Harbor Porpoise Observations in Burrows Pass

December 2009 through December 2010

Pacific Biodiversity Institute

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Abstract

Pacific Biodiversity Institute (PBI) initiated a study of the harbor porpoise in the Puget Sound in 2007. One of the early outcomes of this study was to identify an area, Burrows Pass, south of Anacortes, WA, as part of an apparent stronghold for the harbor porpoise. Subsequently, a series of regular observations of harbor porpoise in Burrows Pass were made from the bluffs of Washington Park from December 2009 through December 2010. The observations are continuing, but the results from the first year are summarized in this report and an initial analysis of the data is presented.

These observations were the first phase of a project to explore and implement various methods of assessing the distribution, population status, and population trend of this species of conservation concern. Consequently, observations were opportunistic and exploratory in nature. The results of this effort were encouraging and are being expanded in 2011 by a second phase of more regular and structured observations.

Two interns and more than 14 volunteers assisted with land-based observations, which were recorded opportunistically for 11 months of the last 12.5 month period. There were 105 hours of observations over 32 days. Porpoise were present for 42 of those 105 hours. Harbor porpoise generally appeared in groups of two to four. Mother and calf pairs were observed and active feeding events were common.

This report presents bar charts of these observations to date showing the number of hours porpoise were observed per unit effort. This report demonstrates that we are able to record data of the porpoise presence and activity. There is some indication of seasonal use of Burrows Pass from this data. The report also includes Appendix A, in which the hours the porpoise were present are plotted on tide charts for each day of observation to look for correlations with tide or current. In these figures, the hours when someone was observing are enclosed in a black box. Porpoise sightings are represented as black dots inside the box. If there were no porpoise observed, there are no black dots. Data for habitat correlation and analysis is being collected and will be used to assess possible locations for reserves and protected areas for the harbor porpoise. WDFW identified locations for forage fish are presented in Appendix B.

After reviewing the data collected, it appears that there is enough information and structure in the observational data that we have taken to date to justify continuing this study. This initial study demonstrates that observational data can be collected at Burrows Pass and points the way toward future research.

Introduction

Background

The harbor porpoise (*Phocoena phocoena*) is a small, shy cetacean that is difficult to observe and monitor in its marine environment. Both the population and range of the Washington Inland Waters stock have declined over the past 60 years. This study was initiated because of the major reduction in the harbor porpoise's range, the lack of significant data on current population status, and the opportunity to apply conservation science to develop information that might be helpful in the recovery of the harbor porpoise. This study continues and extends PBI's primary mission: applying science to aid biodiversity conservation.

The harbor porpoise is a full-time resident of Washington Inland Waters but has experienced a significant decline in range and population from historic levels. In the 1940s and 50s, it was regularly sighted around Olympia. However by the 1980s, its numbers and range had been reduced to the point that it was effectively extirpated from south Puget Sound and rarely seen south of Admiralty Inlet. The primary reason for harbor porpoise decline is thought to be entrapment in gill nets. Habitat loss, decline of forage fish species, pollution, and noise are also contributing factors.

The harbor porpoise is listed as a species of concern in Washington and British Columbia (http://wdfw.wa.gov/conservation/endangered/ 2013)(Baird 2003). Worldwide the species is also in decline. Surveys of the porpoise population were conducted aerially in 1996 and 2002–3 by NOAA. These surveys are conducted approximately every six years and take place over an interval of a few weeks. The area covered in this survey includes the San Juan Islands, Haro Strait, and the Strait of Juan de Fuca. The areas in the south Puget Sound are not included. In an aerial survey approximately 30% of the actual population is counted because a certain fraction is submerged or missed. The count is multiplied by a correction factor to obtain an assessment number for the total stock (Laake 1998; Calambokidis 1993). The infrequency of the surveys, the limited area covered, the correction factor for the population actually counted, and the limited time period over which the survey takes place contribute to the uncertainty of the assessed stock and the population trend.

The harbor porpoise is one of two porpoise species found in the Washington Inland Waters. The other, Dall's porpoise (Phocoenoides Dalli), is slightly larger, but its coloration—dark gray with white areas on the sides and dorsal fin—is strikingly different. And while the harbor porpoise is reclusive, the Dall's will seek out power boats to ride the bow wave. The Dall's porpoise tends to be found in deeper waters and unlike the resident harbor porpoise spends significant time at sea. The other small cetacean, Pacific white-sided dolphin (Lagenorhynchus obliquidens), resides almost entirely at sea, but occasionally is seen in the Strait of Juan de Fuca, the Strait of Georgia, and vicinity.

The project began when one of the PBI board members, Aileen Jeffries, was starting an acoustic study of harbor porpoise echolocation signals and became aware of the major reduction in their range in the interval between 1950 and the present. Since they are a small, reclusive cetacean, they are difficult to observe and survey. She wanted to test if their population trends could be monitored by acoustic recording devices.

Assessment Strategy

Initially, we have been making visual observations to assess how much information could be collected by a land-based observation method. The first element was to identify optimal observation locations and to determine an area over which the animals could be observed effectively. Observations are limited by daylight hours, weather, and the observer's accuracy. We expect these limitations will be removed when the study is complemented by acoustic monitoring. We also have been testing instruments for acoustic monitoring, which is described in another report (Jeffries 2009).

Another element of this initial study is to determine habitat requirements for the harbor porpoise. We are collecting and recording physical site characteristics, forage availability, daily and seasonal cycles of currents, and disturbance factors such as boat traffic. In the future, we will want to track salinity, current, temperature, and other parameters.

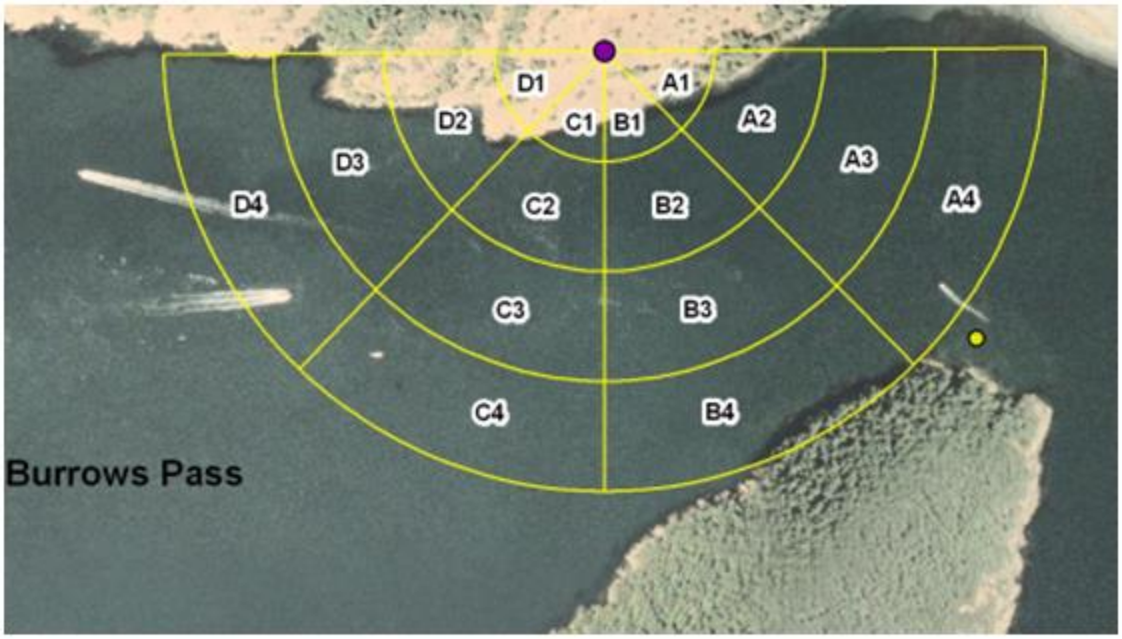
We have analyzed the observation data to learn how frequently the porpoise could be sighted per unit effort. With this preliminary data we are adjusting the sighting schedule and our data collection forms. Also with this preliminary information, we are starting to test correlations between porpoise presence and various physical parameters relating to seasonal and diurnal cycles. As the study progresses, we will be developing a habitat model to compare to visual and acoustic records of porpoise presence.

Observation Locations and Parameters

The position for the majority of our observations to date was located on the bluffs in Washington Park on the north side of Burrows Pass.

