Forage fish: a critical link in the food web

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What is happening?

This past summer there was much excitement in Howe Sound over anchovy sightings. Large schools of adult anchovy were occasionally observed from May through July, and larvae or very small young fish (also called YOY, young of year) were observed into November, so much so that it made the news. Sport fishers, biologists, and citizen scientists all reported seeing more anchovy in 2016 than in 2015, when reports precipitated action to identify the fish, as anchovy hadn't been seen for 10 years prior. In 2016 anchovy were observed in locations all across the outer part of the Sound from Horseshoe Bay to Gibsons, and around Bowen Island and the Paisley Group. They were also reported in the Caulfield area of West Vancouver, in False Creek (Figure 1), and in Indian Arm.

Figure 1. Northern anchovy larvae collected in August 2016 in Burrard Inlet. (Photo: Doug Swanston)
Other species of forage fish in Howe Sound include herring, Pacific sand lance and surf smelt. Herring and their eggs, called spawn, have been witnessed in recent years in upper Howe Sound by many and diligently recorded over the past six years by John Buchanan, citizen scientist. Beach spawning habitat for Pacific sand lance and surf smelt was assessed and mapped around Gambier, Keats, and Bowen Islands in 2014.
Why is it important?

The excitement is warranted because the status of forage fish populations can be an indicator of the health and productivity of nearshore systems in our marine environment. Forage fish are small schooling fishes, aptly named because, as a vital link in the food web, they provide abundant forage for upper trophic feeders, such as salmon, birds, and seals, for their entire life. They are also known as bait fish to anglers. While northern anchovy are occasional visitors to Howe Sound, Pacific herring, surf smelt and Pacific sand lance all contribute to a staple diet for many Howe Sound species. Eulachon and sardines are also examples of forage fish. Other species do provide significant forage in different habitats including salmonids when they are small, Pacific lamprey, and even prawn and shrimp larvae. Young-of-year hake and pollack provide forage further from the shore and are arguably the most abundant small fish, although they are low-fat and provide less energy to predators.

The number of eulachon (also known as oolachan) returning to spawn in the Squamish river was once in the millions (Figure 2) and today they are thought to be extinct.

Most forage fish species depend on nearshore and intertidal habitat for their survival, especially when it comes to reproduction. Herring spawn (lay eggs) in intertidal and subtidal areas on vegetation such as eelgrass and seaweed and even manmade structures like piers. Pacific sand lance and surf smelt spawn on pebble and sand beaches just below the high-tide line. Small fish also depend on subtidal areas such as kelp forests and eelgrass beds for rearing. Howe Sound is lacking the bull kelp beds that are typical elsewhere in the Pacific Northwest and its steeply-sloped banks mean that eelgrass beds have always been limited in their distribution. In some places, subtidal eelgrass has suffered significantly due to log handling and booming practices that starved these habitats of both light and oxygen. All the species that depend on healthy nearshore and beach habitat are vulnerable to impacts from shoreline development.²
Notes on forage fish from the British Columbia Language Project 1976³

“Smelt (surf smelt – schá7kwem) was an important species of food for the Squamish Indian people. In the summer months, the people travelled to Point Grey to collect smelts which spawned on the sandy beaches around Jericho Beach and English Bay.”

Different words in the Squamish language to refer to Squamish River eulachon (s7áynixw) and Fraser River eulachon (swí7ew). A word meaning “time of eulachon” (tem-s7áynixw) refers roughly to a time period corresponding with April.

“The Squamish people recognize two sub-species of the species that is recognized scientifically as Thaleichthys.4 The first sub-species, s7áynixw, the Squamish River eulachon, is apparently found only at the head of Howe Sound and in the Squamish River. This species is ‘four to five inches long,’ is ‘more silver-blue in colour’ than the Fraser River eulachon and has a ‘higher oil content’ than the Fraser River eulachon. Apparently both sub-species spawn during the month of April. ... Until not too long ago, certain Squamish people had the ‘power’ to make eulachons appear in the Squamish River. ... Two such men were Chief George, Chepxím, who died around 1905, and Doctor Jim, Lheḵ’lháḵ’elḵ, who died around 1910. They were the last Squamish men to have this ‘power.’ They each had a small wooden box, in which was kept a ‘powdery’ mixture of eulachon bones, seal bones, duck bones, salmon bones, and sometimes also rotted red cedar wood ‘powder.’ A small handful of this total mixture was placed in a bundle of moss and then placed gently in the water. Four times the water would ‘ripple,’ and then small fish would appear. By the following day, these small fish were full-sized eulachons.”

