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Nearshore Habitat Mapping of the Central and Western Strait of Juan de Fuca III: Pacific Herring Spawning Surveys

Final Report

30 April 2002

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Nearshore mapping of the Strait of Juan de Fuca: III Pacific Herring Spawning Habitat. A Surveys.

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Abstract

Pacific herring, *Clupea harengus pallasi* are common throughout the marine waters of Washington State. As a forage fish, herring play an important role in the diets of many marine organisms. A greater understanding of their life history may positively affect other species that depend on them as a food source, in particular certain local salmonid stocks listed as threatened under the Endangered Species Act. Although adult herring are known to congregate and spawn at various sites within Puget Sound, sampling to determine spawning sites within the Strait of Juan de Fuca has been limited. The primary objective of this project was to sample potential herring spawning substrate (marine vegetation) in locally reported or suspected herring spawning sites, within the central and western Strait of Juan de Fuca, that had not been previously surveyed by the WDFW. Seven embayments were sampled once per month for herring spawn during February and March 2002. Spawn was found at one site, Dungeness Bay, which has been previously documented as spawning habitat and is sampled annually by the WDFW. Stock biomass was calculated for Dungeness Bay for the dates collected using WDFW protocol.

Introduction

Although Pacific herring are commonly grouped together with surf smelt and sandlance under the generic terms “forage fish” or “baitfish”, each species is taxonomically and biologically unique (Moriarity, Shaffer, and Penttila. 2002). Unlike other forage fish, herring do not utilize beach substrates to deposit their eggs. Instead, they deposit transparent adhesive eggs on intertidal and shallow subtidal sea-grasses and marine algae.

Herring eggs are generally found between 0 and –10 feet of tidal elevation, spawning may occur anywhere between the high tide mark and –40 feet in depth (WDFW Herring Fact Sheet). Generally herring eggs remain submerged for their entire incubation period and mortality attributed to predation can be high. Gulls and diving ducks have been reported to cause egg predation rates in the 90-95% range (Pallson 1984). Planktonic larvae are approximately 13 millimeters upon hatching. Juvenile herring will metamorphose into adults forming coloration within three months, and will become fully mature and return to spawn in two to three years. Herring are iteroparous, and will continue to spawn in the successive years.

The mortality rate of adult herring is quite high, averaging 50-70% per year. Because of these mortality rates, the average lifespan of adult herring is usually no more than five years, although adults have been documented up to nine years of age (WDFW Herring Fact Sheet). As adults, Pacific herring are an important and abundant fish species in local waters. Herring are an important prey for a large variety of other marine organisms, are a popular recreational fishing bait, and a significant for commercial and subsistence fisheries (Lemberg et al 1997).

The primary objective of this study is to further sample embayments within the Strait of Juan de Fuca reported by local landowners to herring spawning sites (Clallam County Marine Resources Committee, 2001).

Materials and Methods

Seven sites throughout central and western Strait of Juan de Fuca were sampled once a month for two months during January, February, and March using WDFW herring spawn methodology (O'Toole 1995; Pentilia pers. comm.). The basic procedure involves sampling the bottom vegetation for spawn deposition. Survey areas are grappled for marine vegetation with a boat and "rake". (See Appendix A and B for detailed sampling methodology and schematic of WDFW herring spawn deposition survey and vegetation sampling rake). Paul Clarke, WDFW, gave instruction regarding field sampling techniques and stock biomass calculation protocol was obtained from Kurt Stick, WDFW. Project staff were trained in lab analysis protocols, as well as forage fish egg identification by co-author Dan Penttila, WDFW. Sampling period was timed to coincide with the estimated spawning season for the closest known herring spawning stocks elsewhere in the eastern Strait of Juan de Fuca.

Results

A total of seven embayments within the central and western Strait of Juan de Fuca were sampled monthly for the presence of herring spawn in January, February, and March. The embayments included: Dungeness Bay (sampled in January and February), Freshwater Bay, Crescent Bay, Whiskey Creek area, Pillar Point, Clallam Bay and the Sekiu river area (all sampled in February and March, Figure 1). GPS coordinates for each sampling are listed in .Appendix C.

