-treaty fishery topped 4,000 tons in 1974 (Fig. 4). Declines in the north Puget Sound herring stocks, particularly the Cherry Point stock, led to the closure of both the general purpose and sac-roe fisheries by the mid-1980s. In 1988, a non-tribal spawn-on-kelp and treaty sac-roe fisheries were resumed on the Cherry Point stock. Another decline in Cherry Point stock abundance in the mid-1990s again closed this fishery and has remained closed to date. A minimum spawning biomass of 3,200 tons for the Cherry Point stock is currently required before harvest is considered.

The “sport bait” herring fishery continues to be the only commercial fishery operating in Puget Sound, providing bait for sport salmon and groundfish fisheries. Fishing activity is primarily in south and central Puget Sound and mostly targets 1+ to 2+ year old herring assumed to be an aggregate of stocks within the region. Almost all harvest in recent years has taken by non-tribal fishers using relatively small (maximum length of 200 feet) lampara seines, with a small portion of landings captured via dip bag net gear.

All non-tribal commercial herring fisheries in Washington waters are “limited entry”, which was put into effect in 1974, limiting fishing opportunities to fishers who had made landings in 1971-73. Annual purchase of the gear type license must be made to maintain status. In 2012, licensees included 7 lampara, 6 dip bag, and 2 drag seine gear licenses.

Commercial sport bait fishery landings are generally determined by market conditions, which are heavily influenced by the length of recreational salmon seasons, and holding/processing capacity. Similarly, Williams (1959) and Chapman et al. (1941) reported that herring landings are affected most by variability of fishing effort and that annual catch figures are not a reliable indicator of herring abundance.

Annual landings by the herring sport bait fishery for the last ten years (2003-2012) have averaged 335 tons, ranging from a low of 222 tons in 2006 to a high of 462 tons in 2003 (Fig. 4). The annual maximum harvest guideline is set at 10% of average adult biomass in the south/central Puget Sound region, which has averaged more than 10,000 tons for the last ten years. Landings for 2003-2012 were well below the harvest guideline, ranging from 2% to 6% of the sum of mean adult spawning biomass estimates for south/central Puget Sound stocks for the same time period. Sport bait fishery harvest is primarily of juvenile fish that are presumed to consist of mixed stocks (Trumble 1983).

Seasonal gear closures on documented spawning grounds are in place to protect spawning adult herring from harvest by the commercial bait fishery. Additionally, fishing is not allowed in north Puget Sound or near Discovery Bay to prevent the harvest of Cherry Point and Discovery Bay herring, respectively. Hood Canal has also been closed since 2004 to all commercial herring fishing due to concerns of the impacts of low dissolved oxygen on herring abundance. However, this closure was not based on observed changes in adult spawning biomass estimates of Hood Canal area herring stocks and merits reconsideration, particularly considering the current high abundance of the Quilcene Bay stock.

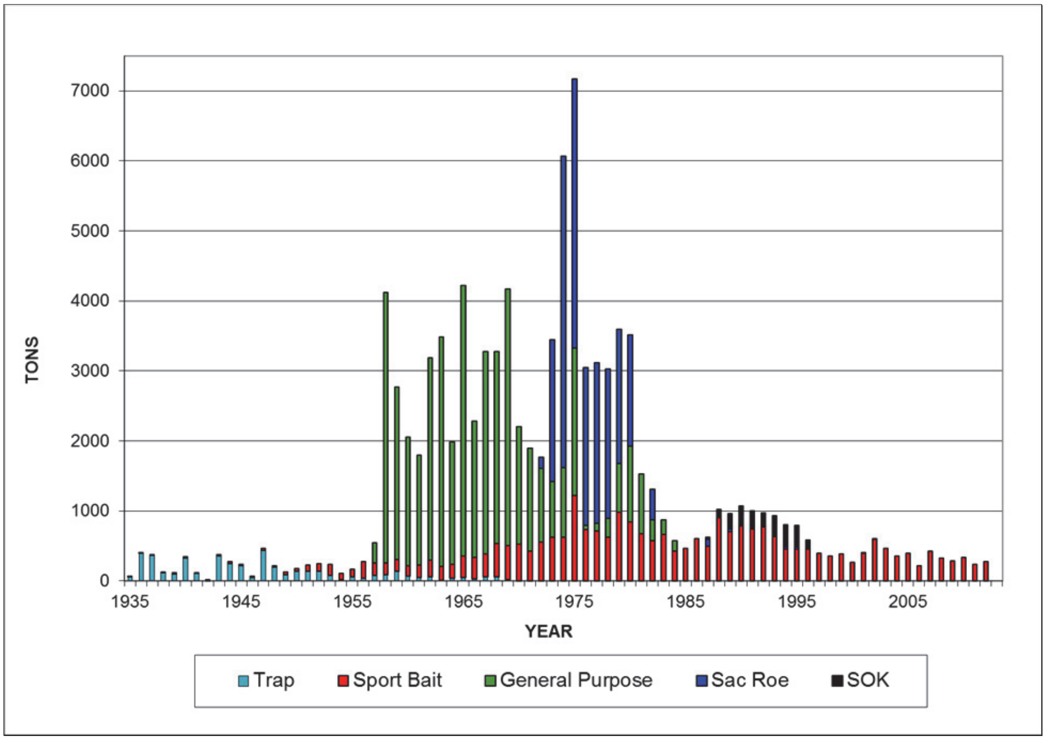


Figure 4. Puget Sound Herring Landings by Fishery Type, 1935-2012.

Natural Mortality

The abundance of Puget Sound herring stocks is impacted significantly by mortality rates. Mortality can be attributed to two types: fishing and natural mortality (all causes other than human harvest).

Adult herring mortality rates of 30-40% are considered typical for herring worldwide (Lemberg et al. 1997). Adult herring mortality and survival was estimated for the Cherry Point stock from 1976-2008. Additional stocks were included in mortality estimates beginning in 1987 when acoustic/trawl survey effort was increased. Discreteness between sampled stocks was assumed for mortality/survival estimates. However, as mentioned in previous sections, this assumption may be flawed for stocks other than the Cherry Point, and possibly the Squaxin Pass, stocks.

An increase in the annual mortality rate estimate for the Cherry Point herring stock has been repeatedly reported, from a range of 20-40% in the late 1970s to an average of 68% since 1990 (Day 1987, Stick and Lindquist 2009, Landis and Bryant 2010). The mean estimated annual natural mortality rate for other sampled stocks since 1990 has averaged 72%; again, very high for herring populations. Fishing mortality since 1997 has averaged about 4% of estimated natural mortality.

Significant gene flow among different stocks would obviously affect the accuracy of calculated mortality rates. However, there is no question that there has been a decrease in the mean and median age (and size) of sampled adult herring in Puget Sound (i.e., proportionately fewer older fish) (Appendix A). Formal risk assessments of the Cherry Point herring stock cited increased mortality of adults as the primary, but not necessarily entire, cause of this decline (EVS 1999), and a combination of reduced recruitment and nonfishery (natural mortality) related losses of older fish as the primary causes of biomass decline (Stout et al. 2001).

Potential causes of increased natural mortality and a lack of recovery include pollution, predation, disease, and climatic changes. A brief description of most of these stressors and the potential impact on herring abundance in Puget Sound is included in the previous herring stock status report (Stick and Lindquist 2009).

Contaminant levels in Puget Sound herring could contribute to natural mortality. West et al. (2008) examined three persistent organic pollutants (POPs) in herring samples taken from three locations in inner Puget Sound and three from the Strait of Georgia (U.S. and British Columbia). Herring sampled from lower/south Puget Sound (Squaxin Pass, Quartermaster Harbor, and Port Orchard) were 3 to 9 times more contaminated with polychlorinated biphenyls (PCBs) and 1.5 to 2.5 times more contaminated with dichloro-diphenyl-trichloroethanes (DDTs) than those from the Strait of Georgia (Semiahmoo Bay, Cherry Point, and Denman/Hornby Island, B.C.). West et al (2008) suggested higher regional sources of POPs, a much smaller drainage area, lower Puget Sound's relative isolation from cleaner oceanic waters, and environmental segregation between "Puget Sound" and "Strait of Georgia" herring as causes for the observed differences in contaminant levels.