“There are several versions recorded of the ‘true event’ that explains the origin of eulachons in the Squamish River.”
What is the current state?

In the middle of July 2015, John Buchanan, citizen scientist, witnessed a fish mass that seemed about half a kilometre long and 100 metres wide at Porteau Cove and “counted 20 seals that were working very well together in a line that basically cut off a section of the school and penned it in a small cove right in front of the beach where the campsites start.” These fish were northern anchovy. Their presence in Howe Sound has been recorded in seven different years since 1971, including 2015 and 2016 (Figure 3). With identification confirmed by a taxonomist, observations of anchovy submitted by scientists, divers, and citizen scientists are recorded in a database of marine life held by the Vancouver Aquarium Marine Science Centre. This unique database holds the only records of anchovy observations that we are aware of for Howe Sound. Northern anchovy are known to be responsive to shifts in ocean condition and are much more commonly found in the waters off California. There is a weak link between El Niño years (warm waters in the North Pacific) and years that anchovy were observed in Howe Sound (Figure 3). Adult anchovy tend to be spotted in years following the warm years when larval recruitment is likely more successful. However, absence of recorded observation of adult anchovy in Howe Sound does not mean they were not present.

**COMPARING EL NIÑO YEARS AND NORTHERN ANCHOVY OBSERVATIONS IN HOWE SOUND**

<table>
<thead>
<tr>
<th>Year</th>
<th>El Niño year</th>
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<tbody>
<tr>
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<td>2011</td>
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<tr>
<td>2016</td>
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*Figure 3. El Niño years compared to years when northern anchovy were observed in Howe Sound.*
Herring were more abundant in Howe Sound in the early 1960s than any time since 1940, according to Fisheries and Oceans Canada (DFO) data (Figure 4).

Even then, the maximum estimated 2,000 tonnes of spawners hardly compares to other locations in the Strait of Georgia like Baynes Sound, for example, that supported up to 70,000 tonnes of herring spawners in the early 1990s. The locations of herring spawn aggregations also shift from year to year. (See an animation on the DFO website.) DFO calculates a cumulative herring spawn index which ranks and classifies each kilometre of herring spawning habitat according to the long-term frequency and magnitude of spawns over time. Spawn locations in Howe Sound are classified as medium, minor, and low, because they rank below the 70th percentile compared to coast wide records of spawn (Figure 5, left panel). Citizen scientist, John Buchanan, has been surveying the north end of Howe Sound and recording herring spawn observations each spring since 2010. His findings since 2011 are mapped (Figure 5, right panel).

While there is some spatial overlap between observations made by DFO and J. Buchanan at the head of the inlet, there is an obvious gap in DFO data along the northwest stretch of coastline in upper Howe Sound where there is now evidence of consistent herring spawn. DFO surveys have been undertaken for stock assessment purposes and this remains the priority.
today, so small but visible spawn may not have been recorded.\textsuperscript{12} Spawn sites are often located by flying over the coast (e.g., Figure 6) with on-the-water surveys to follow. The spawn locations and events recorded by J. Buchanan over the last six years provide valuable insight into the extent of herring spawn habitat in upper Howe Sound.

Herring spawn early in the year and multiple spawn events can extend the period of spawn activity. John Buchanan observed herring spawn in upper Howe Sound as early as January 9th in 2014. DFO data illustrate the variability in the timing of herring spawn. The data also suggest that spawning may be occurring earlier in recent years, but this could be an artifact of limited DFO survey effort in Howe Sound, as data provided by J. Buchanan suggest that the range of spawn dates is still quite broad (Figure 7). Although forage fish are little studied in Howe Sound and the Strait of Georgia, existing research suggests that there may be three spawning stocks of surf smelt in the Strait of Georgia; summer, winter and year round spawners. Sand lance tend to spawn from November to January.\textsuperscript{13} Limited records suggest that in years when northern anchovies arrive, they spawn in July and August, but evidence of larvae late into the fall in 2016 suggest that several spawning events occurred and extended later than August.