A summary of samples per station is given in Table 1. Eelgrass (*Zostera spp.*), and a variety of red and brown algae including *Prionitis spp.*, *Pterygophora sp, and Laminaria spp* were the dominant marine vegetation detected at six of the seven sites(Table 2). No vegetation was detected at Sekiu.

Table 1. Embayments sampled for herring spawn 2002, Clallam County

Sample site	Number of samples	Spawn Detected
Dungeness Bay	50	Very-light (1-50 eggs/in^2)
Freshwater Bay	34	None
Crescent Bay	30	None
Whiskey Creek	25	None
Pillar Point	24	None
Clallam Bay	36	None
Sekiu River	9	None
Total	208	

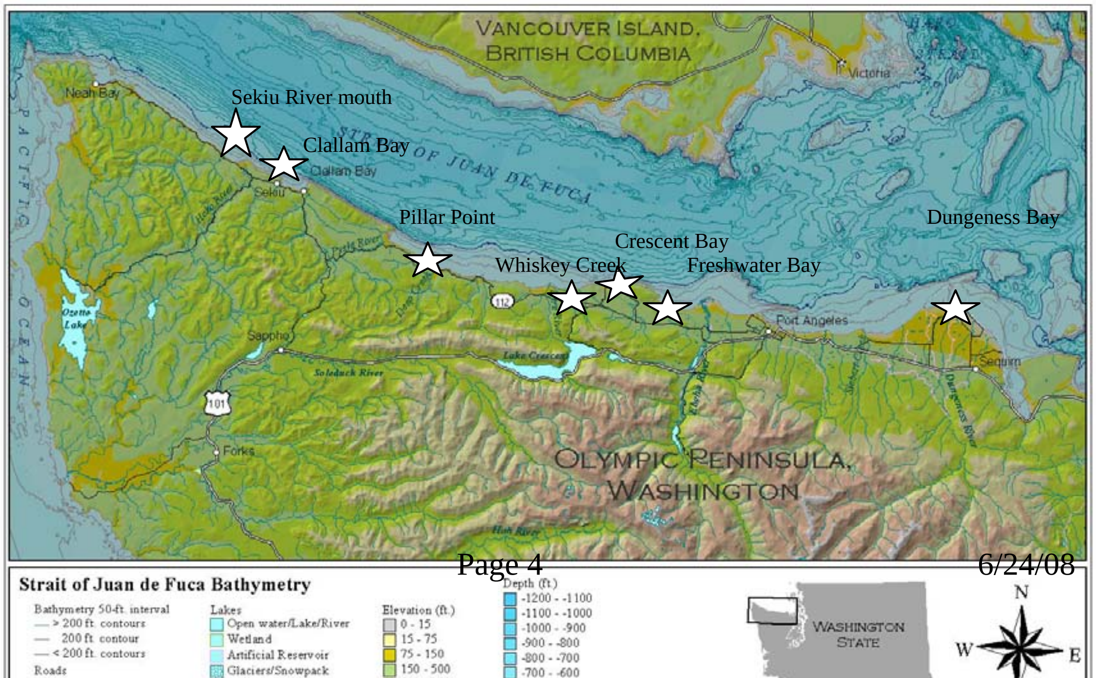

Table 2. Vegetation summary for six embayments . N=Number of samples the vegetation was detected in at each embayment; PO= Percent occurrence of each species by site

