# A Review of Effects on Forage Fishes, Zooplankton and Marine Vegetation from Three Geoduck/Clam Farm Proposals in Henderson Inlet and One Proposal in Eld Inlet, Thurston County, WA

Daniel E. Penttila
Salish Sea Biological, Anacortes, WA

**Education:**

University of Washington, Seattle, WA: BS, with distinction, in Zoology, 1970
University of Oregon, Eugene, OR: MS, Biology, 1971

**Work Experience:**

Washington Dept. of Fisheries/Fish and Wildlife: 38.5 years (Forage Fish Units)
Salish Sea Biological (forage fish studies and consultations): 3+ years

# SURF SMELT
## (Hypomesus pretiosus) (P-62)

- One of three major shore-spawning forage fishes in the Puget Sound region.
- WDF/WDFW surf smelt spawning habitat studies conducted from 1973-2010.
- Smelt spawning habitat occurs within the NW Henderson Inlet farm sites, based on 4 surveys in the vicinity, October 1973-January 1996. (P-76)
- Smelt spawning habitat occurs in the vicinity of the Eld Inlet farm site, based on 8 surveys in the vicinity, February 1990-January 2004. (P-75)

# SURF SMELT
## (Hypomesus pretiosus) (P-62)

### Smelt spawning habits:

- Eggs deposited on silt-free mixed sand/gravel beaches (P-63).
- Eggs deposited in the uppermost one-third of the intertidal zone.
- Spawning occurs in "fall-winter" (Sept.-March) in southern Puget Sound.
- Spawning occurs at irregular time intervals throughout the spawning season, with incubation times of 3-6 weeks depending on ambient temperatures.
- Spawning beaches used perennially.

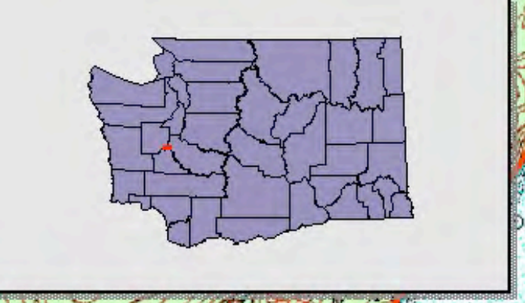
# SURF SMELT
(Hypomesus pretiosus) (P-62)

## Smelt spawning habitat regulatory protections (P-62, P-118)

- Spawning habitat vulnerable to degradation from human shoreline activities.
- Spawning habitat considered "marine habitat of special concern."

## Spawning habitat protective regulatory language included in:

- WAC Hydraulic Code Rules
- State Growth Management Act (FWHCA)
- State Shoreline Management Act
- Federal "Essential Fish Habitat" for ESA-listed salmonids
- Protections reviewed in WDFW's "Protecting Nearshore Habitat and Function in Puget Sound, (rev.) June 2010. (P-118)