Although there are no PCB health effects thresholds for Pacific herring, adult herring in central and southern Puget Sound currently exceed a threshold developed for salmon, and PCB levels in herring are not declining (Puget Sound Partnership Toxics in Fish Vital Sign). Additionally, herring embryos have exhibited concentrations of hydrocarbons exceeding health effects thresholds in a Puget Sound spawning location where chronic embryo mortality has been observed (West et al. in review). Increasing ocean acidification is another factor that could be negatively impacting herring abundance in Washington waters. An increase in the acidity of Puget Sound waters has been documented and is expected to increase in the future (Feeley et al 2010 and NOAA web page). Its impact on important herring prey, particularly crustaceans such as krill and calanoid copepods, is very concerning.

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Appendix A. Estimated biomass in short tons (2000 lbs/ton) and number (millions of fish) at age of spawner herring by stock by year (N caught includes only spawner fishery catches).

SQUAXIN PASS										TOTAL
									GTE	SPAWNER
YEAR		Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	BIOMASS
1975	Tons at Age	1	4	14	45	145	52	30	3	298
	N at Age	0.031	0.05	0.151	0.48	1.35	0.469	0.22	0.031	2.79
	N Caught	0	0	0	0	0	0	0	0	
1976	no age data									2138
1977	Tons at Age	9	10	0	0	0	0	0	0	20
	N at Age	0.001	0.081	0.032	0.049	0.071	0.038	0.01	0.001	0.282
	N Caught	0	0	0	0	0	0	0	0	
1978	Tons at Age	12	11	26	2	3	1	1	2	58
	N at Age	0.241	0.124	0.208	0.011	0.016	0.01	0.007	0.009	0.625
	N Caught	0	0	0	0	0	0	0	0	
1981	Tons at Age	118	478	85	12	47	16	0	13	772
	N at Age	2.366	6.109	0.542	0.067	0.266	0.067	0	0.067	9.5
	N Caught	0	0	0	0	0	0	0	0	
1990	Tons at Age	58	497	11	0	0	0	0	0	566
	N at Age	1.233	9.339	0.159	0	0	0	0	0	10.731
	N Caught	0	0	0	0	0	0	0	0	
1991	Tons at Age	439	409	94	0	0	0	0	0	943
	N at Age	12.459	7.706	1.485	0	0	0	0	0	21.65
	N Caught	0	0	0	0	0	0	0	0	
1992	Tons at Age	70	227	381	89	5	0	0	0	771
	N at Age	1.583	3.858	5.342	1.06	0.036	0	0	0	11.879
	N Caught	0	0	0	0	0	0	0	0	
1995	Tons at Age	62	79	14	2	1	0	0	0	157
	N at Age	1.205	1.0048	0.157	0.023	0.008	0	0	0	2.3978
	N Caught	0	0	0	0	0	0	0	0	
1996	Tons at Age	129	212	33	0	0	0	0	0	374
	N at Age	2.598	3.107	0.368	0	0	0	0	0	6.073
	N Caught	0	0	0	0	0	0	0	0	
1997	Tons at Age	107	37	5	0	0	0	0	0	149
	N at Age	2.156	0.482	0.051	0	0	0	0	0	2.689
	N Caught	0	0	0	0	0	0	0	0	
1998	Tons at Age	22	36	10	0	0	0	0	0	68
	N at Age	0.437	0.502	0.115	0	0	0	0	0	1.054
	N Caught	0	0	0	0	0	0	0	0	

1999	Tons at Age	338	114	21	0	0	0	0	0	474
	N at Age	7.188	1.651	0.226	0	0	0	0	0	9.065
	N Caught	0	0	0	0	0	0	0	0	
2000	Tons at Age	220	149	3	0	0	0	0	0	371
	N at Age	4.333	2.792	0.045	0	0	0	0	0	7.17
	N Caught	0	0	0	0	0	0	0	0	
2001	Tons at Age	1119	439	38	0	0	0	0	0	1597
	N at Age	31.545	8.301	0.535	0	0	0	0	0	40.381
	N Caught	0	0	0	0	0	0	0	0	
2002	Tons at Age	189	2498	466	0	0	0	0	0	3150
	N at Age	4.278	49.35	7.66	0	0	0	0	0	61.288
	N Caught	0	0	0	0	0	0	0	0	
2003	Tons at Age	70	1127	850	119	35	0	0	0	2201
	N at Age	1.743	21.802	13.167	1.623	0.374	0	0	0	38.709
	N Caught	0	0	0	0	0	0	0	0	
2004	Tons at Age	95	346	322	59	2	3	0	0	828
	N at Age	2.161	6.319	5.322	0.861	0.038	0	0	0	14.743
	N Caught	0	0	0	0	0	0	0	0	
2005	Tons at Age	180	102	94	38	22	0	0	0	436
	N at Age	4.286	1.679	1.375	0.538	0.245	0	0	0	8.123
	N Caught	0	0	0	0	0	0	0	0	
2006	Tons at Age	361	228	146	14	7	0	0	0	755
	N at Age	6.856	3.179	1.728	0.149	0.065	0	0	0	11.977
	N Caught	0	0	0	0	0	0	0	0	
2007	Tons at Age	40	379	102	32	4	0	0	0	557
	N at Age	0.701	5.472	1.279	0.391	0.041	0	0	0	7.884
	N Caught	0	0	0	0	0	0	0	0	
2008	Tons at Age	1008	18	0	0	0	0	0	0	1026
	N at Age	31.12	0.232	0	0	0	0	0	0	31.352
	N Caught	0	0	0	0	0	0	0	0	
2009	Tons at Age	7	775	42	0	0	0	0	0	824
	N at Age	0.178	17.839	0.509	0	0	0	0	0	18.526
	N Caught	0	0	0	0	0	0	0	0	

WOLLOCHET BAY

YEAR		Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	GTE Age 9	TOTAL SPAWNER BIOMASS
2000	Tons at Age	45	82	10	3	2	0	0	0	142
	N at Age	0.851	1.226	0.102	0.023	0.011	0	0	0	2.213
	N Caught	0	0	0	0	0	0	0	0	
2001	Tons at Age	59	52	22	0	0	0	0	0	133

	N at Age	1.528	0.719	0.225	0	0	0	0	0	2.472
	N Caught	0	0	0	0	0	0	0	0	
2002	Tons at Age	23	56	19	5	3	0	0	0	106
	N at Age	0.564	1.073	0.2	0.036	0.018	0	0	0	1.891
	N Caught	0	0	0	0	0	0	0	0	
2003	no age data									152
2004	no age data									52
2005	no age data									67
2006	no age data									27
2007	no age data									35
2008	no age data									45
2009	Tons at Age	0	354	6	0	0	0	0	0	360
	N at Age	0	7.07	0.116	0	0	0	0	0	7.186
	N Caught	0	0	0	0	0	0	0	0	

