Summary of Scientific Conclusions of the Review of the Status of Eulachon (*Thaleichthys pacificus*) in Washington, Oregon, and California

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TABLE OF CONTENTS

SUMMARY

The National Marine Fisheries Service's (NMFS) Biological Review Team (BRT) has completed its review of the status of eulachon in Washington, Oregon, and California under the U.S. Endangered Species Act (ESA). The BRT has determined that the petitioned unit of eulachon that spawn in rivers in Washington, Oregon, and California is not a "species" under the ESA, as it does not meet all the biological criteria to be considered a Distinct Population Segment (DPS) as defined by the joint NMFS-U.S. Fish and Wildlife Service (USFWS) interagency policy on vertebrate populations (USFWS-NMFS 1996). However, the BRT has determined that eulachon spawning in Washington, Oregon, and California rivers are part of a DPS that extends beyond the conterminous United States and that the northern boundary of the DPS occurs in northern British Columbia south of the Nass River (most likely) or in Southern British Columbia north of the Fraser River (less likely). The BRT found it difficult to establish a clear northern terrestrial or river boundary for this DPS in light of the fact that the BRT believes the northern boundary is essentially determined by oceanographic processes. However, it was the majority opinion of the BRT that the northern boundary of the DPS is south of the Nass River on the North Coast of British Columbia. The BRT proposes that this DPS be termed the Southern Eulachon DPS. The BRT also concluded that the eulachon spawning in the Nass River and further north consist of at least one additional (northern) DPS.

The BRT qualitatively ranked threats to the Southern Eulachon DPS sub-populations that spawn in the Klamath River, Columbia River, Fraser River, and British Columbia coastal rivers south of the Nass River. In each case, the BRT ranked climate change impacts on ocean conditions as the most serious threat to persistence of eulachon. Climate change impacts on freshwater habitat and eulachon by-catch were scored as moderate to high risk in all sub-areas of the DPS, and dams and water diversions in the Klamath and Columbia rivers and predation in the Fraser and British Columbia coastal rivers were also ranked within the top four threats in their respective regions.

The BRT was concerned that although eulachon are a relatively poorly monitored species, the weight of the available information indicates that the Southern Eulachon DPS has experienced an abrupt decline in abundance throughout its range. Considering this large decline, in addition to other risk factors, the BRT determined that the Southern Eulachon DPS is at "moderate risk" of extinction throughout all of its range.

ACKNOWLEDGMENTS

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The BRT relied on comments and informational reports submitted by the public and by state, tribal, and federal agencies. The authors acknowledge the efforts of all who contributed to this record, especially the Washington Department of Fish and Wildlife (WDFW), Oregon Department of Fish and Wildlife (ODFW), California Department of Fish and Game (CDFG), and Department of Fisheries and Oceans Canada (DFO).

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INTRODUCTION

In 1999 the National Marine Fisheries Service (NMFS) received a petition (Wright 1999) to list eulachon (*Thaleichthys pacificus* Richardson, 1836) in the Columbia River and its tributaries as a threatened or endangered species under the U.S. Endangered Species Act (ESA). NMFS determined that the 1999 eulachon petition failed to present substantial scientific and commercial information indicating that the petitioned action may be warranted (NMFS 1999).

On November 27, 2007, NMFS received a new petition seeking to list eulachon in Washington, Oregon, and California as a threatened or endangered "species" under the ESA (Cowlitz Indian Tribe 2008). NMFS evaluated the petition to determine whether the petitioner provided "substantial information" as required by the ESA to list a species. Additionally, NMFS evaluated whether information contained in the petition might support the identification of a DPS that might warrant listing as a species under the ESA. NMFS determined that the November 27, 2007 petition did present substantial scientific and commercial information, or cited such information in other sources, that the petitioned action may be warranted and, subsequently, NMFS initiated a status review of eulachon in Washington, Oregon, and California (NMFS 2008).

The eulachon Biological Review Team (BRT)[1]– consisting of scientists from the Northwest Fisheries Science Center, Alaska Fisheries Science Center, Southwest Fisheries Science Center, U.S. Fish and Wildlife Service, and U.S. Forest Service – was formed by NMFS, and the team reviewed and evaluated scientific information compiled by NMFS staff from published literature and unpublished data. Information presented at a public meeting in June 2008 in Seattle, Washington and data submitted to the ESA Administrative Record from state agencies and other interested parties was also considered.

The BRT proceeded on the directives included in the "Draft BRT Eulachon Instructions Memo" which was received from the NMFS Northwest Region in draft form on May 19, 2008. In that memo the BRT was charged with consideration of the following questions:

1. Consider, consistent with the criteria defined by the joint NOAA-FWS Distinct Population Segment (DPS) Policy (61 FR 4722; February 7, 1996), whether eulachon warrant delineation into one or more DPSs.

[1] The BRT for eulachon consisted of the following members: Dr. Jonathan Drake, Dr. Robert Emmett, Kurt Fresh, Dr. Richard Gustafson, Mindy Rowse, and David Teel (NMFS, Northwest Fisheries Science Center); Matthew Wilson (NMFS, Alaska Fisheries Science Center); Dr. Peter Adams (NMFS, Southwest Fisheries Science Center); Elizabeth A. K. Spangler (Department of Interior, U. S. Fish and Wildlife Service); and Robert Spangler (U. S. Department of Agriculture, Forest Service).

2. Once the DPS structure for eulachon has been delineated, assess the level of extinction risk facing the species (including any DPS in the U.S.) throughout all of its range.

3. In articulating the assessed level of extinction risk, describe the BRT's confidence that the species or DPS is: at high risk of extinction; at moderate risk; or neither.

4. In the BRT's evaluation of extinction risk, please include a consideration of the threats facing the species/DPS that may or may not be manifested in the current demographic status of populations. Please document the BRT's consideration of these threats according to the statutory listing factors (ESA section 4(a)(1)(A)—(C), and (E)): the present or threatened destruction, modification, or curtailment of its habitat or range; overutilization for commercial, recreational, scientific, or educational purposes; disease or predation; and other natural or manmade factors affecting its continued existence. In describing the threats facing the species/DPS please distinguish between threats (e.g., human actions or natural events) and limiting factors (e.g., the physical, biological, or chemical processes that result in demographic risks to the species/DPS), and qualitatively rank, if possible, the severity of identified threats to the species' persistence. The consideration of the "inadequacy of existing regulatory mechanisms" (section 4(a)(1)(D)) will be conducted by the regional office(s) in concert with the evaluation of efforts being made to protect the species.

5. If the BRT determines that the species or delineated DPS is at neither moderate nor high risk throughout all of its range, please consider whether it is at moderate or high risk throughout a significant portion of its range.

This document provides a summary of the conclusions of the NMFS Biological Review Team for the status review of eulachon from Washington, Oregon, and California. A more comprehensive report is being prepared and will be available in the future.

Summary of Information Presented by the Petitioner

On 27 November 2007, NMFS received a petition from the Cowlitz Indian Tribe (Cowlitz Indian Tribe 2007) to designate a southern eulachon DPS extending from the U.S.-Canada border south to include eulachon spawning in Washington, Oregon, and California and list it as a threatened or endangered species and to designate critical habitat under the ESA.

The DPS Question: Evidence for "Discreteness" and "Significance"

The petitioner noted that early mitochondrial DNA genetic information (McLean et al. 1999) suggested that eulachon did not exhibit genetic discreteness and gave little support for subdivision of population structure throughout the species' range. However, other biological data including the number of vertebrae, size at maturity, fecundity, river-specific spawning times, and population dynamics indicated that there is substantial local stock structure (Hart and McHugh 1944, Hay and McCarter 2000). These latter observations are consistent with the hypothesis that there is local adaptation and genetic differentiation among populations. Recent microsatellite genetic work (Beacham et al. 2005) appears to confirm the existence of significant differentiation among populations. The petitioner summarized these findings as indicating that although the Fraser River, Columbia River mainstem, and the Cowlitz River spawning populations are genetically distinct from each other, they are more closely related to one another than either population is to the more northerly British Columbia populations (Beacham et al. 2005). Although the petitioner felt that the available information is inconclusive, the petitioner noted that eulachon may be composed of several DPSs separated by differences in run timing, spawn timing, meristics, and genetic characteristics

The petitioner concluded that the available genetic, meristic, and life-history information is inconclusive regarding the discreteness of eulachon populations. However, the petitioner argued that under the DPS policy eulachon populations in Washington, Oregon, and California are collectively "discrete" from more northerly populations because they are delimited by an international governmental boundary (i.e., the U.S.-Canada border between Washington and British Columbia) across which there is a significant difference in exploitation control, habitat management, or conservation status. The petitioner noted that the U.S. and Canada differ in their regulatory control of commercial, recreational and tribal eulachon harvest, and also differ in their management of eulachon habitat. The petitioner concluded that there is no assurance that the U.S. and Canada will coordinate management and regulatory efforts sufficiently to conserve eulachon and their habitat, and thus the DPS should be delineated at the border between Washington and British Columbia.

The petitioner argued that the southern eulachon population segment is "significant" under the DPS policy because the loss of the discrete population segment would cause a significant gap in the taxon's range. The petitioner stated that eulachon have largely disappeared in rivers throughout the southern portion of their range, and that eulachon in the Columbia River probably represent the southernmost extant population for the species. The petitioner argued that the loss of the Columbia River eulachon population and any dependent coastal spawning populations could represent the loss of the species throughout its range in the U.S., as well as the loss of a substantial proportion of its historical range.

Summary of Abundance and Population Trends

The petitioner stated that although eulachon abundance exhibits considerable year-to-year variability, nearly all spawning runs from California to southeastern Alaska have declined in the past 20 years, especially since the mid 1990s (Hay and McCarter 2000). Historically, the Columbia River has exhibited the largest returns of any spawning population throughout the species' range. The petitioner noted that from 1938 to 1992, the median commercial catch of eulachon in the Columbia River was approximately 1.9 million pounds. From 1993 to 2006, the median catch had declined to approximately 43,000 pounds, representing a 97.7 percent reduction in catch from the prior period. Although there was an increasing trend in Columbia River eulachon catch from 2000-2003, recent catches are extremely low. The petitioner also presented catch per unit effort and larval survey data (JCRMS 2006) for the Columbia River and tributaries in Oregon and Washington that similarly reflect the depressed status of Columbia

River eulachon during the 1990s, a relative increase during 2001 to 2004, and a decline back to low levels in recent years.

The petitioner also noted that eulachon returns in the Fraser River showed a similar pattern to those in the Columbia River; a rapid decline in the mid-1990s, increased returns during 2001 to 2003, and a recent decline to low levels. The petitioner stated that egg and larval surveys conducted in the Fraser River since 1995 also demonstrate that, despite the implementation of fishing restrictions in British Columbia, the stock has not recovered from its mid-1990s collapse and remains at a precariously low level. An offshore index of Fraser and Columbia River eulachon biomass, calculated from eulachon bycatch in an annual trawl survey of shrimp biomass off the west coast of Vancouver Island, illustrates highly variable biomass over the time series since 1973, but also reflects stock declines in the mid-1990s and in recent years, according to the petitioner. With respect to eulachon populations further south in the species' range, the petitioner noted that populations in the Klamath River, Mad River, Redwood Creek, and Sacramento River are likely extirpated or nearly so.

Summary of Risk Factors

The petitioner described a number of threats facing eulachon range-wide and facing populations in U.S. rivers in particular. The petitioner expressed concern that habitat loss and degradation threaten eulachon, particularly in the Columbia River basin. The petitioner argued that hydroelectric dams block access to historical eulachon spawning grounds, and affect the quality of spawning substrates through flow management, altered delivery of coarse sediments, and siltation. The petitioner expressed strong concern regarding the siltation of spawning substrates in the Cowlitz River due to altered flow management and the accumulation of fine sediments from the Toutle River. The petitioner believes that efforts to retain and stabilize fine sediments generated by the 1980 eruption of Mount St. Helens are inadequate. The petitioner noted that the release of fine sediments from behind a U.S. Army Corps of Engineers sediment retention structure on the Toutle River has been negatively correlated with Cowlitz River eulachon returns 3 to 4 years later. The petitioner also expressed concern that dredging activities in the Cowlitz and Columbia rivers during the eulachon spawning run may entrain and kill fish, or otherwise result in decreased spawning success. The petitioner also noted that eulachon have been shown to carry high levels of chemical pollutants (EPA 2002), and although it has not been demonstrated that high contaminant loads in eulachon result in increased mortality or reduced reproductive success, such effects have been shown in other fish species (Kime 1995). The petitioner concluded that no evidence suggests that disease currently poses a threat to eulachon, but noted information presented in the 1999 petition (Wright 1999) to list eulachon that suggested that predation by pinnipeds may be substantial.

The petitioner expressed concern that depressed eulachon populations are particularly susceptible to overharvest in fisheries where they are targeted or taken as bycatch. The petitioner acknowledged that eulachon harvest has been curtailed significantly in response to population declines, and that were it not for continued low levels of harvest there would be little or no status information available for some populations. However, the petitioner concluded that existing regulatory mechanisms have proven inadequate in recovering eulachon stocks, and that directed harvest and bycatch may be important factors limiting the recovery of impacted stocks. The petitioner emphasized the need for further fishery-independent monitoring and research.

Finally, the petitioner concluded that global climate change is one of the greatest threats facing eulachon, particularly in the southern portion of its range where ocean warming trends may be the most pronounced. The petitioner felt that the risks facing southerly eulachon populations in Washington, Oregon, and California will be exacerbated by such a deterioration of marine conditions. According to the petitioner, these southerly populations, already exhibiting dramatic declines and impacted by other threats (e.g., habitat loss and degradation), might be at risk of extirpation if unfavorable marine conditions predominated in the future.

THE "SPECIES" QUESTION

As amended in 1978, the ESA allows listing of "distinct population segments" of vertebrates as well as named species and subspecies. Guidance on what constitutes a "distinct population segment" is provided by the joint NMFS-U.S. Fish and Wildlife Service (USFWS) interagency policy on vertebrate populations (USFWS-NMFS 1996). To be considered "distinct", a population, or group of populations, must be "discrete" from the remainder of the taxon to which it belongs; and "significant" to the taxon to which it belongs as a whole. Discreteness and Significance are further defined by the Services in the following Policy language (USFWS-NMFS 1996):

> Discreteness: A population segment of a vertebrate species may be considered discrete if it satisfies either one of the following conditions:
> 1. It is markedly separated from other populations of the same taxon as a consequence of physical, physiological, ecological, or behavioral factors. Quantitative measures of genetic or morphological discontinuity may provide evidence of this separation.
> 2. It is delimited by international governmental boundaries within which differences in control of exploitation, management of habitat, conservation status, or regulatory mechanisms exist that are significant in light of section 4(a)(1)(D) of the [Endangered Species] Act.
>
> Significance: If a population segment is considered discrete under one or more of the above conditions, its biological and ecological significance will then be considered in light of congressional guidance (see Senate Report 151, 96th Congress, 1st Session) that the authority to list DPSs be used "sparingly" while encouraging the conservation of genetic diversity. In carrying out this examination, the Services will consider available scientific evidence of the discrete population segment's importance to the taxon to which it belongs. This consideration may include, but is not limited to, the following:
> 1. Persistence of the discrete population segment in an ecological setting unusual or unique for the taxon,
> 2. Evidence that loss of the discrete population segment would result in a significant gap in the range of a taxon,
> 3. Evidence that the discrete population segment represents the only surviving natural occurrence of a taxon that may be more abundant elsewhere as an introduced population outside its historic range, or
> 4. Evidence that the discrete population segment differs markedly from other populations of the species in its genetic characteristics.

The joint policy states that international boundaries within the geographical range of the species may be used to delimit a distinct population segment in the United States. This criterion is applicable if differences in the control of exploitation of the species, the management of the species' habitat, the conservation status of the species, or regulatory mechanisms differ between countries that would influence the conservation status of the population segment in the United

States. However, in past assessments of DPSs of marine fish, NMFS has placed the emphasis on biological information in defining DPSs and has considered political boundaries only at the implementation of ESA listings. Therefore, the BRT focused only on biological information in identifying whether DPSs of eulachon could be delineated.

Taxonomy and Species Description

Scientific Nomenclature

Thaleichthys pacificus (Richardson, 1836) is an anadromous smelt in the Family Osmeridae and is distinguished from other osmerids by possession of from 4-6 gill rakers on the upper half of the arch (others have 8-14 gill rakers), distinct concentric striae on the operculum and suboperculum (other osmerids lack these concentric striae), and from 8-11 pyloric caeca (others have 0-8 pyloric caeca) (McAllister 1963). McAllister (1963) provides a taxonomic synonymy for the species, which was originally described from the Columbia River as *Salmo (Mallotus) pacificus* by Richardson (1836). The Genus *Thaleichthys* has only one species and valid subspecies have not been described (McAllister 1963). The binomial species name is derived from Greek roots; *thaleia* meaning rich, *ichthys* meaning fish, and *pacificus* meaning of the Pacific (Hart 1973).

Common Names

Native, Indian, and First Nations languages

The common name for *Thaleichthys pacificus* is "eulachon" (Nelson et al. 2004), which is originally derived from the Chinook Indian trade language of the lower Columbia River (Hart and McHugh 1944, Moody 2008). Numerous variations include hoolakan, hooligan, hoolikan, olachan, ollachan, oolachan, oolichan, oulachan, oulachon, oulacon, ulchen, ulichan, uthlecan, yshuh (Hart and McHugh 1944), ooligan, olachen, and olachon (Moody 2008). The Yurok Tribe of the lower Klamath River call eulachon "quat-ra" (Larson and Belchik 1998) and the Quinault Tribe gave them the name "páagwáls" (Olson 1936). The First Nations of the lower Fraser River called eulachon "swavie" or "chucka" (Hart and McHugh 1944). Each First Nations group in British Columbia has a unique name for eulachon (Hay and McCarter 2000, Moody 2008) and the Haisla and Tlingit of Alaska call it "juk'wan" or "za'xwen" and "ssag" or "saak," respectively (Krause 1885, Willson et al. 2006).

English

The officially recognized common name for this species by the American Fisheries Society is eulachon (pronounced you-la-kon in the U. S.) (Nelson et al. 2004). Numerous local common English names include candlefish, small fish, savior fish, salvation fish, little fish, fathom fish (because it was sold by the fathom) (Hart and McHugh 1944), and Columbia River smelt.

Eulachon and Human Cultural History

Eulachon were, and still are, highly important ceremonially, nutritionally, medicinally, and economically to First Nations Peoples in British Columbia and Native American tribes in Northern California and the Pacific Northwest. Many ethnographers and historians have stressed the cultural importance of eulachon to the Tlingit of Southeast Alaska (Krause 1885, Olson and Hubbard 1984), Tsimshians of the North Coast of British Columbia (Stewart 1975, Halpin and Seguin 1990), Haisla of Douglas Channel and Gardner Canal of British Columbia (Hawthorne et al. 1960, Hamori-Torok 1990), Haihais and Oowekeeno of Rivers Inlet in British Columbia (Hilton 1990), Nuxalk (formerly known as the Bella Coola) of the Central Coast of British Columbia (Kuhnlein et al. 1982, Kennedy and Bouchard 1990), Kwakwaka'wakw (formerly known as the Kwakiutl) of the North and Central Coast of British Columbia (Curtis 1915, Rohner 1967, Macnair 1971, Codere 1990), Stó:lō of the Fraser River (Duff 1952), Quinault of the Washington Coast (Willoughby 1889, Olson 1936), Chinook and Cowlitz on the lower Columbia River (Boyd and Hajda 1987, Byram and Lewis 2001), and Yurok on the Klamath River (Pilling 1978, Byram and Lewis 2001). In many areas, eulachon returned in the late winter and early spring when other food supplies were scarce and were known, for this reason, as the savior or salvation fish (Boyd and Hajda 1987, Byram and Lewis 2001).

Major aboriginal subsistence fisheries for eulachon reportedly occurred on the Stikine, Nass, Skeena, Kitimat, Bella Coola, Kingcome, Klinaklini, Fraser (Macnair 1971, Kuhnlein et al. 1982), and Columbia rivers (Boyd and Hajda 1987). Eulachon were eaten fresh, smoked, dried, and salted, and as the rendered oil or "grease." Especially to the north of the Fraser River, the fat of the eulachon was rendered into oil, or what is commonly called "grease," which is solid at room temperature and was a common traditional year-round condiment with many foods, as well as a medicine for skin rashes and internal ailments among First Nations Peoples on the Central and North Coasts of British Columbia and in some parts of Alaska (Kuhnlein et al. 1982). Kuhnlein et al. (182, p. 155) stated that:

> The cultural significance of ooligan grease cannot be underestimated, as it was (and continues to be) a prominent food and gift during feasts and potlatch ceremonies. Early ethnographers among the Nuxalk and Kwakiutl people noted that it was a sign of poverty for a family to be without ooligan grease.

Eulachon grease was widely traded to First Nations such as the Haida and Nootka of Vancouver Island and First Nations in the interior of British Columbia that had no rivers with eulachon runs (Krause 1885). Sutherland (2001, p. 8) has stated that "by trading the grease [First nations People] obtained wealth, prestige, and power." Ancient trade routes up the Nass and Bella Coola river valleys, in particular, and through the mountains, became known as "grease trails" after the traffic in eulachon grease, packed in wooden boxes (Collison 1941, Stewart 1977, Byram and Lewis 2001, Hirch 2003). Numerous sources describe the methods, which varied slightly from area to area, of extracting the oil by boiling the fish bodies (MacFie 1865, Lord 1866, Swan 1881, Krause 1885, Macnair 1971, Stewart 1977).

The largest and most important eulachon fisheries for grease production were on the Nass and Klinaklini rivers of British Columbia (Stacey 1995), although grease was produced by all the First Nations with fishing rights on eulachon rivers north of the Fraser River (Swan 1881, Macnair 1971). As many as 2,000 people annually migrated to the eulachon fishing grounds on the Klinaklini River at the head of Knight Inlet (Macnair 1971, Stacey 1995), some traveling from as far as 250 miles away by canoe (Codere 1990). Kennedy and Bouchard (1990, p. 325) in an ethnographic summary of the Bella Coola First Nation noted that "Because of their abundance and their value as a trade item, eulachons (particularly when rendered into highly valued grease) were second only to salmon in importance to the Bella Coola."

Historical and Current Distribution

Freshwater Spawning Distribution

Eulachon spawn in the lower portions of certain rivers draining into the northeastern Pacific Ocean ranging from northern California to the southeastern Bering Sea in Bristol Bay, Alaska (McAllister 1963, Scott and Crossman 1973, Willson et al. 1986) (Table A-1, Figs. 1-3). This distribution coincides closely with the distribution of the coastal temperate rain forest ecosystem on the west coast of North America (Fig. 1). Both Willson et al. (2006) and Moody (2008) have recently reviewed the coastwide spawning distribution of eulachon in North America.

Monaco et al. (1990) and Emmett et al. (1991) summarized distribution and abundance of fishes in U.S. West Coast estuaries (see Table A-2) and based on the references cited therein described adult eulachon as "common" in Grays Harbor and Willapa Bay on the Washington coast, "abundant" in the Columbia River, "common" in Oregon's Umpqua River, and "abundant" in the Klamath River in northern California. In addition, a number of estuaries where eulachon were thought to occur in "rare" relative abundance included Puget Sound and Skagit Bay in Washington; Siuslaw River, Coos Bay, and Rogue River in Oregon; and Humboldt Bay in California (Monaco et al. 1990, Emmett et al. 1991). Hay and McCarter (2000) and Hay (2002) identified 33 eulachon spawning rivers in British Columbia, 24 of these classified as supporting regular yearly spawning runs (Table A-1). Willson et al. (2006) and Moody (2008) list numerous rivers that support eulachon runs in Southeast and South central Alaska and on the Alaska coastline in the southeastern Bering Sea (Table A-1).

Approaches to Addressing Discreteness and Significance

The BRT considered several kinds of information to delineate potential DPS structure in eulachon. To address the discreteness criteria, the BRT primarily considered patterns of genetic variation among eulachon sampled from various locations along the coast, patterns of variation in life-history and morphology, and ecological and environmental differences between eulachon populations. Comparison of spawning distribution, spawn timing, meristic variation in vertebral counts, elemental analysis of otoliths, and genetic variation have also been cited as evidence for stock discrimination in eulachon (Hay and McCarter 2000, Beacham et al. 2005, Hay and Beacham 2005). For the "significance" criteria, the BRT focused primarily on ecological differences among populations, and on whether loss of such populations would create a significant gap in the range of the species.

Life History and Morphology

Isolation between populations may be reflected in several variables, including differences in life history variables (e.g., spawning timing, seasonal migrations), spawning location, parasite incidence, growth rates, morphological variability (e.g., morphometric and meristic traits), and demography (e.g., fecundity, age structure, length and age at maturity, mortality rates), among others. Although some of these traits may have a genetic basis, they are usually also strongly influenced by environmental factors over the life time of an individual or over a few generations. Differences can arise among populations in response to environmental variability among areas and can sometimes be used to infer the degree of independence among populations or subpopulations. Begg et al. (1999) have emphasized the necessity to examine the temporal stability of life history characteristics in order to determine whether differences between populations persist across generations.

Persistence of Spawn Location and Spawn Timing

Eulachon generally spawn in rivers that are glacier-fed and/or have peak spring freshets, and it has been argued that the rapid movement of eggs and larvae by these freshets to estuaries makes it likely that eulachon imprint and home to an estuary into which several rivers drain rather than to individual spawning rivers (Hay and McCarter 2000). Thus the estuary has been invoked as the likely geographic stock unit for eulachon (Hay and McCarter 2000, Hay 2002, Hay and Beacham 2005) (Table A-1).

Variation in spawn timing among rivers has been cited as indicative of local adaptation in eulachon (Hay and McCarter 2000), although the wide overlap in spawn timing and river-entry timing among rivers makes it difficult to discern distinctive geographic patterns in this trait (Table A-3, Figs. 4-5). In general, eulachon spawn earlier in southern portions of their range than in rivers to the north. River-entry and spawning begins as early as December and January in the Columbia River system (Table A-3, Figs. 4-5) and as late as June in central Alaska (Table A-3, Fig. 4). However, they have been known to spawn as early as January in rivers on the Copper River Delta of Alaska and as late as May in Northern California. The general spawn timing pattern is reversed along the coast of British Columbia where the earliest spawning occurs in the Nass River in the far north in February to early March and the latest spawning occurs in the Fraser River in April and May in the far south (Table A-3, Figs. 3-4). There is also some evidence that different waves or runs of eulachon may occur in some basins, based on run-time separation (Table A-3).

These differences in spawn timing result in some populations spawning when water temperatures are as low as 0 – 2˚C, and sometimes under ice (Nass River; Langer et al. 1977), whereas other populations experience spawning temperatures of from 4 – 7˚C (Cowlitz River; Smith and Saalfeld 1955) (see Table A-4).

Morphology

Differences in the mean number of vertebrae in eulachon from northern and southern rivers in British Columbia have been cited as indicative of population separation (Hart and McHugh 1944, Hay and McCarter 2000), although no differences were evident in population means between the Fraser and Columbia rivers (Hay and McCarter 2000) (see Fig. 6). However, meristic differences such as these can vary with environmental conditions and it is impossible to determine the underlying causes of these differences from the available data. In addition, morphometric and meristic differences between groups of fish are often subtle and it can be difficult to relate such differences to a specific degree of isolation among populations.

Coastwide, there appears to be an increase in both mean length and weight of eulachon at maturity with an increase in latitude (Tables A-5, A-6, Fig. 7). Mean eulachon fork length and weight at maturity range from upwards of 215 mm and 70 g in the Twentymile River in Alaska to 175 mm and 37 g in the Columbia River. Although eulachon obtain a larger body size in the northern portion of their range compared to populations in the south this relationship may be somewhat obscured by problems associated with the ageing of this species (Hay and McCarter 2000). Most Pacific herring also exhibit a latitudinal cline in mean size-at-age, such that Pacific herring in southern locations (e.g., California) exhibit small size and Pacific herring in the north (e.g., Bering Sea) obtain a far larger size at a similar age (Stout et al. 2001a, Gustafson et al. 2006). This pattern is typical of many vertebrate ectotherms where higher rearing temperatures result in reduced size at a given stage of development (Lindsey 1966, Atkinson 1994).

Otolith Chemistry

Hay and McCarter (2000) and Hay and Beacham (2005) reported upon attempts to use differences in the elemental make-up of eulachon otoliths (ear bones) to detect stock structure among various rivers on the coast of British Columbia. Significant variation occurred in the elemental analysis associated with the date of the laboratory elemental analysis. Despite these sources of potential error, the results indicated that there were differences in the elemental composition of eulachon otoliths over a broad geographic range, but that "elemental analysis was not useful to distinguish between closely adjacent stocks" (Hay and Beacham 2005, p. 10).

Age Composition

Age determination of eulachon is has been difficult to validate and estimates of age based on otolith increments may not be accurate (Ricker et al. 1954, Hay and McCarter 2000). However, in general, studies using otolith aging techniques have concluded that some eulachon spawn at age-2 or age-5, but most are age-2 or age-3 at spawning (Willson et al. 2006). Recently, Clarke et al. (2007) pioneered a method to estimate eulachon age at spawning from analysis of variations in Ba and Ca in the otoliths. This study indicated that age structure of spawners in the southern areas may be limited to one or at most two year classes (Clarke et al. 2007). According to Clarke et al. (2007):

The number of Ba:Ca peaks measured in the eulachon populations varied; eulachon captured in Barkley Sound, located off the west coast of Vancouver Island (ocean), had 1.5 and 2.5 peaks, Fraser River eulachon were all characterized by three peaks and Columbia River eulachon exhibited two or three peaks. All of the fish in the Kemano and Skeena Rivers examined were characterized by three peaks in Ba:Ca with the exception of two Skeena River fish that had four peaks. Fish collected from the Copper River in Alaska had three or four peaks. The number of peaks in Ba:Ca observed in eulachon otoliths increased with increasing latitude, suggesting that the age at maturity is older for northern populations.

Genetic Differentiation

The analysis of the geographical distribution of genetic variation is a powerful method of identifying discrete populations. In addition, such analysis can sometimes be used to estimate historical dispersals, equilibrium levels of migration (gene flow), and past isolation. Commonly used molecular genetic markers include protein variants (allozymes), microsatellite loci (variable numbers of short tandem DNA repeats), and mitochondrial DNA (mtDNA).

One widely used method of population analysis is sequence or RFLP (restriction fragment length polymorphism) analysis of mtDNA, which codes for several genes that are not found in the cell nucleus. Mitochondrial DNA differs from nuclear DNA (nDNA) in two ways. One way is that recombination is lacking in mtDNA, so that gene combinations (haplotypes) are passed unaltered from one generation to the next, except for new mutations. A second way is that mtDNA is inherited from only the maternal parent in most fishes, so that gene phylogenies correspond to female lineages. These characteristics permit phylogeographical analyses of mtDNA haplotypes, which can potentially indicate dispersal pathways for females and the extent of gene flow between populations (Avise et al. 1987). Although the lack of recombination allows for some types of analysis that are difficult to conduct with other markers (e.g., microsatellites), inferences of population structure (or lack thereof) from mtDNA are limited by the fact that the entire mitochondrial genome is inherited genetically as a single locus. Mitochondrial studies are therefore most useful for detecting deep patterns of population structure, and may not be very powerful for detecting structure among closely related populations.