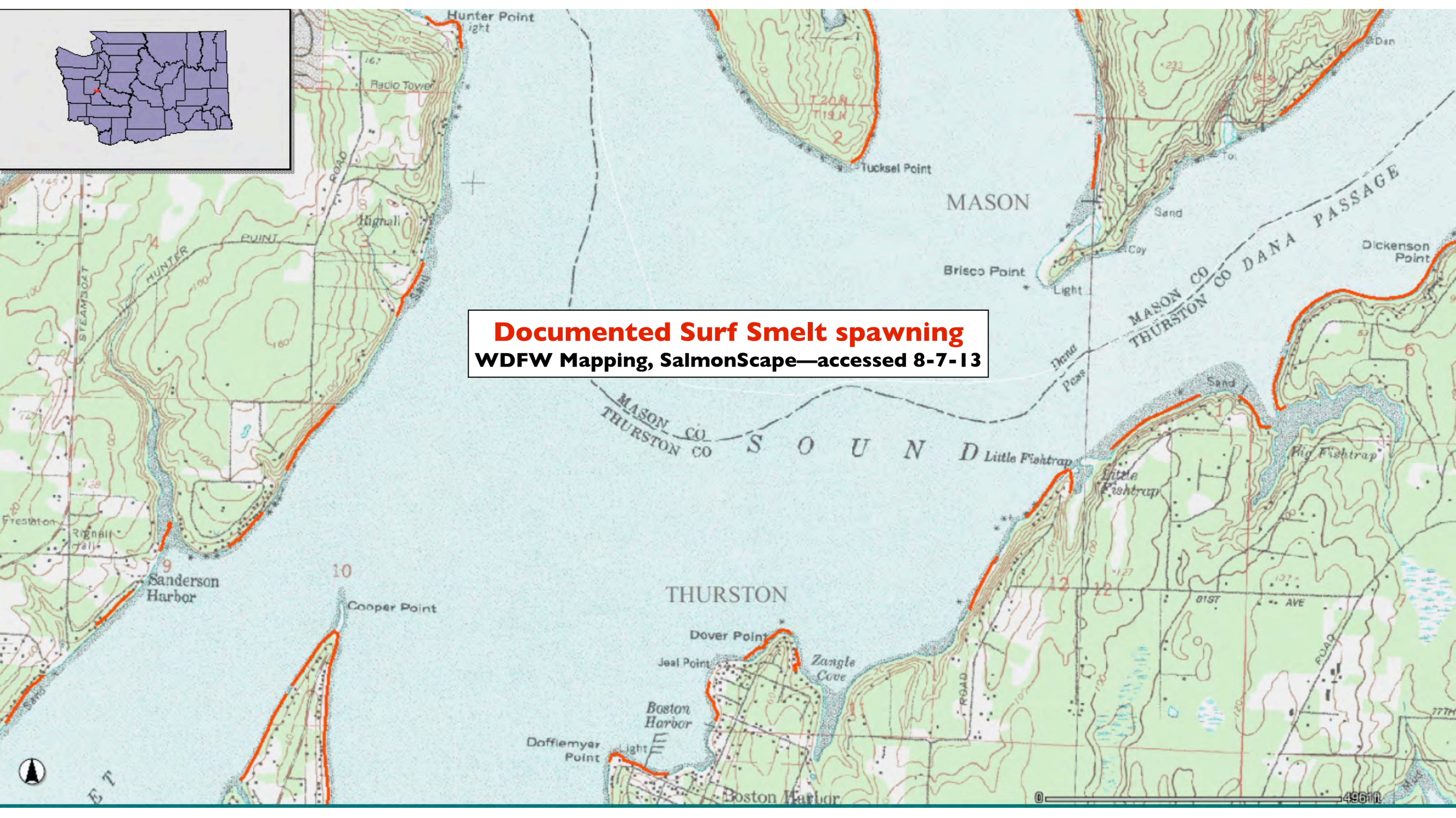


# Documented Surf Smelt spawning

**WDFW Mapping, SalmonScape—accessed 8-7-13**

MASON CO
THURSTON CO
DANA PASSAGE
Light
Itsami Ledge
Dickenson Point
Sand
Big Fishtrap
Cliff Point
Gravel
Light
Johnson Point
Poncin Cove
Baird Cove
92ND AVE
JOHNSON POINT ROAD
LIBBY RD
BAIRD RD
86TH AVE
81ST AVE
Boat Ramp
Hend
T 20 N
T 19 N
5
6
7
8
4
3
9
10
33
INLET

Potential spawning habitat
WDFW Mapping, SalmonScape—accessed 8-7-13
Johnson Point
Light
Gravel
Itsami Ledge
Poncin Cove
Baird Cove
Dickenson Point
Sand
Cliff Point
Big Fishtrap
Boat Ramp
Gravel
Sand
MASON CO
THURSTON CO
DANA PASSAGE
T20N
T19N
92ND AVE
85TH AVE
81ST AVE
LIBBY RD
BAIRD RD
JOHNSON POINT ROAD
N D N I S P


Documented Surf Smelt spawning
WDFW Mapping, SalmonScape—accessed 8-7-13
Hunter Point
Light
Radio Tower
Tucksel Point
MASON
Brisco Point
Light
Sand
Coy
Dickenson Point
MASON CO
THURSTON CO
DANA PASSAGE
Dana Pass
MASON CO
THURSTON CO
SOUND
Little Fishtrap
Big Fishtrap
Little Fishtrap
Sand
HUNTER POINT
STEAMBOAT
ROAD
Rignall
Hignall
Sand
Sanderson Harbor
Cooper Point
THURSTON
Dover Point
Jeal Point
Zangle Cove
Boston Harbor
Dofflemyer Point
Light
Boston Harbor
81ST AVE
ROAD
0
4961ft