No annual abundance surveys of forage fish other than herring are undertaken. In an effort to identify sensitive beach spawn habitat for surf smelt and Pacific sand lance, Ramona de Graaf, of the Sea Watch Society, surveyed and recorded suitable and not suit-

\begin{figure}[h]
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\includegraphics[width=\textwidth]{figure5.png}
\caption{Herring spawn data from two sources. Fisheries and Oceans Canada cumulative spawn habitat index for 2015 (left panel) and survey locations where herring spawn was observed and recorded by citizen scientist, John Buchanan (right panel).}
\end{figure}
able habitat on Gambier, Keats, and Bowen Islands in Howe Sound in 2014 (Figure 8). Suitable habitat was determined using a habitat assessment protocol, the Forage Fish Habitat Assessment, which was developed collaboratively by forage fish biologists from British Columbia and Washington State. Bowen Island was found to have more suitable habitat (almost 3.4 kilometres) than Gambier and Keats Islands, which have about two kilometres each.

Commercial fisheries for forage fish are not common in Howe Sound. Commercial catch of herring in Howe Sound occurred in only seven years between 1950 and 1980 and has not occurred since then. Catches ranged from one to 51 tonnes. Surf smelt are currently managed by DFO for both commercial and recreational

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**Figure 7. Average date of spawn for herring in Howe Sound.**

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**Table: Average Date of Herring Spawn in Howe Sound**

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<thead>
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<th>Year</th>
<th>AVERAGE DATE OF HERRING SPAWN IN HOWE SOUND</th>
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<td>01-Jan</td>
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<tr>
<td>2016</td>
<td>01-Jan</td>
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</tbody>
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**Figure 6. Milky white herring spawn around Hornby Island in the mid-1960s. (Photo: DFO)**
fisheries and commercial fisheries for surf smelt have existed since the mid-1800s. Much of the historical catch in B.C. came from Vancouver beaches. Recreational fishing for surf smelt has increased significantly since the early 1990s, especially on beaches of the Lower Mainland, rivers of Alberni Inlet, and docks in the Prince Rupert area. The most recent stock status report is dated 2002 and the most recent Integrated Fisheries Management Plan is for April 1, 2012 to March 31, 2014.

Threats to beach spawning fishes are numerous, but the number one threat is hard armouring of the beaches; seawalls, riprap, and boat ramps. As sea level rises these fish may lose their place to lay eggs due to a phenomenon known as coastal squeeze (see illustration in Shorelines article). Activities including improper shoreline development, marine shellfish aquaculture in the foreshore, and diversion of sediment-bearing streams through culverts can render beaches unusable for spawning. These shoreline modifications can also limit sediment exchange in the shallow subtidal where sand lance is known to burrow. Acute oil spill events and chronic oiling are deadly as oiling suffocates embryos. Climate change will further affect the survival of forage fish because increasing ocean acidity and increasing sea surface temperatures will likely affect larval survival. Changes in the timing of spring bloom have already been linked to the success of herring larval recruitment in the Strait of Georgia. In particular, the mismatch between spawn timing and the start of the spring plankton bloom was found to have a substantial impact on survival and production of herring.
What is being done?

There are no consistent or comprehensive monitoring efforts in Howe Sound directed at schooling or spawning foraging fish, except herring spawn monitoring by DFO and self-funded efforts by citizen scientist, John Buchanan. Regular small fish surveys are undertaken by DFO in the Strait of Georgia and sometimes, but not consistently, sampling is done in Howe Sound. These surveys are known as the Strait of Georgia juvenile herring and nearshore pelagic ecosystem survey and juvenile salmon trawl surveys and they target juvenile herring and salmon. Catches do include other small fish such as Pacific sand lance and surf smelt, however information on the abundance and distribution of these forage fish species is not regularly reported on. Some additional research has resulted from a growing recognition of the importance of forage fish. A model developed to identify subtidal burying habitat for Pacific sand lance in the Strait of Georgia suggests that suitable burying habitat is quite rare (six percent) in the study domain. Unfortunately Howe Sound was not included the study area.

The Sea Watch Society undertakes spawning surveys and continues to expand the forage fish habitat suitability assessments. Sightings of forage fish species recorded in a database of marine life, which is housed at the Vancouver Aquarium Marine Science Centre, are opportunistic, meaning that they are not the product of systematic surveys, but they do provide evidence of species presence going back in time.

In an effort to increase the survival of herring spawn in upper Howe Sound local stream keepers have wrapped toxic creosote pilings in the Squamish area with weed control fabric. Prior to these efforts, herring eggs would die on the pilings and never hatch. One mission of the Squamish Streamkeepers Society is to enhance then maintain herring spawning habitat in the upper Howe Sound.

A pre-feasibility restoration project studying habitat potential for eulachon and Pacific lamprey in and around the Squamish river estuary is underway, as a partnership between Squamish First Nation and Dieder Wesley from the University of British Columbia.