Microsatellite DNA markers can potentially detect stock structure on finer spatial and temporal scales than can other DNA or protein markers, because of higher levels of polymorphism found in microsatellite DNA (reflecting a high mutation rate). Relatively high levels of variation can increase the statistical power to detect stock structure, particularly among closely related populations. In addition, microsatellite studies usually involve analysis of multiple genetic loci, which increases the power to detect differentiation among populations.

The BRT reviewed four published genetic studies of genetic population structure in eulachon. One of these studies (McLean et al. 1999) used RFLP (restriction fragment length polymorphism) analysis to examine variation in mitochondrial DNA (mtDNA). The other studies (McLean and Taylor 2001, Kaukinen et al. 2004, Beacham et al. 2005) analyzed microsatellite loci.

McLean et al. (1999) examined mtDNA variation in two fragments (each containing two genes NADH-5/NADH-6 and 12S/16S rRNA) in 285 eulachon samples collected at 11 freshwater sites ranging from the Columbia River to Cook Inlet, Alaska and also in 29 ocean-caught fish captured in the Bering Sea. Samples were taken at two sites (Columbia and Cowlitz rivers) in two years and all other locations were sampled in single years. Overall, 37 mtDNA composite haplotypes were observed in the study. Two haplotypes were found in all sampling locations and together accounted for approximately 67% of the samples in the study. Eight additional haplotypes were present at multiple sites and the remaining 27 haplotypes were 'private' (found only in one location). An analysis of the nucleotide substitutions separating the 37 haplotypes revealed that the haplotypes were all closely related, with the number of substitutions ranging between one and thirteen. The mtDNA haplotypes clustered into two major groups and the frequencies of the two haplotype groups differed among sampling sites, particularly in the Alaskan and Bering Sea collections compared to samples from further south, although these differences were not statistically significant. Approximately 97% of mtDNA variation occurs within populations and about 2% is found among regions ($F_{ST} = 0.023$). McLean et al. (1999) also found that genetic distance among sampling locations was correlated with geographic distance ($r^2 = 0.22$, $P = 0.0001$). Based on these results, McLean et al. (1999) concluded that there was little genetic differentiation among distinct freshwater locations throughout the eulachon range. However, McLean et al. (1999) noted that association of geographic distance and genetic differentiation among eulachon populations suggested an emerging population subdivision throughout the range of the species.

In a later study, McLean and Taylor (2001) used five microsatellite loci to examine variation in the same set of populations as McLean et al. (1999). The populations in the Columbia and Cowlitz rivers were represented by two years of samples with a total sample size of 60 fish from each river. However, several populations were represented by very few samples including just five fish from the three rivers in Gardner Canal and just 10 fish from the Fraser River. Results from a hierarchical analysis of molecular variance test were similar to that of the McLean et al. (1999) mtDNA study, with 0.85% of variation occurring among large regions and 3.75% among populations within regions. Tests of differentiation were significant among several pairs of populations in the microsatellite study (27% of tests after correction for multiple comparisons), particularly comparisons that included populations in the Columbia and Cowlitz rivers and those with the Nass River sample and samples taken further south. F_{ST} (a commonly used metric to evaluate population subdivision) was estimated as 0.047 when sample sites were considered separately, and was significantly different from zero. In contrast to the mtDNA analysis, genetic distances among populations using these five microsatellite loci were not correlated with geographic distances. Overall, however, McLean and Taylor (2001) concluded that their microsatellite results were mostly consistent with the mtDNA findings of McLean et al. (1999) and that both studies indicated that eulachon have some degree of population structure.

The most extensive study of eulachon, in terms of sample size and number of loci examined, is that of Beacham et al. (2005). Beacham et al. (2005) examined microsatellite DNA variation in eulachon collected at 9 sites ranging from the Columbia River to Cook Inlet, Alaska using the 14 loci developed by Kaukinen et al. (2004). Sample sizes per site ranged from 74 fish in the Columbia River to 421 from the Fraser River. Samples collected in multiple years were analyzed from populations in the Bella Coola and Kemano rivers (two years of sampling) and also in the Nass River (three years of sampling). Beacham et al. (2005) observed much greater microsatellite diversity within populations than that reported by McLean and Taylor (2001) and all loci were highly polymorphic in all of the sampled populations. Significant genetic differentiation was observed among all comparisons of the nine populations in the study and F_{ST} values for pairs of populations ranged from 0.0014 to 0.0130. A cluster analysis of genetic distances showed genetic affinities among the populations in the Fraser, Columbia, and Cowlitz rivers and also among the Kemano, Klinaklini, and Bella Coola rivers along the central B.C. coast. In particular, there was evidence of a genetic discontinuity north of the Fraser River, with Fraser and Columbia/Cowlitz samples being ~3-6X more divergent from samples further to the north they were to each other (Fig. 8). Similar to the mtDNA study of McLean et al. (1999), Beacham et al. (2005) also found that genetic differentiation among populations (F_{ST}) was correlated with geographic distances ($r = 0.34$, $P < 0.05$).

Beacham et al. (2005) found stronger evidence of population structure than the earlier genetic studies, and concluded that their results indicated that management of eulachon would be appropriately based at the level of the river drainage. In particular, the microsatellite analysis showed that populations of eulachon in different rivers are genetically differentiated from each other at statistically significant levels. The authors suggested that the pattern of eulachon differentiation was similar to that typically found in studies of marine fish but less than that observed in most salmon species.

Although Beacham et al. (2005) found clear evidence of genetic structure among eulachon populations, the authors also noted that important questions remained unresolved. The most important one in terms in identifying DPS for eulachon is the relationship between temporal and geographic patterns of genetic variation. In particular, Beacham et al. (2005) found that year-to-year genetic variation within three British Columbia coastal river systems was similar to the level of variation among the rivers, which suggests that patterns among rivers may not be temporally stable. However, in the comparisons involving the Columbia River samples, the variation between the Columbia samples and one north-of-Fraser sample from the same year was ~5X greater than a comparison within the Columbia from two different years. Taken together, there appears to be little doubt that there is some genetic structure within eulachon and that the most obvious genetic break appears to occur in southern BC north of the Fraser River. To fully characterize genetic relationships among eulachon populations additional research is needed to identify appropriate sampling and data collection strategies.

Ecological Features

The analysis of ecological features or habitat characteristics may be informative in identifying population segments that occupy unusual or distinctive habitats, relative to the biological species as a whole. One of the criteria that may be useful for evaluating discreteness as articulated in the joint DPS policy (USFWS-NMFS 1996) relates to the population being "markedly separated from other populations of the same taxon as a consequence of … ecological … factors." In addition, the persistence of a discrete population segment in an ecological setting unusual or unique for the taxon is also a factor identified in the joint DPS policy (USFWS-NMFS 1996) that may provide evidence of the population's significance. Oceanographic and other ecological features may also contribute to demographic isolation between marine populations.

Freshwater (Spawning) Environment

The presumed fidelity with which eulachon return to their natal river, estuary, inlet, or area implies a close association between a specific stock and its freshwater and/or estuarine environment. Differences in life-history strategies among eulachon populations or stocks may have arisen, in part, in response to selective pressures of different freshwater/estuarine environments. If the boundaries of distinct freshwater or estuarine habitats coincide with substantial differences in life histories it would suggest a certain degree of local adaptation. Therefore, identifying distinct freshwater, terrestrial, and climatic regions may be useful in identifying eulachon DPSs. The Environmental Protection Agency has established a system of ecoregion designations based on soil content, topography, climate, potential vegetation, and land use for the conterminous United States (Omernik 1987). Historically, the distribution of eulachon in Washington, Oregon, and California, corresponds closely with the Coastal Range Level III Ecoregions as defined in Omernik (1987). Similarly, Environment Canada (2008) has established a system of Ecozones and Ecoregions in Canada. Ecozones in Canada have been described as "areas of the earth's surface representative of large and very generalized ecological units characterized by interactive and adjusting abiotic and biotic factors." Each Ecozone consists of numerous Ecoregions which are described as "a part of a province characterized by distinctive regional ecological factors, including climatic, physiography, vegetation, soil, water, fauna, and land use" (Environment Canada 2008).

Ecoregions of the United States

Coastal Range Ecoregion **–** Extending from the Olympic Peninsula through the Coast Range proper and down to the Klamath Mountains and the San Francisco Bay area, this region is influenced by medium to high rainfall levels due to the interaction between marine weather systems and the mountainous nature of the region. Topographically, the region averages about 500 m in elevation, with mountain tops under 1200 m. These mountains are generally rugged with steep canyons. Between the ocean and the mountains lies a narrow coastal plain composed of sand, silt, and gravel. Tributary streams are short and have a steep gradient; therefore, surface runoff is rapid and water storage is relatively short term during periods of no recharge. These rivers are especially prone to low flows during times of drought. Regional rainfall averages 200-240 cm per year, with generally lower levels along the southern Oregon coast. Average annual river flows for most rivers in this region are among the highest found on the West Coast when adjusted for watershed area. Peak flow of coastal rivers occurs during winter rain storms common in December and January. Snow melt adds to the surface runoff in the spring, providing a second flow peak (spring freshet), and there are long periods when the river flows are maintained at a level of at least 50% of peak flow. During July or August there is usually little or no precipitation; this period may expand to two or three months every few years. River flows are correspondingly at their lowest and temperatures at their highest during August and September, with the exception of glacier fed systems. The region is heavily forested primarily with Sitka spruce (*Picea sitchensis*), western hemlock (*Tsuga heterophylla*), and western red cedar (*Thuja plicata*). Forest undergrowth is composed of numerous types of shrubs and herbaceous plants.

Terrestrial Ecozones and Ecoregions of Canada

All rivers that support regular runs of eulachon in British Columbia are within the Pacific Maritime Ecozone, which consists of 14 ecoregions (Fig. 9). The Lower Mainland, Pacific Ranges, and Coastal Gap ecoregions contain rivers supporting regular runs of eulachon as defined in Hay and McCarter (2000) and Hay (2002), and two rivers, the Nass and the Skeena, drain out of the Nass Basin Ecoregion (Environment Canada 2008).

Lower Mainland Ecoregion – (196 in Figure 9) – The Lower Mainland Ecoregion is dominated by the Fraser River and occupies the Fraser River valley from Chilliwack and the Cascade Range foothills downstream to the delta of the Fraser River and northward from there to incorporate the Sunshine Coast. Mean summer and winter air temperatures in this region are 15°C and 3.5°C, respectively. At sea level, less than 10% of winter precipitation falls as snow, although maximum precipitation occurs in the winter. Mean annual precipitation in the Fraser River Valley ranges from 200 cm in the Cascade foothills to 85 cm at the river's mouth. Douglas-fir *(Pseudotsuga menziesii*) dominates native forest stands with an understory typically containing dull Oregon grape (*Mahonia nervosa*), salal (*Gaultheria shallon*), and mosses. Disturbed sites are commonly dominated by stands of red alder (*Alnus rubra*). Drier natural sites consist of mixed stands of Pacific madrone (*Arbutus menziesii*), Douglas-fir, western hemlock, and occasionally, Pacific dogwood (*Cornus nuttallii*). Wetter areas contain mixtures of western red cedar, Douglas-fir, and western hemlock. Soils consist of unconsolidated clay-like and silty marine deposits, silty alluvium, glacial till, and glaciofluvial deposits. Eastern hills in the ecoregion up to 310 m in height are formed from bedrock outcrops of Mesozoic and Paleozoic age.

Pacific Ranges Ecoregion **–** (192 in Figure 9) **–** The Pacific Ranges Ecoregion extends from the southern extent of the steeply sloping irregular Coast Mountains at the US border to Bella Coola in the north. These mountains range from sea level to as high as 4000 m and are made up of granite and crystalline gneisses. Many rivers in this region originate in expansive ice-fields, and numerous glaciers extend into the lowlands. Many steep-sided transverse valleys bisect these mountains and terminate in inlets or fjords. Mean summer and winter air temperatures in this region are 13.5°C and -1°C, respectively. Mean annual precipitation in this ecoregion ranges from 340 cm at high elevations to 150 cm at sea level. This ecoregion consists of three main regions distinguished by altitude; an alpine zone above 1800 m, a subalpine zone between 900 and 1800 m, and a coastal forest zone below 900 m. The coastal forest zone is dominated by stands of western red cedar, western hemlock, and Pacific silver fir (*A. amabilis*); and by Douglas-fir and western hemlock in drier sites.

Coastal Gap Ecoregion **–** (191 in Figure 9) **–** The Coastal Gap Ecoregion extends from Dean Channel north to the border between British Columbia and Alaska and is bounded by the taller Pacific Ranges to the south and the Boundary Ranges to the north. The low-relief mountains in this ecoregion consist of the Kitimat Ranges, which rarely reach higher than 2400 m and are made up of granitic rocks and crystalline gneisses. Although many inlets and fjords bisect this mountainous coastline and terminate in steep-sided, transverse valleys, glaciers are less common and smaller than in areas to the south and north of this ecoregion. Mean summer and winter air temperatures in this region are 13°C and -0.5°C, respectively. This ecoregion has the highest mean annual precipitation in British Columbia, ranging from 200 cm on the coast to over 450 cm at high elevations. At sea level the forests are dominated by western red cedar, yellow cedar (*Chamaecyparis nootkatensis*), and western hemlock. Some Sitka spruce and shore pine (*Pinus contorta* var. *contorta*) are also present with red alder being common on disturbed sites. Low-lying bogs and stream fens are common types of wetlands. Forests in upland areas are dominated by western red cedar and western hemlock, whereas Pacific silver fir and western hemlock are found in areas with poorer drainage.

Nass Basin Ecoregion **–** (187 in Figure 9) **–** The Nass Basin Ecoregion lies between the interior and coastal portions of the Coast Mountains in west-central British Columbia and is an area of low-relief composed of folded Jurassic and Cretaceous sediments that is almost encircled by mountains. The Nass Basin is drained by the Nass and Skeena rivers to the ocean through large gaps in the Coast Mountains and consists of a gently rolling landscape generally below 750 m in altitude. Mean summer and winter air temperatures in this region are 11.5°C and -9.5°C, respectively. Mean annual precipitation ranges up to 250 cm at higher elevations to 150 cm in the lowlands. The moist montane zone is dominated by western red cedar and western hemlock, whereas forests in the subalpine zone contain subalpine fir (*Abies lasiocarpa*), lodgepole pine (*Pinus contorta* var. *latifolia*), and Engelmann spruce (*Picea engelmannii*).

Oceanic Environment

Ware and McFarlane (1989) built upon previous descriptions of oceanic domains in the northeast Pacific Ocean by Dodimead et al. (1963) and Thomson (1981) to identify three principal fish production domains: 1) a southern Coastal Upwelling Domain, 2) a northern Coastal Downwelling Domain, and 3) a Central Subarctic Domain (aka the Alaskan Gyre) (Fig. 10). The boundary between the Coastal Upwelling Domain and Coastal Downwelling Domain occurs where the eastward flowing Subarctic Current (aka the North Pacific Current) bifurcates to form the north-flowing Alaska Current and the south-flowing California Current in the vicinity of a Transitional Zone between the northern tip of Vancouver Island and the northern extent of the Queen Charlotte Islands (Fig. 10). Similarly, Longhurst (2006) identifies an Alaska Downwelling Coastal Province and a California Current Province within the Pacific Coastal Biome.

Longhurst's (2006) work provides a worldwide ecological geography of the sea that identifies 4 primary oceanic biomes and 51 biogeochemical provinces based mainly on differences in regional physical processes that act upon regional patterns of phytoplankton growth that are partially defined by "the interaction between light, nutrients, mixing and stability in the upper part of the water column." This scheme to partition the ocean into provinces differs from previous attempts by relying on oceanographic features that drive phytoplankton ecology rather than on biogeography of species or water current patterns alone (Longhurst 2006). The steps taken and data analyzed to define biogeochemical provinces in the ocean are detailed in Longhurst (2006).

Within Longhurst's (2006) Pacific Coastal Biome, ocean distribution of eulachon spans the Alaska Downwelling Coastal Province and the northern portion of the California Current Province (Fig. 10). Longhurst (2006) places the boundary between the Alaska Coastal Downwelling Province and the California Current Province between the Queen Charlotte Islands at 53 N° and the northern end of Vancouver Island at 47-48° N latitude, where the eastward flowing North Pacific Current encounters the North American continent and bifurcates to form the north-flowing Alaska Current and south-flowing California Current. Different modes of physical forcing and nutrient enrichment characterize these provinces.

Alaska Coastal Downwelling Province **–** The Alaska Coastal Downwelling Province spans the coastal boundary region from the Aleutian Islands east and south to the Queen Charlotte Islands (Haida Gwai'i) at about 53° N latitude and extends seaward to the Alaska Current velocity maximum (Longhurst 2006). The continental shelf in this region is dominated by nearly year-round onshore downwelling winds. Large amounts of precipitation and runoff from melting glaciers along the mountainous Alaskan coast is another feature of this province. In summer and fall, when runoff is at a maximum, waters in the fjord-like coastline and in the Alaska Coastal Current are usually highly stratified in both temperature and salinity. Following the spring phytoplankton bloom, stratification in the top layers of the water column limits nutrient availability and leads to subsequent nutrient depletion. Occasional wind events lead to temporary local upwelling of nutrients and subsequent phytoplankton blooms.

California Current Province (aka California Upwelling Coastal Province) **–** The northern extent of the California Current Province begins where the eastward flowing North Pacific Current splits near Vancouver Island near 47- 48° N latitude, creating the southward flowing California Current and northward flowing Alaska Coastal Current (Longhurst 2006). The southern boundary of this province occurs off the southwest tip of Baja California, where the North Equatorial Current begins. Seasonal wind driven upwelling is a dominate feature of this province. This process carries nutrients onshore where they are upwelled along the coast, leading to high primary production that lasts through much of the spring and summer. Nearshore upwelling also results in higher salinities and lower temperatures compared to offshore locations.

Transitional Pacific **–** A widely recognized Transition Zone (Ware and McFarlane 1989, BC Ministry of Sustainable Resource Management 2002) occurs between the Alaska Coastal Downwelling and California Current provinces whose "northern boundary is indistinct and approximately coincident with the southern limit of the Alaskan Current" (BC Ministry of Sustainable Resource Management 2002, p. 35). This zone is characterized as a mixing area between boreal plankton communities to the north and temperate plankton communities to the south, and incorporates the waters of Queen Charlotte Sound and Hecate Strait (i.e., north of Vancouver Island and inshore of the Queen Charlotte Islands). In the summer, the California

Current may affect the southern portion of this Transition Zone with the inshore Davidson Current flowing south in the summer and north in the winter (BC Ministry of Sustainable Resource Management 2002).

Marine Zoogeographic Provinces

Marine zoogeography attempts to identify regional geographic patterns in marine species' distribution and delineate faunal provinces or regions based largely on the occurrence of endemic species and of unique species' assemblages (Ekman 1953, Hedgpeth 1957, Briggs 1974, Allen and Smith 1988). These province boundaries are usually coincident with changes in the physical environment such as temperature and major oceanographic currents. Similarly to the above ecological features category, boundaries between zoogeographic provinces may indicate changes in the physical environment that are shared with the species under review.

Ekman (1953), Hedgpeth (1957), and Briggs (1974) summarized the distribution patterns of coastal marine fishes and invertebrates and defined major worldwide marine zoogeographic zones or provinces. Along the coastline of the boreal eastern Pacific, which extends roughly from Point Conception, California to the eastern Bering Sea, numerous schemes have been proposed for grouping the faunas into zones or provinces. A number of authors (Ekman 1953, Hedgpeth 1957, Briggs 1974, Allen and Smith 1988) have recognized a zoogeographic zone within the lower boreal eastern Pacific that has been termed the Oregonian Province. Another zone in the upper boreal eastern Pacific has been termed the Aleutian Province (Briggs 1974). However, exact boundaries of zoogeographic provinces in the eastern boreal Pacific are in dispute (Allen and Smith 1988). Briggs (1974) and Allen and Smith (1988) reviewed previous literature from a variety of taxa and from fishes, respectively, and found the coastal region from Puget Sound to Sitka, Alaska to be a "gray zone" or transition zone that could be classified as part of either of two provinces: Aleutian or Oregonian (see Fig. 11). The southern boundary of the Oregonian Province is generally recognized as Point Conception, California and the northern boundary of the Aleutian Province is similarly recognized as Nunivak in the Bering Sea or perhaps the Aleutian Islands (Allen and Smith 1988).

Briggs (1974) placed the boundary between the Oregonian and Aleutian Provinces at Dixon Entrance, based on the well-studied distribution of mollusks, but indicated that distributions of fishes, echinoderms, and marine algae gave evidence for placement of this boundary in the vicinity of Sitka, Alaska. Briggs (1974) placed strong emphasis on the distribution of littoral mollusks (due to the more thorough treatment this group has received) in placing a major faunal break at Dixon Entrance. The authoritative work by Valentine (1966) on distribution of marine mollusks of the northeastern Pacific shelf showed that the Oregonian molluscan assemblage extended to Dixon Entrance with the Aleutian fauna extending northward from that area. Valentine (1966) erected the term Columbian Sub-province to define the zone from Puget Sound to Dixon Entrance.

Several lines of evidence suggest that an important zoogeographic break for marine fishes occurs in the vicinity of Southeast Alaska. Peden and Wilson (1976) investigated the distributions of inshore fishes in British Columbia, and found Dixon Entrance to be of minor importance as a barrier to fish distribution. A more likely boundary between these fish faunas was variously suggested to occur near Sitka, Alaska, off northern Vancouver Island, or off Cape Flattery, Washington (Peden and Wilson 1976, Allen and Smith 1988). Chen (1971) found that of the more than 50 or more rockfish species belonging to the genus *Sebastes* occurring in northern California, more than two-thirds do not extend north of British Columbia or Southeast Alaska. Briggs (1974, p. 278) stated that "about 50 percent of the entire shore fish fauna of western Canada does not extend north of the Alaskan Panhandle." In addition, many marine fish species common to the Bering Sea, extend southward into the Gulf of Alaska but apparently occur no further south (Briggs 1974). Allen and Smith (1988, p. 144) noted that "the relative abundance of some geographically-displacing [marine fish] species suggest that the boundary between these provinces [Aleutian and Oregonian] occurs off northern Vancouver Island."

Blaylock (et al. 1998) examined the distribution of over 25 species of parasites in 432 juvenile and adult Pacific halibut (*Hippoglossus stenolepis*) sampled over much of its North American range and found evidence of three zoogeographic zones as determined by parasite clustering; northern, central, and southern. Similar to studies with other invertebrates, Blaylock et al. (1998, p. 2269) found a breakpoint between zoogeographic zones “in the vicinity of the Queen Charlotte Islands.”

Other Marine Fish DPS Designations

It is also useful to briefly review the size and complexity of other designated DPSs of marine fish that have undergone the status review process and have thus been considered both discrete and significant to their respective biological species. DPSs have been designated for portions of the range of Pacific herring ((NMFS 2000, 2005, 2008), Pacific hake (*Merluccius productus*), Pacific cod (*Gadus macrocephalus*), walleye pollock (*Theragra chalcogramma*) (NMFS 2000), copper rockfish (*Sebastes caurinus*), quillback rockfish (*S. maliger*), brown rockfish (*S. auriculatus*) (NMFS 2001), bocaccio (*S. paucispinis*) (NMFS 2002), and smalltooth sawfish (*Pristis pectinata*) (NMFS 2003). Several marine fish DPSs cover large geographic areas (e.g., Pacific cod and walleye pollock DPSs extend from Puget Sound to Southeast Alaska, two West Coast DPSs of the bocaccio rockfish were designated off Washington and Oregon [the northern DPS] and off California and Mexico [the southern DPS], and all smalltooth sawfish in U.S. waters were designated a separate DPS). At slightly smaller geographic scales, a Southeast Alaska Pacific herring DPS (Carls et al. 2008) and DPSs of Pacific hake and Pacific herring in Georgia Basin (Puget Sound and the Straits of Georgia and Juan de Fuca) were established as separate from coastal hake and herring (Gustafson et al. 2000, Stout et al. 2001a) (see Fig. 12). Three DPSs each of copper and quillback rockfish (Puget Sound Proper DPS, Northern Puget Sound DPS, and coastal DPS) and two of brown rockfish (Puget Sound Proper DPS and coastal DPS) have also been delineated. Many of these marine fish DPSs include a number of identifiable subpopulations with numerous isolated spawning locations and a substantial level of life history and ecological diversity (Gustafson et al. 2000, 2006; Stout et al. 2001b, Carls et al. 2008).

Evaluation of Discreteness and Significance for Eulachon

In past evaluations of distinct population boundaries for marine fish (Gustafson et al. 2000, 2006; Stout et al. 2001a) spawn timing, spawning distribution, tagging, biogeography, ecological factors, seasonal migration patterns, parasite incidence, genetic population structure, morphometrics, meristics, and demographic data (growth rate, fecundity, etc.) have been evaluated for evidence of DPS discreteness and significance. The BRT examined similar evidence for eulachon and found evidence that was informative included genetic data, differences in spawning temperatures and length- and weight-at-maturity of eulachon between northern and southern rivers, ecological features of both the oceanic and terrestrial environments occupied by eulachon, and biogeography.

To allow for expressions of the level of uncertainty in identifying the boundaries of a discrete and significant eulachon population, the BRT adopted a "likelihood point" method, often referred to as the FEMAT method because it is a variation of a method used by scientific teams evaluating options under the Forest Plan (Forest Ecosystem Management: An Ecological, Economic, and Social Assessment Report of the Forest Ecosystem Management Assessment Team, or FEMAT) (FEMAT 1993). This method was previously used in the DPS decisions for Southern Resident killer whales (Krahn et al. 2004) and Pacific herring (Gustafson et al. 2006). In this approach, each BRT member distributes ten "likelihood" points among a number of proposed DPSs, reflecting their opinion of how likely that proposal correctly reflects the true DPS boundary. Thus if a member were certain that the DPS that contains eulachon from California, Oregon, and Washington included all spawning aggregations from the Fraser to the south, he or she could assign all 10 points to that proposal. A member with less certainty about DPS boundaries could split the points among two, three, or even more DPS proposals (Table 1).

The BRT ultimately considered six possible DPS configurations or scenarios that might conceivably incorporate eulachon that spawn in Washington, Oregon, and California rivers. Each BRT member distributed their 10 "likelihood points" amongst these six scenarios. Other possible geographic configurations that incorporated the petitioned unit were contemplated, but were not seriously considered by the BRT. Note that the BRT did not attempt to divide the entire species into DPSs, but rather focused on evaluating whether a DPS could be identified that contains eulachon that spawn in Washington, Oregon, and California. The geographic boundaries (see Figure 13) of possible DPSs considered in this evaluation were:

1) The entire biological species is the "ESA species" (i.e., there is no apparent DPS structure)
2) One DPS inclusive of eulachon in Southeast Alaska to Northern California
3) One DPS south of the Nass River / Dixon Entrance
4) One DPS inclusive of eulachon in the Fraser River to California
5) One DPS south of the Fraser River (i.e., one DPS in Washington, Oregon, and California)
6) Multiple DPSs of eulachon in Washington, Oregon, and California

The distribution of likelihood points among these six scenarios is presented in Table 1. Scenario 1 (no DPS structure) received about 12% of the total likelihood points. Scenarios 2 (one DPS inclusive of eulachon in Southeast Alaska to Northern California) and 5 (one DPS south of the Fraser River) received no support on the BRT. There was also very little support on the BRT for multiple DPSs of eulachon in the conterminous United States; only 4% of the likelihood points were placed in scenario 6 (multiple DPSs of eulachon in Washington, Oregon, and California).

All remaining likelihood points (84%) were distributed among scenarios supporting a DPS at a level larger than the petitioned unit of Washington, Oregon, and California. Scenario 3 (one DPS south of the Nass River / Dixon Entrance) received 57% of the total likelihood points and all but one BRT member placed between 5 and 10 points in this DPS scenario. Scenario 4 (one DPS inclusive of eulachon in the Fraser River to California) received significant support with 27% of all points placed in this scenario and all but two members placed from 2 to 5 of their likelihood points in this DPS scenario.

In discussing the evidence for these alternative scenarios, the BRT focused on the following factors:

In considering the "discreteness" and "significance" criteria (USFWS-NMFS 1996), the BRT concluded that the weight of the available evidence indicated that there are multiple discrete populations of eulachon. In particular, the most comprehensive genetic study of eulachon that has been published to date (Beacham et al. 2005) found reasonably strong evidence of a genetic break between eulachon spawning in the Fraser and Columbia rivers compared to those spawning in rivers further north in British Columbia and Alaska, and also found that nearly all sampled populations were differentiated statistically from each other. Earlier genetic studies (McLean et al. 1999; McLean and Taylor 2001) also found some evidence of population structure, although the evidence was less compelling than that reported by Beacham et al. (2005). However, these earlier studies were characterized by fewer loci and smaller sample sizes than the later study and therefore likely had less power to detect population structure. Overall, the BRT believed the results to be largely consistent among the studies, when differences in sample size and power are taken into account. The BRT did note, however, that there was some uncertainty about the genetic population structure due to the small number of temporally replicated samples in all of the studies, and this uncertainty is reflected in the proportion of the likelihood points that were placed in the "no DPS structure" category (Table 1).

In addition to the genetic data, the BRT considered the strong ecological and environmental break that occurs between the California Current and Alaska Current oceanic domains as contributing evidence for discreteness, a factor that was also important for identifying DPS structure in Pacific cod (Gustafson et al. 2000), killer whales (Krahn et al. 2004), and Southeast Alaska Pacific herring (Carls et al. 2008). The BRT also considered, but did not weigh heavily, the latitudinal differences in spawn timing, body size, and vertebral counts among samples from different rivers. Similar latitudinal patterns in life history characters were considered but did not weigh heavily in DPS decisions for Pacific cod, walleye pollock (Gustafson et al. 2000), and Pacific herring (Stout et al. 2001a). Overall, the BRT believed the genetic and ecological data provided strong evidence that eulachon south of the Nass River were discrete from those in the Nass River and northward, but that there was also evidence (from the genetic data) suggesting that Fraser and Columbia River groups may be discrete from more northern groups.

In evaluating the “significance” criteria, the BRT focused primarily on criteria 1 (ecological setting), 2 (evidence that loss would result in a significant gap in the range of the species), and 4 (markedly differs in genetic characteristics). After carefully discussing all of the available data, the BRT concluded that there was evidence supporting the “significance” criteria under either scenario (3) (One DPS south of the Nass River / Dixon Entrance) or scenario (4) (One DPS inclusive of eulachon in the Fraser River to California). In particular, there is evidence under either scenario for a significant break in ecological setting, and loss of a putative DPS defined by either boundary would without question result in a significant gap (or reduction) in the range of the overall species. The BRT also considered whether the available genetic data provided any evidence for “markedly different” populations, but concluded that although the genetic data provides evidence for discreteness (lack of gene flow) there was little evidence to support the existence of deep intraspecific phylogenetic breaks that the BRT believed were necessary to be considered “marked.”