Potential spawning habitat
WDFW Mapping, SalmonScape—accessed 8-7-13
Hunter Point
Radio Tower
Tucksel Point
MASON
Brisco Point
Light
Dickenson Point
MASON CO
THURSTON CO
DANA PASSAGE
Dana Pass
MASON CO
THURSTON CO
SOUND
Little Fishtrap
Big Fishtrap
Little Fishtrap
Hignall
HUNTER POINT
STEAMBOAT
ROAD
Freestone
Hignall Fall
Sanderson Harbor
Cooper Point
THURSTON
Dover Point
Jeal Point
Zangle Cove
Boston Harbor
Dofflemyer Point
Light
Boston Harbor
81ST AVE
ROAD
0
4960ft

# SURF SMELT
## (Hypomesus pretiosus) (P-62)

### Ecological/Societal Value:

- "Classified" species supporting localized commercial and recreational fishery harvests.
- Known prey item for nearshore dwelling salmonids, including coastal cutthroat trout and bull trout.
- Prey item for wide variety of other predators at all free-living life history stages from larva to adult.
- Surf smelt feed on a variety of planktonic and benthic animal prey.

# SURF SMELT
## (Hypomesus pretiosus) (P-62)

## Specific Concerns:

- Siltation of adjacent spawning beaches by the cumulative effects of production-scale shellfish harvest activities.
- Spawning habitat may overlap with clam-farming zone activities, both harvest and anti-predator netting.
- Mass-mortalities of roving nearshore schools of fish gilling in anti-predator netting.
- Ingestion and mortality of planktonic yolk-sac larvae arising from the adjacent spawning beaches, arising from the continuous generation of larvae from the adjacent spawning beaches throughout the spawning season.
- **Over-arching concern for the lack of forage fish-focused research pertaining to shellfish-aquaculture effects amidst continuous farm expansion.**
  - ✦ For example, an overlay of the current shellfish farm sites and surf smelt spawning habitat areas within Totten and Eld Inlets show that 75% of the shellfish farms are positioned on shorelines also documented as forage fish spawning beaches. (P-74, P-58)

# PACIFIC SAND LANCE
## (Ammodytes hexapterus) (P-62)

- Another of the major shore-spawning forage fishes in the Puget Sound region, and a key element of the marine food web.
- WDF/WDFW sand lance spawning habitat surveys conducted in southern Puget Sound starting in about 1993, after first discovery of intertidal spawning in 1989.
- Sand Lance spawning habitat found in vicinity of Henderson Inlet farm sites. (P-74)
- Sand Lance spawning habitat found directly within the Xia farm site. (P-74)