QUARTERMASTER HARBOR

									GTE	TOTAL SPAWNER
YEAR		**Age 2**	**Age 3**	**Age 4**	**Age 5**	**Age 6**	**Age 7**	**Age 8**	**Age 9**	**BIOMASS**
1995	Tons at Age	1433	410	146	10	0	0	0	0	2001
	N at Age	26.259	4.952	1.497	0.115	0	0	0	0	32.823
	N Caught	0	0	0	0	0	0	0	0	
1996	Tons at Age	477	315	12	0	0	0	0	0	805
	N at Age	8.921	4.401	0.122	0	0	0	0	0	13.444
	N Caught	0	0	0	0	0	0	0	0	
1997	Tons at Age	1147	231	24	0	0	0	0	0	1402
	N at Age	23.909	3.094	0.281	0	0	0	0	0	27.284
	N Caught	0	0	0	0	0	0	0	0	
1998	Tons at Age	287	457	184	19	0	0	0	0	947
	N at Age	4.97	4.97	1.621	0.162	0	0	0	0	11.723
	N Caught	0	0	0	0	0	0	0	0	
1999	Tons at Age	1115	106	38	0	0	0	0	0	1257
	N at Age	22.289	1.454	0.363	0	0	0	0	0	24.106
	N Caught	0	0	0	0	0	0	0	0	
2000	Tons at Age	171	556	16	0	0	0	0	0	743
	N at Age	2.884	8.254	0.199	0	0	0	0	0	11.337
	N Caught	0	0	0	0	0	0	0	0	
2001	Tons at Age	198	1044	78	0	0	0	0	0	1320

	N at Age	3.888	14.176	0.729	0	0	0	0	0	18.793
	N Caught	0	0	0	0	0	0	0	0	
2002	Tons at Age	41	206	167	2	0	0	0	0	416
	N at Age	0.933	2.736	1.741	0.031	0	0	0	0	5.441
	N Caught	0	0	0	0	0	0	0	0	
2003	Tons at Age	150	541	179	60	0	0	0	0	930
	N at Age	3.809	10.093	2.666	0.667	0	0	0	0	17.235
	N Caught	0	0	0	0	0	0	0	0	
2004	Tons at Age	40	186	252	189	32	27	0	0	727
	N at Age	1.003	3.364	3.186	2.006	0.295	0	0	0	10.09
	N Caught	0	0	0	0	0	0	0	0	
2005	Tons at Age	250	278	110	65	45	9	0	0	756
	N at Age	5.93	4.983	1.577	0.82	0.378	0.063	0	0	13.751
	N Caught	0	0	0	0	0	0	0	0	
2006	Tons at Age	659	241	63	0	16	8	0	0	987
	N at Age	12.854	3.613	0.829	0	0.177	0.059	0	0	17.532
	N Caught	0	0	0	0	0	0	0	0	
2007	no age data									441
2008	Tons at Age	403	33	28	27	0	0	0	0	491
	N at Age	11.317	0.458	0.285	0.228	0	0	0	0	12.288
	N Caught	0	0	0	0	0	0	0	0	
2009	Tons at Age	12	787	44	0	0	0	0	0	842
	N at Age	0.255	15.281	0.594	0	0	0	0	0	16.13
	N Caught	0	0	0	0	0	0	0	0	

PORT ORCHARD/MADISON

YEAR		**Age 2**	**Age 3**	**Age 4**	**Age 5**	**Age 6**	**Age 7**	**Age 8**	**GTE Age 9**	**TOTAL SPAWNER BIOMASS**
1988	Tons at Age	431	839	358	36	29	12	0	0	1705
	N at Age	6.807	8.95	2.906	0.293	0.208	0.061	0	0	19.225
	N Caught	0	0	0	0	0	0	0	0	
1989	Tons at Age	670	466	496	108	0	0	0	0	1739
	N at Age	12.009	4.945	4.588	0.782	0.05	0.05	0	0	
	N Caught	0.609	0.251	0.233	0.4	0	0	0	0	
1990	Tons at Age	766	648	174	127	59	22	0	0	1795
	N at Age	15.137	7.943	1.494	0.997	0.409	0.119	0	0	26.099
	N Caught	0	0	0	0	0	0	0	0	
1991	Tons at Age	380	146	118	18	47	12	1	0	722
	N at Age	8.013	2.054	1.231	0.152	0.416	0.078	0.015	0	11.959
	N Caught	0	0	0	0	0	0	0	0	
1992	Tons at Age	156	116	30	9	2	1	0	0	314

	N at Age	3.343	1.679	0.294	0.058	0.011	0.005	0	0	5.39
	N Caught	0	0	0	0	0	0	0	0	
1993	Tons at Age	266	16	15	3	4	0	0	0	304
	N at Age	4.988	0.19	0.148	0.025	0.019	0	0	0	5.37
	N Caught	0	0	0	0	0	0	0	0	
1994	Tons at Age	198	192	22	11	0	0	0	0	424
	N at Age	3.249	2.284	0.182	0.079	0	0	0	0	5.794
	N Caught	0	0	0	0	0	0	0	0	
1995	Tons at Age	619	165	79	0	0	0	0	0	863
	N at Age	11.988	1.87	0.683	0	0	0	0	0	14.541
	N Caught	0	0	0	0	0	0	0	0	
1996	Tons at Age	429	310	63	4	0	0	0	0	806
	N at Age	8.27	4.297	0.631	0.025	0	0	0	0	13.223
	N Caught	0	0	0	0	0	0	0	0	
1997	Tons at Age	214	130	14	2	0	0	0	0	360
	N at Age	4.226	1.645	0.126	0.012	0	0	0	0	6.009
	N Caught	0	0	0	0	0	0	0	0	
1998	Tons at Age	381	87	16	5	0	0	0	0	489
	N at Age	8.156	1.304	0.146	0.04	0	0	0	0	9.646
	N Caught	0	0	0	0	0	0	0	0	
1999	Tons at Age	1765	187	32	22	0	0	0	0	2006
	N at Age	37.913	2.542	0.339	0.017	0	0	0	0	40.811
	N Caught	0	0	0	0	0	0	0	0	
2000	Tons at Age	592	1110	53	2	0	0	0	0	1756
	N at Age	11.406	17.808	0.673	0.017	0	0	0	0	29.904
	N Caught	0	0	0	0	0	0	0	0	
2001	Tons at Age	1158	682	157	10	0	0	0	0	2007
	N at Age	27.825	9.793	1.587	0.075	0	0	0	0	39.28
	N Caught	0	0	0	0	0	0	0	0	
2002	Tons at Age	268	525	56	15	14	0	0	0	878
	N at Age	6.632	8.733	0.745	0.149	0.108	0	0	0	16.367
	N Caught	0	0	0	0	0	0	0	0	
2003	Tons at Age	283	522	228	48	4	1	0	0	1085
	N at Age	7.031	9.783	3.095	0.486	0.04	0.01	0	0	20.445
	N Caught	0	0	0	0	0	0	0	0	
2004	Tons at Age	116	366	169	48	0	0	0	0	700
	N at Age	2.616	5.948	2.078	0.509	0.006	0.003	0	0	11.16
	N Caught	0	0	0	0	0	0	0	0	
2005	Tons at Age	499	826	492	101	39	2	0	0	1958
	N at Age	11.26	13.541	6.481	1.036	0.386	0.022	0	0	32.726

	N Caught	0	0	0	0	0	0	0	0	
2006	Tons at Age	1038	752	288	29	5	0	0	0	2112
	N at Age	19.325	11.094	3.699	0.268	0.038	0	0	0	34.424
	N Caught	0	0	0	0	0	0	0	0	
2007	Tons at Age	155	1187	191	47	7	3	0	0	1589
	N at Age	2.787	16.939	2.261	0.484	0.06	0.015	0	0	22.546
	N Caught	0	0	0	0	0	0	0	0	
2008	Tons at Age	881	193	101	11	0	0	0	0	1186
	N at Age	20.392	2.774	1.176	0.115	0	0	0	0	24.457
	N Caught	0	0	0	0	0	0	0	0	
2009	Tons at Age	5	1564	188	11	0	0	0	0	1768
	N at Age	0.116	30.526	3.01	0.098	0	0	0	0	33.75
	N Caught	0	0	0	0	0	0	0	0	