The BC Shore Spawners Alliance (BCSSA) is an alliance of community groups working to document and protect the intertidal spawning habitat of forage fish (surf smelt and Pacific sand lance). The BCSSA provides presentations, educational resources, protocols, training and equipment to allow for the collection of scientifically credible data. The goal of the BCSSA is to increase efforts to manage and protect shoreline forage fish spawning habitats through science, education, community stewardship, and habitat restoration. Ramona de Graaf, a marine biologist, forage fish specialist, marine educator, and researcher who has been studying and surveying forage fish habitats since 2000, is the BC Shore Spawners Alliance coordinator.

The B.C. Government’s Ministry of Environment Ecosystems Branch prepared a coastal forage fish fact sheet that contains background information and environmental guidelines for urban and rural land development.
What can you do?

**Individual and Organization Actions:**

- Prevent sediment, chemical or oil run-off from your property. Oiling from vessel operations near beaches can potentially cause mortality of incubating forage fish eggs. Siltation of beaches can smother tiny eggs.
- Avoid building breakwaters, riprap, seawalls, docks or pilings near beach habitat that may support forage fish.
- Retain natural shoreline vegetation because shade from overhanging vegetation keeps fish eggs moist in the summer and insects from overhanging vegetation are a source of food for forage fish. The roots of natural vegetation on the foreshore and coastal bluffs also help to bind the soil and minimize erosion. Removing shoreline vegetation increases temperatures within the spawning gravel and removes a food source for young fish. On hot summer days, without shade, eggs can’t survive.
- Re-establish native shoreline vegetation if absent.
- Trim trees to improve your view instead of removing them. This helps to retain the stability of the bank and slope soils and to maintain shade on the beach.
- Set back any new development from the bluff or foreshore, to minimize the future need for foreshore protection.
- Manage storm water and maintain vegetation above bluffs to avoid soil saturation and slumping.
- Retain natural drainage patterns and design storm water systems so that water is cleaned before it enters the foreshore.
- Use soft shore or Green Shores approaches rather than hardening the shoreline.
- Volunteer with the BC Shore Spawners Alliance: facebook.com/foragefish

**Government Actions and Policy:**

- Increase efforts to educate land owners on foreshore regulations.
- Monitor and enforce the legislation (B.C. Land Act) that prohibits changes below the high tide line without lease or license of occupation.
- Prioritize and fund research, monitoring, and protection of forage fish habitats.
Resources

Islands Trust Forage fish Habitat Assessments
islandtrustfund.bc.ca/initiatives/marineconservation/foragefish.aspx

BC Shore Spawners Alliance, a project of Sea Watch Society
facebook.com/foragefish

Friends of Forage Fish
friendsofforagefish.com

Bowen Island surf smelt and Pacific sand lance Spawning Habitat Suitability Assessment Report
islandtrustfund.bc.ca/media/77286/final-report-bowen_oct302014_v6_rcdg-with-maps-for-web2.pdf

Detailed guidelines for protecting fish and wildlife habitats along the foreshore are provided in Develop with Care 2014: Environmental Guidelines for Urban and Rural Land Development in British Columbia
evg.gov.bc.ca/wld/documents/bmp/devwithcare/

Fisheries and Oceans Northern Anchovy fishery - Pacific Region
pac.dfo-mpo.gc.ca/fm-gp/commercial/pelagic-pelagique/anchovy-anchois/index-eng.html
Footnotes


3 Utilization of fish, beach foods, and marine mammals by the Squamish Indian people of British Columbia, Bouchard.003, Survey of California and Other Indian Languages, University of California, Berkeley, http://cla.berkeley.edu/item/2498

4 The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) refers to all pacific stocks of eulachon as Thaleichthys pacificus.

5 Buchanan, J. 2016. Email communication copied to the author.

6 Anchovy sighting data from Gibbs, D.M., C. Gibbs, and A. Lamb. Pacific Marine Life Surveys. Data accessed Sept 16, 2016. Opportunistic sightings are recorded, so the information is not from systematic surveys and anchovy may have been present in years not recorded.


12 Ibid.

13 de Graaf 2014.

14 Data provided by Islands Trust, 2016.

15 de Graaf 2014.


19 https://www.eopugetsound.org/magazine/armoring-sanjuans


23 http://www.squamishstreamkeepers.net/streamkeepers/Welcome.html

24 Didier, W. 2016. Email communication with the author, Feb 26, 2016.