# PACIFIC SAND LANCE
(Ammodytes hexapterus) (P-62)

## Sand Lance habits:

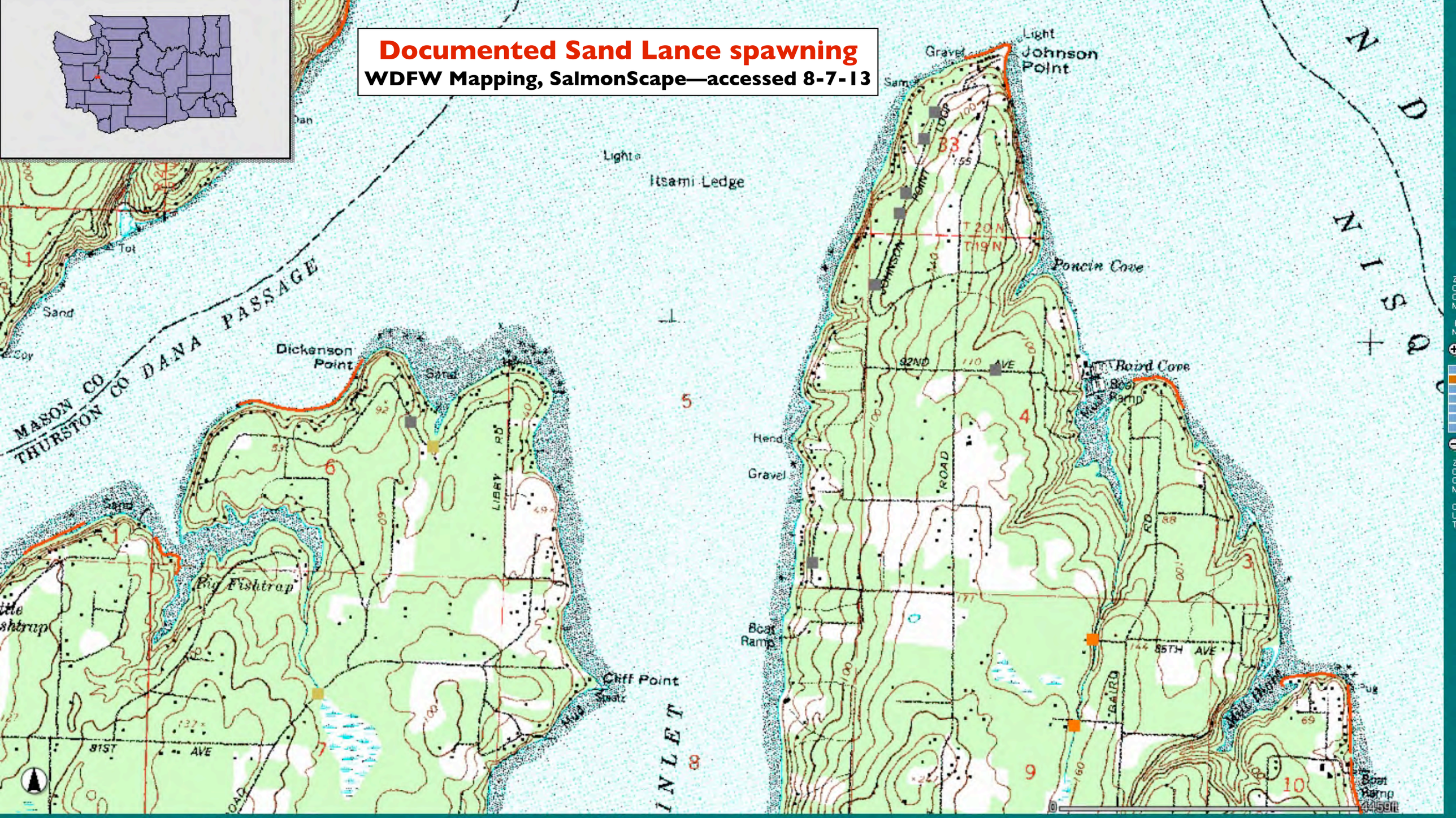
- Sand lance spawning occurs November–February within Puget Sound.
- Spawning activity occurs at irregular intervals during the spawning season.
- Spawning habitat context similar to that of the surf smelt; fine-grained beaches in the upper intertidal zone. (P-63)
- Spawn incubation period is about one month.
- Sand lances burrow diurnally into bottom sediments for refuge.
- Sand lances feed upon a variety of planktonic animals.

# PACIFIC SAND LANCE
## (Ammodytes hexapterus) (P-62)

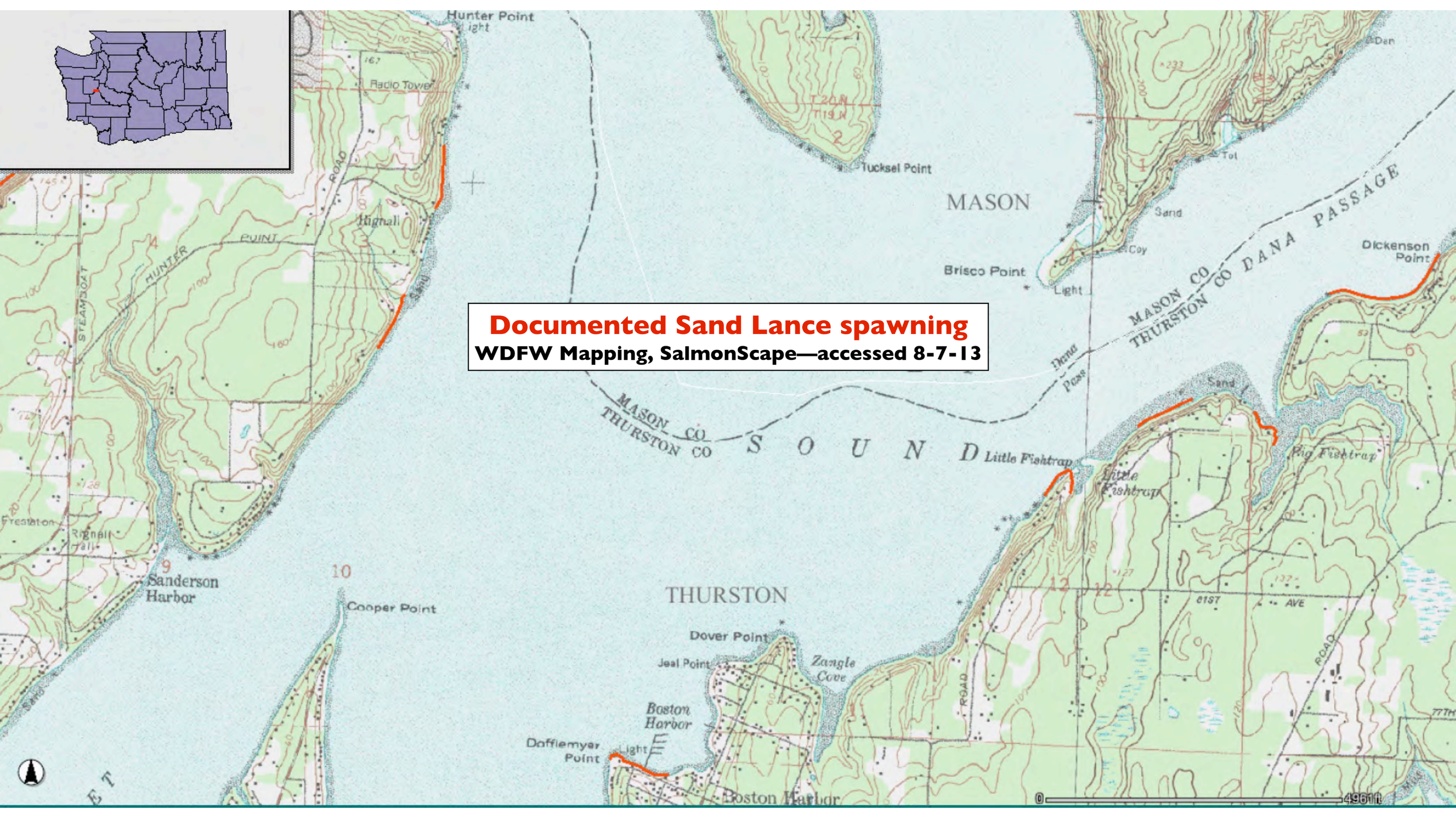
### Specific Effects:

- Spawning habitat vulnerabilities similar to those for surf smelt spawning habitat.
- Spawning habitat similarly denoted as "marine habitat of special concern," with similar regulatory protective language in the Hydraulic Code Rules, GMA, SMA and EFH rules. (P-118)
- Similar effects from larval ingestion mortalities by artificially-dense cultured shellfish.

NOTE: Should proposed geoduck/clam farm operations be dependent on a determination of presence/absence of forage fish spawn on-site, beach sediment sampling protocols specifically designed to detect surf smelt and sand lance eggs dispersed in beach substrates would be available for application on-site by suitably trained ("certified") samplers. (P-65) **It cannot be assumed that either incubating surf smelt or sand lance eggs will simply be visible upon beach surfaces to determine recent spawning usage of a site.**


Documented Sand Lance spawning
WDFW Mapping, SalmonScape—accessed 8-7-13
Johnson Point
Light
Itsami Ledge
Poncin Cove
Baird Cove
Dickenson Point
MASON CO
THURSTON CO
DANA PASSAGE
Big Fishtrap
Cliff Point
Boat Ramp
Gravel
Sand
Tot
Hend
92ND AVE
85TH AVE
JOHNSON POINT LOOP
LIBBY RD
BAIRD ROAD
T 20 N
T 19 N
N
D
N I S P

Potential spawning habitat
WDFW Mapping, SalmonScape—accessed 8-7-13
Johnson Point
Light
Gravel
Itsami Ledge
Poncin Cove
Baird Cove
Dickenson Point
Sand
Cliff Point
Big Fishtrap
Boat Ramp
Gravel
Sand
MASON CO
THURSTON CO
DANA PASSAGE
T20N
T19N
92ND AVE
85TH AVE
81ST AVE
LIBBY RD
BAIRD RD
JOHNSON POINT ROAD
N D N I S P


Documented Sand Lance spawning
WDFW Mapping, SalmonScape—accessed 8-7-13
Hunter Point
Light
Radio Tower
Tucksel Point
MASON
Brisco Point
Light
Dickenson Point
MASON CO
THURSTON CO
DANA PASSAGE
Dana Pass
MASON CO
THURSTON CO
SOUND
Little Fishtrap
Big Fishtrap
Sanderson Harbor
Cooper Point
THURSTON
Dover Point
Jeal Point
Zangle Cove
Boston Harbor
Dofflemyer Point
Light
Boston Harbor
HUNTER POINT ROAD
STEAMBOAT
61ST AVE
ROAD
77TH
Sand
Coy
Tol
Freestone
Rignall
Fall
0
4961ft