PORT GAMBLE

YEAR		Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	GTE Age 9	TOTAL SPAWNER BIOMASS
1976	Tons at Age	58	453	381	86	71	65	13	15	1142
	N at Age	0.866	4.425	2.809	0.548	0.414	0.404	0.058	0.096	9.62
	N Caught									
1977	no age data									2525
1978	Tons at Age	87	270	389	421	403	252	103	60	1984
	N at Age	1.17	2.352	2.465	2.415	2.201	1.22	0.491	0.264	12.578
	N Caught									
1979	Tons at Age	0	548	360	523	179	181	0	0	1790
	N at Age	0	4.46	2.286	2.779	0.84	0.84	0	0	11.206
	N Caught									
1980	no age data									2309
1981	Tons at Age	221	633	380	307	138	47	28	0	1753
	N at Age	2.897	5.409	2.419	1.595	0.598	0.226	0.133	0	13.29
	N Caught									
1987	Tons at Age	935	820	256	35	0	0	0	0	2046
	N at Age	14.535	8.479	2.2	2.33	0	0	0	0	27.544
	N Caught	0.078	0.046	0.012	0.001	0	0	0	0	0.137
1988	Tons at Age	461	713	178	36	0	0	0	0	1390
	N at Age	6.159	6.644	1.319	0.243	0	0	0	0	14.365
	N Caught	0.142	0.153	0.03	0.006	0	0	0	0	0.331
1989	Tons at Age	1339	532	371	153	0	0	0	0	2395
	N at Age	22.302	5.582	3.122	1.119	0	0	0	0	32.125

	N Caught	0.133	0.033	0.019	0.007	0	0	0	0	0.192
1990	Tons at Age	965	1155	606	178	65	0	0	0	2969
	N at Age	15.678	11.974	4.457	1.127	0.376	0	0	0	33.612
	N Caught	0.454	0.347	0.129	0.033	0.011	0	0	0	0.974
1991	Tons at Age	380	915	630	194	104	36	0	0	2259
	N at Age	6.695	10.226	5.677	1.482	0.751	0.22	0	0	25.051
	N Caught	0.265	0.404	0.224	0.059	0.03	0.009	0	0	0.991
1992	Tons at Age	454	1251	454	79	30	0	0	0	2270
	N at Age	6.693	13.44	3.882	0.615	0.2	0	0	0	24.83
	N Caught	0.007	0.013	0.004	0.001	0	0	0	0	0.025
1993	Tons at Age	922	365	183	35	15	0	0	0	1521
	N at Age	18.052	4.107	1.7	0.263	0.098	0	0	0	24.22
	N Caught	0.012	0.003	0.001	0	0	0	0	0	0.016
1994	Tons at Age	1054	986	569	206	40	0	0	0	2857
	N at Age	15.975	10.981	4.834	1.46	0.236	0	0	0	33.486
	N Caught	0	0	0	0	0	0	0	0	0
1995	Tons at Age	1964	742	344	92	13	0	0	0	3158
	N at Age	35.324	8.22	2.968	0.692	0	0.057	0	0	47.261
	N Caught	0	0	0	0	0	0	0	0	0
1996	Tons at Age	805	903	315	37	0	0	0	0	2058
	N at Age	13.915	11.325	2.932	0.289	0	0	0	0	28.461
	N Caught	0	0	0	0	0	0	0	0	
1997	Tons at Age	844	473	77	26	0	0	0	0	1419
	N at Age	13.555	4.741	0.578	0.127	0	0	0	0	19.001
	N Caught	0	0	0	0	0	0	0	0	
1998	Tons at Age	257	486	208	7	13	0	0	0	971
	N at Age	5.013	6.61	2.044	0.05	0.073	0	0	0	13.79
	N Caught	0	0	0	0	0	0	0	0	
1999	Tons at Age	917	582	148	17	0	0	0	0	1664
	N at Age	17.476	7.909	1.531	0.128	0	0	0	0	27.044
	N Caught	0	0	0	0	0	0	0	0	
2000	Tons at Age	890	1338	182	34	12	0	0	0	2459
	N at Age	17.448	20.304	2.091	0.377	0.121	0	0	0	40.341
	N Caught	0	0	0	0	0	0	0	0	
2001	Tons at Age	585	1035	148	11	0	0	0	0	1779
	N at Age	9.328	11.749	1.353	0.071	0	0	0	0	22.501
	N Caught	0	0	0	0	0	0	0	0	
2002	Tons at Age	313	1058	393	49	0	0	0	0	1812

	N at Age	5.91	13.557	3.939	0.348	0	0	0	0	23.754
	N Caught	0	0	0	0	0	0	0	0	
2003	Tons at Age	184	621	231	29	0	0	0	0	1064
	N at Age	5.91	13.557	3.939	0.348	0	0	0	0	23.754
	N Caught	0	0	0	0	0	0	0	0	
2003	no age data									1064
2004	no age data									1257
2005	Tons at Age	361	320	351	216	106	9	0	9	1372
	N at Age	7.528	5.141	4.499	2.295	1.102	0.092	0	0.092	20.749
	N Caught	0	0	0	0	0	0	0	0	
2006	no age data									774
2007	no age data									826
2008	no age data									208
2009	Tons at Age	24	836	192	12	0	0	0	0	1064
	N at Age	0.658	15.97	2.255	0.094	0	0	0	0	18.977
	N Caught	0	0	0	0	0	0	0	0	

KILISUT HARBOR

YEAR		Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	GTE Age 9	TOTAL SPAWNER BIOMASS
1994	Tons at Age	81	149	17	46	0	0	0	0	292
	N at Age	1.176	1.554	0.126	0.252	0	0	0	0	3.108
	N Caught	0	0	0	0	0	0	0	0	
1996	Tons at Age	279	83	18	0	0	0	0	0	380
	N at Age	4.73	0.898	0.132	0	0	0	0	0	5.76
	N Caught	0	0	0	0	0	0	0	0	
1997	Tons at Age	123	103	64	17	0	0	0	0	307
	N at Age	1.688	1.019	0.478	0.096	0	0	0	0	3.281
	N Caught	0	0	0	0	0	0	0	0	
1998	Tons at Age	97	133	72	6	3	0	0	0	311
	N at Age	1.683	1.557	0.609	0.054	0.018	0	0	0	3.921
	N Caught	0	0	0	0	0	0	0	0	
1999	Tons at Age	768	26	7	0	0	0	0	0	802
	N at Age	16.939	0.434	0.059	0	0	0	0	0	17.432
	N Caught	0	0	0	0	0	0	0	0	
2000	Tons at Age	90	17	0	0	0	0	0	0	107
	N at Age	2.084	0.25	0	0	0	0	0	0	2.334
	N Caught	0	0	0	0	0	0	0	0	
2001	Tons at Age	214	348	43	7	0	0	0	0	612

		Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	GTE Age 9	TOTAL SPAWNER BIOMASS
	N at Age	4.065	4.286	0.385	0.05	0	0	0	0	8.786
	N Caught	0	0	0	0	0	0	0	0	
2002	Tons at Age	165	527	75	7	0	0	0	0	774
	N at Age	2.428	6.555	0.81	0.081	0	0	0	0	9.874
	N Caught	0	0	0	0	0	0	0	0	
2003	no age data									448
2004	Tons at Age	39	125	18	2	0	0	0	0	184
	N at Age	1.925	0.578	0.252	0.252	0.074	0.015	0	0	3.096
	N Caught	0	0	0	0	0	0	0	0	
2005	Tons at Age	87	59	11	13	0	0	0	0	170
	N at Age	2	1.114	0.164	0.131	0	0	0	0	3.409
	N Caught	0	0	0	0	0	0	0	0	
2006	no age data									54
2007	no age data									24
2008	no age data									0