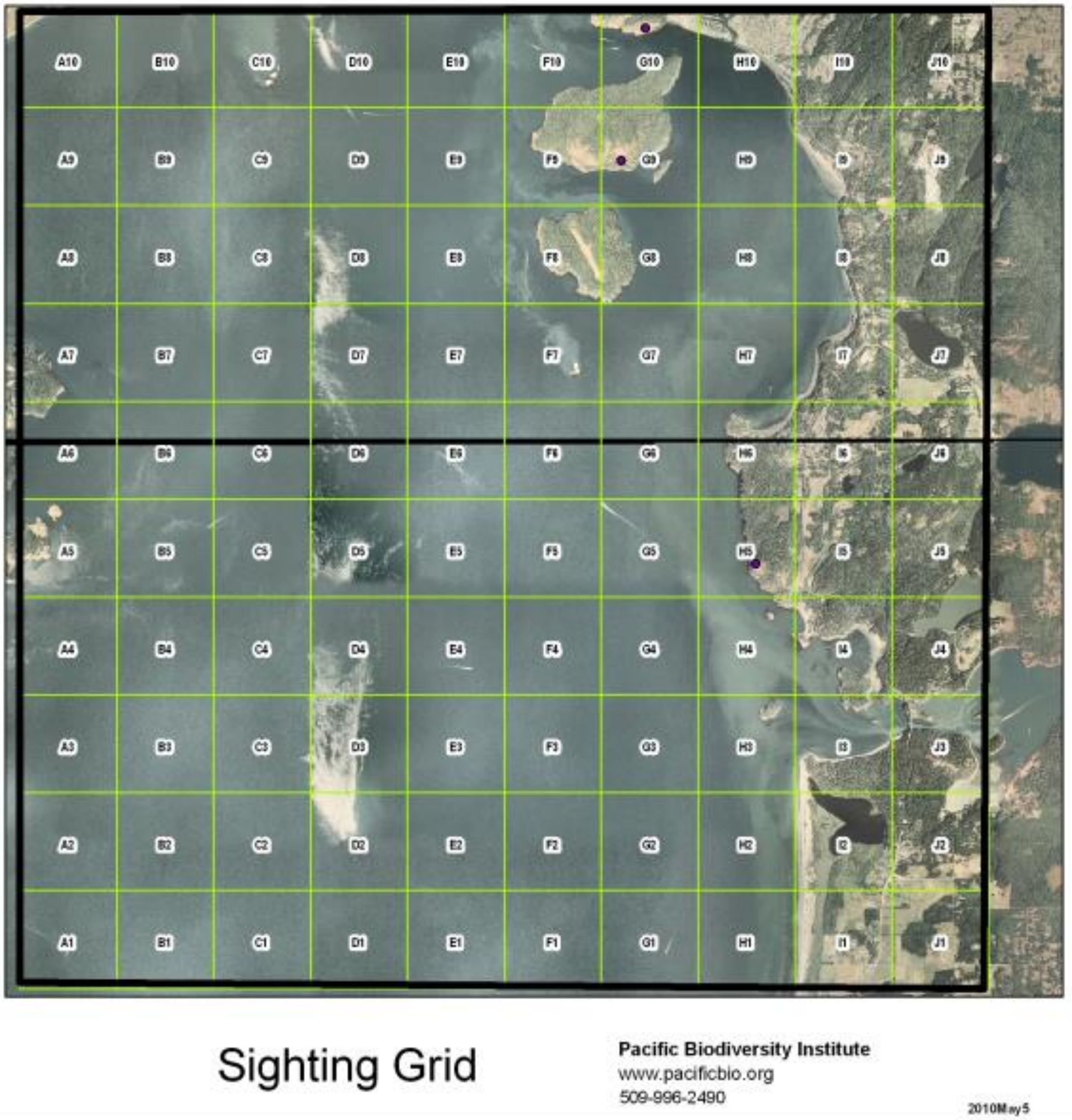
Latitude: 48 29' 28.74"
Longitude: -122 41' 34.65"
Station Height: 54 meters above mean sea level

A sighting grid was constructed using ESRI's ArcGIS Geographic Information System and is shown below. This grid is used for general observations when a precise location is not needed. It breaks the observable area into four wedges that radiate from the observation position, the purple dot. The wedges each cover an arc of 45 degrees and the rings are spaced radially a distance of 125 meters to a distance of 500 meters. Volunteers have remarked how easy it is to use and remember. The yellow dot on the map indicates a tide rip where porpoise are often sighted and is designated A5.



GIS tools will be used extensively in this study to locate and map visual information. The grid above will be used later for a report figure to show shaded grid elements corresponding to frequency of sightings.

In addition to this location, observations were made at Sars Head, south Deception Pass beach, and the lighthouse on Burrows Island. Porpoise were seen from those locations, but systematic observations have not been collected. We were assisted with observations on the water by guides with Anacortes Kayak Tours. This is a very useful collaboration for extending the area we are able to cover. Support from the guides will be sought for the 2011 season. The sighting grid for kayak observations and for other land-based observations around Burrows Bay is shown below. To date the porpoise have been observed in Grid Numbers E7 through E10, F8 through F10, and H2 through H5.



Site Characteristics and Habitat

One of the goals of our study is to identify habitat characteristics that attract harbor porpoise. These characteristics include water depth, current velocity, forage fish, and degree of disturbance. Harbor porpoise are found regularly in some areas and are almost never seen in others. PBI is collecting a record of locations where they can be found in the Puget Sound and noting the best sites for observations.

The NOAA Stock Assessments report that harbor porpoise seem to be found more often in waters where the depths are less than 200 m. The Dall's porpoise is usually associated with deeper waters. Anecdotal evidence and our observations indicate that while there is overlap in the locations where Dall's porpoise and harbor porpoise are found, there is significant separation for the majority of the two populations. For example, we have yet to see Dall's porpoise in Burrows Pass. Frequently, we have seen both Dall's and harbor porpoise in Haro Strait.

Harbor porpoises are regularly sighted in Burrows Pass and Burrows Bay. Surrounding Burrows Bay, good observation locations include Sars Head, Biz Point, the cliffs north of Deception Island, and off the shore near the beach at South Deception Pass Park. Except for the beach, these locations are 20 to 100 meters above the water. We are finding that 50 meters is a good elevation for observations.

Harbor porpoise are also regularly seen in the current rips in Rosario Strait, southwest of Burrows Island and may be spotted there from the lighthouse on Burrows Island. Because of the regular presence of harbor porpoise and the numerous locations from which we can observe them, the Burrows Bay area was selected for our study. We are beginning to collect sightings that indicate the harbor porpoise may also be numerous to the north of Fidalgo Island in the channels around Guemus Island and in Skagit Bay near Penn Cove.

Currents through the Burrows Pass area are variable and may be greater than 5 knots at times. They often flow toward the west on the north side of the Pass for both ebb and flood. On the south side, they appear to be to the east much of the time with what appears to be and may be a dividing flow line diagonally across the Pass. The harbor porpoises are most often seen in tide rip areas where the current is swift. These rips occur at the southeast side of Burrows Pass. They also occur along the north shore of the Pass and near the mouth of the Pass emptying into Rosario Strait. They are also seen in Rosario Strait over an extensive distance west of Burrows Island.

The water depth in Burrows Bay and Burrows Pass is less than 70 m, and in Rosario Strait it is less than 200 m. The sea bed is rocky and gravelly. Cliffs surround most of the Bay and continue down under the water where the rock is broken by terraces of sand and gravel. There are a few sandy, gravelly beaches. There are kelp beds and a little eel grass. One area, Flounder Bay, was probably originally a wetland and has been made into a subdivided, residential moorage development and marina.

Diet and Habitat

The harbor porpoise diet is not well known. They appear to be opportunistic and are known to feed on small fish such as surf smelt and rockfish. According to A. Hall, (Hall 2004) their diet includes clupeids [American shad (*Alosa sapidissima*), Pacific herring (*Clupea pallasii*), Pacific sardine (*Sardinops sagax*)] and gadids [Pacific cod, (*Gadus macrocephalus*) and pollock]. In southern British Columbia, juvenile blackbelly eelpout, opal squid, and sand lance may be seasonally important.

We do see the harbor porpoises feeding in the tide rips at the locations described above. At the same time they are feeding, seals and gulls are usually seen feeding in the same area as well as fishermen trolling. On February 21, 2010, at 1600, when the porpoises were quite active, a fisherman told us the blackmouth (immature Chinook salmon) were feeding on smelt. I would assume the porpoise were feeding on the smelt. This is a topic on which we will be collecting more information. We hope to have a REEF dive group do a survey of the fish and invertebrate species in Burrows Pass. Several seasonal surveys would give us more information about the species on which harbor porpoise feed in this area.

We are collecting Washington Department of Fish and Wildlife maps, which indicate that there are suitable surf smelt and sand lance spawning beds along the north and east sides of Burrows Bay. It appears that not all of the documented potential spawning areas are actually used on an annual basis. Herring holding areas and dates of spawning are also shown in these maps. They indicate that Skagit Bay, which flows into South Burrows Bay and Rosario Strait through Deception Pass, is an important herring holding and spawning area. Areas north of Fidalgo also appear to be important hearing holding and spawning areas. Appendix B contains these maps and discusses the habitat aspect of forage fish important to the harbor porpoise.

Results

The observations in this report of harbor porpoise in Burrows Pass were made from the cliffs of Washington Park from December 2009 through December 2010. During this first phase we were assessing how much information could be collected by volunteers and how accurate and useful that information would be. Consequently, data collection was exploratory in nature. Our continuing study will attempt to assess the population status and trends of this species in the waters around Fidalgo Island. The results of this first effort were encouraging and are being followed in January 2011 by a second phase of more structured observations.

Over 14 volunteers assisted with these observations, and the majority of the observations were made by three observers. The observations were recorded opportunistically for 11 different months of a 12.5 month period. The time of observation varied from sunrise (0700) to dusk (1900), and porpoise were observed over this full range of hours. There were 105 total hours of observations over 32 days, and porpoise were present for 41.6 of those 105 hours. The porpoises generally appeared in groups of two to four. A number of pairs were recognizable as mothers with calves during the interval of time from August into November. The porpoises were seen either traveling through the Pass or circling and feeding. The largest number observed at any one time was 10 and these were scattered around the viewing area in groups of two to five. This number occurred at a time when local fishermen said blackmouth were feeding on smelt, February 21, 2010. On the next day, February 22, there were also many porpoises.