Potential spawning habitat
WDFW Mapping, SalmonScape—accessed 8-7-13
Hunter Point
Radio Tower
Tucksel Point
MASON
Brisco Point
Light
Dickenson Point
MASON CO
THURSTON CO
DANA PASSAGE
Dana Pass
MASON CO
THURSTON CO
SOUND
Little Fishtrap
Big Fishtrap
Little Fishtrap
Hignall
HUNTER POINT
STEAMBOAT
ROAD
Freestone
Hignall Fall
Sanderson Harbor
Cooper Point
THURSTON
Dover Point
Jeal Point
Zangle Cove
Boston Harbor
Dofflemyer Point
Light
Boston Harbor
81ST AVE
ROAD
0
4960ft

# Consumption Of Zooplankton By Suspension-Feeding Bivalves

Consumption of zooplankton has only recently been recognized as a common feeding strategy of bivalves of all types, formerly considered to feed only on phytoplankton.

**Thumbnail sketches of a number of recent journal references on this subject:**

- Lehane and Davenport (2002). Ingestion of mesozooplankton by three species of bivalves; Mytilus edulis [blue musel], Cerastoderma edule [cockle], Aequipecten opercularis [scallop]. *Journal of Marine Biology, UK*. (Scotland waters). Cites previous report of 6mm amphipod being consumed by mussel. **All bivalve species were found to have ingested zooplankton.** (P-86)
- Wong and Levinton (2006). The trophic linkage between zooplankton and benthic suspension feeders: direct evidence form analyses of bivalve fecal pellets. *Marine Biology*. (New York waters) **Mussels species fed on zooplankton, found in both stomachs and "pseudofeces" expelled uneaten, but also dead. Larger animals ate larger plankton.** (P-87)
- Troost, Kamermans and Wolff (2008). Larviphagy in native bivalves and an introduced oyster. *Journal Of Sea Research*. (Dutch waters) **Using blue mussel, cockles and Pacific oysters, all consumed zooplanktonic bivalve larvae.** (P-88)

# Consumption Of Zooplankton By Suspension-Feeding Bivalves

- Lonsdale, Cerrato, et al (2009). Influence of suspension-feeding bivalves on the pelagic food webs of shallow, coastal embayments. *Aquatic Biology*. (New York waters) **Using softshell clams, quahogs and ribbed mussels, all were found to ingest zooplanktonic copepod eggs, and bivalves were considered competitors with zooplankton for phytoplanktonic food supplies.** (P-89)
- Troost, Stamhuis, and van Duren (2009). Feeding current characteristics of three morphologically different bivalve suspension feeders, C. gigas [Pacific oyster], Mytilus edulis [blue mussel], and Cerastoderma edule [cockle] in relation to food competition. *Marine Biology* (Dutch waters) **Describes lab set-ups for feeding rates data suitable for geoduck studies. Cites numerous zooplankton-consumption papers. Filtration rates were considered to increase with shellfish body size.** (P-91)
- Peharda, Ezgeta-Balic, et al (2012). Differential ingestion of zooplankton by four species of bivalves (Mollusca) in the Mail Ston Bay, Croatia. *Marine Biology*. (Adriatic waters) **Zooplankton ingestion was found in oysters, mussels and ark-clams. Ingestions rates go up with specimen size. Ingestion can affect zooplankton community structure. Bivalves compete with zooplankton for phytoplankton food.** (P-90)

# Consumption Of Zooplankton By Suspension-Feeding Bivalves

- From the published scientific literature, it is clear that **all bivalve species tested were found to consume zooplankton of a wide variety of forms, during feeding/respiration activities.** (P-86, 87, 88, 89, 90, 91)
- While published data on the diet of Salish Sea geoducks seems to be lacking, it can only be assumed, at present, that they will readily consume zooplankton as well. Given the concerns raised, in the absence of data, to assume that they do not would be unwise.
- Published data also suggest that zooplankton filtration rates and prey sizes can increase with increasing body size of the filtering animals. (P-87, 90, 91) **Thus it should be assumed that geoducks, reported to be among the largest clams in the region, may be capable of ingesting significant amounts and relatively large sizes of organisms from the nearshore zooplankton community.**
- Geoducks would seem to be amenable to lab observations of filtration rates and the behavior of potential zooplankton prey items in their presence using methodologies outlined in the literature, to answer pressing questions of the effects of enhanced densities of cultured geoducks to the nearshore zooplankton/ ichthyoplankton communities in their vicinity. (P-91)

# Consumption Of Zooplankton By Suspension-Feeding Bivalves

The USFWS NWP48 Consultation document includes the following statement:

- "Since it is plausible that geoducks will compete for prey resources (particularly in sheltered bays and coves and when they are planted in high densities) and dominate as a consumer of the local food web, and then **you must assume that juvenile salmonids and forage fish will have less to eat which will lower their growth and survival** [emphasis added]…I think it would be prudent to alleviate this uncertainty prior to the Corps allowing more widespread geoduck culture given the tenuous condition of salmonids and bull trout populations in Puget Sound." (P-25)
- **I agree with the above statement and wonder why continued expansion of geoduck culture is being supported.**

# Effects of the Proposals on Marine Vegetation

Marine vegetation serves a number of ecological functions (P-183):

- Carbon fixation and detritus production to fuel nearshore food webs.
- Creates three-dimensional structure for habitat and nursery functions for a large number of marine organisms.
- Salmonid migratory/feeding pathways.
- Feeding grounds for birds and other higher animals.
- Herring spawning habitats.

# Effects of the Proposals on Marine Vegetation

Little detail has been made available on the nature of the existing marine vegetation beds on the current NW Henderson Inlet sites or on the site north of Eld Inlet.

- In NW Henderson Inlet, the algae genera *Ulva* , *Enteromorpha*, and *Gracilaria* have been listed in a 2010 Environ shellfish farm site report, apparently for an adjoining parcel to the south .
- The same assemblage of marine algae appears to be present on the Xia/Net Ventures site, judging from site photos included in the 2011 Acera farm site report.
- *Ulva* and *Gracilaria* are herring spawning substrates commonly used in Puget Sound, although no herring spawning is known to occur directly on either proposal site.
- Aside from their regulatory-protected function when serving as herring spawning grounds, marine algae beds should be considered as **habitats deserving of no-net-loss protections**, and thus not disturbed by human activities within the marine photic zone, including aquaculture farm areas. **Routine clearing of marine algae beds from farm plots should be considered a major disturbance.**

# Concluding Statement

- In keeping with WDFW's guidelines for "Protecting Nearshore Habitat and Functions in Puget Sound, 2010", the continued expansion of geoduck farms in Puget Sound would not seem to comply with the SMA: (P-118)
- Cumulative impact analyses are given little credence, even while industry supporters admit that there is no clear indication of how many additional farm sites are going to be added to the landscape into the future.
- Aquaculture farm expansion continues seemingly unabated even with known significant, but researchable, data gaps still persisting as to its long-term impacts.
- Until the needed additional research is done in an acceptable manner for refereed publication, it should not be considered "best available science", upon which decisions as to the permanent dispositions of critical nearshore marine habitats should be based.

9/3/12

# CURRICULUM VITAE

**NAME:** Daniel E. Penttila

**Home Address:** 5108 Kingsway, Anacortes, WA 98221
Tel: (360) 293-8110
E-mail: depenttila@fidalgo.net

**Birth:** May 22, 1948, Portland, OR

**Education:** Graduate, Mt. Vernon Union High School, Mt. Vernon, WA, 1966.

BS, with Distinction, in Zoology, Univ. of Wash. Seattle, WA, 1970.

MS in Biology, University of Oregon, Eugene, OR, 1971.

**Work History:**

Scientific Tech. 2 (temp.) Washington Dept. of Fisheries (WDF), Columbia R. Lab, Vancouver, WA, 1971-72.

Scientific Tech 2, WDF, Puget Sound Baitfish Project, Seattle WA, 1972-73.

Fish Biologist 2, WDF, Puget Sound Baitfish Unit, Seattle, WA, 1973-1979.

Fish Biologist 3, WDF, Forage Fish Unit, Seattle, WA, 1979-85.

Fish Biologist 3, WDF, Marine Habitat Investigations Unit, Seattle, WA 1985-1990.

Fish Biologist 3, WDF/WA Dept. of Fish and Wildlife (WDFW), Forage Fish Unit, Seattle/ Mt. Vernon/ LaConner, WA, 1990-2004.

Fish Biologist 3, WDFW Habitat Program, Region 4 PHS/GMA biologist, LaConner, WA, 2004-05.

Fish Biologist 3, WDFW Habitat Program, Puget Sound Action Team Forage Fish Project, LaConner, WA, 2005-2009.

Fish Biologist 3, WDFW Habitat Program, Puget Sound Partnership Forage Fish Project, LaConner, WA, 2009- June 2010.

Retired from WDFW, June 30, 2010, with 38.5 years of service.

Sole Proprietor, "Salish Sea Biological" marine biological consulting, Anacortes WA, July 2010 – present.