In summary, the BRT believed the evidence most strongly supported scenario 3, but that there was also some evidence for scenarios 4 and 1. The factors supporting each of the top three scenarios are summarized below:

Scenario 3: One DPS south of the Nass River / Dixon Entrance (57% support)

Factors supporting this DPS designation:

1) Beacham et al. (2005) found strong evidence that populations of eulachon in different rivers are genetically differentiated from each other at statistically significant levels and the authors suggested that the pattern of eulachon differentiation was similar to that typically found in studies of marine fish but less than that observed in most Pacific salmon species.

2) A major ecological break occurs in the coastal ocean biome between the Coastal Downwelling Province (Ware and McFarlane 1989, Longhurst 2006) to the north and the California Current Province (Ware and McFarlane 1989, Longhurst 2006) to the south. The northern boundary of the Transition Zone that separates these provinces occurs in the vicinity of the Dixon Entrance at the northern end of the Queen Charlotte Islands. The coastal distribution of eulachon south of the Dixon Entrance occupies an ecologically discrete area that is a combination of this Transition Zone and the northern California Current Province (Longhurst 2006).

3) Dixon Entrance is also the approximate northern boundary that separates two major marine zoogeographic provinces (Oregonian and Aleutian Provinces)

(Briggs 1974), further supporting the ecological discreteness of marine waters south of Dixon Entrance.

4) Stocks of eulachon from the Columbia River to the Klinaklini River in British Columbia experienced a nearly simultaneous collapse in 1994 (Hay and McCarter 2000, Hay 2002), stayed at low levels throughout the 1990s, experienced a rebound in 2001-2003, and subsequently declined to near record low levels of abundance (Hay 2002, JCRMS 2007). The nearly synchronous demographic responses, to what are likely coastwide changes in ocean condition, of all eulachon stocks south of the Nass River strongly suggests that these stocks occupy a common ocean rearing environment. Stocks of eulachon from the Nass River and north remained relatively healthy throughout this period of decline of more southern stocks. Not until 2003 did eulachon stocks in southern Southeast Alaska begin to show serious declines. These demographic patterns are similar to those seen in Pacific salmon stock abundance that fluctuates in opposite directions in the Alaska and California Current domains (Hare et al. 1999), which has been correlated with the Pacific Decadal Oscillation (PDO) (Mantua and Hare 2002).

5) A major break in terrestrial ecoregions also occurs along the North Coast of British Columbia in the vicinity of the Nass River, with both the Nass and Skeena rivers draining the interior Nass Basin Ecoregion (Environment Canada 2008). Evidence of a natural biological boundary coinciding with the international boundary separating Southeast Alaska (SEAK) and British Columbia (Dixon Entrance / Nass River) also supported delineation of a southern boundary for the SEAK Pacific herring DPS. The SEAK herring BRT (Carls et al. 2008, p. 5.7) noted that:

- Different biological zones are apparent along the coast, probably a result of both thermal (north-south) and salinity (east-west) gradients
- A thermal gradient is clearly evident through British Columbia and SEAK.
  - Temperatures in SEAK are colder than in British Columbia
  - SEAK has tidewater glaciers, British Columbia does not, chilling the water and increasing turbidity and possibly nutrients.
  - SEAK mainland topography is heavily influenced by snowfields and glaciers; this is less prevalent in British Columbia

6) Eulachon spawning in rivers on the North Coast of British Columbia (e.g., Nass River) experience significantly colder temperatures at spawning (often spawning under ice) than eulachon spawning to the south, particularly in the Klinaklini, Fraser, and Columbia rivers (Hay and McCarter 2000) (see Table A-4). Hochachka and Somero (2002, pp. 292, 317) emphasized that habitat temperature plays a “strong and frequently dominant role … in governing the distribution patterns of organisms” and that “temperature differences of a few degrees Celsius have sufficient effects on proteins to favor adaptive change.” The dominant role that temperature plays on ectothermic organisms, affecting “essentially every aspect of an organism’s physiology” (Hochachka and Somero 2002, p. 290), suggests that these 2 – 4˚ C temperature differences experienced by adult eulachon and their gametes during spawning (Table A-4) are a strong indicator of potential

physiological differences between eulachon south of the Nass River and those in the Nass River and northward.

Items 2-5 support a discrete and significant eulachon population south of the Nass River / Dixon Entrance on the basis of being “markedly separated on the basis of ecological features” and Item 6 supports a discrete eulachon population south of the Nass River / Dixon Entrance on the basis of being “markedly separated on the basis of physiological features.”

Scenario 4: One DPS inclusive of eulachon in the Fraser River to California (27% support)

Factors supporting this designation:

1) The available genetic data indicate that a substantial genetic break occurs between eulachon populations from the Fraser River and those from rivers further to the north (see genetics discussion). In particular, the largest genetic discontinuity appears to be in Southern BC rather than Northern BC.

2) In contrast to systems to the north of the Fraser River; the Columbia, Fraser, and Klamath rivers have many physiographic and habitat features in common; all three are large rivers with wide valleys, draining extensive interior basins, are fed by spring snow melt, and do not drain off extensive ice sheets.

3) Average length- and weight-at-maturity in eulachon from the Columbia and Fraser rivers, and southern rivers in general are smaller than eulachon from more northern rivers (Fig. 7). However, this pattern is typical in many vertebrate poikilotherms (ectotherms) where higher temperatures lead to reduced size at a given stage of development (Atkinson 1994, Lindsey 1966), so the BRT did not weight this evidence very heavily.

Scenario 1: No DPS structure (12 % support).

Factors supporting this designation:

1) There was a lack of apparent discrete differences in many eulachon life history traits (Hay and McCarter 2000, Hay and Beacham 2005); however, similar uniformity in life history characters over large geographic distances was evident in previous marine fish reviews of Pacific cod, walleye pollock (Gustafson et al. 2000), and Pacific herring (Stout et al. 2001a).

2) Another reason BRT members put some support in this scenario was uncertainty about how strongly to weight the genetic study of Beacham et al. (2005). In particular, although the BRT concluded that the study as a whole clearly supported the existence of discrete genetic populations of eulachon, the BRT was also somewhat concerned about the limited temporal replication in the study.

Given the previous DPS structure established for marine fishes; such as Pacific herring, Pacific cod, Pacific hake, and walleye pollock (Gustafson et al. 2000, 2006; Stout et al. 2001a); it seems unlikely that there would be an absence of DPS structure across the over 2,800 km range of eulachon, an anadromous species with similar among-population genetic differentiation as these purely marine fishes. Pacific herring, which exhibit genetic variation similar to eulachon when compared over the same geographic range (Beacham et al. 2002, 2005; Small et al. 2005), have had DPSs delineated at the geographic level of the Georgia Basin (Stout et al. 2001a) and Southeast Alaska (Carls et al. 2008), based to a large degree on marked differences in ecological features of their habitats. For example, the estimated mean F_{ST} value for Pacific herring over 13 microsatellite DNA loci and 83 sampling sites ranging from California to Southeast Alaska was 0.0032 (Beacham et al. 2002), whereas a similar estimated mean F_{ST} value over 14 loci and 9 eulachon sampling sites ranging from the Columbia River to South Central Alaska was 0.0046 (Beacham et al. 2005). Although nowhere near the same quantity or quality of data exists for eulachon as for the economically more valuable Pacific herring, it is likely that if data comparable to that for Pacific herring were available, an even finer DPS structure for the anadromous eulachon might become apparent. In addition, the biological heterogeneity of eulachon as seen in "the geographical discontinuity of different spawning runs, different spawning times and the apparent homing of each run to individual rivers" (Hay and McCarter 2000, p. 36) strongly argues against the lack of DPS structure.

BRT DPS Determination

In conclusion, it was the majority opinion of the BRT that eulachon from Washington, Oregon, and California are part of a DPS that extends beyond the conterminous United States and that the northern boundary of the DPS occurs in northern British Columbia south of the Nass River (most likely) or in Southern British Columbia north of the Fraser River (less likely). The BRT proposes that this DPS be termed the Southern Eulachon DPS. Although it was not the BRT's objective to subdivide the entire biological species of eulachon into DPSs throughout their range, the identification of a southern eulachon DPS indicates that at least one, and possibly more than one, additional DPS(s) of eulachon occur north of the Skeena River on the North Coast of BC and in Alaska.

Although the BRT could not with any certainty identify multiple populations or DPSs of eulachon within the region south of Dixon Entrance / Nass River, they acknowledged the possibility that significant stock structuring does exist within this region and that a finer DPS structure might be revealed by further information on the behavior, ecology, and genetic population structure of eulachon. The BRT also recognized that the DPS that includes eulachon from California, Oregon, and Washington may represent fish that are uniquely adapted to survive at the southern end of the species' range.

THE “EXTINCTION RISK” QUESTION

The information considered in evaluating a DPS’s status can generally be grouped into two categories: (1) demographic information reflecting the past and present condition of sub-populations (e.g., data on population abundance or density, population trends and growth rates, the number and distribution of populations, exchange rates of individuals among populations, and the ecological, life-history, or genetic diversity among populations); and (2) information on past factors for decline as well as threats faced by the DPS (e.g., habitat loss and degradation, overutilization, disease, climate change). The demographic risk data reviewed by the BRT are summarized in this document. A narrative summary of threats faced by the DPS will be detailed in a comprehensive report that is being prepared and will be available in the future.

Evaluating extinction risk of a species includes considering the available information concerning the abundance, growth rate/productivity, spatial structure/connectivity, and diversity of a species and assessing whether these demographic criteria indicate that it is at high risk of extinction; at moderate risk; or neither. A species at very low levels of abundance and with few populations will be less tolerant to environmental variation, catastrophic events, genetic processes, demographic stochasticity, ecological interactions, and other processes (e.g., Gilpin and Soulé 1986, Meffe and Carroll 1994, Caughley and Gunn 1996). A rate of productivity that is unstable or declining over a long period of time may reflect a variety of causes, but indicates poor resiliency to future environmental variability or change (e.g., Lande 1993, Foley 1997, Middleton and Nisbet 1997). For species at low levels of abundance, in particular, declining or highly variable productivity confers a high level of extinction risk. A species that is not widely distributed across a variety of well-connected habitats will have a diminished capacity for recolonizing locally extirpated populations, and is at increased risk of extinction due to environmental perturbations and catastrophic events (Schlosser and Angermeier 1995, Hanski and Gilpin 1997, Tilman and Lehman 1997, Cooper and Mangel 1999). A species that has lost locally adapted genetic and life-history diversity may lack the characteristics necessary to endure short- and long-term environmental changes (e.g., Hilborn et al. 2003, Wood et al. 2008).

The demographic risk criteria described above are evaluated based on the present species status in the context of historical information, if available. However, there may be threats, or other relevant biological factors, that might alter the determination of the species’ overall level of extinction risk. These threats or other risk factors are not yet reflected in the available demographic data because of the time lags involved, but are nonetheless critical considerations in evaluating a species’ extinction risk (Wainwright and Kope 1999). Forecasting the effects of threats and other risk factors into the foreseeable future is rarely straightforward, and usually necessitates qualitative evaluations and the application of informed professional judgment. This evaluation highlights those factors that may exacerbate or ameliorate demographic risks so that all relevant information may be integrated into the determination of overall extinction risk for the species. Examples of such threats or other relevant factors may include: climatic regime shifts that portend favorable temperature and marine productivity conditions; an El Niño event that is anticipated to result in reduced food quantity or quality; or recent or anticipated increases in the range and/or abundance of predator populations.

In considering the status of eulachon, we evaluated both qualitative and quantitative information. Qualitative evaluations included aspects of several of the risk considerations outlined above, as well as recent, published assessments by agencies of the status of eulachon populations, reviewed below. Additional information presented by the petitioners was considered, as discussed under "Summary of Information Presented by the Petitioners" above.

Absolute Numbers

`The absolute number of individuals in a population is important in assessing two aspects of extinction risk. For small populations that are stable or increasing, population size can be an indicator of whether the population can sustain itself into the future in the face of environmental fluctuations and small-population stochasticity; this aspect is related to the concept of minimum viable populations (MVP) (Gilpin and Soulé 1986, Thompson 1991). For a declining population, the present abundance is an indicator of the expected time until the population reaches critically low numbers; this aspect is related to the concept of "driven extinction" (Caughley 1994). In addition to total numbers, the spatial and temporal distribution of adults is important in assessing risk to a species or DPS.

Several aspects of eulachon biology indicate that large aggregations of adult eulachon are necessary for maintenance of normal reproductive output. Eulachon are a short-lived, high-fecundity, high-mortality forage fish, and such species typically have extremely large population sizes. Research from other marine fishes (Sadovy 2001) suggests that there is likely a biological requirement for a critical threshold density of eulachon during spawning to ensure adequate synchronization of spawning, mate choice, gonadal sterol levels, and fertilization success. Since eulachon sperm may remain viable for only a short time, perhaps only minutes, sexes must synchronize spawning activities closely, unlike other fish such as Pacific herring (Hay and McCarter 2000, Willson et al. 2006). In most samples of spawning eulachon, males greatly outnumber females (although many factors may contribute to these observations) (Willson et al. 2006), and in some instances congregations of males have been observed simultaneously spawning upstream of females that laid eggs as milt drifted downstream (Langer et al. 1977). Sadovy (2001, p. 100) noted that "the idea that, if a population drops below some critical density the intrinsic rate of population increase may not be realized because breeding activity may cease, cannot be readily dismissed and a number of possible Allee effects have been noted" in marine fishes. Sadovy (2001, p. 101) further noted that "aggregating behaviour presumably reflects some biological imperative for sociality during the reproductive season."

In addition, the genetically effective population size of eulachon may be much lower than the census size. Although eulachon exhibit high fecundity (7,000-60,000 eggs; mean ~30,000), survival from egg to larva may vary widely (3-5% in the Kemano River to ~1% in the Wahoo River [Willson et al. 2006]) and may be less than 1% in large egg masses. Larvae are small (4-8 mm long), are rapidly carried by currents to the sea, and rear in the pelagic zone similarly to many marine pelagic fish larvae where the extent of mortality during the transition phase from larva to juvenile is high. In marine species, under conditions of high fecundity and high mortality associated with pelagic larval development local environmental conditions may lead to random "sweepstake recruitment" events where only a small minority of spawning individuals contribute to subsequent generations (Hedgecock 1994). Hauser and Carvalho (2008) report that "data available so far suggest that the scope for sweepstake recruitment may be higher in larger populations, as the N_e/N [ratio of effective size to census size] is lower in larger populations."

Large spawning aggregations of adult eulachon may also be necessary to withstand predation pressure associated with large congregations of predators that target returning adults, and to produce enough eggs and pelagic larvae to swamp out predation in the ocean (Bailey and Houde 1989). Multiple species of predators (sea lions, harbor seals, gulls, bald eagles, ducks, sturgeon, porpoise, killer whale, etc.) commonly congregate at eulachon spawning runs and "local observers often judge arrival of fish by the conspicuous arrival of many predators" (Willson et al. 2006).

Historical Abundance and Carrying Capacity

Knowing the relationship of present abundance to present carrying capacity is important for evaluating the health of populations; but the fact that a population is near its current capacity does not necessarily signify full health. A population near capacity implies that short-term management may not be able to increase fish abundance.

The relationship of current abundance and habitat capacity to historical levels is an important consideration in evaluating risk. Knowledge of historical population conditions provides a perspective for understanding the conditions under which present populations evolved. Historical abundance also provides the basis for scaling long-term trends in populations. Comparison of present and past habitat capacity can also indicate long-term population trends and problems of population fragmentation. For eulachon, current and historical abundance data and information was available in the form of spawner biomass (pounds or metric tons) and/or total spawner counts (numbers of adult fish), offshore juvenile eulachon biomass estimates (metric tons), mean eulachon larval density, catch-per-unit-effort (CPUE), commercial/recreational/subsistence fisheries landings, ethnographic studies, and anecdotal qualitative information.

Trends in Abundance

Short- and long-term trends in abundance are a primary indicator of risk. Trends may be calculated from a variety of quantitative data, which are discussed in detail in specific sections below. Interpretation of trends in terms of population sustainability is difficult for a variety of reasons: First, eulachon are harvested in fisheries, and shifting harvest goals or market conditions directly affect trends in spawning abundance and catch. Second, environmental fluctuations on short timescales affect trend estimates, especially for shorter trends.

Recent Events

A variety of factors, both natural and human-induced, affect the degree of risk facing eulachon populations. Because of timelags in these effects and variability in populations, recent changes in any of these factors may affect current risk without any apparent change in available population statistics. Thus, consideration of these effects must go beyond examination of recent abundance and trends, but forecasting future effects is rarely straightforward and usually involves qualitative evaluations based on informed professional judgment. Events affecting populations may include natural changes in the environment or human-induced changes, either beneficial or detrimental. Possible future effects of recent or proposed conservation measures have not been taken into account in this analysis, but we have considered documented changes in the natural environment. A key question regarding the role of recent events is: Given our uncertainty regarding the future, how do we evaluate the risk that a population may not persist?

It is generally accepted that important shifts in ocean-atmosphere conditions occurred about 1977 and again in 1998 that affected North Pacific marine ecosystems. Several studies have described decadal-scale oscillations in North Pacific climatic and oceanic conditions (Mantua and Hare 2002). These changes have been associated with recruitment patterns of several groundfish species and Pacific herring (McFarlane et al. 2000). As discussed in this report, increases in eulachon in the Columbia, Fraser, and Klinaklini rivers in 2001-2002 may be largely a result of the more favorable ocean conditions for eulachon survival during the transition from larvae to juvenile when these broods entered the ocean in 1998-2000.

One indicator of the ocean-atmosphere variation for the North Pacific is the Pacific Decadal Oscillation (PDO) index; Figure 14 shows that since Fall 2007 (time period E on the graph), monthly PDO values have been negative, whereas PDO values were mostly positive in period D from 2002 to Fall of 2007 and during most of the previous two decades (time period B). One exception is time period C, which corresponds with 1998- 2000 when good ocean conditions for survival of larval eulachon led to the increased run strength noted in 2001-2002. PDO values were generally negative for a long period from the 1950s to the late 1980s (period A). Negative PDO values are associated with relatively cool ocean temperatures off the Pacific Northwest, and positive values are associated with warmer, less productive conditions (Mantua and Hare 2002).

At this time, we do not know whether recent shifts in climate/ocean conditions represent a long-term shift in conditions that will continue affecting stocks into the future or short-term environmental fluctuations that can be expected to be reversed in the near future. Although recent conditions appear to be within the range of historic conditions under which eulachon populations have evolved, the risks associated with poor climate conditions may be exacerbated by human influence on these populations (Lawson 1993).

None of the elements of risk outlined above are easy to evaluate, particularly in light of the great variety in quantity and quality of information available for various populations. Two major types of information were considered: previous assessments that provided integrated reviews of the status of eulachon in our region, and data regarding individual elements of population status, such as abundance, trend, and habitat conditions.

A major problem in evaluations of risk for eulachon is combining information on a variety of risk factors into a single overall assessment of risk facing a population. Conducting an overall assessment of extinction risk involves the consideration of a wide variety of qualitative and quantitative information concerning the threats and demographic risks affecting a species' persistence. Moreover, the type and spatial-temporal coverage of the information available often varies within and among populations. This presents a substantial challenge of integrating disparate types of information into an assessment of a species' overall level of extinction risk. Usually such assessments necessitate qualitative evaluations based on informed professional judgment. In this review, we have used a risk-matrix approach through which the BRT members applied their best scientific judgment to combine qualitative and quantitative evidence regarding multiple risks into an overall assessment.

Official Status in California, Oregon, and Washington

In California, eulachon are classified on the "Fish Species of Special Concern List" as a "Class 3. Watch List" species (see http://www.dfg.ca.gov/wildlife/species/ssc/fish.html [accessed April 2008]). This list was most recently updated in 1995. Class 3 watch list species are defined as

> …taxa occupying much of their native range, but were formerly more widespread or abundant within that range. … The populations of such species need to be assessed periodically (i.e., every five years) and included in long-term plans for protected waterways (e.g., ADMAs).

In Oregon, eulachon are not listed as a state threatened, endangered or candidate species nor are they on the state sensitive species list. However, eulachon are on the list of Strategy Species in Oregon's Nearshore Strategy (ODFW 2006, p. 26). These species are defined in the following manner:

> Strategy species are nearshore species that were identified by the Nearshore Team to be in greatest need of management attention. Identification as a strategy species does not necessarily mean the species is in trouble. Rather, those identified as a strategy species have some significant nearshore management/conservation issue connected to that species that is of interest to managers.

ODFW (2006, p. 28) further refers to eulachon under the category of "Notes on Conservation Needs" as:

> Forage fish. Vulnerable freshwater spawning and nursery grounds. Columbia River population has declined. Other Distinct Population Segments (DPS) may have experienced similar declines

In Washington, eulachon are classified by the Washington Department of Fish and Wildlife (see online at http://wdfw.wa.gov/wlm/diversty/soc/candidat.htm) as a State Candidate Species, which are defined as:

> … fish and wildlife species that the Department will review for possible listing as State Endangered, Threatened, or Sensitive. A species will be considered for

designation as a State Candidate if sufficient evidence suggests that its status may meet the listing criteria defined for State Endangered, Threatened, or Sensitive.

Status in Canada

Eulachon are considered a Group 1 high priority candidate species for review in British Columbia by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). According to the COSEWIC website (http://www.cosewic.gc.ca/eng/sct3/sct3_1_e.cfm), "Group 1 contains species of highest priority for assessment by COSEWIC, and includes species that are suspected to be at high risk of extirpation from Canada." A recent bid to conduct a COSEWIC review has been awarded in Canada and a final product is due in April 2009 (Doug Hay, DFO scientist emeritus, pers. comm. and information online at http://www.cosewic.gc.ca/eng/sct2/sct2_4_e.cfm).

Pickard and Marmorek (2007) reported out the results of a recent Fisheries and Oceans Canada workshop whose purpose was to determine research priorities and recovery strategies for eulachon in the wake of the "recent coast-wide decline." Pickard and Marmorek (2007, p. 1) stated that:

> Recent information indicates that eulachon are declining in many parts of the west coast of North America, though the reasons for this decline and possible remedies are not well understood. In 1994 the Columbia, Fraser and Klinaklini Rivers suffered sudden drastic declines (Hay 1996). Since then First Nations have reported that fish are absent or at very low levels in many other British Columbia (BC) eulachon spawning rivers including: the Kemano, Kitimat, Wannock, Bella Coola, Nass, Skeena, Chilcoot, Unuk, Kitlope and Stikine (Moody 2007, Hay 2007).

According to Schweigert et al. (2007, p. 13):

> In recent years, particularly since 1994, eulachon abundance has declined synchronously in many rivers and virtually disappeared in California. This decrease has been noticeable in the PNCIMA [Pacific North Coast Integrated Management Area] region, with very poor runs in Douglas Channel, Gardner Canal, Dean/Burke channels, and Rivers Inlet areas in the past five years. It is suspected that these declines may be related to large-scale climate change. Recent studies suggest rivers that normally experience spring freshet events may gradually be changing to summer and fall freshets that may impair eulachon spawning runs.

Other Status Assessments

Musick et al. (2000, p. 11) assessed the status of eulachon following the American Fisheries Society (AFS) criteria to define extinction risk in marine fishes (Musick 1999), and classified eulachon in the Columbia River as threatened based on "… commercial landings [that] have declined from average of 2.1 million lbs. annually from 1938-1989 to 5,000 lbs. in 1999, a decline > 0.99." In addition, Musick et al. (2000, p. 11) stated that "Other DPSs from BC to n. CA may have declines similar to that observed in Columbia R."

Hay and McCarter (2000) conducted a review of the status of eulachon for the Canadian Stock Assessment Secretariat of Fisheries and Oceans Canada and concluded at that time that "the widespread decline in the southern part of the range warrants a COSEWIC classification of 'threatened' in Canadian waters." This conclusion was based on

> Available evidence suggests that several rivers in the central coast of BC may be extirpated, while others have declined severely. Only the Nass maintains normal or near-normal runs, although the Fraser, while markedly lower in recent decades and especially since 1994, still has regular, but diminished runs. The Columbia River, with the world's largest eulachon run, declined sharply in 1993, and has remained low since. Apparently all runs in California have declined and several runs that once were large have not been seen in more than 20 years.

General Demographic Indicators

Within the range of the DPS, the BRT examined abundance related information in the published literature; data provided by the Department of Fisheries and Oceans Canada (DFO),Washington Department of Fish and Wildlife (WDFW), and Oregon Department of Fish and Wildlife (ODFW); analyses of available abundance data both past and present summarized in Moody (2008); and information and presentations provided by eulachon experts from DFO, WDFW, ODFW, the Cowlitz Indian Tribe, and the Yurok Indian Tribe assembled during a scientific technical meeting at the NWFSC in June 2008. Information on eulachon abundance fell into the general categories of 1) fisheries-independent scientific surveys of adults, offshore juveniles, and outmigrant larvae, 2) commercial fisheries-dependant landings; 3) recreational fisheries-dependant landings; 4) First Nations subsistence fisheries landings; 5) ethnographic studies, 6) anecdotal qualitative information; and 7) traditional ecological knowledge.

In addition, the BRT reviewed the results of a fuzzy logic expert system developed by Moody (2008) to estimate a past and present relative abundance status index for eulachon in several areas of the southern eulachon DPS. Moody's (2008) expert system uses "catch data to determine the exploitation status of a fishery" and combines this with other data sources such as spawning stock biomass estimates, catch-per-unit-effort data, test fishery catches, larval survey data, or anecdotal comments on run size to estimate the relative abundance status index. This index was produced "using designed heuristic rules and by adjusting weighting parameters" (Moody 2008).

Although humans have exploited eulachon populations for centuries, the perceived abundance of the resource and its low commercial value has resulted in limited regulation of past commercial and recreational fisheries, limited recording of past catches, and, until recently, a lack of assessment surveys of spawning abundance. The BRT recognized that the lack of direct estimates of eulachon abundance based on fishery-independent surveys (spawning stock biomass estimates or escapement counts) prior to 1993 makes it very difficult to quantify trends in eulachon abundance. Since the mid-1990s, monitoring of this resource has improved and a handful of data sets are now available that track eulachon spawning stock abundance, offshore juvenile abundance, or provide an indication of run strength in several sub-areas of the DPS.

Data Availability

Fisheries-independent scientific surveys

There are few direct estimates of spawning biomass of eulachon from rivers within the DPS, although all of these data sets began to be collected after the perceived decline in run sizes occurred in the early 1990s. Spawner biomass (pounds or metric tons) and/or total spawner counts (numbers of adult fish) are available for the Fraser River (1996-2008), Klinaklini River (1995), Kingcome River (1997), Wannock/Kilbella rivers (2005-2006), Bella-Coola River (2001-2004), Kitimat River (1993-1996, 1998-2005), and Skeena River (1997). Even though the results of most of these studies are only available in "gray literature" reports, they were regarded by the BRT as constituting the best scientific and commercial data available for recent eulachon abundance in the DPS and were heavily weighted in the BRT's risk analysis. The BRT was cognizant of the fact that abundance estimates always contain observational error. These factors were taken into account when evaluating the data sets.

Offshore juvenile eulachon biomass estimates were available for Queen Charlotte Sound (1998-2008) and West Coast Vancouver Island (1973, 1975-1983, 1985, 1987-2008). These data were collected by Department of Fisheries and Oceans Canada as part of offshore shrimp biomass assessments.

Mean eulachon larval density data were available in the mainstem Columbia River (1996-2008), Cowlitz River (1986, 1994-2004, 2006-2008), Grays River (1998-2001, 2004-2006, 2008), Elochomann River (1997-2001, 2003, 2008), Kalama River (1995-2002), Lewis River (1997-2003, 2007-2008), and Sandy River (1998-2000, 2003).

Data from a Fraser River test fishery were available for the years 1995-1998, 2000-2005) reported as number of fish caught. Catch-per-unit-effort (CPUE) data were available from the Columbia River (1988-2008), Kemano River (1988-2006), and Kitimat River (1994-2006).

Commercial fisheries-dependant landings

Commercial fisheries landings in pounds or metric tons of eulachon were available for the Klamath River (1963), Umpqua River (1967), Columbia River (1888-1892, 1894-1913, 1915-2008), Fraser River (1881-1996), Kitimat River (1969-1971), and Skeena River (1900-1916, 1919, 1924, 1926-1927, 1929-1932, 1935, 1941).

In some areas of the southern eulachon DPS where escapement counts or estimates of spawning stock biomass are unavailable, catch statistics provide the only available quantitative data source that defines the relative abundance of eulachon occurrence that may be otherwise evident only by simple run strength observation. However, inferring population status or even trends from yearly changes in catch statistics requires assumptions that are seldom met; including similar fishing effort and efficiency, assumptions about the relationship of the harvested portion to the total portion of the stock, and statistical assumptions, such as random sampling.

First Nations and Indian tribal subsistence fisheries landings

First Nations subsistence fisheries landings in pounds or metric tons of eulachon were available for a number of rivers in BC including the Fraser River (1975-1987, 1991), Klinaklini River (1947, 1949-1950, 1952, 1959-1973, 1977), Kingcome River (1950, 1957, 1960-1961, 1963, and 1966), Wannock River (1967-1968, 1971), Bella Coola River (1945-1946, 1948-1989, 1995, 1998), Kemano River (1969-1973, 1988-2006), and Kitimat River (1969-1972).

Recreational fisheries-dependant landings

Recreational fisheries for eulachon are even more poorly documented that those for commercial and subsistence purposes. A popular recreational dip-net fishery for eulachon has a long history on the Columbia River, particularly in tributary rivers such as the Cowlitz and on occasion the Sandy River. Catch records are not maintained for this fishery, although it has been estimated at times to equal the commercial catch (WDFW and ODFW 2001). A similar recreational dip-net fishery occurred in the past on the Fraser River, and landings data exist for a portion of this fishery in the vicinity of Mission, British Columbia for the years 1956, 1963-1967, and 1970-1980 (Moody 2008, p. 49, her Fig. 2.22).

Ethnographic studies

Numerous ethnographic studies emphasize the nutritional and cultural importance of eulachon to coastal mainland Indian tribes and First Nations. The BRT examined ethnographic sources that describe historical distributions and relative abundance of eulachon fisheries within the boundaries of the DPS. Many of the statements in these sources as to the historical distribution and abundance of eulachon consisted of traditional ecological knowledge or were anecdotal in nature.

Anecdotal qualitative information

Anecdotal information is defined in the present context as information "based on personal observation, case study reports, or random investigations rather than systematic scientific evaluation." This category includes memoirs of pioneers, fur trappers, and explorers; newspaper articles; and interviews with local fishers.

The BRT examined a variety of both primary sources (e.g., accounts of early explorers, surveyors, fur trappers, and settlers; and newspaper articles) and secondary (e.g., agency fisheries reports and journal articles that cite personal communications) sources that describe historical distributions and relative abundance of eulachon within the boundaries of the DPS. In addition, the BRT examined documents (e.g., Larson and Belchik 1998, Hay and McCarter 2000, Moody 2008) that frequently cited interviews with local fishers or personal communications from local fisheries managers in their attempt to qualitatively characterize eulachon run strength. Many of the statements in these sources as to the historical distribution of eulachon were largely anecdotal in nature.

Traditional ecological knowledge

Although there is a largely untapped store of knowledge on eulachon residing in the culture and traditions of Native American Indian Tribes and First Nations in Canada, the BRT did not separately consider traditional ecological knowledge sources in its deliberations; however, the BRT did examine secondary sources that presented information on eulachon presence and run size that was gathered from interviews with traditional local fishers.