Vegetation type	**Dungeness Bay**		**Freshwater Bay**		**Crescent Bay**		**Whiskey Creek**		**Pillar Point**		**Clallam Bay**	
	N	**PO**	**N**	**PO**	**N**	**PO**	**N**	**PO**	**N**	**PO**	**N**	**PO**
Phyllospadix			1	2%			1	3%			1	2%
Zostera	44	27%	26	63%	18	40%	16	41%	11	32%	9	20%
Agardhiella	1	1%										
Gracilariopsis	29	18%					1	3%				
Alaria							1	3%				
Bortryoglossum	11	7%			1	2%	1	3%	2	6%		
Callophyllis	2	1%										
Desmarestia			3	7%					1	3%		
Constantinea												
Odonthalia					1	2%						
Porphyra					1	2%						
Ceramium	2	1%										
Egregia			1	2%			4	10%				
Gigartina	1	1%										
Iridaea					1	2%			1	3%		
Plocamium	4	2%									4	9%
Polyneura	5	3%										
Prionitis					1	2%			1	3%		
Glyceriopsis							1		1	3%		
Rhodymenia	1	1%			1	2%						
Ulvoids	29	18%	1	2%	4	9%	1	3%				
Laminaria	2	1%			2	4%	2	5%			6	13%
Nereocystis							2	5%	1	3%	4	9%
Pterygophora			2	5%							8	17%
Macrocystis							2	5%			3	7%
Hydroids	8	5%										
Terrestrial debris	24	15%	2	5%	5	11%			4	12%	6	13%
No vegetation	2	1%	5	12%	10	22%	7	18%	11	32%	5	11%
Unkown									1	3%		
TOTAL	165	100%	41	100%	45	100%	39	100%	34	100%	46	100%

Discussion

No new herring spawning sites were detected during this three month sampling. There are a number of possibly reasons. First, the abundance of herring throughout Washington waters is directly related to stock health, and distribution and intensity of spawning activity is directly related to current stock biomass. If stocks are down (as they are now in many parts of Puget Sound) spawning activity will be lower. This is reflected in spawn numbers for Dungeness Bay (Stick pers comm., Lemberg et al. 1997). Second, many “documented” herring spawning sites in Puget Sound are not used every year. As a result, it may take years to detect a herring spawning ground, and once detected, it commonly takes several years of surveying to fully define the temporal and geographic extent of the spawn ground. Two months of surveying within one year is therefore not sufficient to determine whether or not these areas are used by spawning herring. All these spawn survey sites should be sampled over a number of years to determine whether or not spawning occurs.

Sampling time may be another possible reason for not detecting spawn. The majority of herring stocks that have been documented have a spawning range from January through March. One exception to this is the Cherry point stock, believed to be one of the largest in the state, which is known to spawn from March through June (Lemberg et. al 1997). Since the Strait of Juan de Fuca has not been extensively surveyed for herring spawn, timing of spawning activity is not known. To assist in management decisions, WDFW separates herring populations around the state into individual stocks, citing “strong site specificity, unique growth characteristics, distinctive spawning timing and prespawner holding area behavior” which differ greatly between local populations (Lemberg et al 1997). It is assumed that the herring stocks present in the central and western Strait of Juan de Fuca (if any) spawn at times corresponding with the majority of Puget Sound stocks. While probable, as indicated by the spawning activity in Dungeness Bay which occurs from January through March, it is possible that some mature spawners deposit eggs in later months, similar to the Cherry Point stock.

The conditions of the stocks that comprise the forage fish assemblage are vitally important for species that utilize them as a food source. On a larger perspective, the vitality of the forage fish resource in Washington is also a valuable indicator of the health and productive capacity of our marine environment (Lemberg et al 1997). As a result, forage fish spawning habitats are protected by Washington Administrative Code hydraulic rules (WAC 220-110).

Human interactions with nearshore areas, including armoring and water quality declines, are an increasing concern for the habitat managers of the Strait of Juan de Fuca (Johannesen 2001; Johannesen and Chase 2001; Shaffer 2002a,b; 2001). Nearshore areas with herring spawning grounds and stocks, such as Dungeness Bay, (see Appendix D) are particularly vulnerable. Local populations of herring may be more susceptible to human impacts such as shoreline development. The estimated annual natural mortality for herring is presently 60-70 percent. Worldwide mortality rates are closer to 30-40 percent, which are considered normal. Higher rates, like those presently observed for the local Puget Sound stocks are considered unusual. Relatively good recruitment rates to date have allowed most stocks to sustain themselves despite the elevated mortality rates. Development pressures may stress this balance. Recruitment failure, under the present natural mortality, would lead to dramatic stock biomass declines (WDFW Pacific Herring Fact Sheet). Understanding where herring spawning grounds are, as well and defining how humans can wisely, is therefore a high priority of local stewards and regional mangers if we are to be successful in the long term management of nearshore resources and habitats of the Strait of Juan de Fuca.