**Biographical Sketch:**

Dan Penttila was born and raised in the Pacific Northwest, a second-generation natural resources agency staffer. He has been deeply involved in marine forage fish investigations in western Washington for the Washington Department of Fisheries and Fish and Wildlife since 1972. Professional activities in the region have included herring/surf smelt/sand lance spawning habitat surveys, including development of new survey methods and exploratory surveys into previously un-sampled regions and un-sampled seasons, herring hydro-acoustic/trawl surveys, herring larval/juvenile surveys, eelgrass shading studies, contributions to forage fish habitat protection policies and regulations, testimony as an state expert witness on forage fish habitat conservation matters, delivery of numerous public presentations, workshops and training sessions pertaining to forage fish spawning ecology and survey methods, and numerous reports on the subject. He currently resides in Anacortes, WA, and has one grown daughter.

**Refereed Citations:**

Penttila, D. 1978. Studies of the surf smelt (*Hypomesus pretiosus*) in Puget Sound. WDF Technical Report No. 42, 45 p.

Penttila, D. 2007. Marine forage fishes in Puget Sound. Puget Sound Nearshore Partnership Report No. 2007-03, USACOE, Seattle, WA, 22 p.

Middaugh, D., M. Hemmer, and D. Penttila, 1987. Embryo ecology of the Pacific surf smelt *Hypomesus pretiosus* (Pisces: Osmeridae). Pacific Science, Vol. 41, nos. 1-4, p 44-53.

Penttila, D., 1999. Marine forage fishes of Fidalgo. (in E. Adams (ed.), At Home on Fidalgo, Premier Graphics, Bellingham, WA, 166 p.), p. 42-44.

Shaffer, A., D. Penttila, M. McHenry and D. Vilella, 2007. Observations of eulachon, T*haleichthys pacificus,* in the Elwha River, Olympic Peninsula, WA. Northwest Science, Vol. 81, no. 1, p. 76-81.

McCann, M., E.C. Grossman, R.K. Takesue, D. Penttila, J.P. Walsh, and R. Corbett. 2012. Arrival and expansion of the invasive foraminifera *Trochammina hadai* Uchio in Padilla Bay, Washington. Northwest Science, Vol. 86, No. 1, p. 9-26.

Quinn, T., K. Krueger, K. Pierce, D. Penttila, K. Perry, T. Hicks, and D. Lowry, 2012. Patterns of surf smelt, *Hypomesus pretiosus,* intertidal spawning habitat use in Puget Sound, Washington State. Estuaries and Coasts, DOI 10.1007/s12237-012-9511-1, 15 p.

Shaffer, J.A., P. Crain, T. Kassler. D. Penttila, and D. Barry, 2012. Geomorphic habitat type, drift cell, forage fish and juvenile salmon: are they linked? Journal of Environmental Science and Engineering A 1, p. 688-703.

**Conference Papers:**

Penttila, D.E., 1995a. The WDFW's Puget Sound Intertidal Baitfish Spawning Beach Survey Project. In the Proceedings of the Puget Sound Research 1995 Conference, Bellevue, WA, 1/12-14/95. Pub. by the Puget Sound Water Quality Authority, Olympia, WA, Vol. 1, p. 235-241.

Penttila, D.E., 1995b. Investigations of the spawning habitat of the Pacific sand lance, *Ammodytes hexapterus*, in Puget Sound. in the Proceedings of the Puget Sound Research 1995 Conference, Bellevue, WA, Pub. by the Puget Sound Water Quality Authority, Olympia. WA , Vol. 2, p. 855-859.

Penttila, D.E., 1997. Investigations of intertidal spawning habitats of surf smelt and sand lance in Puget Sound. in the Proceedings of the International Symposium on the Role of Forage Fishes in Marine Ecosystems, Anchorage, AK, 11/13-16/96. Univ. of AK Sea Grant Program, Report No. AK-SG-97-01, p. 395-407.

Penttila, D.E., 2002. Effects of shading upland vegetation on egg survival for summer-spawning surf smelt on upper intertidal beaches in Puget Sound. in the Proceedings of the Puget Sound Research-2001 Conference, Bellevue, WA, 2/12-14/01, pub. by the Puget Sound Water Quality Action Team, Olympia WA, 9 p.

**Agency Awards:**

WDF Certificate of Commendation, 12/14/90, (For the discovery of sand lance spawning habitat in Puget Sound)

WDFW Certificate of Merit, 5/6/05, (for forage fish public-outreach activities)

WDFW Certificate of Merit, 5/13/07, (member of Salmonscape forage fish survey database team)