Summary of Regional Demographic Data

To facilitate evaluation of eulachon distribution and abundance the BRT analyzed the available demographic information on a subpopulation basis, arranged geographically into separate major estuaries, which have been postulated to be the smallest area that likely supports a biological stock (McCarter and Hay 2000, Hay 2002). These major areas are 1) Klamath River and 2) Columbia River (Cowlitz, Grays, Lewis, Kalama, Sandy rivers, etc) in the United States; and 3) Fraser River, 4) Knight Inlet (Klinaklini River), 5) Kingcome Inlet (Kingcome River), 6) Rivers Inlet (Wannock and Kilbella/Chuckwalla rivers), 7) Dean Channel (Bella Coola and Kimsquit rivers), 8) Gardner Canal (Kemano, Kowesas, and Kitlope rivers), Douglas Channel (Kitimat and Kildala rivers), and 9) Skeena River in the Province of British Columbia, Canada.

Eulachon are periodically noted in small numbers in several rivers and creeks on the Washington and Oregon coast. Documentation of these irregular occurrences of eulachon are usually anecdotal and it is uncertain how these fish are related demographically to eulachon in rivers such as the Fraser and Columbia where consistent annual runs occur. Occasionally large runs are noticed, usually by the abundance of predatory birds and marine mammals that accompany these runs, in coastal rivers such as the Queets and Quinault. Usually these large run events are separated in time by periods greater than the generation time of eulachon. We do not know enough about the biology of eulachon to know if these eulachon run events represent self-sustaining populations or are simply stray individuals from larger eulachon systems. It is possible that these populations may exist at levels of abundance that would not be detected by the casual observer, only to become noticed in years of high abundance. Further research on the source and sustainability of eulachon that occasionally appear in these coastal creeks and rivers is needed to fully assess the status of these eulachon aggregations.

Offshore Juvenile Abundance Estimates

Three fisheries independent indices of juvenile offshore biomass are available that indicate status of stock mixtures: 1) a West Coast Vancouver Island eulachon biomass index (Fig. 15), 2) a Queen Charlotte Sound eulachon biomass index (Fig. 16), and 3) the NMFS Alaska Fisheries Science Center Gulf of Alaska bottom trawl estimates for eulachon (Fig. 17).

None of these three indices provides information on spawning stock biomass and each incorporates juvenile biomass derived from 2-4 broodyears; however, these indices are useful predictors for potential future run sizes.

DFO (2008a, p. 11) describes the West Coast Vancouver Island eulachon biomass index as follows (see Fig. 15):

> The offshore biomass index is based on an annual trawl survey conducted in late April/early May by Fisheries and Oceans Canada, Science Branch. The survey initially was designed to index shrimp abundance but since eulachon also are caught by this survey, a eulachon index is possible. It is important to note that this is a biomass index and not a biomass estimate and that eulachon caught in this survey include stocks from both the Fraser River, [and] the Columbia River, and possibly other areas. This survey has been conducted since 1973 and provides an annual index of offshore abundance for the lower WCVI (Areas 121, 23, 123, 124 and 125).

In a similar manner, a Queen Charlotte Sound eulachon biomass index (Fig. 16) is derived from eulachon caught in the fishery-independent shrimp survey that is conducted in May of each year in "Shrimp Management Area (SMA) Queen Charlotte Sound (QCSND)." Recent data indicate that "the 2008 estimate of 451.5 t is a significant increase from the record low 137.1 t in 2007" (DFO 2008b, p. 2).

Although unlikely to include eulachon from the southern DPS, the Alaska Fisheries Science Center Gulf of Alaska (GOA) bottom trawl estimates for eulachon (Fig. 17) are a useful indicator of fluctuations in abundance in the Alaska Current for comparison with conditions in the California Current.

Northern California

Hubbs (1925) and Schultz and DeLacy (1935), leading ichthyologists of their day, described the Klamath River in Northern California as the southern limit of the range of *T. pacificus*. More recent compilations state that large spawning aggregations of eulachon were reported to have once regularly occurred in the Klamath River (Fry 1979, Moyle et al. 1995, Larson and Belchik 1998, Moyle 2002, Hamilton et al. 2005) and on occasion in the Mad River (Moyle et al. 1995, Moyle 2002) and Redwood Creek (Moyle et al. 1995) (Table A-1, Fig. 2). In addition, Moyle et al. (1995) and Moyle (2002) stated that small numbers of eulachon have been reported from the Smith River (Table A-1). California Department of Fish and Game's "Status Report on Living Marine Resources" document (Sweetnam et al. 2001, p. 477-478) stated that "The principal spawning run [of eulachon] in California is in the Klamath River, but runs have also been recorded in the Mad and Smith Rivers and Redwood Creek." Allen et al. (2006) indicated that eulachon usually spawn no further south than the lower Klamath River and Humboldt Bay tributaries.

The California Academy of Sciences (CAS) ichthyology collection database lists eulachon specimens collected from the Klamath River in February 1916 and March 1947 and 1963, and in Redwood Creek in February 1955 (see CAS online collections database at http://research.calacademy.org/research/Ichthyology/collection/index.asp). A search of available online digital newspaper resources revealed an early account of eulachon (a.k.a. candlefish in northern California) in the Klamath River in a newspaper account in 1879 and runs large enough to be noted in local newspaper accounts occurred in the Klamath River in February 1919, March 1968, and April 1963 and 1969; in Redwood Creek in April 1963 and 1967; and in the Mad River in April 1963 (see Appendix B). An early memoir by a traveler surveying timber resources on the Klamath River reported eulachon being harvested (15-20 pounds in a single dipnet haul) by Yurok tribal members in the early 1890s (Pearsall 1928).

Eulachon have been occasionally reported from other freshwater streams of California. Fry (1979, p. 90) reported that the largest eulachon run in California occurred in the Klamath River, and that eulachon occurred in "fresh water from the Gualala River: California, northward." Although Odemar (1964) has been cited as evidence that eulachon occur in the Russian River, Odemar (1964) actually stated that "No runs of *T. pacificus* have been reported in the Russian River, or in any river south of the Mad River, and it does not appear that the fish examined off the Russian River in May 1963 were destined to spawn there."

Eulachon were not observed by Eldridge and Bryan (1972) in a larval fish survey of Humboldt Bay, California, and Barnhart et al. (1992, p. 101) stated that eulachon are "not reported in Humboldt Bay tributaries." However, Monaco et al. (1990) described eulachon as "rare" in Humboldt Bay and, in addition to a several personal communications, cited Gotshall et al. (1980) and Young (1984) as supporting references. Gotshall et al. (1980, p. 229) recorded eulachon as an "occasional visitor" in winter to Humboldt Bay, California. Young (1984) stated that:

> Specimens [of eulachon] have occasionally been taken, during the spawning season, in Jolly Giant and Jacoby Creeks (George Allen, pers. comm., 1980). Both of these streams empty into Humboldt Bay.

Jennings (1996) reported upon observations of adult eulachon in creeks tributary to Humboldt Bay, California in May of 1977. A single spawned-out adult male eulachon was collected in a downstream migrant trap on Jolly Giant Creek, approximately 7 km south of the Mad River, and a total of seven adult eulachon were observed in another downstream migrant trap in Jacoby Creek, located 8.5 km south of the Mad River (Jennings 1996).

Although Minckley et al. (1986, their table 15.1, p. 541) indicate that eulachon were native to the Sacramento River and drainages within the south California Coastal to Baja California region, no verifying references for these assertions were given. Recently, Vincik and Titus (2007) reported on the capture of a single mature male eulachon in a screw trap at mile 142 on the Sacramento River.

Historically, eulachon runs in northern California were said to start as early as December and January and peak in abundance during March and April (Table A-3). Eulachon were of great cultural and subsistence importance to the Yurok Tribe on the Lower Klamath River (Trihey and Associates 1996) and the Yurok People consider eulachon to be a Tribal Trust Species along with spring and fall Chinook salmon, coho salmon, steelhead, Pacific lamprey, and green sturgeon (Trihey and Associates 1996, Larson and Belchik 1998). Eulachon once supported popular recreational fisheries in Northern California rivers, but were never commercially important in California. The only reported commercial catch of eulachon in Northern California occurred in 1963 when a combined total of 56,000 lbs (25 mt) was landed from the Klamath River, the Mad River, and Redwood Creek. According to Larson and Belchik (1998, p. 4):

> Literature regarding …[eulachon] specific to the Klamath River Basin is limited to accounts of mere presence and qualitative descriptions of the species. Though integral components of Yurok culture, eulachon … have not been of commercial importance in the Klamath and are "…totally unstudied as to their run strengths"

Larson and Belchik (1998, p. 6) also reported that according to accounts of Yurok Tribal elders:

> The last noticeable runs of eulachon were observed [in the Klamath River] in 1988 and 1989 by Tribal fishers. Most fishers interviewed perceived a decline in the mid to late 1970s, while about a fifth thought it was in the 1980s. A minority of those interviewed noticed declines in the 1950s and 1960s.

Larson and Belchik (1998, p. 7) further stated that:

> In December 1988 and May 1989, a total of 44 eulachon were identified in outmigrant salmonid seining operations in and above the Klamath River estuary (CDFG unpublished seining data). Though only selected sites are seined and salmonids are the targeted species, no eulachon have been positively identified since at least 1991 (M. Wallace, CDFG, pers. comm.).

As detailed in Larson and Belchik (1998), the Yurok Tribal Fisheries Program spent over 119 hours of staff time from 5 February to 6 May 1996 sampling for eulachon in the lower Klamath River at five different sites, where eulachon had been noted in the past, without encountering a single eulachon. However, one eulachon was captured by a Yurok Tribal member near the mouth of the Klamath River in 1996 (Larson and Belchik 1998). Sweetnam et al. (2001, p. 478), in the California Department of Fish and Game (CDFG) "Status Report on Living Marine Resources", stated that "In recent years, eulachon numbers seem to have declined drastically; so they are now rare or absent from the Mad River and Redwood Creek and scarce in the Klamath River." CDFG (Sweetnam et al. 2001, p. 478) also stated that, "the eulachon and its fishery have been largely ignored in the past" in California, and perhaps the perceived lack of eulachon in the Klamath River, currently and in the recent past, represent a low point in a natural cycle. In January 2007, six eulachon were reportedly caught by tribal fishermen on the Klamath River (Dave Hillemeier, Yurok Tribe, pers. comm.).

The BRT was concerned that there are almost no scientifically obtained abundance data available for eulachon in the Klamath River or any other basin in Northern California. Ethnographic studies, pioneer diaries, interviews with local fishers, personal communications from managers, and newspaper accounts are therefore the best information available that provide documentation of eulachon occurrence in the Klamath River and other rivers on the Northern California coast.

The BRT discussed several possible interpretations of the available information. In particular, the BRT discussed the possibility that historically runs of eulachon in the Klamath River were episodic and perhaps only occasionally large enough to be noticed. The BRT also considered the possibility that eulachon still occur in low but viable numbers in Northern California rivers but are not frequently observed because of the absence of a formal monitoring program. The BRT also discussed the possibility that some eulachon may spawn in estuarine environments and are not observed in the riverine environment.

The BRT concluded, however, that explanations that posit the absence of sustained Klamath River eulachon runs historically are less consistent with the available information than the hypothesis that Klamath River eulachon runs used to be regular and large enough to be readily noticeable and now are at most small and sporadic. In particular, various accounts written by California Department of Fish and Game personnel (Fry 1979, Sweetnam et al. 2001, CDFG 2008), Yurok Tribal Fisheries Department personnel (Larson and Belchik 1998), the National Resource Council's Committee on Endangered and Threatened Fishes in the Klamath River Basin (NRC 2004), or available academic literature (Moyle et al. 1995, Moyle 2002, Hamilton et al. 2005) universally describe accounts of the past occurrence of eulachon in the Klamath River and their subsequent decline. Based on the available information, the BRT was therefore unable to estimate the historical abundance of eulachon in northern California, but the BRT found no reason to discount the veracity of these anecdotal sources, which span a period of approximately 100 years and are nearly universal in their description of noticeable runs of eulachon having once ascended the Klamath River.

Likewise, although the BRT was concerned about the absence of a contemporary monitoring program for eulachon, the information available strongly indicated that noticeable runs of eulachon are not currently spawning in Klamath River or other northern California Rivers. In particular, the BRT thought it likely that if eulachon were returning in any substantial numbers it would be reported by residents or those engaged in recreation, research, or management on rivers in northern California. The BRT noted that large eulachon runs tend to attract the attention of fisherman, and the previous runs on the Klamath River were readily noticeable (e.g., "the fish moved up in huge swarms, followed by large flocks of feeding seabirds" -- Moyle 2002). The BRT therefore concluded that the available information was most readily interpreted as indicating that noticeable, regularly returning runs of eulachon used to be present in the Klamath River, but have been rare or sporadic for a period of several decades.

Although the BRT was reasonably confident that eulachon have declined substantially in Northern California, it is also clear that they have not been totally absent from this area in recent years. In particular, recent reports from Yurok Tribal fisheries biologists of a few eulachon being caught incidentally in other fisheries on the Klamath in 2007 indicates eulachon still enter the Klamath River on occasion in low numbers.

Columbia River

The Columbia River and its tributaries support the largest eulachon run in the world. Despite its size and the importance of the fishery (Appendix B), estimates of adult spawning stock abundance are unavailable and the primary information sources on trends in Columbia River eulachon abundance are catch records. In addition to regular returns to mainstem spawning locations in the Columbia River and on the Cowlitz River (most years), eulachon are known to spawn in the following lower Columbia River tributaries: Grays River (common use), Skamokawa Creek (infrequent use), Elochoman River (periodic use), Kalama River (common use), Lewis River (common use), and Sandy River (common use in large run years) (Table A-1, Fig. 2) (WDFW and ODFW 2008). Commercial fishery records begin in 1888 (Table 2-4, Fig. 18) and local newspapers record catches in the Columbia River as early as 1869 (see Appendix B). A large recreational dip-net fishery for which catch records are unavailable has existed in concert with commercial fisheries, and the importance of the eulachon run to local Indian tribes was documented as early as the Lewis and Clark Expedition (Burroughs 1961, WDFW and ODFW 2001). JCRMS (2007) stated that "limited past creel census information suggest that the recreational catch may equal the commercial landings in some years when smelt are abundant for a long period of time."

The BRT did not have confidence in the fishery landings, particularly prior to 2001 (see below), in the Columbia River as an accurate index of the actual abundance of the species. Landings are influenced by market conditions, fishing effort, weather, and many other factors other than actual fish abundance (WDFW and ODFW 2008). After implementation in 2000 of the interim Joint State Eulachon Management Plan (WDFW and ODFW 2001), the commercial fishery landings have become a relatively accurate index of the trend in the run size of eulachon returning to the Columbia River. For instance, eulachon returns increased during 2001-2003, dropped slightly in 2004, and then dropped dramatically in 2005, which is reflected in both the commercial landings and CPUE data collected during 2001-2007. This pattern was also essentially identical to that seen in offshore eulachon abundance indices (Figs. 15-16) and in abundance and catch records in several other rivers (e.g., Fraser and Klinaklini rivers) in the DPS. The WDFW and ODFW Joint Columbia River Management Staff (JCRMS 2007) have concluded that recent commercial landings "do provide a useful measure of the relative annual run strength." In particular, State fisheries managers of Columbia River eulachon use commercial landings to judge whether population trends are upward, neutral, or downward (JCRMS 2007).

Although not useful for estimating an accurate trend, the long-term landings data do indicate that commercial catch levels were consistently high (>500 mt and often >1000 mt) for the three quarters of a century period from about 1915 to 1992 (Figure 18). In 1993, the catches declined greatly to 233 mt in 1993 to an average of <40 mt between 1994 and 2000. From 2001 to 2004, the catches increased to an average of 266 mt, before falling to <5 mt from 2005 to 2008. Fishing restriction were instituted in 1995, so the low catches after than time are in part due to fishing restrictions (Figures 19 and 20). Nonetheless, the steep decline in 1993 and subsequent low abundance as indexed by the fishery is generally accepted by fishery managers as indicating a marked decline in the abundance of the stock. The WDFW and ODFW Joint Columbia River Management Staff (JCRMS 2007) concluded that, "run sizes [of Columbia River eulachon], as indexed by commercial landings, remained relatively stable for several decades until landings dropped suddenly in 1993 and remained low for several years thereafter." Following this period of time, "Due to reduced seasons during 1995-2000, landings are not completely comparable with previous years; however, it is apparent that the abundance of smelt in the Columbia River Basin was much reduced during 1993-2000" (JCRMS 2005) (Table 2, Figs. 18-21).

A previous petition (Wright 1999) and NMFS finding on this petition (NMFS 1999) mentioned years where zero catches were reported for eulachon in the Columbia River. The present status review uncovered additional published Columbia River commercial fishery landings data in annual reports of state and federal fisheries agencies that fill in most of these gaps in the catch record (Table 2, Fig. 18), with the exception of 1893 and 1914. In both cases, a survey of available online digital newspaper resources (see Appendix B) found articles describing the presence of eulachon in the Columbia River in those years.

The Columbia River eulachon commercial fishery has been managed according to the Joint State Eulachon Management Plan since 2001 (with an interim plan in effect in 2000), which provides for three levels of fishing based on parental run strength, juvenile production, and ocean productivity. Effort in this fishery typically involves fewer than 10 vessels. WDFW and ODFW (2008) described these three levels of fishing: 1) Level One fisheries are the most conservative (commercial and recreational openings of 12-24 h per week for Columbia and Cowlitz rivers) and are designed to act as a test fishery when there are indications of a poor return or great uncertainty in potential run strength; 2) Level Two fisheries (commercial and recreational openings of 2-3 days per week and potential of expansion to other tributaries) are indicated when fishery data suggest a moderate or strong run size; and 3) Level Three fisheries (commercial openings up to 4 days per week in all areas and all tributaries open to recreational fishing 4-7 days per week) may occur when abundance and productivity indicators are very strong.

The Columbia River eulachon fishery operated as a level one test fishery in 2001; began as a level two fishery, in 2002 switching to level three on February 1; operated at level three in 2003; started off as level three in 2004, with some later tributary commercial fishery restrictions; operated at level two in 2005 until February 23 when it was reduced to a level one fishery; and has operated as a level one test fishery in 2006 through 2008 (JCRMS 2005, 2006, 2007). The ability to adjust in-season fishery levels based on observed returns to the fishery, and its accurate tracking of past fluctuations in run strength, illustrates the utility of the Columbia River eulachon fishery statistics as an index of relative annual abundance (JCRMS 2007) (see Figs. 19-20).

There is some information indicating that there have been periods of relatively low eulachon abundance in the past in the Columbia River. In particular, several anecdotal sources reported on a decline in the 1830s to 1860s (Suckley 1860, Alexander 1877, Hinrichsen 1998, Martin 2008). Eulachon were once again seen in large numbers in the early-mid 1860s (Hinrichsen 1998, Martin 2008). Based on the available information, the BRT concluded that this information was probably accurate and likely indicated that a true decline in eulachon returns and subsequent recovery occurred during that time period.

Subsequent to the decline in 1993, state and tribal fishery agencies have instituted additional monitoring efforts for Columbia River eulachon. For example, Figure 22 presents data from a larval sampling program that measures larval densities (averaged across stations and depths at selected index sites) that was initiated in 1994 for the Cowlitz River and was expanded to include the Kalama River in 1995, the mainstem Columbia River in 1996, Elochoman and Lewis rivers in 1997, and the Grays and Sandy rivers in 1998 (JCRMS 2005). Inter-annual comparison of larval densities prior to about 2003 is unreliable because "larval sampling techniques … did not include repeat sampling of the same area over the duration of the out migration period" (JCRMS 2007, p. 23), but since that time multiple surveys have been conducted each season at mainstem Columbia River sites that sample downstream of all the potential spawning locations, with the exception of Grays River. Notably, the larval densities show a peak in 2001-2002 that corresponds to a similar peak in catches (Figure 18) and offshore juvenile abundance (Figures 15 and 16). Although spawning stock abundance has not been estimated using these larval surveys, the combination of data from the larval density survey and commercial and recreational landings "provides an indication of the relative run strength of eulachon in the Columbia River" (JCRMS 2007, p. 23).

The BRT had concerns about the absence of fishery independent abundance data for Columbia River eulachon prior to the mid-1990s. The BRT agreed with state fishery managers, however, that the available catch and effort information indicate an abrupt decline in abundance in the early 1990's, and there is no evidence that the population has returned to its former level. The decline in the early 1990's appeared to coincide with a decline of eulachon in British Columbia (see below), suggesting that a common cause, such as changing ocean conditions, was responsible for declines in both areas.

Fraser River

Eulachon return on a regular basis to the Fraser River and on an irregular basis to the Squamish River in Howe Sound to the north (Table A-1, Fig. 3) (Hay and McCarter 2000, Moody 2008). Eulachon usually begin to ascend the Fraser River at the end of March and spawning occurs in April until the middle of May. Eulachon are no longer seen spawning in some areas of the Fraser River where they used to occur. Historically, spawning occurred "primarily between Chilliwack and Mission in areas of coarse sand but also in localized areas of the North and South Arms as well as in the vicinity of the Pitt and Alouette Rivers" (Higgins et al. 1987). Currently spawning is confined to areas downstream of Mission, British Columbia.

In the past, the Fraser River eulachon run supported First Nations subsistence fisheries, and large commercial and recreational fisheries. Between 1941 and 1996 commercial landings averaged about 83 metric tons (Tables 4-5, Fig. 23). For much of this period the commercial fishery landings are not a good indicator of relative abundance, since landings were largely driven by market demand (Moody 2008). In 1997, the commercial eulachon fishery was closed and commercial landings have occurred in only two of the last ten years; in 2002 and 2004, when 5.76 and 0.44 metric tons were landed, respectively (Table 4, Fig. 23) (DFO 2006). Hay et al. (2003) estimated that First Nations and recreational fisheries historically landed about 10 metric tons, annually. Estimates of recreational fishery landings were presented in graphical form in Moody (2008; her figure 2.22) for a portion of the Fraser River (1956, 1963-1967, 1970-1980, closed since 2005). Moody (2008) stated that First Nation catch amounted to 2.57 metric tons in 2003. However, by 2005 all First Nation, commercial, and recreational fisheries were closed due to conservation concerns (DFO 2006). A eulachon test fishery operated on the Fraser River near New Westminster from 1995 to 2005 (with the exception of 1999) (Figure 23); however, this fishery has not operated since 2005 (DFO 2008a). This test fishery was meant to be an in-season measure of eulachon run-strength and resulting data consisted of the total number of eulachon caught daily at the same site, with the same gear, over the same time period, and at similar tidal conditions (Therriault and McCarter 2005, DFO 2008a). When in operation, a catch of less than 5,000 in this test fishery was considered a conservation concern (DFO 2006).

Table 5 and Figure 24 present spawning stock biomass data (DFO 2008a) that is derived from

> … an intensive sampling process [that] takes place in the Fraser River during the seven to eight weeks following spawning (April/May). This survey uses towed, small mesh nets to gather samples of eulachon eggs and larvae. The number of eggs and larvae gathered in each tow are hand-counted at the Pacific Biological Station. The egg and larval count is then combined with data on the daily Fraser River discharge and historical data on eulachon fecundity (eggs produced/female) to generate an estimate of spawning stock biomass.

DFO (2008a, p. 11) stated that:

> A low spawning stock biomass for one year is cause for caution and a low spawning stock biomass for two consecutive years indicates a conservation concern. A low spawning stock biomass has been defined as less than 150 metric tons.

The most recent population assessment of Fraser River eulachon by Fisheries and Oceans Canada (DFO 2007, p. 3) stated that:

> Despite limited directed fisheries in recent years, the Fraser River eulachon stock remains at a precariously low level. This stock has failed to recover from its collapse. SSB [spawning stock biomass] estimated from the egg and larval survey conducted in 2006 was 29 tonnes. The framework documents suggest that a low SSB (<150 tonnes) for one year is cause for concern and a restriction on removals should be activated while a low SSB for two (or more) consecutive years is more cause for alarm and should signal a halt to all removals (Hay et al. 2003; Hay et

al. 2005). Since 2007 is the fourth consecutive year where Fraser River eulachon SSB has been below 150 tonnes, unprecedented in this short time series, no removals should be allowed in 2008.

Subsequent to this statement, spawner biomass for the 2008 eulachon run in the Fraser River has been estimated at 10 metric tons (see data online at http://www-sci.pac.dfo-mpo.gc.ca/herring/herspawn/pages/river1_e.htm). Figure 25 presents the Fraser River eulachon spawner abundance trend over the time period of the available data (1995-2008). A trend of 0.77 (95% CI, 0.65-0.90) for Fraser River eulachon was calculated from these data. Over the three-generation time of ~10 years, the overall biomass of the Fraser River eulachon population has undergone a 92.5% decline (1998, 134 mt; 2008, 10 mt). Under the IUCN decline criteria (A1), a reduction in population size of this magnitude "where the reduction or its causes may not have ceased or may not be understood or may not be reversible" (IUCN 2006), would place Fraser River eulachon in the IUCN "Critically Endangered" category (IUCN 2001, 2006).

The methodology on the Fraser River of utilizing mean egg and larval plankton density and river discharge rates (gathered throughout a seven week outmigrant period at five locations) in combination with known relative fecundity (egg production per gram of female) and sex ratio to estimate spawning stock biomass has passed rigorous scientific review in Canada (Hay et al. 2002, 2003, 2005; McCarter and Hay 2003; Therriault and McCarter 2005). This methodology is similar to methods utilized since the early 1970s by many fisheries agencies (WDFW, DFO, California Department of Fish and Game, and Alaska Department of Fish and Game) to calculate Pacific herring spawning stock abundance based on estimates of intertidal and subtidal egg deposition and relative fecundity. The BRT therefore was confident that observed trends in the Fraser River spawning stock abundance data represented a true picture of the status of Fraser River eulachon.

According to Therriault and McCarter (2005), the Fraser River test fishery data did not correspond well with the spawning stock estimates that were based on the egg and larval survey and this may have resulted from variation in the catchability of adults. Eulachon abundance can be inflated when they form dense schools, which can lead to an overestimate of abundance. On the other hand, eulachon may avoid the test fishery gear leading to an underestimate of the run size. Due to these and other problems with the test fishery methodology (see Therriault and McCarter 2005), the BRT did not put a lot of confidence in these data.

The BRT did not formally analyze commercial, recreational or subsistence fishery landings between 1881 and the present in the Fraser River as it is believed that for much of this period the commercial fishery landings were largely driven by market demand (Hay et al. 2002, Moody 2008). However, these data do indicate that eulachon were generally present at harvestable abundance levels in the Fraser River during this time period.

Knight Inlet

Hay and McCarter (2000) reported that an annual run of eulachon return on a regular basis to the Klinaklini River at the head of Knight Inlet on the British Columbia Coast (Table A-1, Fig. 3) Other irregular eulachon runs in the Johnstone Strait Region include the Kakweiken

River, Homathko River (Bute Inlet), and Stafford and Apple rivers (Loughborough Inlet). Peak spawn timing in the area occurs about the middle of April (Hay and McCarter 2000, Hay 2002, Moody 2008).

There is only a single year's estimate of spawning stock biomass for the Klinaklini River (1995). Records of a commercial fishery are available for 1943-1945 and 1947. First Nations fisheries landings on the Klinaklini River are available for 1947, 1949-1950, 1952, 1959-1973 and 1977 (Table 4); however, after 1977 there is very limited documentation of run sizes of eulachon on the Klinaklini River and these are all anecdotal in nature. These anecdotal qualitative run size comments are listed in Table 7 and indicate an improvement in recent run size estimates.

Prior to 1943 when fisheries dependant catch records begin our information for run size of the Klinaklini River is either anecdotal or comes from ethnographic studies. Numerous ethnographic studies describe a large First Nations eulachon fishery on the Klinaklini River that attracted up to 2,000 Kwakiutl First Nation members in the late 19th century (Macnair 1971), some from as far as 250 miles away by canoe (Codere 1990).

There were commercial eulachon fisheries in Knight Inlet in the 1940s that primarily supplied food for the fur farm industry. Combined commercial and First Nations subsistence fisheries landed between 18 and 90 metric tons annually from 1943 and 1977 in Knight Inlet (Moody 2008), although landings reported by Hay and McCarter (2000) and reported in Table 4 were somewhat higher. At times, eulachon landings from Kingcome and Knight Inlet may have been reported as Knight Inlet landings, which may explain some of this discrepancy (Moody 2008). Berry and Jacob (1998, as cited in Moody 2008) "estimated spawning biomass at approximately 40 metric tons in the Klinaklini River in 1995" with a larval-based assessment (Hay and McCarter 2000). This value was "thought to be approximately 15% of the historic run size" (Berry and Jacob 1998, as cited in Moody 2008). Based on anecdotal information, Moody (2008) stated that eulachon returns to the Klinaklini River were said to be low "during the 2004 and 2005 seasons … but in 2007, the Klinaklini returns improved and, overall, it appeared to be a "very good run" (Table 7).

The BRT was concerned that there are few scientifically obtained abundance data available for eulachon in Knight Inlet, about the absence of a contemporary monitoring program for eulachon, and about the anecdotal nature of the available information. However, the BRT concluded that available catch records, the extensive ethnographic literature, and anecdotal information indicates that Klinaklini River eulachon were probably present in larger annual runs in the past and that current run sizes of eulachon appear inconsistent with the historic level of grease production extensively documented in the ethnographic literature (see summaries in Macnair 1971, Codere 1990). However, anecdotal information indicates that recent returns of eulachon to the Klinaklini River have improved from a low point in 2004-2005, so the status of this population is not entirely clear.

Kingcome Inlet

Hay and McCarter (2000) reported that an annual run of eulachon return on a regular basis to the Kingcome River at the head of Kingcome Inlet on the British Columbia Central Coast (Table A-1, Fig. 3). Peak spawn timing in the area occurs about the middle of April (Moody 2008). Berry and Jacob (1998, p. 4) reported that "there were at least four "waves" of spawning with peaks on April 2, April 15, April 21, and May 2, 1997, with the largest occurring around April 15" in the Kingcome River. Berry and Jacob (1998) also reported that there was a spawn in the Kingcome River prior to March 16 and again in early June as indicated by the presence of eggs in the water column.

There is only a single year's estimate of spawning stock biomass for the Kingcome River (1997). First Nations fisheries landings on the Kingcome River are available for 1950, 1957, 1960-1961, 1963, and 1966 (Moody 2008, her figure 2.20); however, after 1977 there is very limited documentation of run sizes of eulachon on the Kingcome River and these are all anecdotal in nature. These qualitative run size comments are listed in Table 7 and indicate a decline in recent run size estimates.

When Kingcome Inlet First Nation fisheries landings have been reported separately from Knight Inlet, the estimates have averaged around an annual catch of 9 metric tons (Moody 2008). Moody (2008) reported that the eulachon run in the Kingcome River in 1971 was "very small" and "light catches" were reported in 1972. Berry and Jacob (1998) stated that a minimum estimated 14.35 metric tons of eulachon spawned in the Kingcome River from March 16 to June 3, 1997. Based on anecdotal information, Moody (2008) reported that "In 2001 the Kingcome run improved and was considered "good" in 2002, with approximately 330 gallons of grease produced." The eulachon run to the Kingcome River was considered to be "poor" in 2003 and 2004 and of "average" size in 2005 (Moody 2008). However, eulachon were reportedly "absent" from the Kingcome River in 2006 "and only small returns were seen in 2007" (Table 10) (Moody 2008).