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Appendix A. (REPRINTED FROM THE FOLLOWING PUBLICATIONS, CITE THESE, -NOT THIS REPORT-, WHEN CITING TECHNIQUES OF THIS STUDY).

Lemberg, N.A., M.F. O'Toole, D.E.Penttila and K.C. Stick 1997. Forage Fish Status Report. Washington Dept. of Fish and Wildlife, Fish Management Program. Stock Status Report No. 98-1. Olympia, Wa.

O'Toole, M.F. in press. Puget Sound herring age and size composition, 1994. In Lemberg, N.[ed.] 1995. Puget Sound Baitfish Review, 1994. Wash.Dept. Fish. Progess .Report, Washington Department of Fish and Wildlife, LaConner, Washington)

Stick, K. 1994 Herring Spawn Deposition Survey Summary. Washington Department of Fisheries manuscript, Washington Department of Fish and Wildlife, LaConner Washington.)

Surveyed spots are generally at 200 to 400 yard intervals along the shoreline of spawning grounds and are plotted. In this survey distances were somewhat shorter ranging from 50-200 yards for detection purposes.

If new spawning grounds are found, sampling is continued until at least two consecutive sampling stations are encountered. The sampled sites are plotted on field charts, grappled vegetation types (to genus) are recorded, herring spawn deposition intensity is estimated and recorded, and spawn samples are collected and preserved.

Seven different spawn deposition intensities are used to calculate estimated spawning biomass: "very light", "light", "light medium", "medium", "medium heavy", "heavy", and "very heavy" (Table A1). A "trace" category is recorded when between one and three eggs are observed for an entire rake sample of substrate or eggs are present on a single piece of substrate that is considered to be drift. No spawning escapement is estimated from "trace" spawn deposition intensity.

Table A1. Herring spawn deposition intensity scale

Spawn Intensity Category	VERY LIGHT	LIGHT	LIGHT MEDIUM	MEDIUM	MEDIUM HEAVY	HEAVY	VERY HEAVY
Eggs/inch^2 of Substrate	1-50	50-150	150-250	250-450	450-650	650-1150	> 1150
Approx. median Eggs/inch^2 used to estimate Biomass	26	127	214	358	536	766	1533
Estimated Tons of Herring Per Mile of Spawn	43	214	360	600	900	1286	2571

Stock Biomass Calculation Protocol

The biomass of spawner herring is estimated in short tons from the length of each spawn deposition, and estimated spawn intensity outlined by Hourston et al (1972) and described by Trumble et al (1977) and Meyer and Adair (1978) as follows:

Basic procedure: Sample aquatic vegetation in lower intertidal and upper subtidal zones for the presence of herring eggs. Estimate the density of eggs per unit eggs per unit area over a given length of the surveyed vegetated zone. Convert the egg density into number of eggs per unit area based on the width of the surveyed zone. Based on fecundity per unit body weight, convert eggs/unit area into tons of adult herring.