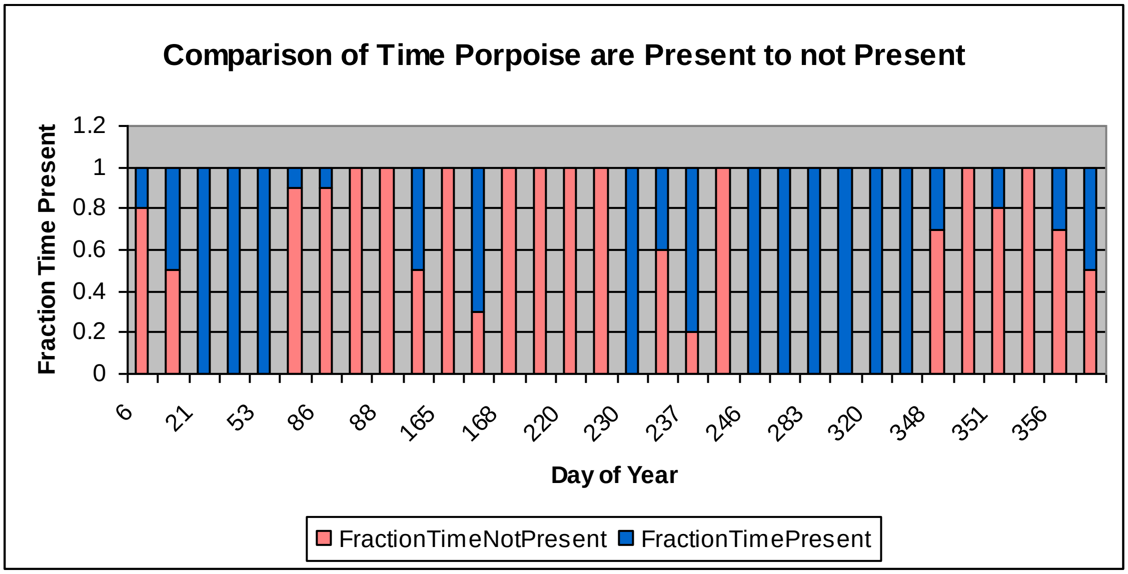
Because there was relatively little data, the sightings were grouped by hour and by day. The initial analysis did not use the count of number of porpoises present but rather a presence or absence of porpoise for each hour of observation. The distribution of sightings throughout the viewing area of Burrows Pass has not been analyzed.

Discussion

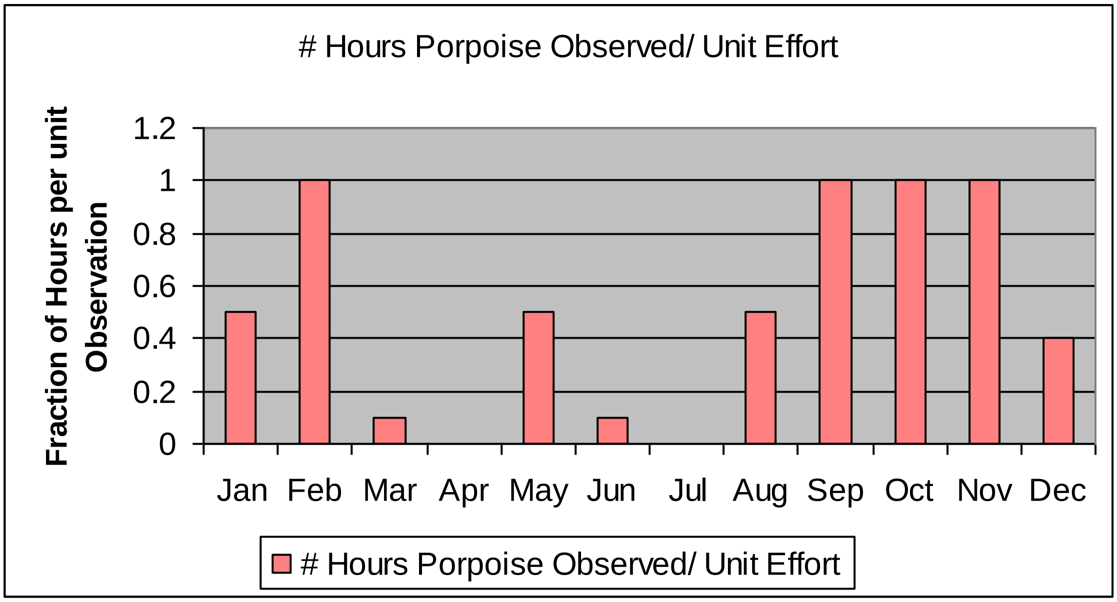
Since the data collected is somewhat limited, the analysis was limited to a determination of the time the porpoise were seen in the area in relationship to the unit of observation effort per sighting. The data described below is from the observation location at the bluffs in Washington Park looking into Burrows Pass.

We looked for seasonality and found that there may be a seasonal variation. We did not have enough data to test a diurnal cycle but did establish that porpoise were sighted during all daylight hours.

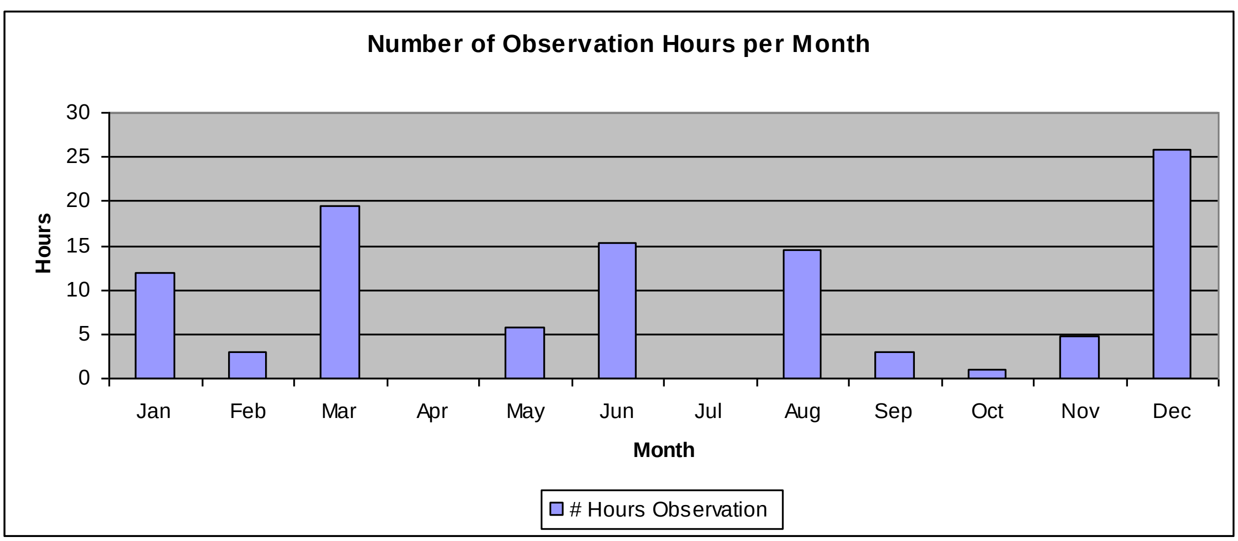
The figure below illustrates the number of hours each day that an observer saw porpoises present divided by the number of hours that day that an observer was looking for porpoise. If porpoises were present the whole time the fraction of time present is equal to a value of 1. The bar chart does show that there were groups of days in which porpoise were always present or never present. Based on this initial data, I hypothesize that porpoises use of Burrows Pass may vary on a seasonal basis.

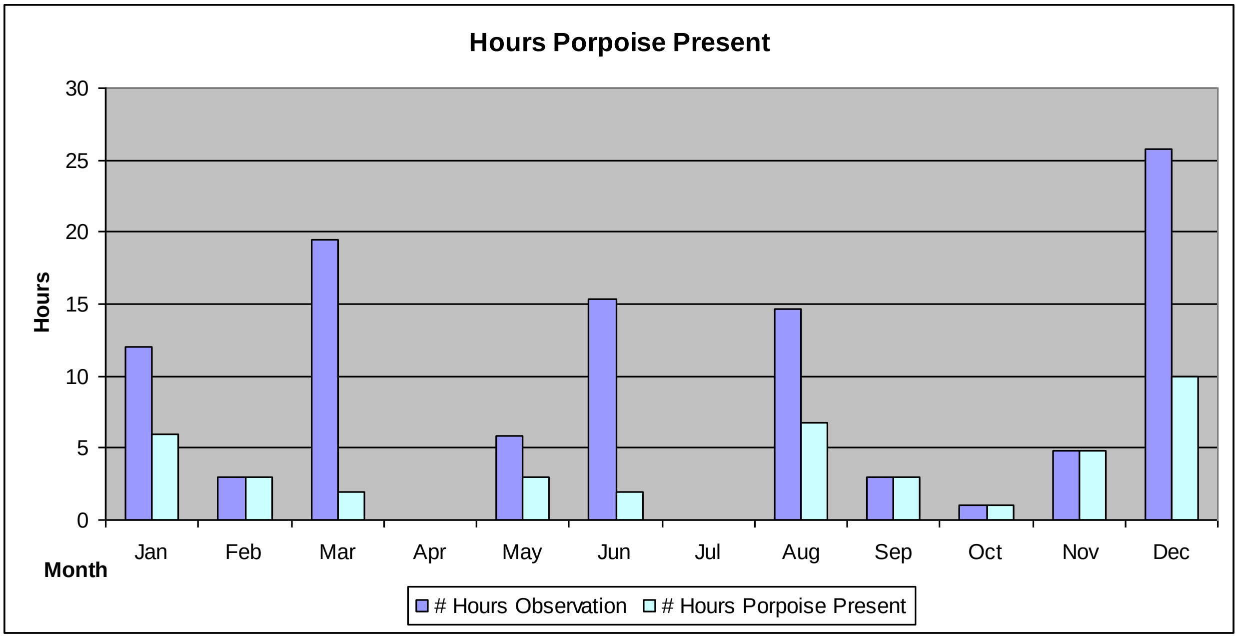


An important element of observational data is the measure of sightings per unit effort. The bar chart below shows on a monthly basis how much of the time there were porpoise present during the entire observation period. If porpoise were present the entire observation time the value is 1, which is the maximum return per unit effort.