The BRT was concerned that there are few scientifically obtained abundance data available for eulachon in Kingcome Inlet, about the absence of a contemporary monitoring program for eulachon, and about the anecdotal nature of the evidence. However, the BRT felt that available catch records and anecdotal information indicates that Kingcome River eulachon were probably present in larger annual runs in the past.

Rivers Inlet

Hay and McCarter (2000) reported that an annual run of eulachon return on a regular basis to the Wannock, Chuckwalla, and Kilbella rivers in Rivers Inlet on the Central Coast of British Columbia (Table A-1, Fig. 3). The spawning stock biomass of eulachon in Rivers Inlet was estimated using scientific survey methods in 2005 and 2006. First Nations fisheries landings on the Wannock River are available for 1967, 1968, and 1971; however, after 1971 there is very limited documentation of run sizes of eulachon in Rivers Inlet and (with the exception of the information available for 2005-2006) these are anecdotal in nature. These anecdotal qualitative run size comments are listed in Table 7 and indicate a decline in recent run size estimates.

First Nation fishery landings data for the Wannock River were limited to the years 1967, 1968, and 1971 when catches were 1.81, 2.27, and 4.54 metric tons, respectively (Moody 2008). Moody (2008) stated that eulachon in "the Wannock River had been gradually declining since the 1970s" and that no eulachon have been caught in First Nations fisheries in the Rivers Inlet area since 1997, when about 150 kilograms of eulachon were landed from the Kilbella and Chuckwalla rivers (Berry and Jacob 1998). Berry and Jacob (1998, p. 3-4) further reported that "Virtually no eulachon eggs or larvae were found in any of the 376 samples from the Wannock R. in 1997" and "this observation is consistent with in-field observations of eulachon entering the river mouth only to exit and possibly go to the nearby Chukwalla or Kilbella R to spawn." In 2005, an estimated 2,700 adults returned to the Wannock River, based on the capture of only eleven adults during spawner abundance surveys (Burrows 2005, as cited in Moody 2008). An additional three adult eulachon were taken on the Kilbella River in 2005 (Burrows 2005, as cited in Moody 2008). Moody (2008) stated that this adult spawner survey was repeated in 2006 and although "no adults [were] captured … an estimate of 23,000 adult spawners was calculated …" (Table 7).

The BRT was concerned that there are few scientifically obtained abundance data available for eulachon in Rivers Inlet, about the absence of a contemporary monitoring program for eulachon, and about the anecdotal nature of the evidence. The BRT was also concerned that the incomplete record of eulachon catch and spawn biomass in Rivers Inlet does not establish whether or not eulachon returned on an annual basis to this system in the past. However, the BRT felt that available recent estimates of spawning stock abundance, catch records, ethnographic literature (Hilton 1990), and anecdotal information indicates that Rivers Inlet eulachon were present in larger annual runs in the past. The BRT also felt that the recent spawning stock estimates of 2,700 to 23,000 individual spawners is cause for concern as these numbers indicate that this sub-population may be at risk from small population concerns, such as Allee effects and random genetic and demographic effects.

Dean Channel

Hay and McCarter (2000) reported that an annual run of eulachon return on a regular basis to the Bella Coola, Dean, and Kimsquit rivers in Dean Channel (Table A-1, Figs. 1, 3). Kennedy and Bouchard (1990, p. 325) summarized ethnographic studies on the Nuxalk (Bella Coola) First Nation and stated that "because of their abundance and their value as a trade item, eulachons (particularly when rendered into highly valued grease) were second only to salmon in importance to the Bella Coola." Moody (2008) indicated that historically, peak run timing of eulachon in the Bella Coola River occurred in late March or early April (Table A-3). Moody (2007) also reported that recent run-timing of eulachon to the Bella Coola River occurs earlier in the season than it did historically.

Spawning stock biomass data for the Bella Coola River were available for 2001-2004. Records of the Nuxalk First Nation eulachon fishery on the Bella Coola River are available for

1945-1946, 1948-1989, 1995, and 1998 (Moody 2008, her figure 3.13). Moody (2008) also provided estimated First Nations eulachon catch based on a model of eulachon “grease” production from 1980 to 1998. Anecdotal qualitative run size comments are listed in Table 7.

Moody (2007) reports relative abundance estimates, based on egg and larval surveys similar to those used on the Fraser River, for the Bella Coola River in 2001 (0.039 mt), 2002 (0045-0.050 mt), 2003 (.016 mt), and 2004 (0.0072 mt). Nuxalk First Nation subsistence fishery landings of eulachon from the Bella Coola River show an average catch of 18 mt between 1948 and 1984 (see Table 4 and Figure 26), with a low of 0.3 mt in 1960 and a high of nearly 70 mt in 1954, based on data available in Hay (2002). These data suggest that recent (2001-2004) spawner biomass in Bella Coola River is approximately two orders of magnitude less than the average First Nations eulachon landings were between 1948 and 1984. According to Moody (2007), it has been nine years since the last First Nations fishery occurred on the Bella Coola River.

Anecdotal information indicated that only a very few eulachon are currently found in other rivers in Dean Channel such as the Kimsquit River and in the Taleomy, Assek, and Noeick rivers in South Bentnick Arm off Dean Channel (Moody 2008). Moody (2007, 2008) also stated that “it appears that 1996 was the last large run of eulachon to the Bella Coola River” and noticeable runs have not returned to the “Dean Channel/Bella Coola area since 1999” (Table 7).

The BRT believes that available spawning stock biomass data collected since 2001, catch records, extensive ethnographic literature, and anecdotal information indicates that Bella Coola River and Dean Channel eulachon in general were present in much larger annual runs in the past. The present run sizes of eulachon appear inconsistent with the historic level of grease production that is extensively documented in the ethnographic literature on the Nuxalk First Nations Peoples (Kennedy and Bouchard 1990, Moody 2008). The BRT was concerned that this information and available data indicate that eulachon in Dean Channel may be at risk from small population concerns, such as Allee effects and random genetic and demographic effects.

Gardner Canal

Hay and McCarter (2000) reported that an annual run of eulachon return on a regular basis to the Kemano, Kowesas, and Kitlope rivers in Gardner Canal (Table A-1, Figs. 1, 3). Eulachon spawn in late March and early April on the Kemano River, which is unusual in being a clear, non-turbid system in a region that is dominated by glacially turbid rivers (Moody 2008).

First Nations fisheries landings on the Kemano River are available for 1969-1973 and 1988-2007. CPUE data in this fishery from 1988-2007 (reported as metric tons caught per set) were presented in graphical form in Moody (2008, her figure 2.16). A summary of ethnographic studies of the Haisla First Nation indicates that “eulachon were especially important with runs in the … Kemano and Kitlope rivers…in such numbers that they were an important export” (Hamori-Torok 1990, p. 306). Anecdotal qualitative run size comments on Kemano River eulachon are listed in Table 7 and indicate a decline in recent run size estimates.

First Nation fisheries landings on the Kemano River ranged from 18.1 to 81.7 metric tons from 1969 to 1973 (average of 44.3 metric tons) (Moody 2008, her figure 2.16). Rio Tinto Alcan operate a hydroelectric generation facility on the Kemano River and, as part of an environmental management plan, Rio Tinto Alcan have funded monitoring of eulachon since 1988 (Lewis et al. 2002). From 1988 to 1998, landings ranged from 20.6 to 93.0 mt (average of 57 metric tons) (Table 4) (Lewis et al. 2002; Moody 2008). However, according to Moody (2008), no run occurred in 1999.

First Nations landings in the Kemano River were low from 2000 to 2002, but improved to between 60 and 80 metric tons in 2003 and 2004 (ALCAN 2005; Moody 2008, her figure 2.16); however, anecdotal information indicated that eulachon returns were not detected in the Kemano River in both 2005 and 2006 (Table 7) (ALCAN 2006, 2007; EcoMetrix 2006, as cited in Moody 2008). Based on anecdotal information, Moody (2008) reported that "eulachon were seen in the Kemano estuary in 2007. However, they did not ascend the river." CPUE data showed similar trends to the First Nation fishery landings, with a sharp drop from about 2.5 mt per set in 1998 to less than 0.5 mt per set from 1999-2002, a rebound to between 0.5 and 1 mt per set in 2003-2004, and no fish caught in 2005-2007 (Lewis et al. 2002; Moody 2008, her figure 2.16).

It is the BRT's best professional judgment that available CPUE data collected since 1988, First Nations catch records, extensive ethnographic literature, and anecdotal information indicates that Kemano River, and Gardner Canal eulachon in general, were present in larger annual runs in the past and that present run sizes of eulachon appear inconsistent with the historic level of grease production that is well documented for this region in the ethnographic literature (Hamori-Torok 1990).

In addition, the BRT believes that the inability to detect eulachon in the Kemano River since 2004 using the same monitoring methods that have been in place since 1988 (Lewis et al. 2002; Moody 2008, her fig. 2.16) and anecdotal information, from Rio Tinto ALCAN biological surveys that eulachon have failed to return to the Kemano River in 2005-2007 (ALCAN 2005, 2006, 2007), is cause for concern as this information indicates that this sub-population may be at risk from small population concerns, such as Allee effects and random genetic and demographic effects.

Douglas Channel

Hay and McCarter (2000) reported that an annual run of eulachon return on a regular basis to the Kitimat and Kildala rivers in Douglas Channel (Table A-1, Fig. 3). Spawning in the Kitimat River reportedly peaks in mid to late March (Moody 2008).

The spawning stock biomass of eulachon in the Kitimat River was estimated using scientific survey methods in 1993. First Nations fisheries landings on the Kitimat River are available for 1969-1972. Catch per unit effort in this fishery, reported as number of fish caught in a 24 h period and estimated spawner abundance are available for 1994-1996 and 1998-2007. A summary of ethnographic studies of the Haisla First Nation indicates that "eulachon were especially important with runs in the Kitimat, [and] Kildala…rivers in such numbers that they were an important export" (Hamori-Torok 1990, p. 308). Anecdotal qualitative run size comments on Kitimat River eulachon are listed in Table 7 and indicate a decline in recent run size estimates.

Between 1969 and 1972, Kitimat River First Nations fisheries landings of eulachon ranged from 27.2 to 81.6 metric tons (Moody 2008, her fig. 2.14). The Kitimat River First Nations eulachon fishery reportedly came to an end in 1972 as pollution by industrial (pulp mill) and municipal effluent discharges made the eulachon unpalatable (Pederson et al. 1995, Moody 2008). Pederson et al. (1995) estimated a total spawning biomass in the Kitimat River of 22.6 metric tons or about 514,000 individual eulachon in 1993. According to Moody (2008, p. 34), CPUE of eulachon on the Kitimat River, as presented in EcoMetrix (2006), declined from 50-60 fish per 24 h gill net set in 1994-1996 to less than 2 eulachon per gill net set since 1998. According to EcoMetrix (2006, as cited in Moody 2008), abundance of eulachon from 1994 to 1996 ranged between 527,000 and 440,000 individual spawners and from 1998 to 2005 ranged between 13,600 and <1000. Based on anecdotal information, Moody (2008, p. 34) stated that "the last strong run returned to the Kitimat River in 1991 and runs from 1992-1996 were estimated at half the size of 1991" (Table 7).

The BRT believes that the available spawning stock biomass data available for 1993, CPUE data since 1994, First Nations landing records, extensive ethnographic literature, and anecdotal information indicates that Kitimat River and Douglas Channel eulachon in general were present in larger annual runs in the past and that present run size estimates of eulachon appear inconsistent with the historic level of grease production extensively documented in the ethnographic literature (Hamori-Torok 1990).

The BRT believes that the decline in estimated spawning stock on the Kitimat River from an annual run size of over 500,000 eulachon in the mid-1990s to levels of less than 1,000 individual eulachon in 2005 (EcoMetrix 2006, Moody 2008) is cause for concern as these numbers indicate that this sub-population may be at risk from small population concerns, such as Allee effects and random genetic and demographic effects.

Skeena River

Hay and McCarter (2000) and Moody (2008) reported that an annual run of eulachon return on a regular basis to the Skeena River and its tributaries (particularly the Ecstall and Khyex rivers) (Table A-1, Fig. 3). The Skeena River run was reportedly small, of short duration, and difficult to harvest because of the large size of the mainstem Skeena River (Stoffels 2001, Moody 2008). Based on anecdotal information, eulachon historically returned to the Skeena River around the first week of March but in the past decade returns have occasionally returned as early as mid February (Moody 2008).

The spawning stock biomass of eulachon in the Skeena River was estimated using scientific survey methods in 1997. Combined commercial and First Nations fisheries landings on the Skeena River are available for 1900-1916, 1919, 1924, 1926-1927, 1929-1932, 1935, 1941 (Table 4). Qualitative run size comments on Kitimat River eulachon are listed in Table 7 and indicate a decline in recent run size estimates.

Lewis (1997) estimated the total spawning stock abundance of the Skeena River eulachon at only 3.0 metric tons in 1997. A small commercial eulachon fishery operated between 1924 and 1946 (landings ranged from 15.4 mt in 1924 to 0.9 mt in 1935) (Moody 2008). However, total landings records were as high as 100 metric tons at one time and averaged 27.5 metric tons from 1900-1941 (Table 4). It is likely that demands of local market have likely driven subsistence and past commercial fisheries statistics on the Skeena River and the BRT did not believe that these data were a good index of abundance. Moody (2008) reported anecdotal information indicating that very few Skeena River eulachon were observed between 1997 and 1999, a good run occurred in 2005, and virtually no eulachon were observed in 2006 (Table 10) (Moody 2008).

The BRT was concerned that there are few scientifically obtained abundance data available for eulachon in Knight Inlet, about the absence of a contemporary monitoring program for eulachon, and about the anecdotal nature of the evidence. However, the BRT felt that available catch records and anecdotal information indicate that Skeena River eulachon were present in larger annual runs in the past that at one time supported a large fishery. Although the current status of this subpopulation is unknown, the BRT believe that anecdotal information indicates declines in abundance have occurred.

Assessment of Demographic Risk and the Risk Matrix Approach

In previous NMFS status reviews, BRTs have used a “risk matrix” as a method to organize and summarize the professional judgment of a panel of knowledgeable scientists. This approach is described in detail by Wainright and Kope (1999) and has been used for over 10 years in Pacific salmonid status reviews (e.g., Good et al. 2005, Hard et al. 2007), as well as in reviews of Pacific hake, walleye pollock, Pacific cod (Gustafson et al. 2000), Puget Sound rockfishes (Stout et al. 2001b), Pacific herring (Stout et al. 2001a; Gustafson et al. 2006), and black abalone (Butler et al. 2008). In this risk matrix approach, the collective condition of individual populations is summarized at the DPS level according to four demographic risk criteria: abundance, growth rate/productivity, spatial structure/connectivity, and diversity (Table 8). These viability criteria, outlined in McElhany et al. (2000), reflect concepts that are well founded in conservation biology and are generally applicable to a wide variety of species. These criteria describe demographic risks that individually and collectively provide strong indicators of extinction risk. The summary of demographic risks and other pertinent information obtained by this approach is then considered by the BRT in determining the species’ overall level of extinction risk.

After reviewing all relevant biological information for the species, each BRT member assigns a risk score (see below) to each of the four demographic criteria. The scores are tallied (means, modes, and range of scores), reviewed, and the range of perspectives discussed by the BRT before making its overall risk determination (see Table 8 for a summary of demographic risk scores). Although this process helps to integrate and summarize a large amount of diverse information, there is no simple way to translate the risk matrix scores directly into a determination of overall extinction risk. For example, a DPS with a single extant sub-population might be at a high level of extinction risk because of high risk to spatial structure/connectivity, even if it exhibited low risk for the other demographic criteria. Another species might be at risk of extinction because of moderate risks to several demographic criteria.

Scoring Population Viability Criteria—Risks for each demographic criterion are ranked on a scale of 1 (very low risk) to 5 (very high risk):

1. ***Very Low Risk***. Unlikely that this factor contributes significantly to risk of extinction, either by itself or in combination with other factors.

2. ***Low Risk***. Unlikely that this factor contributes significantly to risk of extinction by itself, but some concern that it may, in combination with other factors.

3. ***Moderate Risk***. This factor contributes significantly to long-term risk of extinction, but does not in itself constitute a danger of extinction in the near future.

4. ***High Risk***. This factor contributes significantly to long-term risk of extinction and is likely to contribute to short-term risk of extinction in the foreseeable future.

5. ***Very High Risk***. This factor by itself indicates danger of extinction in the near future.

Recent events—The "recent events" category considers events that have predictable consequences for DPS status in the foreseeable future but have occurred too recently to be reflected in the demographic data. Examples include a climatic regime shift or El Niño that may be anticipated to result in increased or decreased predation in subsequent years. This category is scored as follows:

++ (double plus):	expect a strong improvement in status of the DPS;
+ (single plus):	expect some improvement in status;
0 :	neutral effect on status;
- (single minus):	expect some decline in status;
-- (double minus):	expect strong decline in status.

Qualitative Threats Assessment

Although the question of how a DPS came to be at risk is important, a population or DPS that has been reduced to low abundance will continue to be at risk for demographic and genetic reasons until it reaches a larger size, regardless of the reasons for its initial decline. Furthermore, in some cases, a factor that was important in causing the original declines may no longer be an impediment to recovery. Unlike some ESA-listed species that face a single primary threat, eulachon face numerous potential threats throughout every stage of their life cycle. It is therefore relatively easy to simply list current and past potential threats to eulachon populations, but it is much more difficult to evaluate the relative importance of a wide range of interacting factors. The BRT also recognized that evaluating the degree to which factors for decline will continue to pose a threat generally requires consideration of issues that are more in the realm of social science than biological science—such as whether proposed changes will be funded, and, if funded, will be implemented effectively.

Nevertheless, the potential role that various threats have played in the decline of the Southern Eulachon DPS was examined by the BRT in light of the question posed to the BRT by the Northwest Region as articulated in the following text.

> In your evaluation of extinction risk, please include a consideration of the threats facing the species/DPS that may or may not be manifested in the current demographic status of populations. Please document your consideration of these threats according to the statutory listing factors (ESA section 4(a)(1)(A)—(C), and (E)): the present or threatened destruction, modification, or curtailment of its habitat or range; overutilization for commercial, recreational, scientific, or educational purposes; disease or predation; and other natural or manmade factors affecting its continued existence. In describing the threats facing the species/DPS please distinguish between threats (e.g., human actions or natural events) and limiting factors (e.g., the physical, biological, or chemical processes that result in demographic risks to the species/DPS), and qualitatively rank, if possible, the severity of identified threats to the species' persistence.

The potential roles that sixteen current threats may play in the decline of the Southern Eulachon DPS were ranked according to severity in the Klamath, Columbia, and Fraser rivers and in that portion of the DPS along the mainland coast of British Columbia (Tables 9-13). Also noted is the ESA factor for decline within which each threat falls (Table 9).

The results of the BRT's analysis of the severity of threats to eulachon are presented in Tables 10-13 in rank order from most severe to least severe for each geographical subset as determined by the mean BRT threat scores. Also presented in these tables are the standard deviation (SD) about the mean threat scores, the modal score, the range of scores, and the number of BRT members scoring the threat.

The BRT ranked climate change impacts on ocean conditions as the most serious threat to persistence of eulachon in all four sub-areas of the DPS: Klamath River, Columbia River, Fraser River, and British Columbia coastal rivers south of the Nass River. Climate change impacts on freshwater habitat and eulachon by-catch in offshore shrimp fisheries were also ranked in the top four threats in all sub-areas of the DPS. Dams and water diversions in the Klamath and Columbia rivers and predation in the Fraser and British Columbia coastal rivers filled out the last of the top four threats. In most categories some portion of the BRT felt that insufficient data were available to score the threat severity (thereby marking the threat severity as "unknown") as indicated by the number of BRT members voting (column N) in Tables 10-13.

Overall Risk Determination

The BRT's determination of overall risk to the species used the categories of at "high risk" of extinction; at "moderate risk" of extinction; or "not at risk" of extinction. Table 14, describes these qualitative "reference" levels of extinction risk. Quantitative and qualitative conservation assessments for other species have often used a 100-year time frame in their extinction risk evaluations (Morris et al. 1999, McElhany et al. 2000) and the BRT adopted this time scale as the period over which it had confidence in evaluating risk. The overall extinction risk determination reflected informed professional judgment by each BRT member. This assessment was guided by the results of the risk matrix analysis, integrating information about demographic risks with expectations about likely interactions with threats and other factors.

To allow individuals to express uncertainty in determining the overall level of extinction risk facing the species, the BRT adopted the "likelihood point" method, often referred to as the "FEMAT" method because it is a variation of a method used by scientific teams evaluating options under the Northwest Forest Plan (FEMAT 1993). See Table 15 for an example worksheet and results. In this approach, each BRT member distributes ten likelihood points among the three species extinction risk categories, reflecting their opinion of how likely that category correctly reflects the true species status. Thus, if a member were certain that the species was in the "not at risk" category, he or she could assign all ten points to that category. A reviewer with less certainty about the species' status could split the points among two or even three categories. This method has been used in all status review updates for anadromous Pacific salmonids since 1999, as well as in reviews of Puget Sound rockfishes (Stout et al. 2001b), Pacific herring (Stout et al. 2001a; Gustafson et al. 2006), Pacific hake, walleye pollock, Pacific cod (Gustafson et al. 2000), and black abalone (Butler et al. 2008).

Summary of Risk Conclusions for the Southern Eulachon DPS

The BRT's scores for overall risk to the Southern Eulachon DPS, throughout all of its range, were heavily weighted to "moderate risk" with this category receiving 60% of the likelihood points. "High risk" received 32% of the likelihood points and "not at risk" received 8% of the points. The BRT was concerned that although eulachon are a relatively poorly monitored species, most of the available information indicates that the Southern Eulachon DPS has experienced an abrupt decline in abundance throughout its range. The BRT was particularly concerned that two large spawning populations – in the Columbia and Fraser Rivers – have both declined to what appear to be historically low levels, and overall risk scores for abundance ranged from 4 to 5 (see Table 8). The BRT was concerned that there is very little monitoring data available for Northern California eulachon, but determined that the available information suggests that eulachon in Northern California experienced an abrupt decline several decades ago. The BRT was also concerned that recent attempts to estimate actual spawner abundance in some rivers in British Columbia that are known to have supported significant First Nations fisheries in the past have resulted in very low estimates of spawning stock. The BRT was also concerned that the current sizes of Central and North Coast British Columbia eulachon populations appear inconsistent with the ethnographic literature that describes an extensive grease trading network based upon eulachon catch (discussed by Hay, 2002, p. 103).

In addition, the BRT was concerned that the current abundance of the many individual populations within the DPS may be sufficiently low to be an additional risk factor, even for populations (such as the Columbia and Fraser) where the absolute population size seems large compared to many other at risk fish populations. Indeed, the BRT considered a central question in this review to be whether a DPS or sub-population may be at risk of extinction when there may be hundreds of thousands or perhaps millions of individuals remaining in the population. In evaluating this issue, the BRT concluded that eulachon (and other similar forage fishes) (see Dulvy et al. 2004) may be at significant risk at population sizes that are a fraction of their historical levels but are still large compared to what would be considered normal for other ESA listed species (see above discussion in the "Absolute Numbers" section).

Of relevance to this issue are recent reviews of extinction risk in marine fishes illustrating that forage fish are not immune to risk of extirpation at the population scale (Dulvy et al. 2003, Reynolds et al. 2005). Hutchings (2000, 2001a, 2001b) and others (Dulvy et al. 2003, Mace and Hudson 1999, Hutchings and Reynolds 2004) cite empirical analyses indicating that marine fishes likely have similar extinction probabilities to those of nonmarine taxa. A number of inshore populations of Atlantic cod and Atlantic herring have either been extirpated or have not shown signs of recovery from depletions that are unprecedented in the historic record (Smedbol and Stevenson 2001). An example involves the disappearance of the Icelandic spring-spawning population of Atlantic herring (Beverton 1990), whose last known census population size in 1972 was 700,000 (Dulvy et al. 2004).

The BRT believe that high eulachon minimum viable population sizes are necessary 1) to ensure a critical threshold density of adult eulachon are available during breeding events for maintenance of normal reproductive processes, 2) to produce enough offspring to counteract high in-river egg and larval mortality and planktonic larval mortality in the ocean, and 3) to produce enough offspring to buffer against the action of local environmental conditions which may lead to random "sweepstake recruitment" events where only a small minority of spawning individuals contribute to subsequent generations. In species with this life history pattern, the genetically effective population size can be several orders of magnitude lower than the census size (Hedgecock 1994; ICES 2004), and minimum viable census sizes may therefore be on the order of 50,000 to 500,000 (Dulvy et al. 2004). The BRT was concerned that in a number of sub-areas of the DPS (Klamath, Fraser River, Bella Coola River, Rivers Inlet, etc.) population sizes of eulachon are below what would be considered MVP sizes for highly fecund species.

The BRT noted that variable year-class strength in marine fishes with pelagic larvae is dependent on survival of larvae prior to recruitment and is driven by match-mismatch of larvae and their planktonic food supply (Hjort 1914, Lasker 1975, Sinclair and Tremblay 1984), oceanographic transport mechanisms (Parrish et al. 1981), variable environmental ocean conditions (Shepherd et al. 1984, McFarlane et al. 2000), and predation (Bailey and Houde 1989). The operation of these dynamic ocean conditions and their impacts on eulachon recruitment were amply illustrated in the Columbia River population where high larval densities were observed in 2000-2003, followed by lower than average adult returns in 2004, 2005, and 2006 (JCRMS 2007).

Failure to time spawning activity with river conditions conducive to successful fertilization and egg survival, and to the appearance of larval prey species in the oceanic environment also contribute to high rates of environmentally driven egg and larval mortality. The BRT was concerned that there is evidence that climate change is leading to relatively rapid changes in both oceanic and freshwater environmental conditions that eulachon are unable to tolerate. Eulachon are basically a cold-water species and are adapted to feed on a northern suite of copepods in the ocean during the critical transition period from larvae to juvenile and much of their recent recruitment failure may be traced to mortality during this critical period. However, there have been recent shifts in the suite of copepod species available to eulachon that favor a more southerly species assemblage (Mackas et al. 2001, 2007; Hooff and Peterson 2006) and the BRT was concerned that climate change may be contributing to a mismatch between eulachon life history and prey species. It is also likely that pelagic fish with their shorter life cycles may be less resilient to long-term climatic changes than longer-lived demersal species.

However, the ability of the Columbia River eulachon stock to respond rapidly to the good ocean conditions of the late 1999-early 2002 period illustrates the species' resiliency and the BRT viewed this resiliency as providing the species with a buffer against future environmental perturbations. The productivity potential or intrinsic rate of increase of eulachon (Musick et al. 2000) as indicated by life history characteristics such as low age-at-maturity, small body size, and planktonic larvae was recognized by the BRT as likely conferring eulachon with some resilience to extinction as they retain the ability to rapidly respond to favorable ocean conditions. However, the BRT was concerned that there is no empirical or theoretical grounds to conclude that high fecundity as a life history character confers resilience on a fish species in comparison to a species with lower fecundity (Sadovy 2001, Reynolds et al. 2005). Overall, the BRT's risk scores for growth rate and productivity of the DPS ranged from 2 to 5 with a mean score of 3 (see Table 8). Recent ocean conditions in the California Current Province in the Fall of 2007 and Spring-Summer of 2008 were considered favorable for eulachon (see PDO data online at http://jisao.washington.edu/pdo/ and http://www.nwfsc.noaa.gov/research/divisions/fed/oeip/b-latest-updates.cfm) and the BRT postulated that this may indicate elevated eulachon returns may be expected starting with the 2011 run year. However, the BRT was concerned that these changes in the ocean, favorable to eulachon larval survival, may be of short-term duration, similar to the late 1998-early 2002 period.

In terms of threats related to diversity, the BRT was concerned that not only are eulachon semelparous (spawn once and die) but if recent estimates of age structure in eulachon are correct (Clarke et al. 2007) then spawning adults—particularly in southern areas such as the Columbia and Fraser rivers—may be limited to a single age class, which likely increases their vulnerability to perturbations and provides less of a buffer against year-class failure than species such as herring that spawn repeatedly and have variable ages at maturity. The BRT was also concerned about the apparently very low abundance of the Klamath River sub-population, which might be expected to have unique adaptations to conditions at the southernmost extent of the range and about the potential loss of biocomplexity in Fraser River eulachon due to contraction of spawning locations, as documented by Higgins et al. (1987). The BRT noted some positive signs including observations that eulachon continue to display variation in spawn timing, age-at-maturity, and spawning locations, and a high degree of biocomplexity (i.e., many spawning locations and spawn-timing variation) in Columbia River eulachon, which may buffer this stock from freshwater environmental perturbations. Overall, the BRT risk scores for diversity of the DPS ranged from 2 to 3 with a mean score of 2.6 (see Table 8).

The BRT also had concerns about risks related to spatial structure and distribution. In particular, because the major spawning populations within the DPS appear to have declined substantially, the BRT was concerned that if some formerly significant populations, such as the Klamath River, become extirpated, there will be less opportunity for successful recolonization. In addition, the apparent decline of populations in Northern California may result in contraction of the southern portion of the DPS's range. The BRT also noted that several populations that used to support significant First Nations fisheries on the British Columbia coast have declined to very low levels (e.g., Bella Coola River and Wannock River). Positive signs for spatial structure and connectivity noted by the BRT include considerations that eulachon appear to have the potential to re-colonize given their apparent ability to stray from the natal spawning area, at least within rivers sharing the same estuary. In addition, the perceived historical spatial structure of the DPS, with the possible exception of the Klamath River, remains intact. Overall, the BRT scores for spatial structure and connectivity of the DPS ranged from 3 to 5 with a mean score of 3.7 (see Table 8).

The BRT noted several recent events that appear likely to impact eulachon. Global patterns suggest the long-term trend is for a warmer, less productive ocean regime in the California Current and the Transitional Pacific. The recent decline in abundance or relative abundance of eulachon in many systems coupled with the probable disruption of metapopulation structure may make it more difficult for eulachon to adapt to warming ocean conditions. In addition, warming conditions have allowed both Pacific hake (Phillips et al. 2007) and Pacific sardine (*Sardinops sagax*) (Emmett et al. 2005) to expand their distributions to the north, increasing predation on eulachon by Pacific hake and competition for food resources by both species. Recent invasions of Asian copepods into the Columbia River estuary (Cordell et al. 2008) may have a negative influence on the Columbia River population. However, cold ocean conditions in Spring 2008 suggest that this may be a good year for eulachon recruitment. The effects of these recent positive and negative events are difficult to estimate; most members indicated that the net effect is likely to be negative.

"Significant Portion of Its Range" Question

The BRT concluded that the Southern Eulachon DPS is at "moderate risk' of extinction throughout all of its range and in effect answered the question in the affirmative as to "whether the Southern Eulachon DPS is at risk throughout a significant portion of its range."