Let l_i be the length (yards) of the vegetated zone between mid point of sample i-l and i, and the mid point of sample i and i+l,

w_i be the width (yards) of vegetation zone,

d_i be the density of deposited eggs (number/in^2),

f be the estimated fecundity of spawning herring (eggs/g body weight),

and c_j be a constant (j= 1.2), where c_1 = 1296 inches squared/yard squared (36^2), and c_2 =2.2046 x 10^{-6} tons/gram (2/ (2000 lbs/tons*453.5924 grams/lb));

then, the number of eggs deposited in zone i is

$$E_i = c_i \, l_i \, w_i \, d_i \qquad (1)$$

The biomass of adult herring which spawned the deposited eggs in zone i is estimated from:

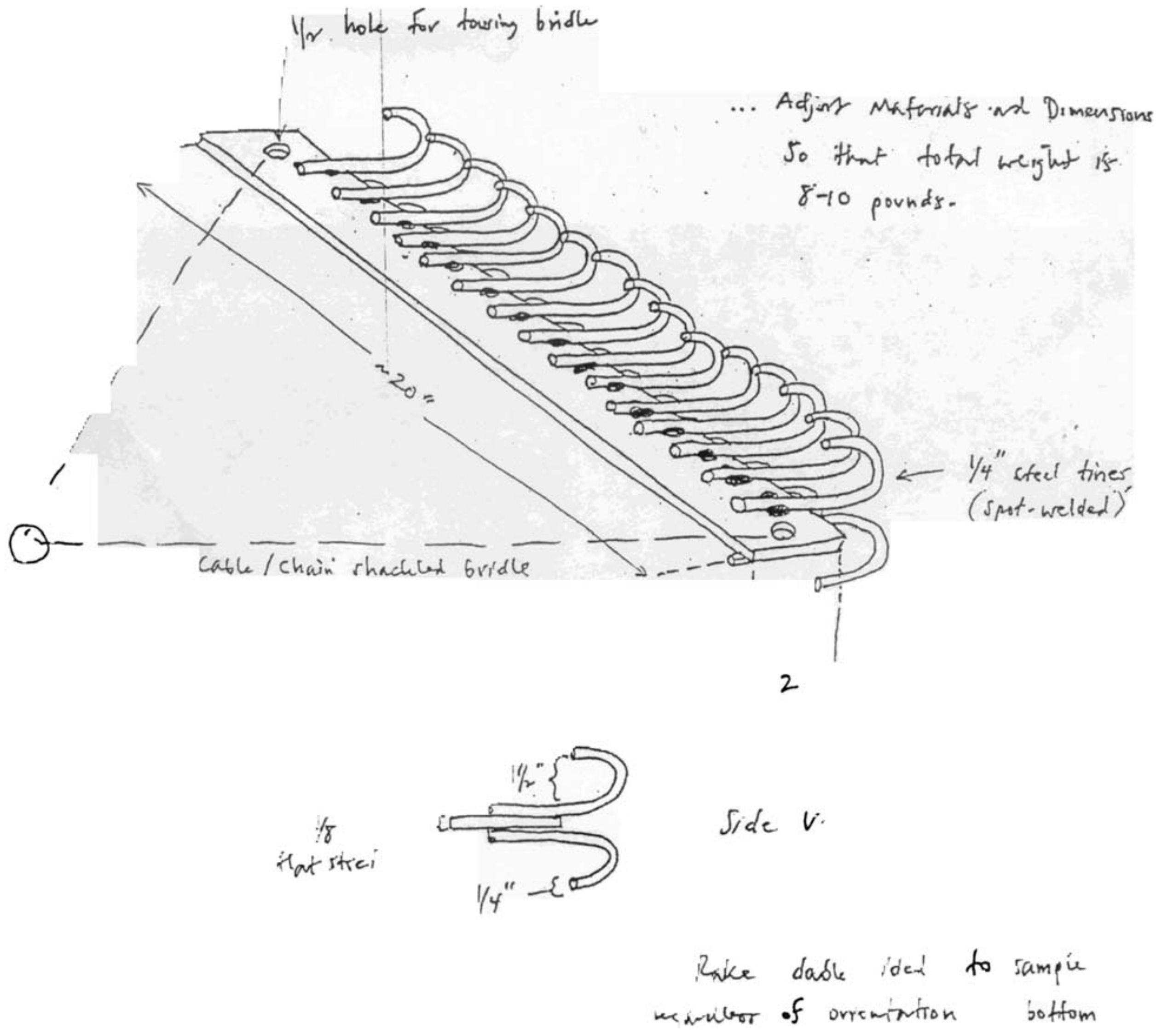
$$B_i = c_2 \, (E_i / f).$$

The total egg deposition and tons of spawners is obtained by summing over i, i.e., summing over all vegetated zones sampled.It is assumed that 1) f = 200 eggs/g, and 2) w = 66.7 yards for all vegetated zones. Furthermore, the c_2 assumes a 50:50 sex ratio, hence the 2 in the numerator.