The two bar charts below demonstrate that much of the observation time was expended in several months (March, June, and December) when there were few porpoise present. And conversely, it demonstrates that in February, September, October, and November porpoise were present constantly during the observation periods. Much less time was spent observing in September, October, and November than in some other months. As mentioned earlier, this initial data was collected in an opportunistic, exploratory manner. In hindsight, we would have liked to have spent more time in the months September through November and will do so in 2011. This initial data indicates that there were very few porpoise in March and June. We are not certain that there were always abundant porpoises in September through November.





I hypothesize that there will be more porpoise present when the current is fast, tide rips are formed, and the forage fish are more vulnerable to predators. Also I hypothesize that the porpoise are feeding on forage fish that are holding to spawn. We are collecting data to test this and will be examining these hypotheses in the subsequent report.

To test the relationship between sightings and currents, I have collected tide and current data. In a first examination of the data, a tidal chart for each observation day was plotted, a box was drawn to show the hours in which observations were made, and points were placed on the tidal curve to indicate when porpoise were sighted. These charts are collected in Appendix A. No pattern is visually obvious from the figures, but this data will be analyzed in our continuing study. In a second effort to show a correlation between the current and the presence of porpoise, I will be taking the current vector at the time of observation and relating it to the number of porpoise sighted by:

- Taking the peak values for tidal current for the day and fitting sine curves
- Computing the current during the hours of observation
- Analyzing the correlation between the tidal current versus the number of porpoise observed. This relationship is non-linear and will have to be analyzed accordingly.

In the past year, the boat density was observed to vary from 1 per hour to 20 per hour. In some of the times when porpoise were feeding and abundant, boats were seen to travel through the center of the pod cluster. We were not able to generalize on the porpoise reaction to the boats. In the coming year, there will be a focus on a count of the number of boats per hour. We will attempt to establish if there is a correlation between porpoise presence and boat traffic.

In addition to sighting for the observation grid, we examined telephoto photographs to determine if individuals could be recognized and found one porpoise with a nick in its dorsal fin and one that was a lighter gray color. Not much work has been done on this topic. Various behaviors were identified: feeding, traveling, mothers with calves, and we think we observed one mother nursing. We looked for a reaction to boats and could not confirm a displacement when they were intently feeding. On one occasion, I was in a kayak observing a mother and calf feeding when a power boat approached. The mother moved with her calf to the opposite side of our kayaks away from the power boat and continued feeding.

Other wildlife were often seen. Seals were most frequent and often were feeding with the porpoise. Gulls, eagles, otter, heron, cormorant, and kingfishers were regularly seen. These will be recorded more systematically in the coming year.

Conclusion

This study has broadened to include visual, photographic, and habitat elements to complement acoustic recordings. In the coming year, we will test photographic techniques to complement observations. We will place one passive acoustic monitor at the east end of Burrows Pass. We will be applying for additional grant money to place an array of passive acoustic monitors (PAMs) in the waters around Fidalgo Island. The visual and photographic records we will be collecting will be used to "calibrate" the acoustic data produced by the acoustic monitors. Passive acoustic monitors will allow us to record porpoise presence continuously day and night. Porpoise presence data from acoustic monitors will be far more complete and cost-effective than any other method we have used to date.

Data analysis will be developed to look for diurnal cycles relating to currents and tides. In addition, GIS tools will be used to examine and model habitat use with seasonal cycles.

In conclusion, there appears to be enough structure to the observations we have taken to date to justify continuing this study.

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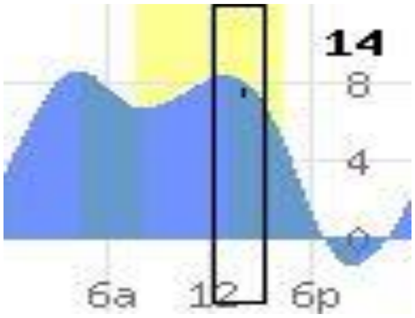
Appendix A

December 2009



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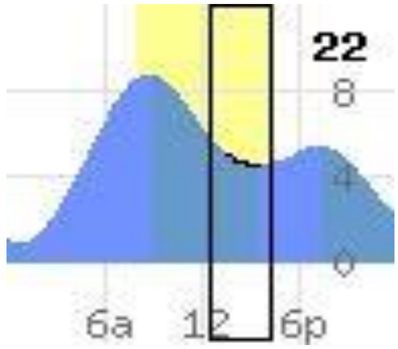

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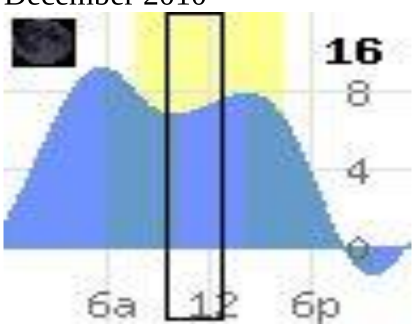

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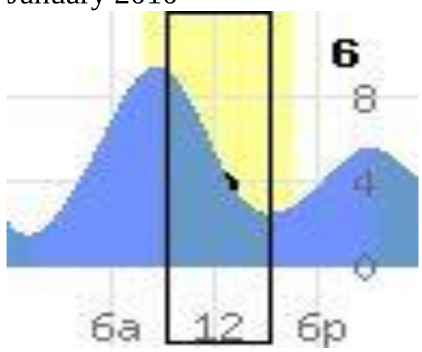

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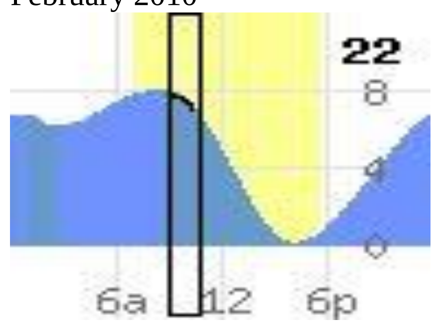

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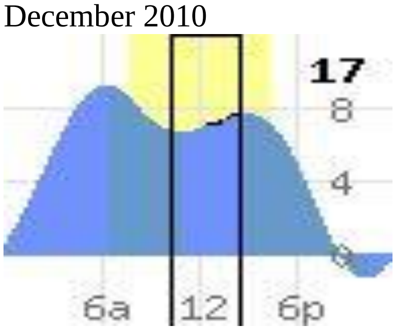

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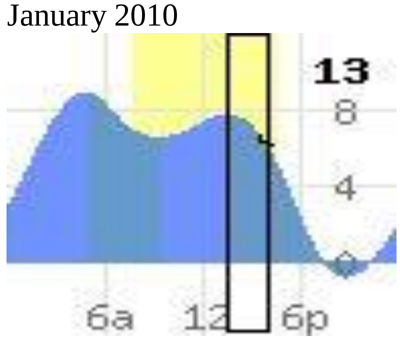

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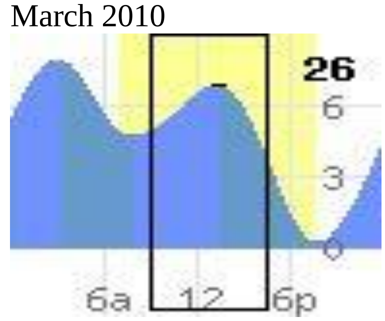

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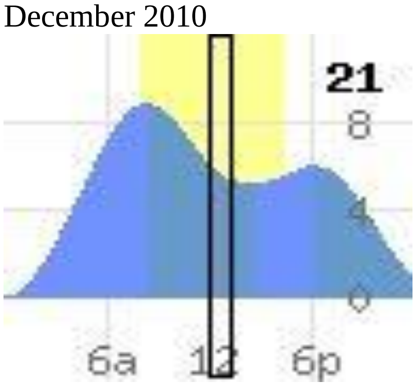

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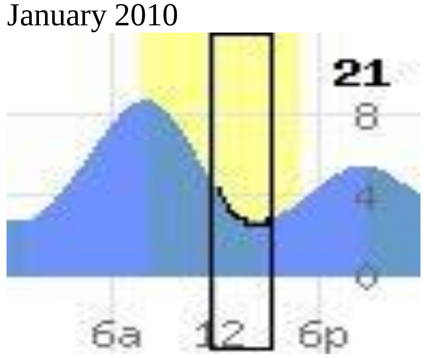