CITATIONS

ALCAN. 2005. Alcan Primary Metal – British Columbia's Environmental Annual Report 2004. Online at http://www.alcaninbc.com/environmental-reports/2004/pdf-downloads/Alcan_EAR_2004.pdf [accessed July 2008].

ALCAN. 2006. Alcan Primary Metal – British Columbia's Environmental Annual Report 2005. Online at http://www.alcaninbc.com/environmental-reports/2005%20Alcan%20EAR.pdf [accessed July 2008].

ALCAN. 2007. Alcan Primary Metal – British Columbia's Annual Environmental Report 2006. Online at http://www.alcaninbc.com/environmental-reports/2006%20AER%205.1.pdf [accessed July 2008].

Alexander, A. C. 1877. Report of the Inspector of Fisheries for British Columbia, for the year of 1876. Appendix No. 21 in Report of the Commissioner of Fisheries for the year ending 31st December, 1876, p. 339-347. MacLean, Roger & Co., Ottawa, Ontario.

Allen, L. G., M. M. Yoklavich, G. M. Cailliet, and M. H. Horn. 2006. Bays and estuaries. *In* L. G. Allen, D. J. Pondella, and M. H. Horn (eds.), The ecology of marine fishes: California and adjacent waters, p. 119-148. Univ. California Press, Berkeley.

Allen, M. J., and G. B. Smith. 1988. Atlas and zoogeography of common fishes in the Bering Sea and Northeastern Pacific. NOAA Tech. Rep. 66.

Atkinson, D. 1994. Temperature and organism size—a biological law for ectotherms? Adv. Ecol. Res. 25: 1-58.

Avise, J. C., J. Arnold, R. M. Ball, E. Bermingham, T. Lamb, J. E. Neigel, C. A. Reeb, and N. C. Saunders. 1987. Intraspecific phylogeography: the mitochondrial DNA bridge between population genetics and systematics. Annual Rev. Ecol. Syst. 18:489-522.

Bailey, K. M., and E. D. Houde. 1989. Predation on eggs and larvae of marine fishes and the recruitment problem. Adv. Mar. Bio. 25: 1-83.

Barnhart, R. A., M. J. Boyd, and J. E. Pequegnat. 1992. The ecology of Humboldt Bay, California: An estuarine profile. U.S. Fish and Wildlife Service Biological Report No. 1. 121 p.

Barrett, B. M., F. M. Thompson and S. N. Wick. 1984. Adult anadromous investigations: May-October 1983. Alaska Department of Fish and Game, Susitna Hydro Aquatic Studies.

Beacham, T. D, D. E. Hay, and K. D. Le. 2005. Population structure and stock identification of eulachon (*Thaleichthys pacificus*), an anadromous smelt, in the Pacific Northwest. Mar. Biotech. 7:363-372.

Beacham, T. D., J. F. Schweigert, C. MacConnachie, K. D. Le, K. Labaree, and K. M. Miller. 2002. Population structure of herring (*Clupea pallasi*) in British Columbia determined by microsatellites, with comparisons to southeast Alaska and California. Fisheries and Oceans Canada, Canadian Science Advisory Secretariat, Research Document 2002/109. Online at http://www.dfo-mpo.gc.ca/csas/Csas/English/Research_Years/2002/2002_109e.htm [accessed July 2008].

Begg, G. A., J. A. Hare, and D. D. Sheehan. 1999. The role of life history parameters as indicators of stock structure. Fish. Res. 43:141–163.

Berry, M. D., and W. Jacob. 1998. 1997 Eulachon research on the Kingcome and Wannock Rivers – final report. Final report to the Science Council of British Columbia (SCBC #96/97-715). 7 p. Online at http://www.for.gov.bc.ca/hfd/library/FRBC1997/FRBC1997MR206.PDF [accessed July 2008].

Beverton, R. J. H. 1990. Small pelagic fish and the threat of fishing; are they endangered? J. Fish Biol. 37(Suppl. A): 5-16.

Blaylock, R. B., L. Margolis, and J. C. Holmes. 1998. Zoogeography of the parasites of Pacific halibut (*Hippoglossus stenolepis*) in the northeast Pacific. Can. J. Zool. 76:2262–2273.

Boyd, R. T., and Y. P. Hajda. 1987. Seasonal population movement along the lower Columbia river: the social and ecological context. Am. Ethnologist 14: 309-326.

Brennan, B. M. 1936. Forty-second to forty-fifth annual reports of the State Department of Fisheries for the period from, April 1, 1931, to March 31, 1935, fiscal years of 1931 to 1934, inclusive. Olympia, WA, Washington Department of Fisheries.

Briggs, J.C. 1974. Marine zoogeography. McGraw-Hill Book Co., N.Y.

BC Ministry of Sustainable Resource Management. 2002. British Columbia marine ecological classification: marine ecosections and ecounits, Version 2.0. Province of British Columbia, Resources Information Standards Committee, 49 p. Online at http://ilmbwww.gov.bc.ca/risc/pubs/coastal/marine/version%202/bcmec_version_2.pdf [accessed July 2008].

Buchheister, A., and M. T. Wilson. 2005. Shrinkage correction and length conversion equations for *Theragra chalcogramma*, *Mallotus villosus* and *Thaleichthys pacificus*. J. Fish Biol. 67: 541-548.

Burroughs, R. D. 1961. The natural history of the Lewis and Clark expedition. Michigan State Univ. Press, Lansing, MI.

Burrows, B. 2005. Unpublished. Oolichon study on the Wannock and Kilbella rivers March/April, 2005. Wuikinuxv Fisheries Department. Rivers Inlet, British Columbia.

Butler, J., A. DeVogelaere, R. Gustafson, C. Mobley, M. Neuman, D. Richards, S. Rumsey, B. Taylor, and G. VanBlaricom. 2008. Status review report for black abalone (*Haliotis cracherodii* Leach, 1814), DRAFT – 4 January 2008. NOAA Tech. Memo. NMFS-SWR-##. Online at http://swr.nmfs.noaa.gov/media/BASR_Report_Draft_11_January_2008.pdf [accessed July 2008].

Byram, S., and D. G. Lewis. 2001. Ourigan: wealth of the Northwest Coast. Oregon Historical Quarterly 102: 127-157.

CDFG (California Department of Fish and Game). 2008. Letter dated June 13, 2008 to Peter B. Adams, Southwest Fisheries Science Center from Steve Cannata, California Department of Fish and Game. Subject: Eulachon Data Search. 3 p.

Canadian Bureau of Statistics. 1917-1941. Fisheries Statistics of Canada, 1917-1941. Canada-Department of Trade and Commerce, Dominion Bureau of Statistics, Fisheries Statistics Branch. Printer to the King's Most Excellent Majesty, Ottawa.

Carls, M. G., S. W. Johnson, M. R. Lindeberg, A. D. Neff, P. M. Harris, and R. Waples. 2008. Status review of Lynn Canal herring (*Clupea pallasii*). Online at http://www.fakr.noaa.gov/protectedresources/herring/statusrev0308.pdf [accessed July 2008].

Caughley, G. 1994. Directions in conservation biology. J. Anim. Ecol. 63:215-244.

Caughley, G., and A. Gunn. 1996. Conservation biology in theory and practice. Blackwell Science, Cambridge, MA.

Chen, L. 1971. Systematics, variation, distribution, and biology of rockfishes of the subgenus *Sebastomus* (Pisces, Scorpaenidae, *Sebastes*). Bull. Scripps Inst. Oceanogr. Univ. California. 18: 1-107.

Clanton, R. E. 1913. Biennial report of the Department of Fisheries of the State of Oregon to the Twenty-seventh Legislative Assembly, regular session, 1913. Oregon Dept. Fish., Willis S. Duniway, State Printer, Salem, OR.

Clarke, A. D., A. Lewis and K. H. Telmer 2007. Life history and age at maturity of an anadromous smelt, the eulachon *Thaleichthys pacificus* (Richardson). J. Fish Biol. 71:1479-1493.

Cleaver, F. C. 1951. Fisheries statistics of Oregon. Oregon Fish Commission Contribution No. 16. Oregon Fish Commission, Portland, OR.

Codere, H. 1990. Kwakiutl: traditional culture. *In* W. Suttles (ed.), Handbook of North American Indians, Vol. 7, Northwest Coast, p. 359-377. Smithsonian Institution, Washington, DC.

Collins, J. W. 1892. Report on the fisheries of the Pacific Coast of the United States. Rep. U.S. Comm. Fish and Fish. XVI, Appendix 1:3–269.

Collison, H. A. 1941. The oolichan fishery. British Columbia Historical Quarterly 5(1): 25-31.

Cooper, A. B., and M. S. Mangel. 1999. The dangers of undetected metapopulation structure for the conservation of salmonids. Fish. Bull. 97: 213-226.

Cordell, J. R., S. M. Bollens, R. Draheim, and M. Sytsma. 2008. Asian copepods on the move: recent invasions in the Columbia–Snake River system, USA. ICES J. Mar. Sci. 65: 753–758.

Cowlitz Indian Tribe. 2007. Petition to list the Southern Eulachon (*Thaleichthys pacificus*) Distinct Population Segment as threatened or endangered under the federal Endangered Species Act, November 9, 2007. Cowlitz Indian Tribe, Longview, WA. Online at http://www.nwr.noaa.gov/Other-Marine-Species/upload/Smelt_Petition_11_07.pdf [accessed June 2008}.

Crawford, J. 1890. First Report of the State Fish Commissioner. State of Washington. O. C. White, State Printer, Olympia, WA.

Crawford, J. 1892. Third annual report of the State Fish Commissioner of the State of Washington. O. C. White, State Printer, Olympia, WA.

Crawford, J. 1894. Fifth annual report of the State Fish Commissioner of the State of Washington. O. C. White, State Printer, Olympia, WA.

Crawford, J. 1896. Seventh annual report of the State Fish Commissioner of the State of Washington. O. C. White, State Printer, Olympia, WA.

Curtis, E. S. 1915. The North American Indian. Vol. 10. Johnson Reprint Corp., New York.

Dammers, W. 1988. Columbia River smelt commercial harvest, age and larval sampling. Memo from Wolf Dammers to Don McIsaac, Washington Department of Fisheries, dated January 28, 1988.

Darwin, L. H. 1917. Twenty-sixth and twenty-seventh annual reports of State Fish Commissioner to the Governor of the State of Washington April 1, 1915, to March 31, 1917. Wash. Dep. Fish. Game, Olympia, WA.

Darwin, L. H. 1920. Twenty-eighth and twenty-ninth annual reports of State Fish Commissioner to the Governor of the State of Washington April 1, 1917, to March 31, 1919. Wash. Dep. Fish. Game, Olympia, WA.

Darwin, L. H. 1921. Thirtieth and thirty-first annual reports of State Fish Commissioner to the Governor of the State of Washington April 1, 1919, to March 31, 1921. Wash. Dep. Fish. Game, Olympia, WA.

DeLacy, A. C., and B. S. Batts. 1963. Possible population heterogeneity in the Columbia River smelt. Fisheries Research Institute Circular No. 198. College of Fisheries, Univ. of Washington, Seattle, WA.

DFO (Department of Fisheries and Oceans Canada). 2006. Fraser River eulachon (*Thaleichthys pacificus*): 2006 population assessment and harvest recommendations for 2007. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2006/039.

DFO (Department of Fisheries and Oceans Canada). 2007. Fraser River eulachon (*Thaleichthys pacificus*): 2007 population assessment and harvest recommendations for 2008. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2007/048.

DFO (Department of Fisheries and Oceans Canada). 2008a. Eulachon integrated fisheries management plan April 1, 2008 to March 31, 2009. Department of Fisheries and Oceans Canada. Online at http://www-ops2.pac.dfo-mpo.gc.ca/xnet/content/mplans/plans08/2008_IFMP-Eulachon.pdf [accessed June 2008].

DFO (Department of Fisheries and Oceans Canada). 2008b. Shrimp Survey Bulletin 08-02, July 2008. Online at http://www-ops2.pac.dfo-mpo.gc.ca/xnet/content/shellfish/shrimp/Surveys/0802.pdf [accessed June 2008].

Dodimead, A. J., F. Favorite, and T. Hirano. 1963. Salmon of the North Pacific Ocean – Part II. Review of oceanography of the subarctic Pacific region. Int. North Pac. Fish. Comm. Bull. 13.

Duff, W. 1952. The upper Stalo Indians: An introductory ethnography. MA thesis, Univ. Washington, Seattle.

Dulvy, N. K., Y. Sadovy, and J. D. Reynolds. 2003. Extinction vulnerability in marine populations. Fish Fish. 4:25–64.

Dulvy, N. K., J. R. Ellis, N. B. Goodwin, A. Grant, J. D. Reynolds, and S. Jennings. 2004. Methods of assessing extinction risk in marine fishes. Fish Fish. 5:255–276.

EcoMetrix (EcoMetrix Incorporated). 2006. Summary of 2006 eulachon study results and 2007 study design. Report prepared for EUROCAN PULP and PAPER CO., Kitimat, British Columbia.

Ekman, S. 1953. Zoogeography of the sea. Sidgwick and Jackson Ltd., London. 417 p.

Eldridge, M. B., and C. F. Bryan. 1972. Larval fish survey of Humboldt Bay, California. U.S. Department of Commerce Technical Report NMFS SSRF-665.

Emmett R.L., R.D. Brodeur, T. W. Miller, S. S. Pool, G. K. Krutzikowsky, P. J. Bentley, and J. McCrae. 2005. Pacific sardine (*Sardinops sagax*) abundance, distribution, and ecological relationships in the Pacific Northwest. CalCOFI Rep. 46:122–143.

Emmett, R. L., S. A. Hinton, S. L. Stone, and M. E. Monaco. 1991. Distribution and abundance of fishes and invertebates in West Coast Estuaries, Volume II: Species life history summaries. ELMR Report Number 8, Strategic Assessment Branch, NOS/NOAA. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service.

Environment Canada. 2008. A National Ecological Framework for Canada. Online at http://www.ec.gc.ca/soer-ree/English/Framework/default.cfm [accessed July 2008].

EPA (Environmental Protection Agency). 2002. Columbia River Basin fish contaminant survey 1996-1998. EPA 910-R-02-006, Environmental Protection Agency, Region 10, Seattle, WA.

Fiedler, R. H. 1930. Fishery industries of the United States, 1928. Bureau of Fisheries Document No. 1067. Appendix IX (pages 401-625) in Rep. U. S. Commissioner of Fisheries for the fiscal year 1929 with appendixes.

FEMAT (Forest Ecosystem Management Assessment Team). 1993. Forest ecosystem management: An ecological, economic, and social assessment. USDA Forest Service, BLM, USFWS, NOAA, EPA, and National Park Service, Portland, Oregon.

Foley, P. 1997. Extinction models for local populations. *In* I. Hanski and M. E. Gilpin (eds.), Metapopulation biology, p. 215-246. Academic Press, NY.

Franzel, J., and K. A. Nelson. 1981. Stikine River eulachon (*Thaleichthys pacificus*). Petersburg, AK: U.S. Department of Agriculture, Forest Service, Petersburg Ranger District.

Fry, D. H., Jr. 1979. Anadromous fishes of California., Calif. Dept. Fish & Game, Sacramento, CA.

Gilpin, M. E., and M. E. Soule. 1986. Minimum viable populations: process of species extinctions. Pages 19-34 in M. E. Soule (editor), Conservation biology: the science of scarcity and diversity. Sinauer, Sunderland, MA.

Good, T. P., R. S. Waples, and P. Adams (editors). 2005. Updated status of federally listed ESUs of West Coast salmon and steelhead. U.S. Department of Commerce, NOAA Tech. Memo. NMFS-NWFSC-66. Online at http://www.nwfsc.noaa.gov/assets/25/6226_08302005_132955_brttechmemo66final2.pdf [accessed July 2008].

Gotshall, D. W., G. H. Allen, and R. A. Barnhart. 1980. An annotated checklist of fishes from Humboldt Bay, California. Calif. Fish Game 66: 220-232.

Gustafson R. G., W. H. Lenarz, B. B. McCain, C. C. Schmitt, W. S. Grant, T. L. Builder, and R. D. Methot. 2000. Status review of Pacific hake, Pacific cod, and walleye pollock from Puget Sound, Washington. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-44. Online at http://www.nwfsc.noaa.gov/publications/techmemos/tm44/tm44.htm [accessed July 2008].

Gustafson R.G., J. Drake, M.J. Ford, J.M. Myers, E.E. Holmes, and R.S. Waples. 2006. Status review of Cherry Point Pacific herring *(Clupea pallasii)* and updated status review of the Georgia Basin Pacific herring distinct population segment under the Endangered Species Act. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-76. Online at http://www.nwfsc.noaa.gov/assets/25/6539_08072006_141228_HerringTM76Final.pdf [accessed July 2008].

Halpin, M. M., and M. Seguin. 1990. Tsimshian, peoples: Southern Tsimshian, Coast Tsimshian, Nishga, and Gitskan. *In* W. Suttles (ed.), Handbook of North American Indians, Vol. 7, Northwest Coast, p. 267-284. Smithsonian Institution, Washington, DC.

Hamilton, J. B., G. L. Curtis, S. M. Snedaker, and D. K. White. 2005. Distribution of anadromous fishes in the Upper Klamath River watershed prior to hydropower dams - A synthesis of the historical evidence. Fisheries 30(4):10-20.

Hamori-Torok, C. 1990. Haisla. *In* W. Suttles (ed.), Handbook of North American Indians, Vol. 7, Northwest Coast, p. 306-311. Smithsonian Institution, Washington, DC.

Hanski, I. A., and M. E. Gilpin (eds). 1997. Metapopulation biology. Academic Press, San Diego, CA.

Hard, J. J., J. M. Myers, M. J. Ford, R.G. Cope, G. R. Pess, R. S. Waples, G. A. Winans, B. A. Berejikian, F. W. Waknitz, P. B. Adams. P. A. Bisson, D. E. Campton, and R. R. Reisenbichler. 2007. Status review of Puget Sound steelhead *(Oncorhynchus mykiss).* U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-81. Online at http://www.nwfsc.noaa.gov/assets/25/6649_07312007_160715_SRSteelheadTM81Final.pdf [accessed July 2008].

Hare, S. R., N. J. Mantua, and R. C. Francis. 1999. Inverse production regimes: Alaskan and west coast salmon. Fisheries 24: 6-14.

Hart, J. L. 1943. Comparison of eulachon catch statistics for three years. Fish. Res. Bd. Canada, Progress Reports of the Pacific Coast Stations 56:6.

Hart, J. L. 1973. Pacific fishes of Canada. Fisheries Research Board of Canada Bulletin No. 180. 739 p.

Hart, J. L., and J. L. McHugh. 1944. The smelts (Osmeridae) of British Columbia. Fish. Res. Board Can. Bull. No. 64.

Hauser, L., and G. R. Carvalho. 2008. Paradigm shifts in marine fisheries genetics: ugly hypotheses slain by beautiful facts. Fish Fish. 9: 333-362.

Hawthorne, H. B., C. S. Belshaw, and S. M. Jamieson. 1960. The Indians of British Columbia. A study of contemporary social adjustment. Univ. of Toronto Press.

Hay, D. E. 1996. Coastal pelagics—Herring and eulachon. Canadian Technical Report of Fisheries and Aquatic Sciences No. 2108, Proceedings, Marine Ecosystem Monitoring Network—1995 March, Nanaimo, Canada. p. 33-36.

Hay, D. 2002. The eulachon in Northern British Columbia. *In* T. Pitcher, M. Vasconcellos, S. Heymans, C. Brignall, and N. Haggan (eds.), Information supporting past and present ecosystem models of Northern British Columbia and the Newfoundland Shelf, p. 98-107. Fisheries Centre Research Reports, Vol. 10, No. 1, Fisheries Centre, Univ. British Columbia, Vancouver.

Hay, D. 2007. Eulachons-biological review. Presentation at the Feb 2007 Workshop to Determine Research Priorities for Eulachon. Online at http://www.pac.dfo-mpo.gc.ca/sci/herring/hertags/2007eulawkshp_ch.pdf [accessed August 2008].

Hay, D. E., and T. D. Beacham. 2005. Stock identification of eulachon (*Thaleichthys pacificus*), an anadromous smelt in the eastern Pacific. Paper presented at ICES 2005 Annual Science Conference, Aberdeen, Scotland, UK. Online at http://www.ices.dk/products/CMdocs/2005/K/K1405.pdf [accessed March 2008].

Hay, D. E. and P. B. McCarter. 2000. Status of the eulachon *Thaleichthys pacificus* in Canada. Department of Fisheries and Oceans Canada, Canadian Stock Assessment Secretariat, Research Document 2000-145. Ottawa, Ontario. Online at http://www.dfo-mpo.gc.ca/csas/csas/DocREC/2000/PDF/2000_145e.pdf [accessed June 2008].

Hay, D.E., P. B. McCarter, R. Joy, M. Thompson, and K. West. 2002. Fraser River eulachon biomass assessments and spawning distribution: 1995-2002. Canadian Science Advisory Secretariat Research Document 2002/117, 57 p.

Hay, D. E., K. C. West, and A. D. Anderson. 2003. Indicators and 'response' points for management of Fraser River eulachon: a comparison and discussion with recommendations. Canadian Science Advisory Secretariat Research Document 2003/051.

Online at http://www.dfo-mpo.gc.ca/csas/Csas/DocREC/2003/RES2003_051_E.pdf [accessed June 2008].

Hay, D. E., K. West, A. D. Anderson, and D. Rutherford. 2005. Indicators and "response" points for management of Fraser River eulachon: protocols for managing a data-limited fishery. Fisheries Assessment and Management in Data-Limited Situations, Alaska Sea Grant College Program. AK-SG-05-02: 25 p.

Hedgecock, D. 1994. Does variance in reproductive success limit effective population sizes of marine organisms? *In* A.R. Beaumont (ed.), Genetics and Evolution of Aquatic Organisms, p. 122–134. Chapman & Hall, London.

Hedgpeth, J. W. 1957. Marine biogeography. *In* Hedgpeth, J. W. (ed.), Treatise on marine ecology and paleoecology, p. 359-382. Geol. Soc. Am. Mem. 67.

Higgins, P. S., I. K. Birtwell, B. T. Atagi, D. Chilton, M. Gang, G. M. Kruzynski, H. Mahood, G. E. Piercey, B. A. Raymond, I. H. Rogers, and S. Spohn. 1987. Some characteristics of the eulachon (*Thaleichthys pacificus*) captured in the Fraser River estuary, B.C., April 1986. Can. Manuscr. Rep. Fish. Aquat. Sci. 1913.

Hilborn, R., T. P. Quinn, D. E. Schindler, and D. E. Rogers. 2003. Biocomplexity and fisheries sustainability. Proc. Natl. Acad. Sci. 100:6564–6568.

Hilton, S. F. 1990. Haihais, Bella Bella, and Oowekeeno. *In* W. Suttles (ed.), Handbook of North American Indians, Vol. 7, Northwest Coast, p. 312-322. Smithsonian Institution, Washington, DC.

Hinrichsen, R. A. 1998. The ghost run of the Cowlitz. Cowlitz Historical Quarterly 40(2): 5-21.

Hirch, M. 2003. Trading across time and space: Culture along the North American "Grease Trails" from a European perspective. Canadian Studies International Interdisciplinary Conference: Across Time & Space Visions of Canada from Abroad, University College of the Cariboo, Kamloops, Sept 12-14, 2003. Online at http://www.cwis.org/fwdp/pdf/Oolichan%20Paper%20(Mirjam).pdf

Hjort, J. 1914. Fluctuations in the great fisheries of Northern Europe. Cons. Perm. Int. Explor. Mer Rapp. P.-V. Reun. 20: 1-13.

Hochachka, P. W., and G. N. Somero. 2002. Biochemical adaptation: mechanism and process in physiological evolution. Oxford Univ. Press, New York.

Hooff, R. C., and W. T. Peterson. 2006. Copepod biodiversity as an indicator of changes in ocean and climate conditions of the northern California current ecosystem. Limnol. Oceanogr. 51: 2607-2620.

Hubbs, C. L. 1925. A revision of the osmerid fishes of the North Pacific. Proceedings of the Biological Society of Washington 38: 49-56.

Hutchings, J. A. 2000. Collapse and recovery of marine fishes. Nature 406:882–885.

Hutchings, J. A. 2001a. Conservation biology of marine fishes: Perceptions and caveats regarding assignment of extinction risk. Can. J. Fish. Aquat. Sci. 58:108–121.

Hutchings, J. A. 2001b. Influence of population decline, fishing, and spawner variability on the recovery of marine fishes. J. Fish Biol. 59 (Suppl. A):306–322.

Hutchings, J. A., and J. D. Reynolds. 2004. Marine fish population collapses: Consequences for recovery and extinction risk. BioScience 54:297–309.

ICES (International Council for the Exploration of the Seas). 2004. Report of the working group on the application of genetics in fisheries and mariculture. ICES, Copenhagen, ICES CM, No. 2004/F:04.

IUCN (IUCN – The World Conservation Union). 2001. IUCN Red List Categories and Criteria: Version 3.1. IUCN Species Survival Commission. IUCN, Gland, Switzerland, and Cambridge, UK. Online at http://www.iucnredlist.org/info/categories_criteria [accessed July 2008].

IUCN (IUCN – The World Conservation Union). 2006. Guidelines for using the IUCN Red List categories and criteria. Version 6.2. Prepared by the Standards and Petitions Working Group of the IUCN SSC Biodiversity Assessments Sub-Committee in December 2006. Online at http://intranet.iucn.org/webfiles/doc/SSC/RedList/RedListGuidelines.pdf. [accessed July 2008].

Jennings, M. R. 1996. Past occurrence of eulachon, *Thaleichthys pacificus*, in streams tributary to Humboldt Bay, California. Calif. Fish and Game 82(6):147-148.

JCRMS (Joint Columbia River Management Staff). 2005. Joint staff report concerning commercial seasons for sturgeon and smelt in 2006. Oregon Department of Fish and Wildlife and Washington Department of Fish and Wildlife. Online at http://wdfw.wa.gov/fish/crc/dec0605jointstaff.pdf [accessed March 2008].

JCRMS (Joint Columbia River Management Staff). 2006. 2007 joint staff report: stock status and fisheries for sturgeon and smelt. Oregon Department of Fish and Wildlife and Washington Department of Fish and Wildlife. Online at http://wdfw.wa.gov/fish/crc/sturgeon_smelt07.pdf [accessed March 2008].

JCRMS (Joint Columbia River Management Staff). 2007. 2008 joint staff report concerning stock status and fisheries for sturgeon and smelt. Oregon Department of Fish and

Wildlife and Washington Department of Fish and Wildlife. Online at http://wdfw.wa.gov/fish/crc/crc2008_sturgeon_smelt_js_rpt.pdf [accessed March 2008].

Joyce, T. L., M. B. Lambert, and S. Moffitt. 2004. Eulachon subsistence harvest opportunities. Final Report No. FIS02-075-1. USFWS Office of Subsistence Management, Fisheries Resource Monitoring Program, Anchorage, AK.

Kaukinen, K. H., K. J. Supernault, and K. M. Miller. 2004. Development of microsatellite loci in eulachon fish (*Thaleichthys pacificus*). Mol. Ecol. Notes 4:632-634.

Kelson, J. 1996. Kitamaat River 1995 oolichan (*Thaleicthys pacificus*) study. Report prepared by the Kitamaat Village Council for the BC Ministry of Forests. 22p.

Kelson, J. 1997. Kitamaat River 1997 oolichan (*Thaleicthys paclficus*) study Progress Report (May - July, 1997). Final report to the Science Council of British Columbia (SCBC #96/97-025). Online at http://www.for.gov.bc.ca/hfd/library/frbc1997/frbc1997mr215.pdf [accessed July 2008].

Kennedy, D. I. D., and R. T. Bouchard. 1990. Bella Coola. *In* W. Suttles (ed.), Handbook of North American Indians, Vol. 7, Northwest Coast, p. 323-339. Smithsonian Institution, Washington, DC.

Kershaw, T. R. 1902. Thirteenth annual report of the State Fish Commissioner to the Governor of the State of Washington. Metropolitan Press, Seattle.

Kershaw, T. R. 1904. 14th and 15th annual reports of the State Fish Commissioner to the Governor of the State of Washington. Metropolitan Press, Seattle.

Kime, D. E. 1995. The effects of pollution on reproduction in fish. Rev. Fish Biol. Fisheries 5: 52-96.

Krahn, M. M., P. R. Wade, S. T. Kalinowski, M. E. Dahlheim, B. L. Taylor, M. B. Hanson, G. M. Ylitalo, R. P. Angliss, J. E. Stein, and R. S. Waples. 2002. Status review of Southern Resident Killer Whales (*Orcinus orca*) under the Endangered Species Act. U.S. Dept. of Commerce, NOAA Tech. Memo., NMFS-NWFSC-54. Online at http://www.nwfsc.noaa.gov/assets/25/4243_06162004_130449_tm54.pdf [accessed August 2008].

Krause, A. 1885. Die Tlinkit-Indianer. Ergebnisse einer Reise nach der Nordwestküste von Amerika und der Beringstrasse. H. Costenoble, Jena. Transl. by E. Gunther and published in 1956 as The Tlingit Indians: Results of a trip to the northwest coast of America and the Bering Straits. Univ. Washington Press, Seattle.

Kubik, S. W., and R. Wadman. 1977. Inventory and cataloging of sport fish and sport fish waters of the Lower Susitna River and Cook Inlet drainages. Alaska Department of Fish and Game, Sport Fish Division, Federal Aid in Sport Fish Restoration, Annual Performance Report 1976-1977, Project F-9-9(18)G-I-H, Juneau, AK.

Kubik, S. W., and R. Wadman. 1978. Inventory and cataloging of sport fish and sport fish waters of Western Prince William Sound, Lower Susitna and Central Cook Inlet drainages. Alaska Department of Fish and Game, Federal Aid in Fish Restoration, Annual Performance Report, 1977-1978, Project F-9-10(19)G-I-H, Juneau, AK.

Kuhnlein, H. V., A. C. Chan, J. N. Thompson, and S. Nakai. 1982. Ooligan grease: A nutritious fat used by native people of coastal British Columbia. J. Ethnobiology 2: 154-161.

Lande, R. 1993. Risks of population extinction from demographic and environmental stochasticity and random catastrophes. American Naturalist 142:911-927.

Langer, O. E., B. G. Shepherd, and P. R. Vroom. 1977. Biology of the Nass River eulachon (*Thaleichthys pacificus*). Canadian Fisheries and Marine Service Technical Report 77-10, 56 p.

Larson, Z. S., and M. R. Belchik. 1998. A preliminary status review of eulachon and Pacific lamprey in the Klamath River Basin. Yurok Tribal Fisheries Program, Klamath, CA.

Lasker, R. 1975. Field criteria for survival of anchovy larvae: the relation between inshore chlorophyll maximum layers and successful first feeding. Fish. Bull. 73: 453-462.

Lawson, P. W. 1993. Cycles in ocean productiviy, trends in habitat quality, and the restoration of salmon runs in Oregon. Fisheries (Bethesda, MD) 18(8): 6-10.

Lewis, A. F. J. 1997. Skeena eulachon study 1997. Report prepared by Triton Environmental Consultants Ltd., Terrace, BC and the Tsimshian Tribal Council, Prince Rupert, British Columbia for Forest Renewal BC. Final report to the Science Council of British Columbia (SCBC #96/97-123). Online at http://www.for.gov.bc.ca/hfd/library/FRBC1997/FRBC1997MR216.PDF [accessed July 2008].