Spawning dates are determined in the laboratory by analyzing the stages of embryonic development observed in collected spawn samples.

Biweekly surveys are considered to be the minimum survey frequency to enable an annual spawning escapement estimate and weekly or semiweekly surveys provide a more accurate estimate. This is particularly the case in areas where spawn deposition intensities greater than "very light" occur and bird predation on spawn is intense.

APPENDIX B. DIAGRAM OF HERRING RAKE (FROM PENTTILA 1993)



Appendix C.

Sample Site Information (NOTE Dungeness Bay site locations available from Kurt Stick, WDFW LaConner office).

Date Sampled		Sample Number	Sample Location	
			Lat.	Long.
22-Feb-02	Freshwater Bay	1	N48 08 765'	W123 38.369'
		2	N48 08 649'	W123 38.111'
		3	N48 08.647'	W123 38.109'
		4	N48 08.576'	W123 38.013'
		5	N48 08.555'	W123 37.944'
		6	N48 08.526'	W123 37.966'
		7	N48 08.585'	W123 38.070'
		8	N48 08.665'	W123 38.165'
		9	N48 08.706'	W123 38.268'
		10	N48 08.752'	W123 38.335'
		11	N48 08.821'	W123 38.418'
		12	N48 08.842	W123 38.405'
		13	N48 08.868'	W123 38.334'
		14	N48 08.906'	W123 38.301'
22-Feb-02	Cresent Bay	1	N48 09.740'	W123 43.613'
		2	N48 09.689'	W123 43.619'
		3	N48 09.640'	W123 43.626'
		4	N48 09.609'	W123 43.594'
		5	N48 09.588'	W123 43.518'
		6	N48 09.581'	W123 43.423'
		7	N48 09.589'	W123 43.465'
		8	N48 09.609'	W123 43.528'
		9	N48 09.631'	W123 43.608'
		10	N48 09.669'	W123 43.627'
		11	N48 09.724'	W123 43.605'
		12	N48 09.760'	W123 43.652'
		13	N48 09.891'	W123 42.476'
		14	N48 09.930'	W123 42.447'
22-Feb-02	Whiskey Creek	1	N48 09.938'	W123 42.410'
		2	N48 09.368'	W123 46.734'
		3	N48 09.407'	W123 46.630'
		4	N48 09.422'	W123 46.514'
		5	N48 09.434'	W123 46.407'
		6	N48 09.447'	W123 46.347'
		7	N48 09.413'	W123 46.574'
		8	N48 09.412'	W123 46.593'
		9	N48 09.416'	W123 46.610'
		10	N48 09.423'	W123 46.633'
		11	N48 09.432'	W123 46.714'
		12	N48 09.411'	W123 46.775'
23-Feb-02	Clallam Bay	1	N48 15.304'	W123 16.167'
		2	N48 15.329'	W123 16.132'