PORT SUSAN

YEAR		Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	GTE Age 9	TOTAL SPAWNER BIOMASS
1995	Tons at Age	176	122	60	5	0	0	0	0	363
	N at Age	2.643	1.144	0.483	0.025	0	0	0	0	4.295
	N Caught	0	0	0	0	0	0	0	0	
1996	Tons at Age	36	58	16	0	0	0	0	0	110
	N at Age	0.548	0.644	0.137	0	0	0	0	0	1.329
	N Caught	0	0	0	0	0	0	0	0	
1997	Tons at Age	198	524	96	10	0	0	0	0	828
	N at Age	2.884	5.438	0.824	0.082	0	0	0	0	9.228
	N Caught	0	0	0	0	0	0	0	0	
1998	Tons at Age	279	1202	565	38	0	0	0	0	2084
	N at Age	5.127	15.227	5.438	0.311	0	0	0	0	26.103
	N Caught	0	0	0	0	0	0	0	0	
1999	no age data									545
2000	Tons at Age	166	428	184	6	0	0	0	0	785
	N at Age	2.665	5.552	1.926	0.051	0	0	0	0	10.194
	N Caught	0	0	0	0	0	0	0	0	
2001	Tons at Age	357	207	23	0	0	0	0	0	587
	N at Age	6.839	2.55	0.232	0	0	0	0	0	9.621

	N Caught	0	0	0	0	0	0	0	0	
2002	Tons at Age	71	353	310	41	0	0	0	0	775
	N at Age	1.384	5.015	3.517	0.404	0	0	0	0	10.32
	N Caught	0	0	0	0	0	0	0	0	
2003	Tons at Age	85	298	53	14	0	0	0	0	450
	N at Age	2.219	4.851	0.721	0.155	0	0	0	0	7.946
	N Caught	0	0	0	0	0	0	0	0	
2004	Tons at Age	74	144	152	51	7	0	0	0	429
	N at Age	1.556	2.413	2.063	0.623	0.078	0	0	0	6.733
	N Caught	0	0	0	0	0	0	0	0	
2005	no age data									157
2006	no age data									321
2007	Tons at Age	10	295	254	69	15	0	0	0	643
	N at Age	0.142	4.248	2.832	0.708	0.142	0	0	0	8.072
	N Caught	0	0	0	0	0	0	0	0	
2008	no age data									345
2009	Tons at Age	0	154	254	81	17	0	0	0	252
	N at Age	0	2.692	2.832	0.958	0.183	0	0	0	3.833
	N Caught	0	0	0	0	0	0	0	0	

HOLMES HARBOR

YEAR		Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	GTE Age 9	TOTAL SPAWNER BIOMASS
1996	Tons at Age	230	68	38	0	0	0	0	0	336
	N at Age	4.479	0.817	0.328	0	0	0	0	0	5.624
	N Caught	0	0	0	0	0	0	0	0	
1997	Tons at Age	277	200	52	0	0	0	0	0	530
	N at Age	5.256	2.471	0.47	0	0	0	0	0	8.197
	N Caught	0	0	0	0	0	0	0	0	
1998	Tons at Age	134	166	128	26	12	0	0	0	464
	N at Age	3.052	2.616	1.134	0.174	0.087	0	0	0	7.063
	N Caught	0	0	0	0	0	0	0	0	
1999	no age data									175
2000	no age data									281
2001	no age data									275
2002	no age data									573
2003	no age data									678

2004	no age data									673
2005	no age data									498
2006	no age data									1297
2007	no age data									572
2008	Tons at Age	80	444	159	3	0	0	0	0	686
	N at Age	2.077	6.153	1.951	0.025	0	0	0	0	10.206
	N Caught	0	0	0	0	0	0	0	0	
2009	Tons at Age	11	358	559	103	14	0	0	0	1045
	N at Age	0.284	7.385	6.154	0.947	0.095	0	0	0	14.865
	N Caught	0	0	0	0	0	0	0	0	

SKAGIT BAY

YEAR		Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	GTE Age 9	TOTAL SPAWNER BIOMASS
1995	Tons at Age	257	366	267	0	0	0	0	0	891
	N at Age	3.739	3.49	2.243	0	0	0	0	0	9.472
	N Caught	0	0	0	0	0	0	0	0	
1996	Tons at Age	629	107	0	0	0	0	0	0	736
	N at Age	13.718	1.407	0	0	0	0	0	0	15.125
	N Caught	0	0	0	0	0	0	0	0	
1997	Tons at Age	791	101	0	0	0	0	0	0	892
	N at Age	18.055	1.509	0	0	0	0	0	0	19.564
	N Caught	0	0	0	0	0	0	0	0	
1998	Tons at Age	127	62	20	0	0	0	0	0	209
	N at Age	3.031	1.023	0.218	0	0	0	0	0	4.272
	N Caught	0	0	0	0	0	0	0	0	
1999	no age data									905
2000	Tons at Age	464	161	21	0	0	0	0	0	646
	N at Age	10.04	2.584	0.262	0	0	0	0	0	12.886
	N Caught	0	0	0	0	0	0	0	0	
2001	Tons at Age	688	1243	226	13	0	0	0	0	2170
	N at Age	12.82	15.768	2.143	0.095	0	0	0	0	30.826
	N Caught	0	0	0	0	0	0	0	0	
2002	Tons at Age	465	1108	576	66	0	0	0	0	2215
	N at Age	9.403	16.494	6.937	0.616	0	0	0	0	33.45
	N Caught	0	0	0	0	0	0	0	0	
2003	Tons at Age	1199	1426	331	27	0	0	0	0	2983
	N at Age	30.342	24.875	4.641	0.236	0	0	0	0	60.094
	N Caught	0	0	0	0	0	0	0	0	

2004	Tons at Age	300	646	238	47	7	6	0	0	1245
	N at Age	6.915	11.927	3.742	0.702	0.081	0	0	0	23.448
	N Caught	0	0	0	0	0	0	0	0	
2005	Tons at Age	234	419	408	93	15	0	0	0	1169
	N at Age	4.94	6.642	5.967	1.111	0.147	0	0	0	18.807
	N Caught	0	0	0	0	0	0	0	0	
2006	Tons at Age	1421.5	979.347	397.141	28.0099	0	0	0	0	2826
	N at Age	25.258	13.165	4.439	0.306	0	0	0	0	43.168
	N Caught	0	0	0	0	0	0	0	0	
2007	Tons at Age	35.9709	893.277	268.783	37.9693	0	0	0	0	1236
	N at Age	0.703	13.786	3.63	0.453	0	0	0	0	18.572
	N Caught	0	0	0	0	0	0	0	0	
2008	Tons at Age	181	874	273	14	0	0	0	0	1342
	N at Age	4.216	12.227	3.318	0.128	0	0	0	0	19.889
	N Caught	0	0	0	0	0	0	0	0	
2009	Tons at Age	17	776	213	30	0	0	0	0	1036
	N at Age	0.449	14.835	2.925	0.372	0	0	0	0	18.581
	N Caught	0	0	0	0	0	0	0	0	

FIDALGO BAY

YEAR		Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	GTE Age 9	TOTAL SPAWNER BIOMASS
1992	Tons at Age	270	767	269	81	13	0	0	0	1399
	N at Age	6.987	13.581	3.641	1.083	0.197	0	0	0	25.489
	N Caught	0	0	0	0	0	0	0	0	
1993	Tons at Age	894	356	128	26	14	0	0	0	1417
	N at Age	19.706	6.031	1.699	0.17	0.085	0	0	0	27.691
	N Caught	0	0	0	0	0	0	0	0	
1994	Tons at Age	548	454	153	45	6	0	0	0	1207
	N at Age	10.43	7.327	2.111	0.487	0.103	0	0	0	20.458
	N Caught	0	0	0	0	0	0	0	0	
1995	Tons at Age	772	240	106	27	28	0	0	0	1173
	N at Age	19.078	4.101	1.426	0.357	0.357	0	0	0	25.319
	N Caught	0	0	0	0	0	0	0	0	
1996	Tons at Age	210	291	74	15	0	0	0	0	590
	N at Age	4.792	4.25	0.995	0.09	0	0	0	0	10.127
	N Caught	0	0	0	0	0	0	0	0	
1997	Tons at Age	543	301	85	0	0	0	0	0	929
	N at Age	14.166	4.481	0.723	0	0	0	0	0	19.37
	N Caught	0	0	0	0	0	0	0	0	