Lewis, A. F. J., M. D. McGurk, and M. G. Galesloot. 2002. Alcan's Kemano River eulachon (*Thaleichthys pacificus*) monitoring program 1988-1998. Consultant's report prepared by Ecofish Research Ltd. for Alcan Primary Metal Ltd., Kitimat, B.C.

Lindsey, C. C. 1966. Body sizes of poikilotherm vertebrates at different latitudes. Evolution 20: 456-465.

Little, A. C. 1898. Ninth annual report of the State Fish Commissioner to the Governor of the State of Washington. Olympia, WA, Gwin Hicks, State Printer.

Little, A. C. 1901. Tenth and eeleventh annual reports of the State Fish Commissioner to the Governor of the State of Washington. 1899-1900. Olympia, WA, Gwin Hicks, State Printer.

Longhurst, A. R. 2006. Ecological geography of the sea, 2nd edition. Elsevier Academic Press, Amsterdam.

Lord, J. K. 1866. The naturalist in Vancouver Island and British Columbia, Vol. 1. Richard Bentley, London. Republished by Elibron Classics.

Mace, G. M., and E. J. Hudson. 1999. Attitudes toward sustainability and extinction. Cons. Biol. 13:242–246.

MacFie, M. 1865. Vancouver Island and British Columbia. Their history, resources, and prospects. Longman, Green, Longman, Roberts & Green, London.

Mackas, D. L., S. Batten, and M. Trudel. 2007. Effects on zooplankton of a warmer ocean: Recent evidence from the Northeast Pacific. Prog. Oceanogr. 75: 223–252.

Mackas, D.L., R. E. Thomson, and M. Galbraith. 2001. Changes in the zooplankton community of the British Columbia continental margin, 1985-1999, and their covariation with oceanographic conditions. Can. J. Fish. Aquat. Sci. 58: 685-702.

Macnair, P. L. 1971. Descriptive notes on the Kwakiutl manufacture of eulachon oil. Syesis 4: 169-177.

Mantua, N. J., and S. R. Hare. 2002. The Pacific decadal oscillation. J. Oceanogr. 58: 35-44.

Martin, I. 2008. Notes on historical smelt migrations in the Columbia and Cowlitz Rivers, Exhibit AA. Attachment to Letter to Chief NMFS, Protected Resources Division from T. V. Dulcich; Schwabe,Williamson & Wyatt, Attorneys at Law, re. Code No. RIN0648-XF87 - Comment on Request for Information Regarding Proposed Listing of Pacific Eulachon as an Endangered or Threatened Species under the Endangered Species Act, dated 12 May 2008.

Maybury, C. R. 1930. Thirty-eighth and thirty-ninth annual reports of the State Department of Fisheries and Game, Division of Fisheries, for the period from April 1, 1927, to March 31, 1929, fiscal years of 1927 and 1928. Washington Dept. of Fisheries and Game, Jay Thomas, Public Printer, Olympia, WA.

McAllister, D. E. 1963. A revision of the smelt family, Osmeridae. National Museum of Canada, Biological Series 71, Bull. No. 191:1-53.

McCallister, H. C., and R. E. Clanton. 1911. Biennial report of the Department of Fisheries of the State of Oregon to the Twenty-sixth Legislative Assembly 1911. Oregon Department of Fisheries, Willis S. Duniway, State Printer, Salem, OR.

McCarter, P. B., and D. Hay. 2003. Eulachon embryonic egg and larval outdrift sampling manual for ocean and river surveys. Can. Tech. Rept. Fish. Aquat. Sci. 2451. 33 p.

McElhany, P., M. Ruckelshaus, M. Ford, T. Wainwright, and E. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. U. S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-42.

McFarlane, G. A., J. R. King, and R. J. Beamish. 2000. Have there been recent changes in climate? Ask the fish. Progr. Oceanogr. 47: 147-169.

McGuire, H. D. 1896. Third and fourth annual reports of the Fish and Game Protector of the State of Oregon, 1895-1896. W. H. Leeds, State Printer, Salem, OR.

McGuire, H. D. 1898. Fifth and sixth annual reports of the Fish and Game Protector of the State of Oregon, 1897-1898. W. H. Leeds, State Printer, Salem, OR.

McLean, J. E., D. E. Hay, and E. B. Taylor. 1999. Marine population structure in an anadromous fish: Life history influences patterns of mitochondrial DNA variation in the eulachon, *Thaleichthys pacificus*. Mol. Ecol. 8:S143-S158.

McLean, J. E., and E. B. Taylor. 2001. Resolution of population structure in a species with high gene flow: microsatellite variation in the eulachon (Osmeridae: *Thaleichthys pacificus*). Mar. Biol. 139:411-420.

Meffe, G., and R. Carroll. 1994. Principles of conservation biology. Sinauer Associates, Inc., Sunderland, MA.

Middleton, D. A. J., and R. M. Nisbet. 1997. Population persistence time: estimates, models, mechanisms. Ecol. Appl. 7: 107-117.

Miller, B. S., and S. F. Borton. 1980. Geographical distribution of Puget Sound fishes: maps and data source sheets. Volume 1. Family Petromysontidae (Lampreys) through Family Syngnathidae (Pipefishes). Fish. Res. Inst., Univ. Washington, Seattle, WA.

Minckley, W. L., D. A. Hendrickson, and C. E. Bond. 1986. Geography of western North American freshwater fishes: Description and relationship to intracontinental tectonism. *In* C. H. Hocutt and E. O. Wiley (eds.), The zoogeography of North American freshwater fishes, p. 519-613. New York, John Wiley and Sons.

Moffitt, S., B. Marston, and M. Miller. 2002. Summary of eulachon research in the Copper River Delta, 1998-2002. Regional information report no. 2A02-34. Anchorage: Alaska Department of Fish and Game.

Monaco, M. E., R. L. Emmett, S. A. Hinton, and D. M. Nelson. 1990. Distribution and abundance of fishes and invertebrates in West Coast estuaries. Volume I: Data summaries. ELMR Rep. No. 4, Strategic Assessment Branch, NOS/NOAA. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service.

Moody, M. 2007. The Bella Coola eulachon fishery, its importance and its past and current status. Presentation at the Feb 2007 Workshop to Determine Research Priorities for Eulachon. Online at http://www.pac.dfo-mpo.gc.ca/sci/herring/hertags/2007eulawkshp_ch.pdf [accessed August 2008].

Moody, M. F. 2008. Eulachon past and present. Masters thesis, Univ. British Columbia, Vancouver, BC. 292 p. Online at https://circle.ubc.ca/bitstream/2429/676/1/ubc_2008_spring_moody_megan.pdf [accessed July 2008].

Morris, W., D. Doak, M. Groom, P. Kareiva, J. Fieberg, L. Gerber, P. Murphy, and D. Thomson. 1999. A practical handbook for population viability analysis. The Nature Conservancy, Washington D.C.

Moyle, P. B. 2002. Inland Fishes of California. Revised and Expanded. Univ. Calif. Press, Berkeley and Los Angeles, CA.

Moyle, P. B., R. M. Yoshiyama, J. E. Williams, and E. D. Wikramanayake. 1995. Eulachon. *In* Fish species of special concern in California, Second Edition, p. 123-127. California Department of Fish & Game, Inland Fisheries Division, Rancho Cordova, CA.

Musick, J. A. 1999. Criteria to define extinction risk in marine fishes. Fisheries 24:6–14.

Musick, J. A., M. M. Harbin, S. A. Berkeley, G. H. Burgess, A. M. Eklund, L. Findley, R. G. Gilmore, J. T. Golden, D. S. Ha, G. R. Huntsman, J. C. McGovern, G. R. Sedberry, S. J. Parker, S. G. Poss, E. Sala, T. W. Schmidt, H. Weeks, and S. G. Wright. 2000. Marine, estuarine, and diadromous fish stocks at risk of extinction in North America (exclusive of Pacific salmonids). Fisheries 25(11): 6-30.

NMFS (National Marine Fisheries Service). 1999. Endangered and threatened wildlife and plants; 90-day finding for a petition to list Columbia River eulachon (*Thaleichthys pacificus*) as endangered or threatened. Federal Register (Docket No. 991116306-9306-01; 29 November 1999) 64(228):66601–66603.

NMFS (National Marine Fisheries Service). 2000. Endangered and threatened species: Puget Sound populations of Pacific hake, Pacific cod, and walleye pollock. (Docket No. 001103310-0310-01; 24 November 2000) 65(227):70514–70521.

NMFS (National Marine Fisheries Service). 2001. Endangered and threatened species: Puget Sound populations of copper rockfish, quillback rockfish, brown rockfish, and Pacific herring. Federal Register (Docket No. 010312061–1061–01; 3 April 2001) 66(64):17659–17668.

NMFS (National Marine Fisheries Service). 2002. Endangered and threatened wildlife and plants; 12-month finding on a petition to list bocaccio as threatened. Federal Register (19 November 2002) 67(223):69704–69708.

NMFS (National Marine Fisheries Service). 2003. Endangered and threatened species; Final endangered status for a distinct population segment of smalltooth sawfish (*Pristis pectinata*) in the United States. Federal Register (Docket No. 000303059–3034–03; 1 April 2003) 68(62):15674–15680.

NMFS (National Marine Fisheries Service). 2005. Listing endangered and threatened species and designating critical habitat: 12–month finding on petition to list the Cherry Point stock of Pacific herring as an endangered or threatened species. Federal Register Docket No. (040511147–5142–02; I.D. 042804B; 7 June 2005) 70(108):33116–33122.

NMFS (National Marine Fisheries Service). 2008. Listing endangered and threatened species: Notification of finding on a petition to list Pacific eulachon as an endangered or threatened species under the Endangered Species Act. Federal Register (Docket No. 080229343–8368–01; 21 March 2008) 73(49):13185–13189.

NRC (National Research Council). 2004. Endangered and threatened fishes in the Klamath River Basin: Causes of decline and strategies for recovery. Committee on Endangered and Threatened Fishes in the Klamath River Basin, National Research Council. The National Academies Press, Washington, DC.

Nelson, J. S., E. J. Crossman, H. Espinosa-Pérez, L. T. Findley, C. R. Gilbert, R. N. Lea, and J. D. Williams. 2004. Common and scientific names of fishes from the United States, Canada, and Mexico. Sixth edition. American Fisheries Society, Bethesda, MD.

Odemar, M. W. 1964. Southern range extension of the eulachon, *Thaleichthys pacificus*. Calif. Fish Game 50: 305-307.

Olson, W. M., and L. T. Hubbard, Jr. 1984. Fishing: The key to Tlingit culture. *In* B. Gunda (ed.), The Fishing culture of the world: studies in ethnology, cultural ecology, and folklore, Vol. 2, p. 917-938.

Omernik, J. M. 1987. Ecoregions of the conterminous United States. Ann. Assoc. Am. Geographers 77:118–125.

ODFW (Oregon Department of Fish and Wildlife). 2006. The Oregon nearshore strategy. Online at http://www.dfw.state.or.us/MRP/nearshore/strategy/Strategy.pdf [accessed June 2008].

OFC (Oregon Fish Commission). 1970. Pelagic fisheries and coastal rivers investigation. Progress Report - Coastal Rivers Section, July 1, 1966 - June 30, 1967. Fish Commission of Oregon, Research Division.

Ormseth, O. A., and J. Vollenweider. 2007. Appendix 2: Forage fishes in the Gulf of Alaska. *In* Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska, p. 1021-1023. North Pacific Fishery Management Council, Anchorage, AK. Online at http://www.afsc.noaa.gov/REFM/docs/2007/GOAforage.pdf [accessed July 2008].

Parente, W. D., and G. R. Snyder. 1970. A pictorial record of the hatching and early development of the eulachon (*Thaleichthys pacificus*). Northwest Science 44:50-57.

Parliament of Canada. 1900-1916. Annual report on the fisheries of Province of British Columbia (1900-1916). In Sessional Papers of the Dominion of Canada, Canadian Department of Marine Fisheries, Annual Reports of the Inspector of Fisheries for British Columbia,1900-1916.

Parrish, R. H., C. S. Nelson, and A. Bakun. 1981. Transport mechanisms and reproductive success of fishes in the California Current. Biol. Oceanogr. 1: 175-203.

Pearsall, C. E. 1928. Clarence E. Pearsall, Autobiography. *In* C. E. Pearsall (ed.), History and genealogy of the Pearsall family in England and America, p. 1483-1757. H. S. Crocker Co., San Francisco.

Peden, A. E., and D. E. Wilson. 1976. Distribution of intertidal and subtidal fishes of northern British Columbia and southeastern Alaska. Syesis 9:221–248.

Pederson, R. V. K., U. N. Orr, and D. E. Hay. 1995. Distribution and preliminary stock assessment (1993) of the eulachon *Thaleichthys pacificus* in the lower Kitimat River, British Columbia. Can. Manuscr. Rep. Fish. Aquat. Sci. No. 2330. Online at http://www-sci.pac.dfo-mpo.gc.ca/herring/hertags/1995EulaKitimat.pdf [accessed June 2008].

Phillips, A. J., S. Ralston, R. D. Brodeur, T. D. Auth, R. L. Emmett, C. Johnson, and V. G. Wespestad. 2007. Northern shift in the location of spawning and recruitment of Pacific hake (*Merluccius productus*) in the Northern California Current suggest a northward expansion of their spawning area. CalCOFI Rep. 48: 215-229.

Pickard, D., and D.R. Marmorek. 2007. A workshop to determine research priorities for eulachon, workshop report. Prepared by ESSA Technologies Ltd., Vancouver, BC for Fisheries and Oceans Canada. Online at http://www.pac.dfo-mpo.gc.ca/sci/herring/hertags/2007eulawkshp.pdf [accessed August 2008].

Pilling, A. R. 1978. Yurok. *In* R. F. Heizer (ed.), Handbook of North American Indians, Vol. 8, California, p. 137-154. Smithsonian Institution, Washington, DC.

Pollock, C. R. 1925. Thirty-fourth and thirty-fifth annual reports of the State Supervisor of Fisheries for the period from April 1, 1923, to March 31, 1925. Washington Dept. of Fisheries and Game, Jay Thomas, Public Printer, Olympia, WA.

Pollock, C. R. 1928. Thirty-sixth and thirty-seventh annual reports of the State Department of Fisheries and Game, Division of Fisheries, for the period from April 1, 1925, to March 31, 1927. Washington Dept. of Fisheries and Game, Jay Thomas, Public Printer, Olympia, WA.

Pollock, C. R. 1932. Fortieth and forty-first annual reports of the State Department of Fisheries and Game, Division of Fisheries, for the period from April 1, 1929, to March 31, 1931. Washington Dept. of Fisheries and Game, Jay Thomas, Public Printer, Olympia, WA.

Radcliffe, L. 1920. Fishery industries of the United States. Report of the Division of Statistics and Methods of the fisheries for 1918. Appendix X in Report of the United States Commissioner of Fisheries for the fiscal year 1918 with appendixes.

Reed, F. C. 1900. Annual reports of the Department of Fisheries of the State of Oregon to the Legislative Assembly, twenty-first regular session, 1901. Oregon Department of Fisheries, W. H. Leeds, State Printer, Salem, OR.

Reed, F. C., E. P. Thompson, and R. C. Campbell. 1891. Third and fourth annual reports of the State Board of Fish Commissioners to the Governor of Oregon, sixteenth regular session legislative assembly, 1889-1890. F. C. Baker, State Printer, Salem, OR.

Reed, F. C., E. P. Thompson, and G. T. Myers. 1892. Fifth and sixth annual reports of the State Board of Fish Commissioners to the Governor of Oregon, 1891-1892. F. C. Baker, State Printer, Salem, OR.

Reynolds, J. D., N. K. Dulvy, N. B. Goodwin, and J. A. Hutchings. 2005. Biology of extinction risk in marine fishes. Proc. R. Soc. B 272: 2337–2344.

Richardson, J. 1836. *Salmo* (*Mallotus*?) *pacificus* (Richardson) North-west Capelin. *In* Fauna boreali-Americana; or the zoology of the northern parts of British America. Part third, the fish, p. 226-228. R. Bentley, London. (Reprint published 1974-1978 by Arno Press, New York).

Ricker, W. E., D. F. Manzer, and E. A. Neave. 1954. The Fraser River eulachon fishery, 1941-1953. Fisheries Research Board of Canada, Manuscript Report No. 583.

Riseland, J. L. 1907. Sixteenth and seventeenth annual reports of the State Fish Commissioner and Game Warden to the Governor of the State of Washington. C. W. Corham, Public Printer, Olympia, WA.

Riseland, J. L. 1909. Eighteenth and nineteenth annual reports of the State Fish Commissioner and ex-officio Game Warden to the Governor of the State of Washington, 1907-1908. E. L. Boardman, Public Printer, Olympia, WA.

Riseland, J. L. 1911. Twentieth and twenty-first annual reports of the State Fish Commissioner and ex-officio Game Warden to the Governor of the State of Washington 1909-1910. E. L. Boardman, Public Printer, Olympia, WA.

Riseland, J. L. 1913. Twenty-second and twenty-third annual reports of the State Fish Commissioner and ex-officio Game Warden to the Governor of the State of Washington. Department of Fisheries and Game, Frank Lamborn, Public Printer, Olympia, WA.

Rohner, R. P. 1967. The people of the Gilford: A contemporary Kwakiutl village. Natl. Mus. Canada Bull. 225, Anthropol. Ser. No. 83. Ottawa.

Sadovy, Y. 2001. The threat of fishing to highly fecund fishes. J. Fish Biol. 59 (Suppl. A), 90–108.

Schlosser, I. J., and P. L. Angermeier. 1995. Spatial variation in demographic processes of lotic fishes: conceptual models, empirical evidence, and implications for conservation. *In* J. L. Nielsen (ed.), Evolution and the aquatic ecosystem: defining unique units in population conservation, p. 392-401. American Fisheries Society, Symposium 17, Bethesda, MD.

Schultz, L. P., and A. C. DeLacy. 1935. Fishes of the American Northwest. Journal of the Pan-Pacific Research Institute 10: 365-380.

Schweigert, J., B. McCarter, T. Therriault, L. Flostrand, C. Hrabok, P. Winchell, and D. Johannessen. 2007. Ecosystem overview: Pacific North Coast integrated management area (PNCIMA), Appendix H: pelagic fishes. Canadian Technical Report of Fisheries and Aquatic Sciences 2667. Online at http://www.dfo-mpo.gc.ca/library/328842%20Appendix%20H.pdf [accessed August 2008].

Scott, W. B., and E. J. Crossman. 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada Bulletin No. 184.

Sette, O. E. 1926. Fishery industries of the United States. Bureau of Fisheries Document No. 997. Appendix VII (pages 209-408) in Rep. U. S. Commissioner of Fisheries for the fiscal year 1925 and appendixes.

Sette, O. E. 1928. Fishery industries of the United States, 1926. Bureau of Fisheries Document No. 1025. Pages 337-483 in Rep. U. S. Commissioner of Fisheries for the fiscal year 1927 with appendixes.

Sette, O. E., and R. H. Fiedler. 1929. Fishery industries of the United States, 1927. Bureau of Fisheries Document No. 1050. Pages 401-547 in Rep. U. S. Commissioner of Fisheries for the fiscal year 1928 with appendixes.

Shaffer, J. A., D. Penttila, M. McHenry, and D. Vilella. 2007. Observations of eulachon, *Thaleichthys pacificus*, in the Elwha River, Olympic Peninsula Washington. Northwest Science 81: 76-81.

Shepherd, J. G., J. G. Pope, and R. D. Cousens. 1984. Variations in fish stocks and hypotheses concerning their links with climate. Cons. Perm. Int. Explor. Mer Rapp. P.-V. Reun. 185: 255-267.

Sinclair, M., and M. J. Tremblay. 1984. Timing of spawning of Atlantic herring (*Clupea harengus harengus*) populations and the match-mismatch theory. Can. J. Fish. Aquat. Sci. 41: 1055-1065.

Small, M., J. Loxterman, A. Frye, J. Von Bargen, C. Bowman, and S. Young. 2005. Temporal and spatial genetic structure among some Pacific herring population in Puget Sound and the southern Strait of Georgia. Trans. Am. Fish. Soc. 134:1329–1341.

Smedbol, R., and R. Stephenson. 2001. The importance of managing within-species diversity in cod and herring fisheries of the north-western Atlantic. J. Fish Biol. 59(Suppl. A): 109–128.

Smith, R. T. 1941. Notes on 1941 Nemah River smelt run. Typewritten manuscript.

Smith, W. E., and R. W. Saalfeld. 1955. Studies on Columbia River smelt *Thaleichthys pacificus* (Richardson). Washington Department of Fisheries, Fisheries Research Paper 1(3): 3-26.

Smith, W. E., R. W. Saalfeld, E. H. LeMier, J. M. Smith, E. L. Preston, and C. O. Junge. 1953. 1953 smelt investigations, January through April, 1953. *In* Columbia River Progress Report, January through April 1953, p. 3-15. State of Washington, Department of Fisheries, Olympia, WA.

Spangler, E. A. K. 2002. The ecology of eulachon (*Thaleichthys pacificus*) in Twentymile River, Alaska. M.S. Thesis. University of Alaska, Fairbanks.

Spangler, E., R. Spangler, and B. Norcross. 2003. Eulachon subsistence use and ecology investigations of Cook Inlet, 2000-2002. Fisheries Resource Monitoring Program, Final Report 00-041, U.S. Fish and Wildlife Service, Office of Subsistence Management, Anchorage, AK.

Stables, T. B., C. J. Perrin, and M. L. Rosenau. 2005. Acoustic and trawl surveys to locate eulachon aggregations in the lower Fraser River, British Columbia. N. Am. J. Fish. Management 25: 675-688.

Stacey, D. A. 1995. Eulachon an historical overview. Common Resources Fishery Research, Report prepared for Department of Fisheries and Oceans Canada. 75 p.

Stewart, F. L. 1975. The seasonal availability of fish species used by the coast Tsimshians of northern British Columbia. Syesis 8: 375-388.

Stewart, H. 1977. Indian fishing: Early methods on the northwest coast. University of Washington Press, Seattle.

Stoffels, D. 2001. Background report: eulachon in the north. Online at Coasthttp://www.livinglandscapes.bc.ca/northwest/eulachon/resources/NCeulachon.pdf [accessed May 2008].

Stout, H. A., R. G. Gustafson, W. H. Lenarz, B. B. McCain, D. M. Van Doornik, T. L. Builder, and R. D. Methot. 2001a. Status review of Pacific herring in Puget Sound, Washington. U.S. Dept. Commer., NOAA Tech Memo. NMFS-NWFSC-45. Online at http://www.nwfsc.noaa.gov/publications/techmemos/tm45/tm45.htm [accessed July 2008].

Stout, H. A., B. B. McCain, R. D. Vetter, T. L. Builder, W. H. Lenarz, L. L. Johnson, and R. D. Methot. 2001b. Status review of copper rockfish, quillback rockfish, and brown rockfish in Puget Sound, Washington. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-46. Online at http://www.nwfsc.noaa.gov/publications/techmemos/tm46/tm46.htm [accessed May 2008].

Suckley, G. 1860. Report on the fishes collected on the survey. Chapter I. Report upon the Salmonidae. *In* Reports of explorations and surveys, to ascertain the most practicable and economical route for a railroad from the Mississippi River to the Pacific Ocean, Pacific Railroad Rep. 12 (Pt. III), No. 5:307–368.

Sutherland, R. 2001. Oolichan fishery of northern British Columbia. British Columbia Historical News 34: 8-13.

Swan, J. G. 1881. The euchalon or candle-fish of the Northwest coast. Proc. U.S. Nat. Mus. (1880) 3: 257-264.

Sweetnam, D. A., R. D. Baxter, and P. B. Moyle. 2001. True smelts. *In* W. S. Leet, C. M. Dewees, R. Klingbeil and E. J. Larson (eds.), California's living marine resources: A status report, p. 472-479. Calif. Dept. Fish and Game, Sacramento.

Therriault T. W., and P. B. McCarter. 2005. Using an eulachon indicator framework to provide advice on Fraser River harvest opportunities for 2006. Canadian Science Advisory Secretariat Research Document 2005/077, 15 p.

Thomson, R. E. 1981. Oceanography of the British Columbia coast. Can. Spec. Publ. Fish. Aquat. Sci. 56.

Thompson, G. G. 1991. Determining minimum viable populations under the Endangered Species Act. NOAA Tech. Memo. NMFS F/NWC-198, 78 p.

Tilman, D., and C. L. Lehman. 1997. Habitat destruction and species extinctions. *In* D. Tilman and P. Kareiva (eds.), Spatial ecology: the role of space in population dynamics and interspecific interactions, p. 233-249. Princeton Univ. Press, NJ.

Trihey and Associates. 1996. Instream flow requirements for Tribal Trust Species in the Klamath River. Prepared for the Yurok Tribe, Eureka, CA by Trihey and Associates, Inc., Concord, CA. 43 p.

USFWS-NMFS (United States Fish and Wildlife Service, and National Marine Fisheries Service). 1996. Policy regarding the recognition of distinct vertebrate population segments under the Endangered Species Act. Federal Register (7 February 1996) 61(26):4722-4725.

Valentine, J.W. 1966. Numerical analysis of marine molluscan ranges on the extratropical northeastern Pacific shelf. Limnol. Oceanogr. 11:198-211.

Van Dusen, H. G. 1903. Annual reports of the Department of Fisheries of the State of Oregon to the Legislative Assembly, twenty-second regular session, 1903. Oregon Department of Fisheries, W. H. Leeds, State Printer, Salem, OR.

Van Dusen, H. G. 1904. Annual reports of the Department of Fisheries of the State of Oregon for the years 1903 and 1904 to the twenty-third Legislative Assembly (regular session), 1905. Oregon Department of Fisheries, J. R. Whitney, State Printer, Salem, OR.

Van Dusen, H. G. 1907. Annual reports of the Department of Fisheries of the State of Oregon to the Legislative Assembly, twenty-fourth regular session, 1909. Oregon Department of Fisheries, Willis S. Duniway, State Printer, Salem, OR.

Van Dusen, H. G., and H. C. McCallister. 1908. Annual reports of the Department of Fisheries of the State of Oregon for the years 1907-1908 to the twenty-fifth Legislative Assembly, regular session, 1909. Oregon Department of Fisheries, Willis S. Duniway, State Printer, Salem, OR.

Vincik, R. F., and R. G. Titus. 2007. Occurrence of a eulachon, *Thaleichthys pacificus*, in the Lower Sacramento River, California. Cal. Fish Game 93: 161-165.

Wainwright, T. C. and R. G. Kope. 1999. Short Communication: Methods of extinction risk assessment developed for U.S. West Coast salmon. ICES J. Mar. Sci. 56:444-448.

Ware, D. M., and G. A. McFarlane. 1989. Fisheries production domains in the northeast Pacific Ocean. *In* R. J. Beamish, and G. A. McFarlane (eds.), Effects of ocean variability on recruitment and an evaluation of parameters used in stock assessment models. Can. Spec. Publ. Fish. Aquat. Sci. 108: 359-379.

WDFW (Washington Department of Fish and Wildlife). 2008. Columbia/Cowlitz smelt updates March 19, 2008. Online at http://wdfw.wa.gov/fish/creel/smelt/2008/mar1908.htm [accessed March 2008].

WDFW (Washington Department of Fish and Wildlife) and ODFW (Oregon Department of Fish and Wildlife). 2001. Washington and Oregon eulachon management plan. Washington Department of Fish and Wildlife and Oregon Department of Fish and Wildlife. Online at http://wdfw.wa.gov/fish/creel/smelt/wa-ore_eulachonmgmt.pdf [accessed June 2008].

WDFW (Washington Department of Fish and Wildlife) and ODFW (Oregon Department of Fish and Wildlife). 2002. Status report Columbia River fish runs and fisheries 1938-2000. Washington Department of Fish and Wildlife and Oregon Department of Fish and Wildlife.

WDFW (Washington Department of Fish and Wildlife) and ODFW (Oregon Department of Fish and Wildlife). 2008. Summary of Questions and Requested Information.

Wilcox, W. A. 1898. Notes on the fisheries of the Pacific coast in 1895. Rep. U.S. Comm. Fish and Fisheries for the year ending June 30, 1896. XXII:575–659.

Wilcox, W. A. 1907. The commercial fisheries of the Pacific coast states in 1904. Bur. Fish. Doc. No. 612. *In* Rep. of the Comm. Fish for the fiscal year 1905 and special papers.

Willoughby, C. 1889. Indians of the Quinaielt Agency, Washington Territory. Annual Report of the Smithsonian Institution, year ending June 30, 1886. Part 1, p. 267-282.

Willson, M. F., R. H. Armstrong, M. C. Hermans, and K Koski. 2006. Eulachon: a review of biology and an annotated bibliography. Alaska Fisheries Science Center Processed Report 2006-12. Auke Bay Laboratory, Alaska Fish. Sci. Cent., NOAA, Natl. Mar, Fish. Serv., Juneau, AK. Online at http://www.afsc.noaa.gov/publications/ProcRpt/PR%202006-12.pdf [accessed March 2008].

Womble, J. N. 2003. Seasonal distribution of Steller sea lions (*Eumetopias jubatus*) in relation to high-quality ephemeral prey species in southeastern Alaska. Master's thesis, Univ. Alaska, Fairbanks.

Wood, C. C., J. W. Bickham, J. Nelson, C. J. Foote, and J. C. Patton. 2008. Recurrent evolution of life history ecotypes in sockeye salmon: implications for conservation and future evolution. Evolutionary Applications 1: 207–221.

Wright, S. 1999. Petition to list eulachon *Thaleichthys pacificus* as threatened or endangered under the Endangered Species Act. Online at http://www.nwr.noaa.gov/Other-Marine-Species/upload/Smelt_Petition_7_99.pdf [accessed June 2008].

Young, J. S. 1984. Identification of larval smelt (Osteichthyes: Salmoniformes: Osmeridae) from northern California. M.S. Thesis, Humboldt State Univ., Arcata, CA.

TABLES

Table 1. Worksheet for evaluating potential DPS(s) of eulachon (*Thaleichthys pacificus*) that incorporate spawning populations in California, Oregon, and Washington using the "likelihood point" method (FEMAT 1993).

	1) Entire species (no DPS structure)	2) One DPS south of Yakutat Forelands	3) One DPS south of Nass River / Dixon Entrance	4) One DPS - Fraser River and south	5) One DPS south of Fraser River	6) Multiple DPSs in WA, OR, and CA
Number of likelihood points[1]	11		51	24		4
Percentage of total likelihood points[2]	12.2%		56.7%	26.7%		4.4%

1 - Each Biological Review Team member distributes ten likelihood points among the six DPS scenarios. Placement of all ten points in a given scenario reflects 100% certainty that this is the DPS configuration that incorporates eulachon from Washington, Oregon, and California. Distributing points between scenarios reflects uncertainty in whether a given scenario reflects the true DPS delineation.
2 – Nine of ten BRT members in attendance.

Table 2. Eulachon (aka Columbia River smelt) landings (pounds) from the Columbia River and tributary commercial fisheries.