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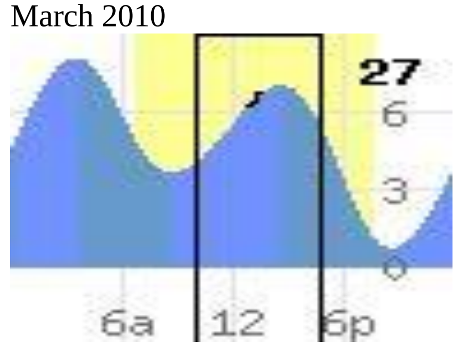

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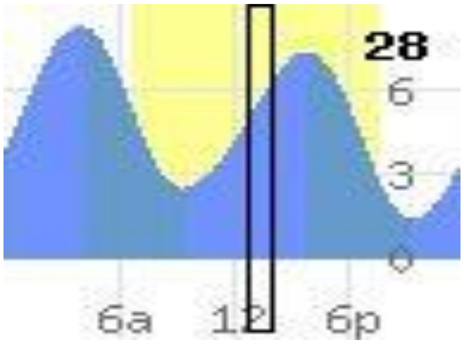

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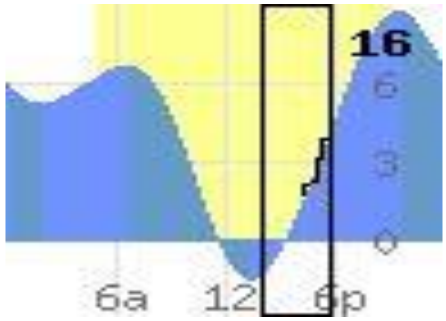

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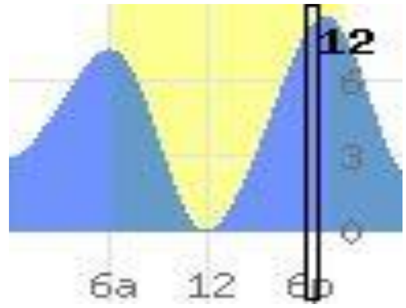

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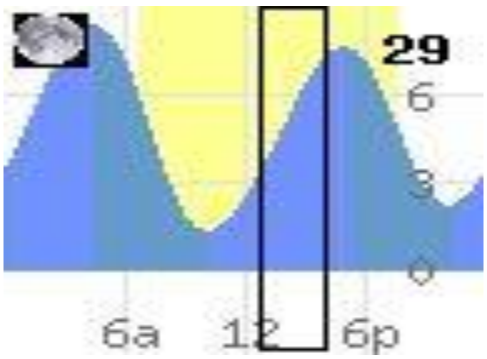

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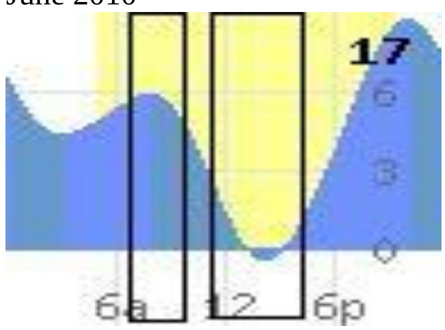

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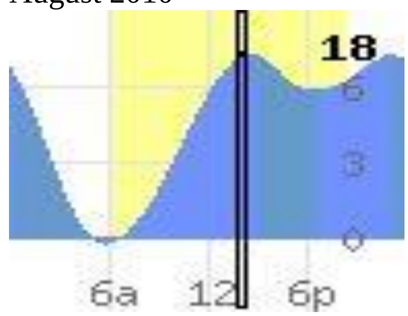

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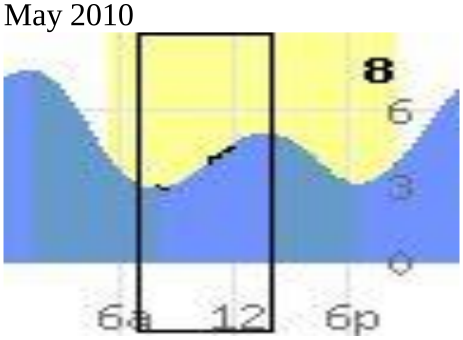

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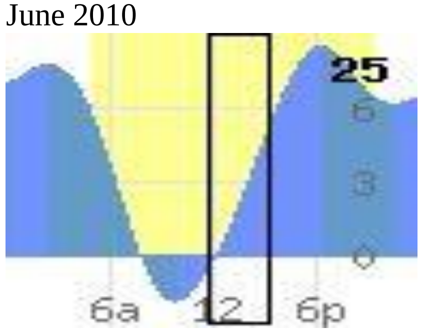

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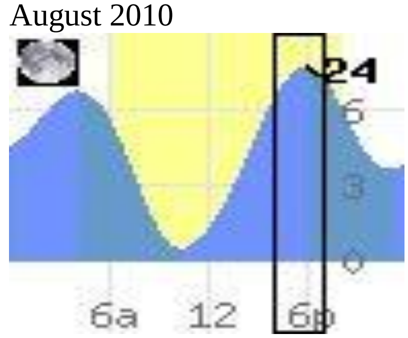

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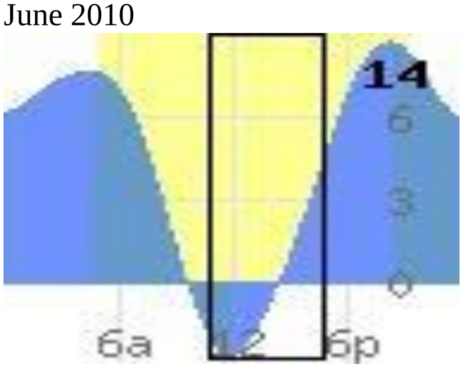

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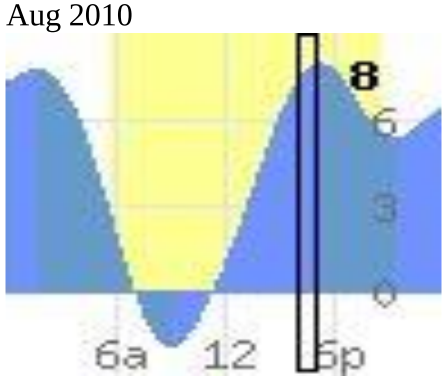

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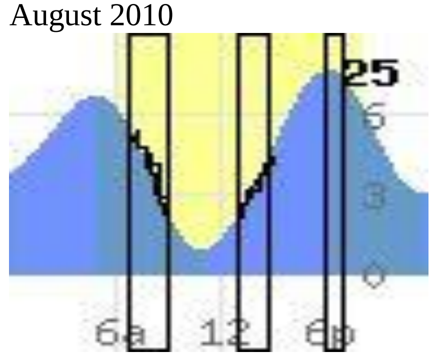

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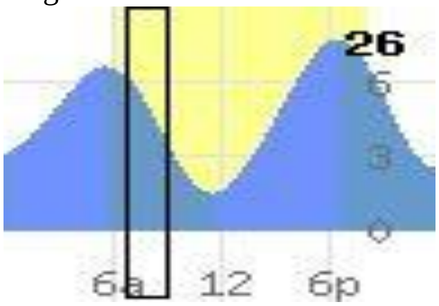

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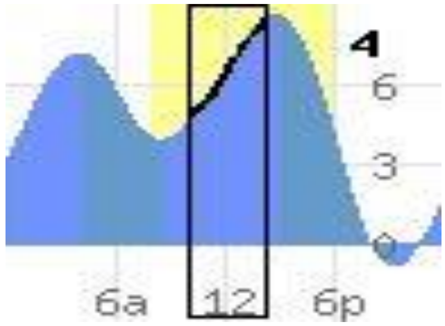

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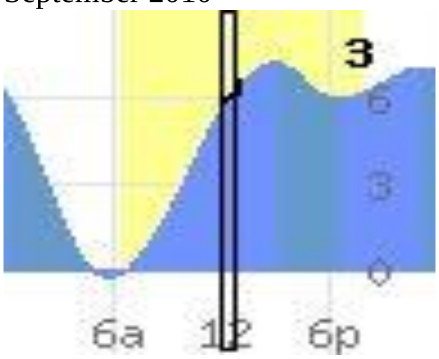

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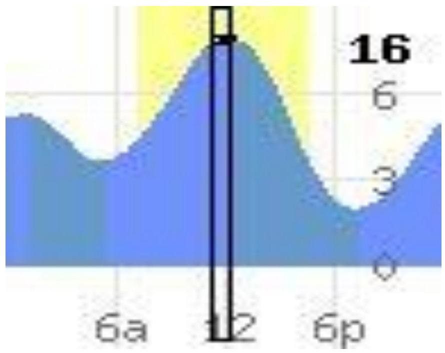

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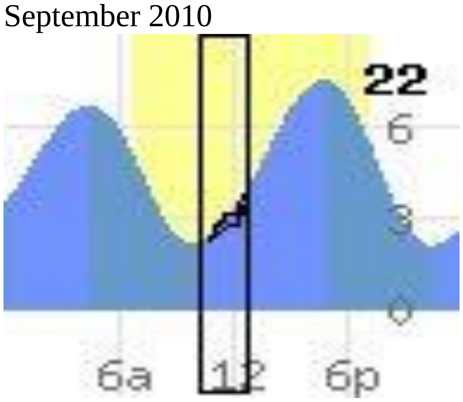