		3	N48 15.371'	W124 16.112'
		4	N48 15.326'	W124 15.995'
		5	N48 15.329'	W124 16.053'
		6	N48 15.318'	W124 16.145'
		7	N48 15.313'	W124 16.221'
		8	N48 15.328'	W124 16.266'
		9	N48 15.300'	W124 16.007'
		10	N48 15.302'	W124 16.080'
		11	N48 15.299'	W124 16.169'
		12	N48 15.302'	W124 16.234'
		13	N48 15.307'	W124 16.270'
		14	N48 15.330'	W124 16.372'
		15	N48 15.503'	W124 17.110'
		16	N48 15.480'	W124 17.233'
		17	N48 15.489'	W124 17.301'
		18	N48 15.493'	W124 17.340'
		19	N48 15.506'	W124 17.331'
		20	N48 15.502'	W124 17.481'
		21	N48 15.519'	W124 17.604'
		22	N48 15.599'	W124 17.806'
		23	N48 15.806'	W124 17.989'
		24	N48 15.991'	W124 17.998'
23-Feb-02	Sekiu River	1	N48 17.287'	W124 23.304'
		2	N48 17.542'	W124 23.781'
		3	N48 17.611'	W124 23.852'
		4	N48 17.717'	W124 23.899'
		5	N48 17.856'	W124 23.971'
12-Mar-02	Freshwater Bay	1	N48 08.938'	W123 38.281'
		2	N48 08.922'	W123 38.324'
		3	N48 08.907'	W123 38.370'
		4	N48 08.866'	W123 38.421'
		5	N48 08.830'	W123 38.391'
		6	N48 08.786'	W123 38.360'
		7	N48 08.762'	W123 38.321'
		8	N48 08.744'	W123 38.304'
		9	N48 08.735'	W123 38.294'
		10	N48 08.693'	W123 38.231'
		11	N48 08.657'	W123 38.164'
		12	N48 08.645'	W123 38.137'
		13	N48 08.632'	W123 38.092'
		14	N48 08.598'	W123 38.070'
		15	N48 08.573'	W123 38.021'
		16	N48 08.566'	W123 37.901'
		17	N48 08.628'	W123 37.993'
		18	N48 08.649'	W123 38.027'
		19	N48 08.763'	W123 38.176'
		20	N48 08.306'	W123 38.237'
12-Mar-02	Crescent Bay	1	N48 09.748'	W123 43.636'
		2	N48 09.745'	W123 43.657'
		3	N48 09.723'	W123 43.677'
		4	N48 09.646'	W123 43.644'

		5	N48 09.640'	W123 43.629'
		6	N48 09.611'	W123 43.582'
		7	N48 09.596'	W123 43.538'
		8	N48 09.602'	W123 43.508'
		9	N48 09.648'	W123 43.532'
		10	N48 09.694'	W123 43.567'
		11	N48 09.723'	W123 43.595'
		12	N48 09.765'	W123 43.626'
		13	N48 09.916'	W123 42.479'
		14	N48 09.935'	W123 42.444'
		15	N48 09.937'	W123 42.413'
		16	N48 09.976'	W123 42.441'
12-Mar-02	Whiskey Creek	1	N48 09.412'	W123 46.688'
		2	N48 09.424'	W123 46.659'
		3	N48 09.429'	W123 46.650'
		4	N48 09.435'	W123 46.582'
		5	N48 09.407'	W123 46.521'
		6	N48 09.360'	W123 46.690'
		7	N48 09.38'	W123 46.61'
		8	N48 09.40'	W123 46.67'
		9	N48 09.41'	W123 46.73'
		10	N48 09.39'	W123 46.80'
		11	N48 09.38'	W123 46.88'
		12	N48 09.38'	W123 46.88'
12-Mar-02	Pillar Pt	1	N48 12.596'	W124 05.890'
		2	N48 12.612'	W124 05.898'
		3	N48 12.720'	W124 06.044'
		4	N48 12.776'	W124 06.114'
		5	N48 12.681'	W124 06.041'
		6	N48 12.646'	W124 06.010'
		7	N48 12.589'	W124 05.964'
		8	N48 12.374'	W124 05.705'
		9	N48 12.251'	W124 05.610'
		10	N48 12.180'	W124 05.505'
		11	N48 12.112'	W124 05.551'
		12	N48 12.994'	W124 05.464'
		13	N48 12.930'	W124 05.375'
		14	N48 11.928'	W124 05.273'
		15	N48 11.940'	W124 05.343'
		16	N48 11.982'	W124 05.422'
		17	N48 12.035'	W124 05.473'
		18	N48 12.070'	W124 05.495'
		19	N48 12.102'	W124 05.518'
		20	N48 12.248'	W124 05.535'
		21	N48 12.389'	W124 05.667'
		22	N48 12.498'	W124 05.781'
		23	N48 12.557'	W124 05.860'
		24	N48 12.632'	W124 05.946'
		25	N48 12.652'	W124 06.011'
12-Mar-02	Clallam Bay	1	N48 15.345'	W124 16.406'
		2	N48 15.347'	W124 16.387'