1998	Tons at Age	500	284	43	18	0	0	0	0	844
	N at Age	11.006	4.442	0.464	0.133	0	0	0	0	16.045
	N Caught	0	0	0	0	0	0	0	0	
1999	no age data									1005
2000	Tons at Age	404	300	18	15	0	0	0	0	737
	N at Age	8.32	4.53	0.277	0.185	0	0	0	0	13.312
	N Caught	0	0	0	0	0	0	0	0	
2001	Tons at Age	169	569	171	35	0	0	0	0	944
	N at Age	3.31	8.851	1.924	0.308	0	0	0	0	14.393
	N Caught	0	0	0	0	0	0	0	0	
2002	Tons at Age	593	165	91	15	0	0	0	0	865
	N at Age	14.214	2.496	0.977	0.109	0	0	0	0	17.796
	N Caught	0	0	0	0	0	0	0	0	
2003	Tons at Age	48	254	164	94	8	0	0	0	569
	N at Age	1.004	4.319	2.008	0.703	0.1	0	0	0	8.134
	N Caught	0	0	0	0	0	0	0	0	
2004	no age data									339
2005	no age data									231
2006	no age data									323
2007	no age data									159
2008	no age data									156

SAMISH/PORTAGE BAY

YEAR		Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	GTE Age 9	TOTAL SPAWNER BIOMASS
1994	Tons at Age	348	88	18	4	0	0	0	0	459
	N at Age	6.599	1.245	0.244	0.032	0	0	0	0	8.12
	N Caught	0	0	0	0	0	0	0	0	
1995	Tons at Age	128	39	21	6	0	0	0	0	194
	N at Age	2.611	0.5	0.231	0.067	0	0	0	0	3.409
	N Caught	0	0	0	0	0	0	0	0	
1996	Tons at Age	259	333	44	0	0	0	0	0	636
	N at Age	4.336	4.336	0.417	0	0	0	0	0	9.089
	N Caught	0	0	0	0	0	0	0	0	
1997	Tons at Age	310	165	30	4	0	0	0	0	509
	N at Age	6.203	1.948	0.253	0.035	0	0	0	0	8.439
	N Caught	0	0	0	0	0	0	0	0	

1998	Tons at Age	284	286	72	0	0	0	0	0	643
	N at Age	6.525	5.171	0.985	0	0	0	0	0	12.681
	N Caught	0	0	0	0	0	0	0	0	
1999	no age data									555
2000	no age data									196
2001	Tons at Age	255	173	41	0	0	0	0	0	470
	N at Age	4.871	2.389	0.375	0	0	0	0	0	7.635
	N Caught	0	0	0	0	0	0	0	0	
2002	Tons at Age	194	203	71	22	5	0	0	0	496
	N at Age	4.591	3.549	0.899	0.19	0.047	0	0	0	9.276
	N Caught	0	0	0	0	0	0	0	0	
2003	Tons at Age	20	109	98	56	12	0	5	0	299
	N at Age	0.437	1.598	1.046	0.513	0.076	0	0.038	0	3.708
	N Caught	0	0	0	0	0	0	0	0	
2004	no age data									351
2005	no age data									218
2006	no age data									412
2007	no age data									348
2008	no age data									409

INTERIOR SAN JUAN ISLANDS

YEAR		Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	GTE Age 9	TOTAL SPAWNER BIOMASS
1993	Tons at Age	343	107	23	0	0	0	0	0	472
	N at Age	6.438	1.231	0.189	0	0	0	0	0	7.858
	N Caught	0	0	0	0	0	0	0	0	
1996	Tons at Age	113	137	23	4	0	0	0	0	277
	N at Age	2.378	2.201	0.276	0.031	0	0	0	0	4.886
	N Caught	0	0	0	0	0	0	0	0	
1997	Tons at Age	30	0	0	0	0	0	0	0	30
	N at Age	0.677	0	0	0	0	0	0	0	0.677
	N Caught	0	0	0	0	0	0	0	0	
1998	no age data									
1999	no age data									197
2000	Tons at Age	112	16	0	0	0	0	0	0	128
	N at Age	2.798	0.289	0	0	0	0	0	0	3.087
	N Caught	0	0	0	0	0	0	0	0	

2001	no age data									219
2002	no age data									158
2003	no age data									72
2004	no age data									67
2005	no age data									41
2006	no age data									285
2007	no age data									33
2008	no age data									60

SEMIAHMOO BAY

YEAR		Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	GTE Age 9	TOTAL SPAWNER BIOMASS
1988	Tons at Age	664	1063	189	49	0	0	0	0	1965
	N at Age	9.508	10.914	1.406	0.335	0	0	0	0	22.163
	N Caught	0	0	0	0	0	0	0	0	
1989	Tons at Age	655	583	396	48	19	0	0	0	1701
	N at Age	10.89	5.954	3.081	0.32	0.134	0	0	0	20.379
	N Caught	0	0	0	0	0	0	0	0	
1990	Tons at Age	1330	380	116	75	29	0	0	0	1930
	N at Age	25.239	5.013	0.994	0.54	0.195	0	0	0	31.981
	N Caught	0	0	0	0	0	0	0	0	
1991	Tons at Age	1164	536	155	136	70	0	0	0	2061
	N at Age	21.772	6.887	1.555	0.889	0.444	0	0	0	31.547
	N Caught	0	0	0	0	0	0	0	0	
1992	Tons at Age	417	729	207	81	41	14	12	0	1501
	N at Age	7.716	8.901	1.819	0.56	0.251	0.063	0.063	0	19.373
	N Caught	0	0	0	0	0	0	0	0	
1993	Tons at Age	1390	268	164	63	10	6	0	0	1902
	N at Age	25.266	3.201	1.485	0.439	0.061	0.045	0	0	30.497
	N Caught	0	0	0	0	0	0	0	0	
1994	Tons at Age	870	367	119	18	14	0	0	0	1389
	N at Age	14.375	4.231	1.114	0.15	0.077	0	0	0	19.947
	N Caught	0	0.0001	0.001	0.0003	0.0008	0	0	0	
1996	Tons at Age	688	423	87	17	5	0	0	0	1219
	N at Age	12.746	4.869	0.654	0.123	0	0.033	0	0	18.425
	N Caught	0	0	0	0	0	0	0	0	
1997	Tons at Age	297	260	50	13	0	0	0	0	621

	N at Age	5.88	2.973	0.387	0	0.062	0	0	0	9.302
	N Caught	0	0	0	0	0	0	0	0	
1998	Tons at Age	601	230	74	16	0	0	0	0	919
	N at Age	14.121	3.896	0.852	0.122	0	0	0	0	18.991
	N Caught	0	0	0	0	0	0	0	0	
1999	no age data									868
2000	Tons at Age	793	126	7	0	0	0	0	0	926
	N at Age	16.063	1.866	0.08	0	0	0	0	0	18.009
	N Caught	0	0	0	0	0	0	0	0	
2001	no age data									1098
2002	no age data									1012
2003	no age data									1087
2004	no age data									629
2005	no age data									870
2006	no age data									1277
2007	no age data									1124
2008	no age data									662