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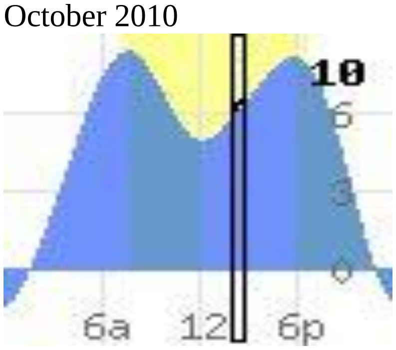


Appendix B

Forage Fish Spawning Habitat

The presence of forage fish is a requirement for harbor porpoise habitat. Pacific herring (*Clupea pallasi*), surf smelt (*Hypomesus pretiosus*), and Pacific sand lance (*Ammodytes hexapterus)* are known to be forage fish for the harbor porpoise. All of these spawn in the nearshore zone of the Puget Sound. Herring attach their eggs to benetic vegetation like eelgrass, and smelt and sand lance lay eggs in the sand just below the high tide line (Penttila 2007). Scientists have documented forage fish populations and habitats in a number of reports (Penttila 1984, 1998, 2000, 2007; Small 2005; Stick 1993, 2009; Su 2006; Dowty 2010; Mumford 2007).

Forage fish spawning can be related back to porpoise habitat by observing that these fish move into a holding area for a month or more before and during spawning. This implies that one might find a correlation in seasonal porpoise presence and these holding areas. The maps below show the potential and actual spawning areas for smelt and sand lance and the documented spawning areas for herring. The maps imply that the area north of Fidalgo, Fidalgo Bay, and the area in the Skagit Bay might be important harbor porpoise feeding areas. And, possibly the area near Portage Bay is important. One might speculate that the forage fish move out through Deception Pass after spawning and that the young of all the forage fish are to some degree swept out by the Deception Pass currents. This might correlate with the presence of harbor porpoise near Deception Island.

Surf Smelt and Sand Lance

WDFW surveys indicate both smelt and sand lance spawn throughout much of the year in the Puget Sound and their spawning ecology is similar. There is some variation for the peak of the spawning activity in different sub basins. First year smelt are often seen near the spawning area, but by the time they are three years old they are rarely detected by WDFW hydro-acoustic or trawl surveys. They do not appear to form large schools or to migrate (Penttila 2007). Because of this they are thought to be nearshore or close to the bottom. Sport fishermen often collect smelt using hand dip nets from beaches. Sand lance do commonly bury in middle intertidal hardshell-clam substrates. Also, sand lance are seen in "bait-balls," of tightly clustered fish near the surface, where they attract sea birds. There is little information about where these forage fish are when they are not ready to spawn (private communication Dave Lowry).

Spawning generally takes place on beaches with sand or gravel. Figures 1 and 2 are taken from WDFW web site, SalmonScape (http://wdfw.wa.gov/mapping/salmonscape/index.html). These figures show that there is a large area of shoreline that is potential spawning area for smelt and sand lance, but that a small portion of that is actually used.

Surf smelt do not generally form large open-water pelagic schools. They may reside near the shoreline in the general area of their spawning sites for their entire lives. Sand lance spawning occurs in fall-winter, between November and February in Puget Sound, mostly during the early part of this period. Juvenile sand lance are common in the nearshore zone through their first summer of life. Pursued and concentrated by alcid seabirds, they commonly attract a variety of predators to their dense surface schools, which salt-water anglers refer to as bait-balls.

Figure 1. Potential spawning habitat - surf smelt and sand lance (SalmonScape, WDFW).

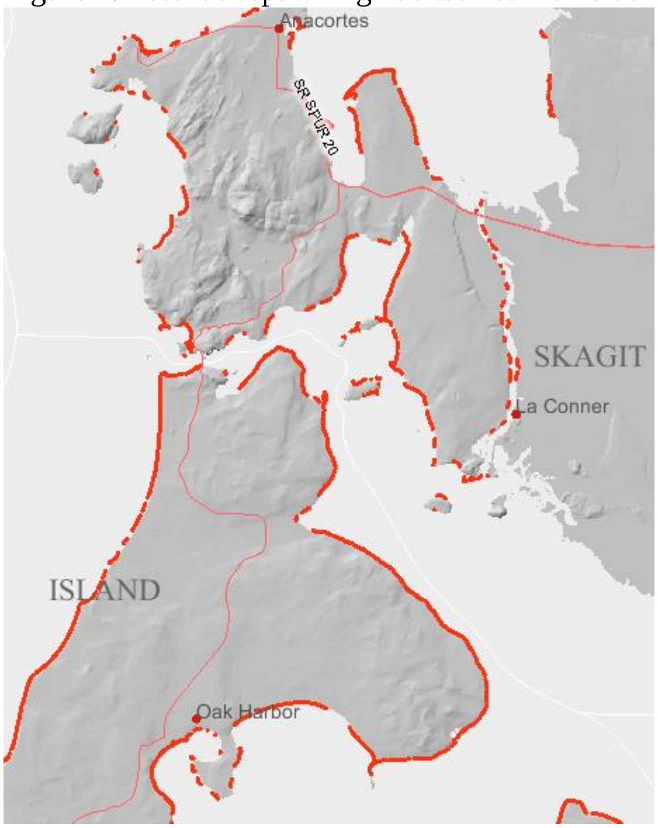
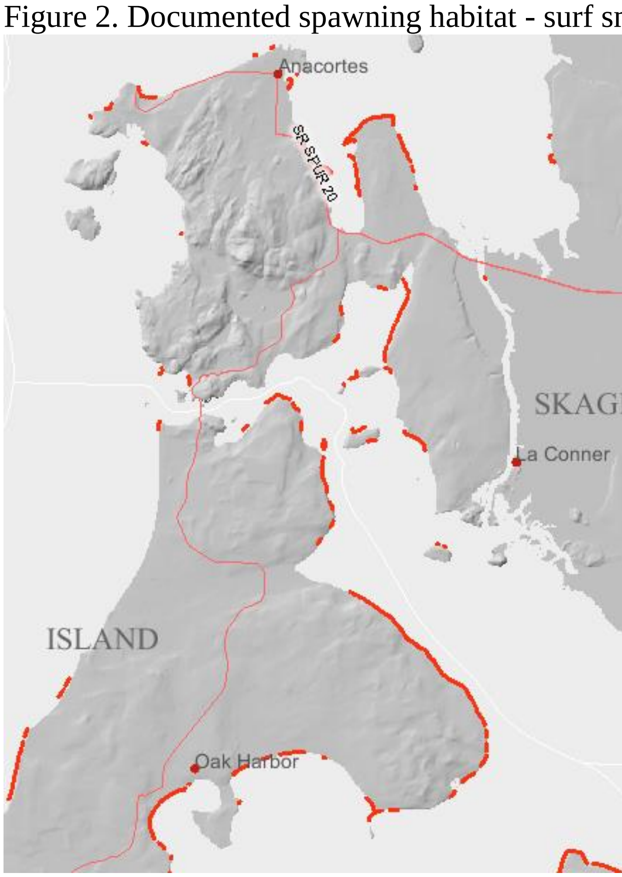
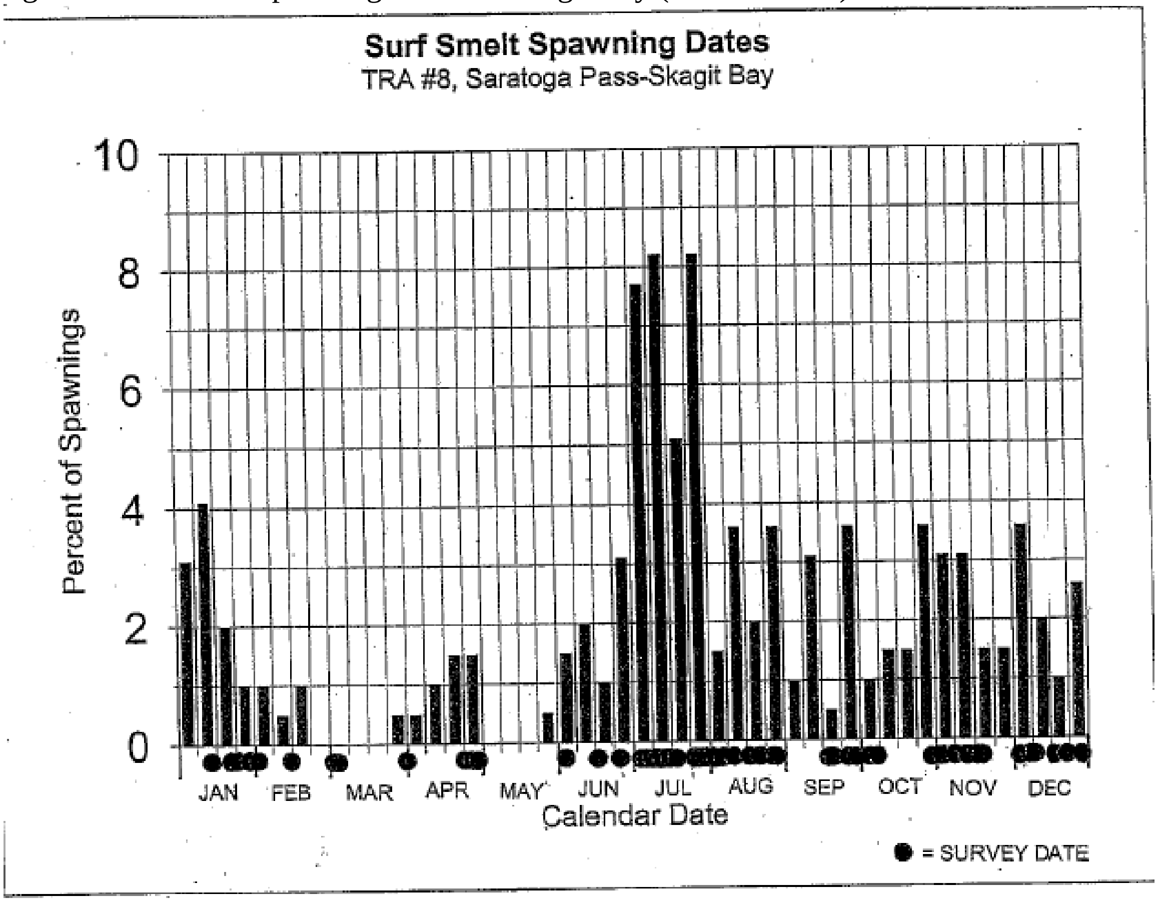