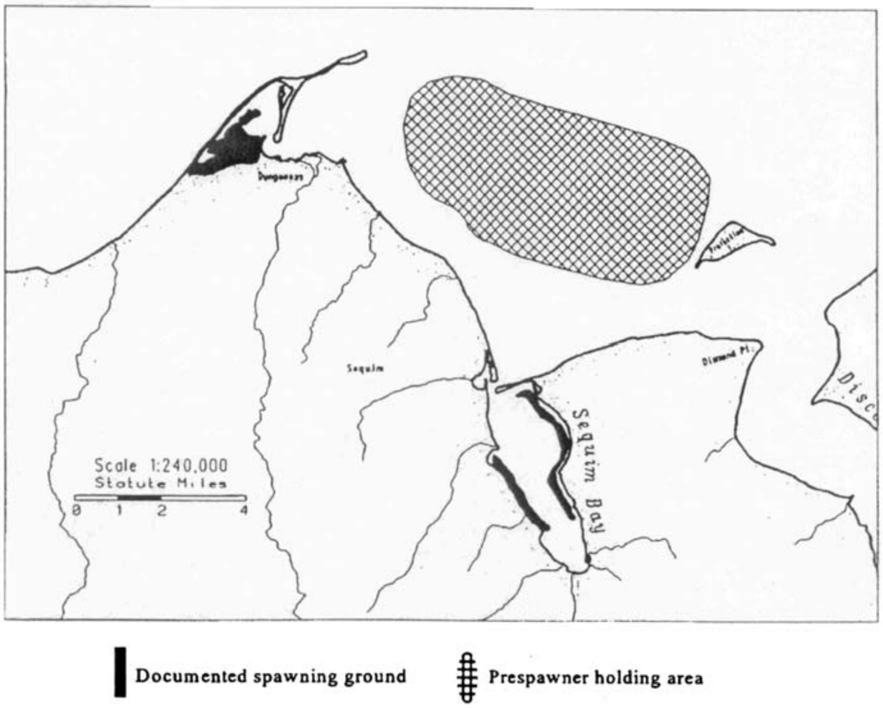
		3	N48 15.347'	W124 16.345'
		4	N48 15.326'	W124 16.259'
		5	N48 15.328'	W124 16.220'
		6	N48 15.321'	W124 16.181'
		7	N48 15.317'	W124 16.122'
		8	N48 15.333'	W124 16.043'
		9	N48 15.337'	W124 15.998'
		10	N48 15.350'	W124 15.999'
		11	N48 15.354'	W124 16.108'
		12	N48 15.376'	W124 15.981'
12-Mar-02	Sekiu	1	N48 17.334'	W124 23.295'
		2	N48 17.351'	W124 23.280'
		3	N48 17.388'	W124 23.269'
		4	N48 17.303'	W124 23.248'

DUNGENESS BAY HERRING STOCK

OVERVIEW

The Dungeness Bay herring are a small Strait of Juan de Fuca stock. Since 1994, all spawn deposition for this stock has been observed in the Dungeness Bay portion of its documented spawning grounds.

SPAWNING GROUND



SPAWNING TIMING

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec

MEAN LENGTH OF 2/3/4/&5 YEAR OLDS

158mm/179mm/194mm/na (1996)

APPENDIX D. DUNGENESS BAY HERRING SPAWNING LOCATIONS (REPRINTED FROM LEMBURGE ET AL. 1997).