CHERRY POINT

YEAR		Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	GTE Age 9	TOTAL SPAWNER BIOMASS
1973	Tons at Age	15	765	5864	4649	2880	645	90	0	14998
	N at Age	0.163	7.562	35.128	22.768	12.523	2.765	0.407	0	81.315
	N Caught	0.022	1.013	4.816	3.249	1.566	0.321	0.053	0	
1974	Tons at Age	42	1690	2430	4761	3281	1466	251	28	13963
	N at Age	0.542	23.213	16.619	26.284	15.897	6.594	0.994	0.09	90.322
	N Caught	0.025	1.331	3.593	9.236	6.773	2.715	0.34	0.084	
1975	Tons at Age	10	1954	1003	1923	3039	1819	538	52	10337
	N at Age	0.162	15.416	6.091	9.271	13.584	7.277	1.994	0.162	53.903
	N Caught	0.027	2.847	2.141	4.206	5.949	2.937	0.742	0.049	
1976	Tons at Age	379	794	2854	1587	2132	2653	1137	308	11844
	N at Age	5.528	10.169	18.087	8.327	9.828	11.057	4.368	1.229	68.251
	N Caught	0.535	1.014	3.415	1.922	2.136	2.173	0.703	0.195	
1977	Tons at Age	932	2486	843	1409	1065	1609	1665	1088	11097
	N at Age	13.912	22.406	6.151	7.908	5.199	6.81	6.663	4.1	73.221
	N Caught	0.826	1.568	2.394	2.003	2.052	1.768	0.965	0.429	
1978	Tons at Age	77	4521	1920	878	944	636	834	1174	10973

	N at Age	1.237	41.753	14.15	5.026	4.717	2.784	3.402	4.253	77.32
	N Caught	0.117	4.969	2.655	1.343	1.534	0.836	0.817	0.869	
1979	Tons at Age	269	976	3983	1872	747	996	438	687	9957
	N at Age	3.824	8.066	25.751	10.038	3.525	4.242	1.733	2.629	59.748
	N Caught	0.579	1.265	4.45	2.095	1.014	0.909	0.392	0.533	
1980	Tons at Age	3209	690	793	1847	1549	494	345	308	9329
	N at Age	40.156	6.217	5.047	9.948	7.241	2.121	1.317	1.097	73.144
	N Caught	4.897	1.041	1.736	1.822	0.965	0.338	0.154	0.161	
1981	Tons at Age	448	2631	740	647	1188	348	87	131	6219
	N at Age	5.991	20.715	4.894	3.164	5.274	1.392	0.338	0.422	42.189
	N Caught	0	0	0	0	0	0	0	0	
1982	Tons at Age	1261	1122	1747	614	299	230	64	0	5342
	N at Age	16.415	8.957	10.665	3.166	1.292	0.958	0.25	0	41.662
	N Caught	0.275	0.764	0.405	0.146	0.127	0.053	0.015	0.001	
1983	Tons at Age	1846	1580	1451	2185	597	161	202	40	8063
	N at Age	24.702	12.504	8.661	10.918	2.623	0.671	0.793	0.183	60.993
	N Caught	0	0	0	0	0	0	0	0	
1984	Tons at Age	1664	779	926	1151	985	242	71	77	5901
	N at Age	23.954	6.494	5.868	5.724	4.425	1.01	0.289	0.289	48.1
	N Caught	0	0	0	0	0	0	0	0	
1985	Tons at Age	1659	2385	1020	271	207	150	40	29	5760
	N at Age	23.895	21.667	6.907	1.448	0.947	0.613	0.167	0	55.7
	N Caught	0	0	0	0	0	0	0	0	
1986	Tons at Age	2393	1718	754	414	250	74	51	11	5671
	N at Age	30.802	14.959	5.465	2.208	1.214	0.276	0.221	0.055	55.2
	N Caught	0	0	0	0	0	0	0	0	
1987	Tons at Age	814	1287	622	199	90	37	22	37	3108
	N at Age	12.576	11.026	4.261	1.103	0.447	0.149	0.089	0.119	29.8
	N Caught	0.578	0.523	0.232	0.074	0.03	0.012	0.004	0.008	
1988	Tons at Age	1089	1793	1014	385	111	35	0	4	4428
	N at Age	14.794	16.12	6.593	2.01	0.523	0.161	0	0	40.2
	N Caught	0.408	0.448	0.194	0.063	0.017	0.004	0	0.001	
1989	Tons at Age	2086	809	745	348	12	8	0	0	4003
	N at Age	34.104	7.889	4.998	1.911	0.049	0.049	0	0	49
	N Caught	1.86	0.441	0.38	0.196	0.003	0.004	0	0	
1990	Tons at Age	1864	1769	450	605	265	25	20	0	4998
	N at Age	27.183	18.389	3.091	3.198	1.279	0.107	0.107	0	53.3
	N Caught	1.509	1.024	0.188	0.22	0.091	0.007	0.005	0	
1991	Tons at Age	754	1766	1151	499	398	46	14	0	4624
	N at Age	10.613	16.758	7.82	2.673	1.796	0.2	0.04	0	39.9

	N Caught	0.545	0.871	0.451	0.175	0.121	0.013	0.004	0	
1992	Tons at Age	1527	850	1119	349	88	60	8	0	4009
	N at Age	23.758	8.288	7.82	1.955	0.383	0.255	0.043	0	42.5
	N Caught	1.05	0.369	0.382	0.109	0.022	0.015	0.002	0	
1993	Tons at Age	3475	626	299	240	171	69	10	0	4894
	N at Age	55.342	6.767	2.211	1.407	0.871	0.268	0.067	0	67
	N Caught	3.179	0.392	0.152	0.121	0.092	0.029	0.006	0	
1994	Tons at Age	4876	873	304	133	114	19	6	0	6324
	N at Age	73.725	9.248	2.161	0.691	0.519	0.086	0	0	86.43
	N Caught	3.695	0.47	0.156	0.076	0.049	0.007	0.003	0	
1995	Tons at Age	1519	1942	320	99	189	33	4	0	4105
	N at Age	20.262	18.08	2.223	0.503	0.713	0.126	0	0	41.95
	N Caught	1.514	1.362	0.204	0.069	0.094	0.014	0.002	0	
1996	Tons at Age	573	1111	1083	204	53	68	6	0	3095
	N at Age	8.654	10.789	7.789	1.125	0.202	0.288	0.029	0	28.847
	N Caught	0.359	0.45	0.343	0.059	0.009	0.013	0.001	0	
1997	Tons at Age	236	630	595	82	33	0	0	0	1574
	N at Age	3.856	6.051	4.36	0.445	0.133	0	0	0	14.83
	N Caught	0	0	0	0	0	0	0	0	
1998	Tons at Age	841	205	196	59	21	0	0	0	1322
	N at Age	13.064	2.143	1.361	0.323	0.119	0	0	0	17.01
	N Caught	0	0	0	0	0	0	0	0	
1999	Tons at Age	267	884	82	29	4	0	0	0	1266
	N at Age	4.183	9.129	0.65	0.155	0.014	0	0	0	14.131
	N Caught	0	0	0	0	0	0	0	0	
2000	Tons at Age	370	249	185	3	0	0	0	0	808
	N at Age	5.221	2.514	1.413	0.018	0	0	0	0	9.175
	N Caught	0	0	0	0	0	0	0	0	
2001	Tons at Age	374	565	247	56	0	0	0	0	1241
	N at Age	5.592	6.434	1.897	0.328	0	0	0	0	14.265
	N Caught	0	0	0	0	0	0	0	0	
2002	Tons at Age	646	430	174	37	43	0	0	0	1330
	N at Age	11.173	5.202	1.52	0.22	0.22	0	0	0	18.317
	N Caught	0	0	0	0	0	0	0	0	
2003	Tons at Age	838	596	122	42	13	0	0	0	1611
	N at Age	14.411	7.876	1.245	0.311	0.072	0	0	0	23.939
	N Caught	0	0	0	0	0	0	0	0	
2004	Tons at Age	23	388	740	406	101	54	23	0	1734
	N at Age	0.375	4.168	5.717	2.668	0.584	0.264	0.107	0	13.894