Figure 2. Documented spawning habitat - surf smelt and sand lance (SalmonScape – WDFW).



Figures 3 and 4 show the spawning dates for surf smelt peak in July in the Skagit Bay area. They are fairly continuous in Fidalgo Bay from mid-May to mid-March.

Figure 3. Surf smelt spawning dates for Skagit Bay (Penttila 2000).



196 spawning dates
61 surveys, 1972-1995

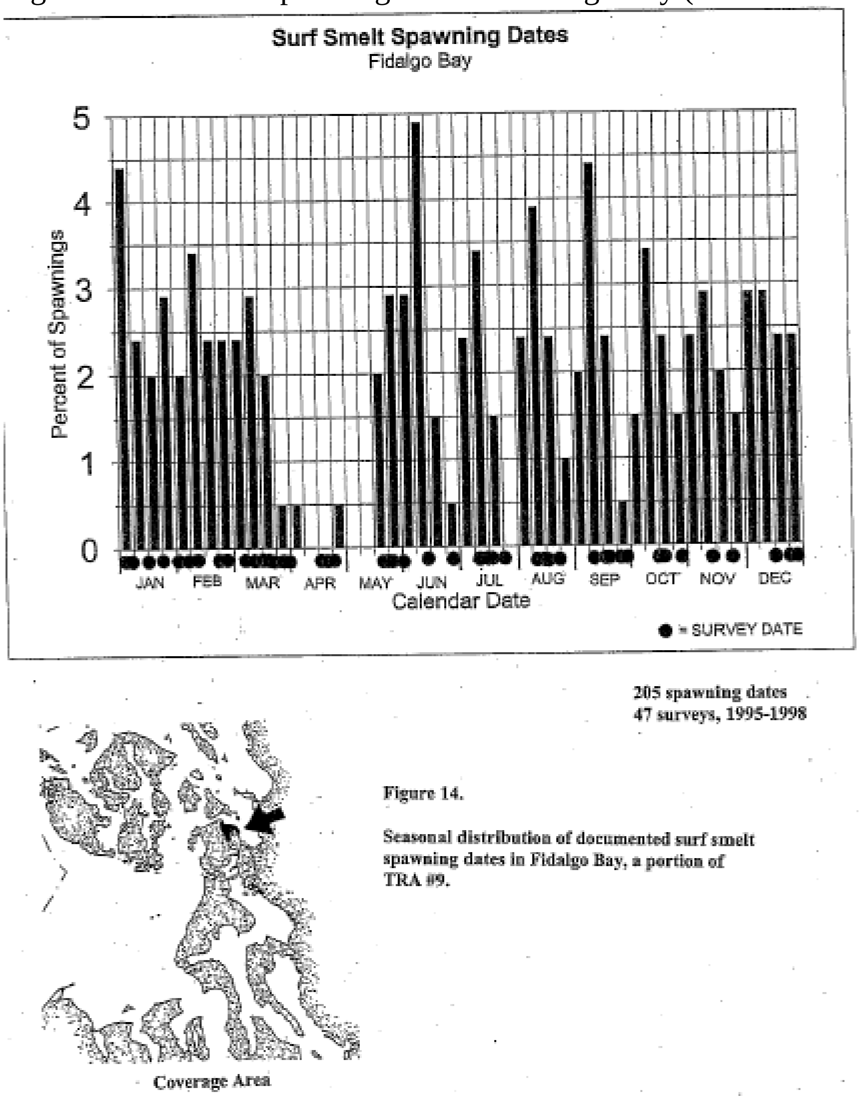
61 surveys, 1972-1995

Coverage Area

Figure 13.

Seasonal distribution of documented surf smelt spawning dates in TRA #8, Saratoga Passage-Skagit Bay.

Figure 4. Surf smelt spawning dates for Fidalgo Bay (Penttila 2000).



Herring

Herring spawning appears to be well documented. This is the forage fish that is most closely assessed by WDFW in Stock Reports (Small 2005) (Stick 1994, 2009). Herring generally are thought to spawn in February and March on benetic marine vegetation. “The late-winter/early-spring herring spawning/hatching season might have evolved to take best advantage of the spring increase in planktonic productivity, which may be triggered earlier, more densely, and more consistently in sheltered bays.” (Stick 2009)

According to Penttila, 2007, “the consistency of spawning site usage is coupled by an apparent consistency in the usage of certain pre-spawning holding areas, where ripening fish assemble adjacent to spawning sites some months before the onset of spawning activity.”

Figure 5, below, gives the major identified herring spawning areas in the Puget Sound (Stick 2009). Figures 6, 7, and 8 are the spawning areas, holding areas, and dates for three areas near the Burrows Bay study area: Skagit Bay, Fidalgo Bay, and Portage Bay. All of these maps are collected for later work on harbor porpoise habitat mapping. Note the information on spawning dates and the mapped holding areas give excellent information to try to correlate with observed porpoise presence. The holding areas are shown in green and are near the spawning areas, which are shown in red. In particular, the spawning dates for the three areas run from mid-January or early February through mid-April. The peak is mid-February to mid-March. As we learn more about the duration and character of the holding time, we may be able to correlate the herring spawning to the porpoise activity.

Figure 5. Herring spawning areas in Puget Sound (Stick 2009).

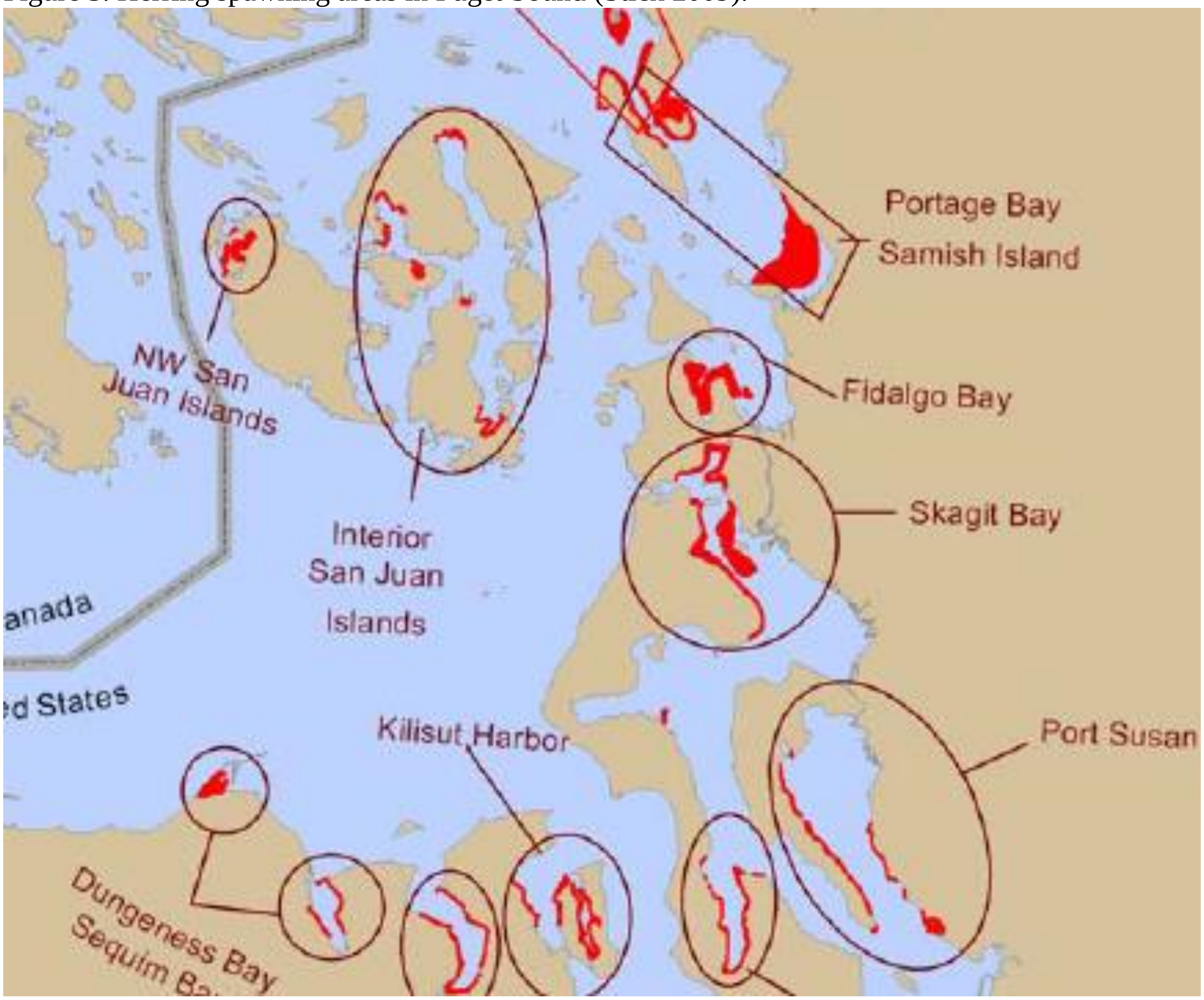


Figure 6. Herring spawning areas, holding areas, and spawning dates for Skagit Bay (Stick 2009).

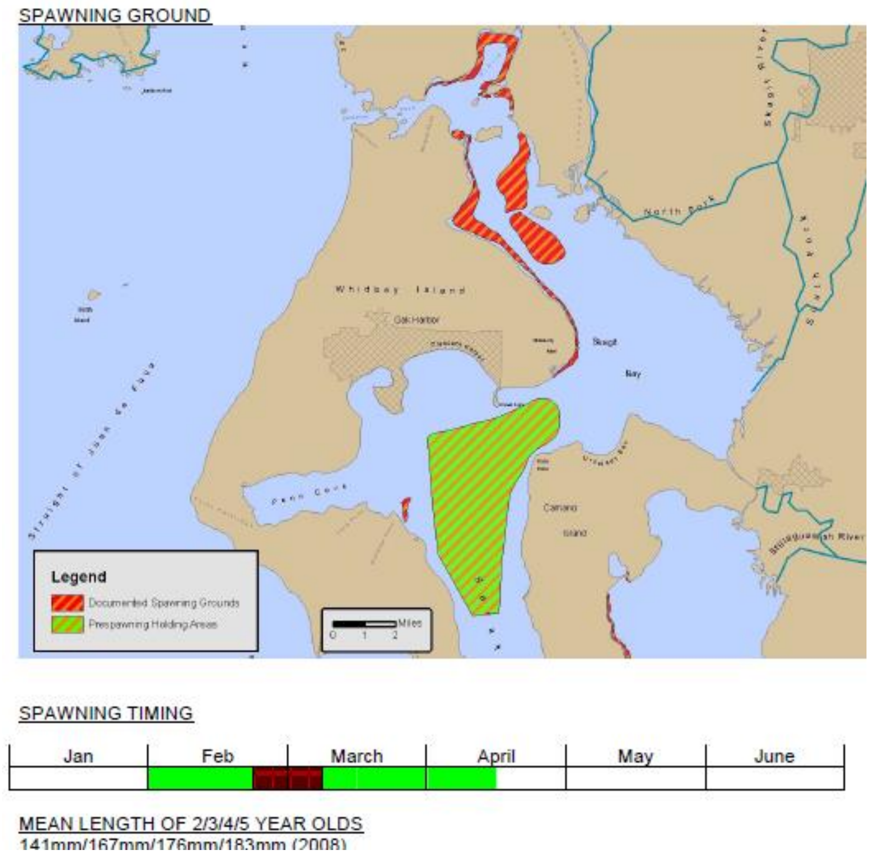


Figure 7. Herring spawning areas, holding areas, and spawning dates for Fidalgo Bay (Stick 2009).

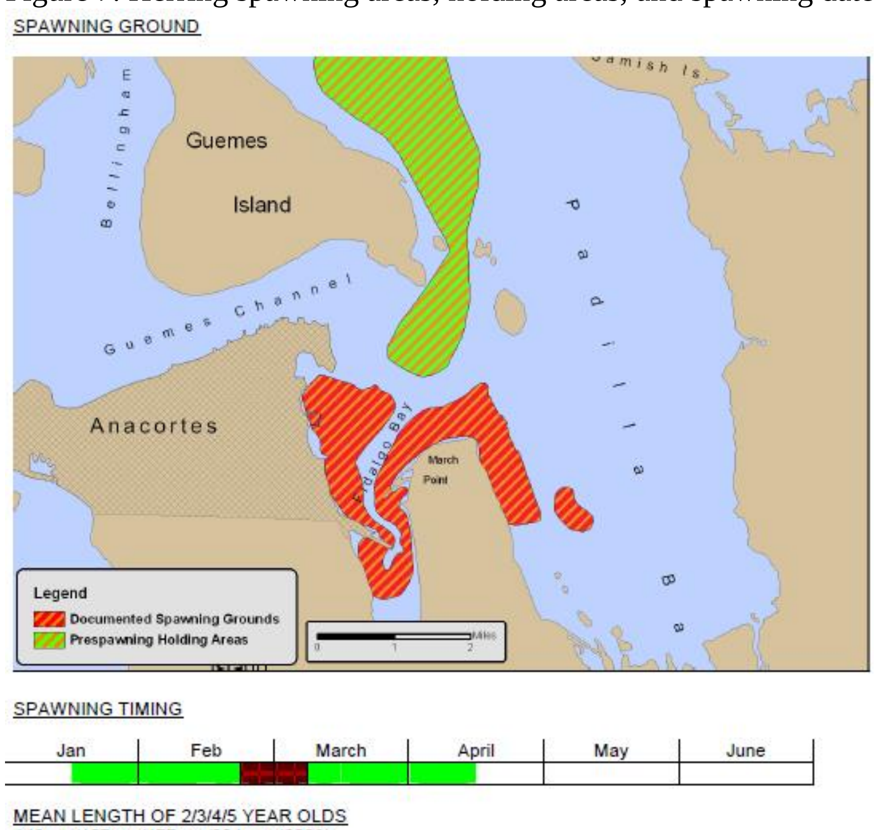
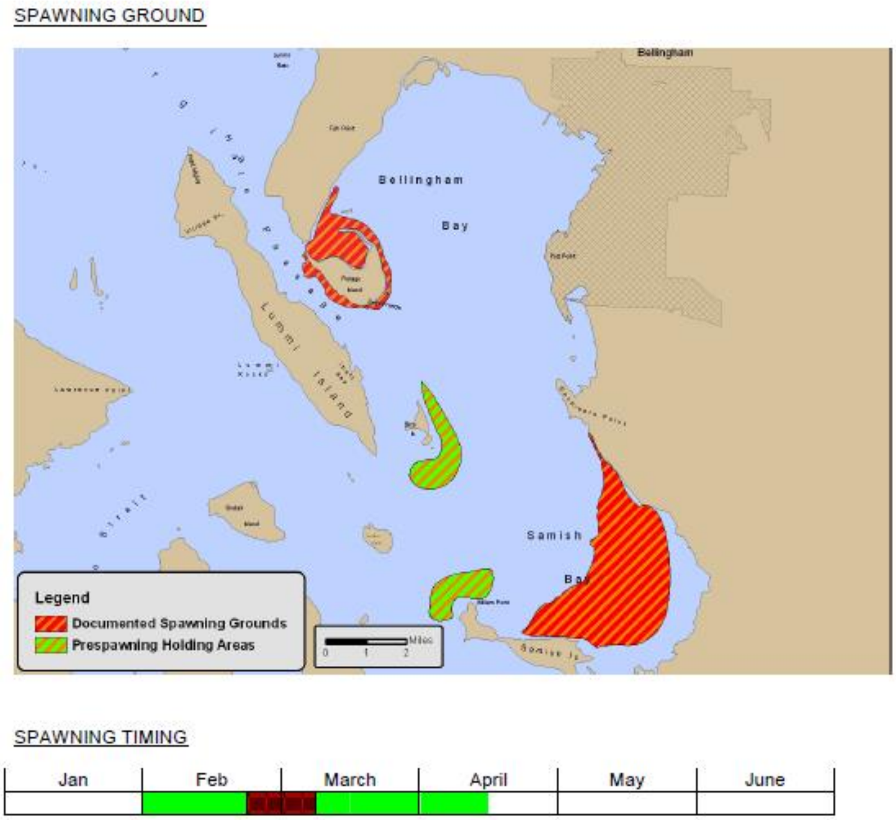


Figure 8. Herring spawning areas, holding areas, and spawning dates for Portage Bay (Stick 2009).

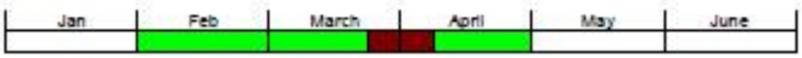


MEAN LENGTH OF 2/3/4/5 YEAR OLDS
146mm/166mm/185mm/192mm (2003)

Central WA
Holmes Harbor

SPAWNING GROUND

SPAWNING TIMING



MEAN LENGTH OF 2/3/4/5 YEAR OLDS
137mm/170mm/176mm/190mm (2008)