	N Caught	0	0	0	0	0	0	0	0	
2005	Tons at Age	267	1522	169	36	16	0	0	0	2010
	N at Age	5.196	26.045	2.236	0.328	0.109	0	0	0	33.914
	N Caught	0	0	0	0	0	0	0	0	0
2006	Tons at Age	541	1491	129	55	0	0	0	0	2216
	N at Age	6.252	16.721	1.145	0.519	0	0	0	0	24.637
	N Caught	0	0	0	0	0	0	0	0	0
2007	Tons at Age	241	1411	503	14	0	0	0	0	2169
	N at Age	3.886	19.932	5.253	0.072	0	0	0	0	29.143
	N Caught	0	0	0	0	0	0	0	0	0
2008	Tons at Age	0	999	353	0	0	0	0	0	1352
	N at Age	0	11.424	3.36	0	0	0	0	0	14.784
	N Caught	0	0	0	0	0	0	0	0	0
2009	no age data									
2010	no age data									
2011	Tons at Age	388	735	503	165	13	0	0	0	1301
	N at Age	7.266	13.154	5.253	2.215	0.122	0	0	0	22.757
	N Caught	0	0	0	0	0	0	0	0	0

DISCOVERY BAY

YEAR		Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	GTE Age 9	TOTAL SPAWNER BIOMASS
1976	Tons at Age	1	59	270	100	86	123	38	21	697
	N at Age	0.014	0.602	2.113	0.579	0.466	0.635	0.184	0.108	4.706
	N Caught	0	0	0	0	0	0	0	0	
1977	Tons at Age	88	312	268	317	149	192	97	67	1488
	N at Age	1.165	3.088	2.058	2.07	0.939	1.108	0.532	0.339	11.31
	N Caught	0	0	0	0	0	0	0	0	
1978	Tons at Age	0	0	0	0	0	0	0	0	1305
	N at Age	0	0	0	0	0	0	0	0	
	N Caught	0	0	0	0	0	0	0	0	
1979	Tons at Age	71	116	132	159	89	173	102	42	882
	N at Age	0.891	1.102	0.972	1.009	0.551	0.922	0.539	0.21	6.19
	N Caught	0	0	0	0	0	0	0	0	
1980	Tons at Age	1877	763	274	71	119	52	58	0	3220
	N at Age	25.405	7.703	2.111	0.518	0.778	0.259	0.259	0	37.034
	N Caught	0	0	0	0	0	0	0	0	
1981	Tons at Age	61	1243	614	328	347	316	101	61	3070
	N at Age	0.975	10.866	4.333	2.155	1.951	1.701	0.476	0.25	22.685
	N Caught	0	0	0	0	0	0	0	0	

1988	Tons at Age	536	263	55	0	0	0	0	0	853
	N at Age	7.64	2.67	0.4	0	0	0	0	0	
	N Caught	0	0	0	0	0	0	0	0	
1996	Tons at Age	431	290	28	5	0	0	0	0	752
	N at Age	6.65	3.172	0.191	0.038	0	0	0	0	10.051
	N Caught	0	0	0	0	0	0	0	0	
1997	Tons at Age	176	23	0	0	0	0	0	0	199
	N at Age	4.335	0.36	0.003	0	0	0	0	0	4.698
	N Caught	0	0	0	0	0	0	0	0	
1998	no age data									0
1999	no age data									307
2000	no age data									159
2001	no age data									137
2002	no age data									148
2003	no age data									207
2004	no age data									252
2005	no age data									33
2006	no age data									1325
2007	no age data									42
2008	no age data									248

Appendix B. Puget Sound herring spawning biomass estimates by stock by year, 1973-2012.

PUGET SOUND HERRING SPAWNING BIOMASS ESTIMATES (TONS)
(BLANK CELL INDICATES NO ESTIMATE MADE THAT YEAR)

	SQUAXIN	WOLLOCHET			ELLIOT		SOUTH	QUILCENE	PORT	KILISUT	DISCO.	SEQUIM	DUNG.	PORT	HOLMES	SKAGIT	FIDALGO	SAMISH/	INT.	N.W. SAN	SEMIAHMOO	CHERRY
YEAR	PASS	PURDY	BAY	QM	BAY	PO-PM	HOOD	BAY	GAMBLE	HARBOR	BAY	BAY	BAY	SUSAN	HARBOR	BAY	BAY	PORTAGE	SAN JUAN	JUAN IS.	BAY	POINT
1973																						14998
1974																						13963
1975	298					887				279								109			772	10337
1976	2138			1357		447	492	279	1142	495	697	47			126	478		77	10	157	321	11844
1977	20			1413		1348	444	232	2525		1488	94			135	227		32	18	29	634	11097
1978	58			1860				14	1984	254	1305	10										10973
1979	137			1941		1255			1790		882							333				9957
1980	683			1930		2133			2309	477	3220	335	43		78	453	276	1008				9329
1981	772			1777		891			1753	324	3070						456				1008	6219
1982				1778		1214	177		1463		2356			1391	78		182	310			1389	5342
1983				909		1651			2407		2578		197	1398			640	159			874	8063
1984				1386		1293			2685		3144	31		1555			742	160			772	5901
1985				667		1415			2387		1447	18		1321	914		761	78			2325	5760
1986				1181		1926			2050		1566		234	934			731	79			1464	5671
1987				924		2538		68	2046		1593			1216		1552	887			400		3108
1988				750		1705			1390		853			570		1340					1965	4428
1989				898		1739			2395		1225			345	693			58	541		1701	4003
1990	566			681		1795			2969	364	855			291	380				391	218	1930	4998
1991	943			580		722	357	204	2259	613	925			245			1079		60	298	2061	4624
1992	771			518		314	144	97	2270		727			545			1399	262	17		1501	4009
1993	596			1075		304			1521	538	737	11		1693			1417	198	472		1902	4894
1994	225			1412		424			2857	292	375	0		365			1207	459			1389	6324
1995	157			2001		863		817	3158		261		287	363		891	1173	194			1245	4105
1996	374			805		806	239	328	2058	380	747	0	180	110	336	736	590	636	277	53	1219	3095
1997	149			1402		360	226	465	1419	307	199	0	158	828	530	893	929	509	30	79	621	1574
1998	68			947		489	101	1152	971	311	0	0	112	2084	464	209	844	643		107	919	1322
1999	474			1257		2006	516	2464	1664	802	307	0	352	545	175	905	1005	555	197		868	1266
2000	371		142	743		1756	140	2426	2459	107	159	0	138	785	281	646	737	196	128	90	926	808
2001	1597		133	1320		2007	187	2091	1779	612	137	6	87	587	275	2170	944	470	219	62	1098	1241
2002	3150		106	416		878	166	2585	1812	774	148	0	131	775	573	2215	865	496	158	131	1012	1330
2003	2201		152	930		1085	207	916	1064	448	207	0	44	450	678	2983	569	299	72	13	1087	1611
2004	828		52	727		700	176	2342	1257	184	252	0	22	429	673	1245	339	351	67	0	629	1734
2005	436		67	756		1958	210	1125	1372	170	33	0	0	157	498	1169	231	218	41	0	870	2010
2006	755		27	987		2112	244	2530	774	54	1325	0	0	321	1297	2826	323	412	285	0	1277	2216
2007	557		35	441		1589	70	2372	826	24	42	0	34	643	572	1236	159	348	33	0	1124	2169
2008	1025	496	45	491		1186	223	2531	208	0	248	0	69	345	686	1342	156	409	60	0	662	1352
2009	824	125	360	843		1768	156	3064	1064	0	205	0	46	252	1045	1036	15	320	0	0	990	1341
2010	510	500	11	143		350	214	2012	433	0	26	0	75	152	673	402	103	649	24	0	909	774
2011	565	711	21	96		123	156	4443	1464	0	0	0	104	138	3003	469	119	387	0	0	1605	1301
2012	589	135	31	108	290	217	264	2626	404	0	105		43	61	678	443	89	430	5	0	879	1120