Year	Columbia River	Grays River	Cowlitz River	Kalama River	Lewis River	Sandy River	Oregon only	Washington only	Total	Source
1888							150,000		150,000	Collins (1892, p. 231)
1889							60,000[1]		60,000	Reed et al. (1891, p. 39)
1890								1,000	1,000	Crawford (1890, p. 8)
1891							150,000[1]		150,000	Reed et al. (1892, p. 9)
1892							125,000[1]	500,000	625,000	Reed et al. (1892, p. 42); Crawford (1892, p. 9-10
1893									present	
1894								300,000[2]	300,000	Crawford (1894, p. 5)
1895	31,125		20,625		230,500				282,250	Wilcox (1898, p. 604, p. 607, p. 629)
1896							338,675	338,675	677,350	McGuire (1896, p. 77); Crawford (1896, p. 9)
1897							677,480[1]	344,000	1,021,480	McGuire (1898, p. 35); Little (1898, p. 88)
1898							450,000[1]	287,000	737,000	McGuire (1898, p. 118); Little (1898, p. 15)
1899							280,500[1]	280,420	560,920	Reed (1900, p. 19); Little (1901, p. 72)
1900							260,200[1]	227,400	487,600	Reed (1900, p. 69); Little (1901, p. 82)
1901							265,380[1]		265,380	Van Dusen (1903, p. 52)
1902							122,454[1]	450,000	572,454	Van Dusen (1903, p. 135); Kershaw (1902, p. 82)
1903							102,000[1]	300,000	402,000	Van Dusen (1904, p. 69); Kershaw (1904, p. 81)
1904							15,138	425,322	440,460	Wilcox (1907, p. 33-34, p. 45)
1905							143,015[1]	340,000	483,015	Van Dusen (1907, p. 111); Riseland (1907, p. 81)

Year	Columbia River	Grays River	Cowlitz River	Kalama River	Lewis River	Sandy River	Oregon only	Washington only	Total	Source
1906							163,000[1]	340,000	503,000	Van Dusen (1907, p. 190); Riseland (1907, p. 56)
1907							169,804[1]		169,804	Van Dusen and McCallister (1908, p. 110)
1908							262,022[1]	340,000	602,022	Van Dusen and McCallister (1908, p. 150); Riseland (1909, p. 25)
1909							209,608[1]	340,000	549,608	McCallister and Clanton (1911, p. 36); Riseland (1909, p. 37)
1910							272,478[1]	350,000	622,478	McCallister and Clanton (1911, p. 44); Riseland (1911, p. 46)
1911							174,639[1]	175,000	349,639	Clanton (1913, p. 112); Riseland (1911, p. 58)
1912							320,336[1]	175,000	495,336	Clanton (1913, p. 112); Riseland (1913, p. 48)
1913								200,000	200,000	Riseland (1913, p. 63)
1914									present	
1915			1,609,500						1,609,500	Radcliffe (1920, p. 64-65)
1916								641,595		Darwin (1917, p. 103)
1917								2,806,129	2,806,129	Darwin (1917, p. 173)
1918								1,633,700	1,633,700	Darwin (1920, p. 64)
1919								2,405,360	2,405,360	Darwin (1920, p. 121)
1920								977,084	977,084	Darwin (1921, p. 162)
1921								1,051,283	1,051,283	Darwin (1921, p. 236)
1922							215,000	1,156,180	1,371,180	Sette (1926, p. 306); Brennan (1936, p.100)
1923							277,195	752,223	1,029,418	Sette (1926, p .346-347) ; Brennan (1936, p. 100)
1924							226,800	779,422	1,006,222	Sette (1928, p. 409); Pollock (1925, p. 44)

Year	Columbia River	Grays River	Cowlitz River	Kalama River	Lewis River	Sandy River	Oregon only	Washington only	Total	Source
1925							308,676	1,092,028	1,400,704	Sette (1928, p. 445); (Pollock 1925, p. 97)
1926							72,900	1,194,314	1,267,214	Sette and Fiedler (1929, p. 514); (Pollock 1928, p. 104)
1927							411,732	881,314	1,293,046	Fiedler (1930, p. 570); (Pollock 1928, p. 168)
1928							19,148	1,149,670	1,168,818	Maybury (1930, p. 33); (Cleaver 1951, p. 80)
1929							50,061	1,158,419	1,208,480	Maybury (1930, p. 84); (Cleaver 1951, p. 80)
1930							194,172	1,260,314	1,454,486	Pollock (1932, p. 14, 49); Cleaver (1951, p. 80)
1931							435,306	1,521,966	1,957,272	Pollock (1932, p. 14, 103); Cleaver (1951, p. 80)
1932							233,993	1,349,955	1,583,948	Brennan (1936, p.100); Cleaver (1951, p. 80)
1933							520,418	872,172	1,392,590	Brennan (1936, p.100); Cleaver (1951, p. 80)
1934							563,036	957,120	1,520,156	Brennan (1936, p.100); Cleaver (1951, p. 80)
1935							132,773	2,199,185	2,331,958	Brennan (1936, p.100); Cleaver (1951, p. 80)
1936	194,705	27,200	2,583,525	0	144,325	134,102			3,083,857	Cleaver (1951, p. 154)
1937	432,063	7,350	1,999,030	0	0	0			2,438,443	Cleaver (1951, p. 154)
1938	866,700	2,100	33,100	76,600	63,100	0			1,041,600	WDFW and ODFW (2002)
1939	721,600	35,700	996,400	0	1,342,700	0			3,096,400	WDFW and ODFW (2002)
1940	820,200	53,700	736,800	3,000	1,341,300	127,500			3,082,500	WDFW and ODFW (2002)
1941	193,200	0	1,793,000	0	377,000	168,600			2,531,800	WDFW and ODFW (2002)
1942	318,600	51,800	1,555,300	0	0	760,300			2,686,000	WDFW and ODFW (2002)
1943	643,000	3,700	2,972,500	0	273,200	84,900			3,977,300	WDFW and ODFW (2002)
1944	572,700	10,900	1,126,400	44,300	514,200	0			2,268,500	WDFW and ODFW (2002)

Year	Columbia River	Grays River	Cowlitz River	Kalama River	Lewis River	Sandy River	Oregon only	Washington only	Total	Source
1945	633,300	59,200	2,048,400	32,500	1,552,800	1,393,100			5,719,300	WDFW and ODFW (2002)
1946	253,200	300	2,674,000	0	0	348,500			3,276,000	WDFW and ODFW (2002)
1947	352,300	0	1,192,600	0	0	0			1,544,900	WDFW and ODFW (2002)
1948	1,015,800	0	2,197,800	0	547,600	212,900			3,974,100	WDFW and ODFW (2002)
1949	919,100	300	800	0	1,940,900	472,500			3,333,600	WDFW and ODFW (2002)
1950	912,700	11,600	0	1,000	557,200	0			1,482,500	WDFW and ODFW (2002)
1951	1,337,600	0	0	0	0	179,300			1,516,900	WDFW and ODFW (2002)
1952	867,100	0	380,600	17,800	8,100	1,300			1,274,900	WDFW and ODFW (2002)
1953	439,300	15,600	795,400	2,800	0	457,900			1,711,000	WDFW and ODFW (2002)
1954	673,900	0	792,900	16,200	360,900	40,400			1,884,300	WDFW and ODFW (2002)
1955	887,500	0	1,349,600	0	0	0			2,237,100	WDFW and ODFW (2002)
1956	877,400	0	575,100	32,600	0	198,800			1,683,900	WDFW and ODFW (2002)
1957	377,500	2,200	987,800	0	0	211,500			1,579,000	WDFW and ODFW (2002)
1958	373,300	0	2,243,100	0	0	0			2,616,400	WDFW and ODFW (2002)
1959	760,000	0	62,300	44,100	889,700	0			1,756,100	WDFW and ODFW (2002)
1960	185,700	700	985,800	0	0	0			1,172,200	WDFW and ODFW (2002)
1961	466,400	0	585,900	0	0	0			1,052,300	WDFW and ODFW (2002)
1962	690,300	0	783,300	0	0	0			1,473,600	WDFW and ODFW (2002)
1963	222,300	21,300	833,500	0	0	0			1,077,100	WDFW and ODFW (2002)
1964	452,900	0	388,900	0	0	0			841,800	WDFW and ODFW (2002)
1965	828,700	0	0	0	82,000	0			910,700	WDFW and ODFW (2002)
1966	712,200	0	316,100	0	0	0			1,028,300	WDFW and ODFW (2002)

Year	Columbia River	Grays River	Cowlitz River	Kalama River	Lewis River	Sandy River	Oregon only	Washington only	Total	Source
1967	357,100	23,200	620,500	0	0	0			1,000,800	WDFW and ODFW (2002)
1968	133,300	1,200	813,000	0	0	0			947,500	WDFW and ODFW (2002)
1969	113,700	52,800	917,200	0	0	0			1,083,700	WDFW and ODFW (2002)
1970	238,200	4,500	559,700	55,900	325,600	0			1,183,900	WDFW and ODFW (2002)
1971	364,500	0	509,400	0	902,800	0			1,776,700	WDFW and ODFW (2002)
1972	304,100	0	1,339,400	0	0	0			1,643,500	WDFW and ODFW (2002)
1973	132,000	0	2,302,400	0	0	0			2,434,400	WDFW and ODFW (2002)
1974	868,400	6,200	1,474,700	0	500	12,000			2,361,800	WDFW and ODFW (2002)
1975	28,300	0	2,049,300	0	0	0			2,077,600	WDFW and ODFW (2002)
1976	9,400	0	3,055,300	0	0	10,400			3,075,100	WDFW and ODFW (2002)
1977	662,700	0	0	326,200	0	764,100			1,753,000	WDFW and ODFW (2002)
1978	16,600	0	2,642,700	0	21,000	0			2,680,300	WDFW and ODFW (2002)
1979	313,600	0	18,200	0	233,300	591,600			1,156,700	WDFW and ODFW (2002)
1980	160,100	8,800	116,500	700	2,651,600	273,800			3,211,500	WDFW and ODFW (2002)
1981	158,200	0	932,500	0	567,100	14,500			1,672,300	WDFW and ODFW (2002)
1982	304,200	0	1,343,200	8,200	554,400	0			2,210,000	WDFW and ODFW (2002)
1983	58,700	0	1,307,300	0	1,364,400	0			2,730,400	WDFW and ODFW (2002)
1984	120,400	0	377,600	0	0	0			498,000	WDFW and ODFW (2002)
1985	537,800	34,900	1,160,800	0	0	304,500			2,038,000	WDFW and ODFW (2002)
1986	53,000	0	3,736,100	0	49,700	0			3,838,800	WDFW and ODFW (2002)
1987	73,600	0	1,321,000	700	500,400	0			1,895,700	WDFW and ODFW (2002)
1988	72,800	0	2,244,300	0	549,600	1,000			2,867,700	WDFW and ODFW (2002)

Year	Columbia River	Grays River	Cowlitz River	Kalama River	Lewis River	Sandy River	Oregon only	Washington only	Total	Source
1989	65,200	0	3,001,600	0	0	0			3,066,800	WDFW and ODFW (2002)
1990	6,400	0	2,756,200	0	21,600	0			2,784,200	JCRMS (2007)
1991	5,800	0	2,944,600	0	0	0			2,950,400	JCRMS (2007)
1992	800	0	3,673,000	0	0	0			3,673,800	JCRMS (2007)
1993	33,200	0	413,900	66,800	0	0			513,900	JCRMS (2007)
1994	200	0	43,200	0	0	0			43,400	JCRMS (2007)
1995	7,700	0	431,400	900	0	0			440,000	JCRMS (2007)
1996	7,100	0	2,000	0	0	0			9,100	JCRMS (2007)
1997	37,100	0	21,500	0	0	0			58,600	JCRMS (2007)
1998	11,900	0	200	0	0	0			12,100	JCRMS (2007)
1999	20,900	0	0	0	0	0			20,900	JCRMS (2007)
2000	31,000	0	0	0	0	0			31,000	JCRMS (2007)
2001	158,800	0	154,300	0	0	0			313,100	JCRMS (2007)
2002	58,000	0	169,600	0	493,600	0			721,200	JCRMS (2007)
2003	66,900	0	464,400	0	529,100	23,000			1,083,400	JCRMS (2007)
2004	15,400		216,200						231,600	JCRMS (2007)
2005	100		100						200	JCRMS (2007)
2006	13,100		0						13,100	JCRMS (2007)
2007	7,100		1,200						8,300	JCRMS (2007)
2008	11,041		5,900						16,941	WDFW (2008)

1 – Some Oregon commercial smelt catch values may be statewide smelt catch and may include an unknown number of non-eulachon smelt caught in coastal streams.
2 – Crawford (1894, p. 5) reported landings that equated to a monetary value of $3,000. At an average of one cent per pound this equates to approximately 300,000 pounds of eulachon.

Table 3. Eulachon landings (pounds) from the Columbia River and tributary commercial fishery and total numbers of fish in the catch, assuming a range of 10.8 to 12.3 eulachon to the pound, based on the mean reported weight of eulachon in the Columbia River of 37 to 42 g. Landings data from sources listed in Table 2.

Year	Total landings (pounds)	Number of fish at 10.8 per pound	Number of fish at 12.3 per pound
1888	150,000	1,620,000	1,845,000
1889	60,000	648,000	738,000
1890	1,000	10,800	12,300
1891	150,000	1,620,000	1,845,000
1892	625,000	6,750,000	7,687,500
1893	unknown	--	--
1894	300,000	3,240,000	3,690,000
1895	313,375	3,384,450	3,854,513
1896	677,350	7,315,380	8,331,405
1897	1,021,480	11,031,984	12,564,204
1898	737,000	7,959,600	9,065,100
1899	560,920	6,057,936	6,899,316
1900	487,600	5,266,080	5,997,480
1901	265,380	2,866,104	3,264,174
1902	572,454	6,182,503	7,041,184
1903	402,000	4,341,600	4,944,600
1904	440,460	4,756,968	5,417,658
1905	483,015	5,216,562	5,941,085
1906	503,000	5,432,400	6,186,900
1907	169,804	1,833,883	2,088,589
1908	602,022	6,501,838	7,404,871
1909	549,608	5,935,766	6,760,178
1910	622,478	6,722,762	7,656,479
1911	349,639	3,776,101	4,300,560
1912	495,336	5,349,629	6,092,633
1913	200,000	2,160,000	2,460,000
1914	unknown	--	--
1915	1,609,500	17,382,600	19,796,850
1916	641,595	6,929,226	7,891,619
1917	2,806,129	30,306,193	34,515,387
1918	1,633,700	17,643,960	20,094,510
1919	2,405,360	25,977,888	29,585,928
1920	977,084	10,552,507	12,018,133
1921	1,051,283	11,353,856	12,930,781
1922	1,371,180	14,808,744	16,865,514
1923	1,029,418	11,117,714	12,661,841
1924	1,006,222	10,867,198	12,376,531
1925	1,400,704	15,127,603	17,228,659
1926	1,267,214	13,685,911	15,586,732
1927	1,293,046	13,964,897	15,904,466

Year	Total landings (pounds)	Number of fish at 10.8 per pound	Number of fish at 12.3 per pound
1928	1,168,818	12,623,234	14,376,461
1929	1,208,480	13,051,584	14,864,304
1930	1,454,486	15,708,449	17,890,178
1931	1,957,272	21,138,538	24,074,446
1932	1,583,948	17,106,638	19,482,560
1933	1,392,590	15,039,972	17,128,857
1934	1,520,156	16,417,685	18,697,919
1935	2,331,958	25,185,146	28,683,083
1936	3,083,857	33,305,656	37,931,441
1937	2,438,443	26,335,184	29,992,849
1938	1,041,600	11,249,280	12,811,680
1939	3,096,400	33,441,120	38,085,720
1940	3,082,500	33,291,000	37,914,750
1941	2,531,800	27,343,440	31,141,140
1942	2,686,000	29,008,800	33,037,800
1943	3,977,300	42,954,840	48,920,790
1944	2,268,500	24,499,800	27,902,550
1945	5,719,300	61,768,440	70,347,390
1946	3,276,000	35,380,800	40,294,800
1947	1,544,900	16,684,920	19,002,270
1948	3,974,100	42,920,280	48,881,430
1949	3,333,600	36,002,880	41,003,280
1950	1,482,500	16,011,000	18,234,750
1951	1,516,900	16,382,520	18,657,870
1952	1,274,900	13,768,920	15,681,270
1953	1,711,000	18,478,800	21,045,300
1954	1,884,300	20,350,440	23,176,890
1955	2,237,100	24,160,680	27,516,330
1956	1,683,900	18,186,120	20,711,970
1957	1,579,000	17,053,200	19,421,700
1958	2,616,400	28,257,120	32,181,720
1959	1,756,100	18,965,880	21,600,030
1960	1,172,200	12,659,760	14,418,060
1961	1,052,300	11,364,840	12,943,290
1962	1,473,600	15,914,880	18,125,280
1963	1,077,100	11,632,680	13,248,330
1964	841,800	9,091,440	10,354,140
1965	910,700	9,835,560	11,201,610
1966	1,028,300	11,105,640	12,648,090
1967	1,000,800	10,808,640	12,309,840
1968	947,500	10,233,000	11,654,250
1969	1,083,700	11,703,960	13,329,510
1970	1,183,900	12,786,120	14,561,970
1971	1,776,700	19,188,360	21,853,410
1972	1,643,500	17,749,800	20,215,050
1973	2,434,400	26,291,520	29,943,120

Year	Total landings (pounds)	Number of fish at 10.8 per pound	Number of fish at 12.3 per pound
1974	2,361,800	25,507,440	29,050,140
1975	2,077,600	22,438,080	25,554,480
1976	3,075,100	33,211,080	37,823,730
1977	1,753,000	18,932,400	21,561,900
1978	2,680,300	28,947,240	32,967,690
1979	1,156,700	12,492,360	14,227,410
1980	3,211,500	34,684,200	39,501,450
1981	1,672,300	18,060,840	20,569,290
1982	2,210,000	23,868,000	27,183,000
1983	2,730,400	29,488,320	33,583,920
1984	498,000	5,378,400	6,125,400
1985	2,038,000	22,010,400	25,067,400
1986	3,838,800	41,459,040	47,217,240
1987	1,895,700	20,473,560	23,317,110
1988	2,867,700	30,971,160	35,272,710
1989	3,066,800	33,121,440	37,721,640
1990	2,784,200	30,069,360	34,245,660
1991	2,950,400	31,864,320	36,289,920
1992	3,673,800	39,677,040	45,187,740
1993	513,900	5,550,120	6,320,970
1994	43,400	468,720	533,820
1995	440,000	4,752,000	5,412,000
1996	9,100	98,280	111,930
1997	58,600	632,880	720,780
1998	12,100	130,680	148,830
1999	20,900	225,720	257,070
2000	31,000	334,800	381,300
2001	313,100	3,381,480	3,851,130
2002	721,200	7,788,960	8,870,760
2003	1,083,400	11,700,720	13,325,820
2004	231,600	2,501,280	2,848,680
2005	200	2,160	2,460
2006	13,100	141,480	161,130
2007	8,310	89,748	102,213
2008	16,941	182,963	208,374

Table 4. Estimated eulachon fishery landings (metric tons) for available subsets of the southern DPS of eulachon. Data from sources listed in Table 2; Hay (2002); Lewis et al (2002); Moody (2008); Parlaiment of Canada (1900-1916); and Canadian Bureau of Statistics (1917-1941). Fraser and Skeena river data reported in cwt (hundredweight) were assumed to be short hundredweight and were converted using 100 lbs = 1 cwt, the conversion currently used by Statistics Canada.

Year	Columbia River	Fraser River	Knight Inlet (Klinaklini River)	Bella Coola River	Kemano River	Skeena River
1888	68.04					
1889	27.22					
1890	0.45					
1891	68.04					
1892	283.50					
1893	present					
1894	136.08					
1895	142.14					
1896	307.24					
1897	463.34					
1898	334.30					
1899	254.43					
1900	221.17	113.40				27.2
1901	120.37	108.86				27.2
1902	259.66	90.72				22.7
1903	182.34	128.97				22.7
1904	199.79	129.27				18.1
1905	219.09	22.68				4.5
1906	228.16	13.61				5.4
1907	77.02	6.80				4.5
1908	273.07	10.21				4.1
1909	249.30	31.75				4.5
1910	282.35	42.50				136.1
1911	158.59	32.66				113.4
1912	224.68	36.29				90.7
1913	90.72	10.52				68.0
1914	Large run	6.44				54.4
1915	730.06	12.34				45.4
1916	291.02	12.52				45.4
1917	1,272.84	17.28				
1918	741.03	15.20				
1919	1,091.05	5.94				1.9
1920	443.20	5.22				
1921	476.85	8.53				
1922	621.96	7.98				
1923	466.94	19.87				
1924	456.41	36.51				15.4
1925	635.35	16.19				

Year	Columbia River	Fraser River	Knight Inlet (Klinaklini River)	Bella Coola River	Kemano River	Skeena River
1926	574.80	17.24				1.1
1927	586.52	12.97				9.1
1928	530.17	18.73				
1929	548.16	9.71				6.6
1930	659.74	35.33				5.4
1931	887.80	6.30				2.7
1932	718.47	5.03				3.3
1933	631.67	6.94				
1934	689.53	10.25				
1935	1,057.76	15.47				0.9
1936	1,398.81	10.07				
1937	1,106.06	4.08				
1938	472.46	7.67				
1939	1,404.50	20.59				
1940	1,398.20	34.16				
1941	1,148.41	50.1				1.0
1942	1,218.35	152.7				
1943	1,804.07	154.8				
1944	1,028.97	65.7		present		
1945	2,594.23	73.87		8.0		
1946	1,485.97	115.7		10.0		
1947	700.75	231.1	135.0	present		
1948	1,802.62	112.8		20.0		
1949	1,512.10	102.7	70.0	8.5		
1950	672.45	36.2	100.0	44.0		
1951	688.05	189.3	20.0	10.0		
1952	578.28	421.0	27.5	12.3		
1953	776.10	158.6		41.7		
1954	854.70	151.6		69.4		
1955	1,014.73	238.8		7.6		
1956	763.80	235.5		6.2		
1957	716.22	33.2		5.6		
1958	1,186.78	92.1		8.4		
1959	796.55	132.0	45.0	7.0		
1960	531.70	84.0	60.0	0.3		
1961	477.32	216.9		2.0		
1962	668.41	178.2	70.0	2.8		
1963	488.56	159.3		8.4		
1964	381.83	105.5		22.4		
1965	413.09	87.8	100.0	11.8		
1966	466.43	101.9		9.2		
1967	453.96	86.8	100.0	11.5		
1968	429.78	46.0	100.0	10.6		
1969	491.56	29.8	80.0	7.8		
1970	537.01	71.7	40.0	9.2		
1971	805.90	34.5	20.0	16.8		

Year	Columbia River	Fraser River	Knight Inlet (Klinaklini River)	Bella Coola River	Kemano River	Skeena River
1972	745.48	53.2	50.0	6.7		
1973	1,104.23	53.1	40.0	12.3		
1974	1,071.29	75.3		10.6		
1975	942.38	27.7		12.0		
1976	1,394.84	36.7		50.0		
1977	795.15	32.2	50.0	35.0		
1978	1,215.76	38.6		25.0		
1979	524.67	22.3		19.8		
1980	1,456.71	24.4		33.0		
1981	758.54	21.2		38.5		
1982	1,002.44	13.7		22.0		
1983	1,238.49	10.8		30.5		
1984	225.89	11.8		30.0		
1985	924.42	29.2		present		
1986	1,741.25	49.6		present		
1987	859.88	19.3		present		
1988	1,300.77	39.5		present	43.2	
1989	1,391.08	18.7		present	50.2	
1990	1,262.89	19.9		present	44.1	
1991	1,338.28	12.3		present	57.2	
1992	1,666.41	19.6		present	65.4	
1993	233.10	8.7		present	93.0	
1994	19.69	6.1		20.0	20.6	
1995	199.58	15.5		22.0	69.2	
1996	4.13	63.2		present	81.0	
1997	26.58	Closed		present	41.9	
1998	5.49	Closed		present	61.7	
1999	9.48	Closed		0.0	0.0	
2000	14.06	Closed		0.0	<5.0	
2001	142.02	Closed			<10.0	
2002	327.13	5.8			~5.0	
2003	491.42	Closed			~80.0	
2004	105.05	0.4			~60.0	
2005	0.09	Closed			0.0	
2006	5.94	Closed			0.0	
2007	3.77	Closed			0.0	
2008	7.69	Closed				

Table 5. Estimated eulachon spawner biomass (metric tons) in the Fraser River and total number of eulachon, assuming a range of 9.9 to 13.3 eulachon to the pound, based on the mean reported weight of eulachon in the Columbia River of 34 to 46 g. Landings data from DFO (2008a) and data online at http://www-sci.pac.dfo-mpo.gc.ca/herring/herspawn/pages/river1_e.htm.

Year	Total biomass (mt)	Total biomass (pounds)	Number of fish at 9.9 per pound	Number of fish at 13.3 per pound
1995	302	665,796	6,591,381	8,855,087
1996	1916	4,224,057	41,818,164	56,179,957
1997	74	163,142	1,615,107	2,169,790
1998	134	295,419	2,924,652	3,929,078
1999	420	925,942	9,166,821	12,315,022
2000	127	279,987	2,771,872	3,723,828
2001	609	1,342,615	13,291,890	17,856,782
2002	492	1,084,674	10,738,276	14,426,169
2003	267	588,634	5,827,479	7,828,835
2004	33	72,753	720,250	967,609
2005	16	35,274	349,212	469,144
2006	29	63,934	632,947	850,323
2007	44	97,003	960,334	1,290,145
2008	10	22,046	218,258	293,215

Table 6. Available estimated eulachon spawner biomass or estimated total number of spawners in British Columbia rivers in the DPS.

Year	Fraser River (mt)[1]	Klinaklini River (mt)[2]	Kingcome River (mt)[2]	Wannock/Kilbella rivers (# of fish)[3]	Bella-Coola River (mt)[3]	Kitimat River (# of fish)[4]	Skeena River (mt)[5]
1993	--					514,000	
1994	--					527,000	
1995	302	40				*	
1996	1916					440,000	
1997	74		14.4				3.0
1998	134					*	
1999	420					*	
2000	127					*	
2001	609				0.039	*	
2002	492				~0.050	*	
2003	267				0.016	*	
2004	33				0.007	*	
2005	16			2,700		*	
2006	29			23,000		<1,000	
2007	44						
2008	10						

1- Data from DFO (2008a) and online at http://www-sci.pac.dfo-mpo.gc.ca/herring/herspawn/pages/river1_e.htm.
2 - Berry and Jacob (1998, as cited in Moody 2008)
3 - Moody (2008)
4 – Pederson et al. (1995) and Ecometrix (2006, as cited in Moody 2008)
5 - Lewis (1997)

Table 7. Qualitative assessments of eulachon run strength for rivers north of the Fraser River 1991-2007.

Year	Klinaklini River	Kingcome River	Bella Coola River	Rivers Inlet	Kemano River	Kitimat River	Skeena River
1991						last strong run [1]	
1992							
1993							
1994							
1995	~ 15% of the historic run size [1]						
1996			Last large run [1]				
1997							
1998			Average run [1]			Non-existent [2]	Very few [1]
1999			No run [1] Small run [2]	No run [2] Run failed [1]	Negligible [2]	Non-existent [2]	Very few [1]
2000	None or poor [2] Very low [3]	No run[2]	No run [3]	No run [2]	Kowesas – low [2] Kemano – low [2] Kitlope – low [2]	Very low in 2000 [3]	Little activity observed [3]
2001		Improved run [1]		No catch [1]	Low catch [1]		
2002		Good run [1]		No catch [1]	Low catch [1]		
2003		Poor run [1]		No catch [1]		Good [3]	
2004	Low returns [1]	Poor run [1]	Run virtually gone [3]	No catch [1]	Good spawning success [4]		
2005	Low returns [1]	Average run [1]		Run size of 2,700 [1]	Almost no eulachon returned [5]		Good run [1]
2006		Run absent [1]	Run virtually gone [3]	Run size of 23,000 [1]	No significant eulachon returns [6]	Lowest on record, < 1000 spawners [1]	Virtually no run[1]
2007	Very good run [1]	Small returns [1]			In estuary but did not ascend the river [1]		

1 – Moody (2008); 2 – Hay and McCarter (2000); 3 – Appendix C in Pickard and Marmorek (2007); 4 – ALCAN (2005); 5 – ALCAN (2006); 6 – ALCAN (2007).

Table 8. Template for the risk matrix used in BRT deliberations. The matrix is divided into five sections that correspond to the four VSP "parameters" (McElhany et al. 2000) plus a "recent events" category.

Risk Category	**Mean (± SD) and modal score**
Abundance[1] Comments:	4.3 (± 0.48) 4
Growth Rate/Productivity[1] Comments:	3.0 (± 1.05) 2
Spatial Structure and Connectivity[1] Comments:	3.7 (± 0.67) 4
Diversity[1] Comments:	2.6 (± 0.52) 3
Recent Events[2]	

[1] Rate overall risk to the DPS on 5-point scale (1–very low risk; 2–low risk; 3–moderate risk; 4–high risk; 5–very high risk).
[2] Rate recent events from double plus (++) strong benefit to double minus (– –) strong detriment.

Table 9. Example worksheet for analysis of the severity of current threats to the Southern Eulachon DPS. Threats were scored as: 1 – very low, 2 – low, 3 – moderate, 4 – high, and 5 – very high. Insufficient data to score the threat severity is indicated by "u" for unknown. Threats that are not applicable to the area are indicated by "N/A". Threats are arranged within the four statutory listing factors: 1) the present or threatened destruction, modification, or curtailment of its habitat or range; 2) overutilization for commercial, recreational, scientific, or educational purposes; 3) disease or predation; and 4) other natural or manmade factors affecting its continued existence.

River Basin	Dams /water diversions	Dredging	Shoreline construction	Climate change impacts on ocean conditions	Climate change impacts on freshwater habitat	Water quality	Catastrophic events	Commercial harvest	Recreational harvest	Tribal/First Nations fisheries	Scientific monitoring	Disease	Predation	Competition	Eulachon by-catch	Non-indigenous species
Klamath River		N/A						N/A			N/A					
Columbia River																
Fraser River																
British Columbia coast								N/A								
ESA listing factor	(1) The present or threatened destruction, modification, or curtailment of habitat or range							(2) Overutilization for commercial, recreational, scientific, or educational purposes				(3) Disease or predation		(4) Other natural or manmade factors		

Table 10. Results of qualitative ranking by the eulachon BRT of severity of threats for Klamath River eulachon. Threats were scored as: 1 – very low, 2 – low, 3 – moderate, 4 – high, and 5 – very high. N = number of BRT members voting; members not voting marked severity of threat as either "unknown" or "not/applicable."

	Mean	SD	Mode	Range	N
Climate change impacts on ocean conditions	4.2	0.6	4	3-5	10
Dams / water diversions	3.4	0.9	3	2-5	8
Eulachon by-catch	3.3	0.7	3	2-4	9
Climate change impacts on freshwater habitat	3.3	0.7	3	2-4	10
Predation	2.7	0.9	3	1-4	9
Water quality	2.5	1.1	3	1-4	10
Catastrophic events	2.3	1.8	1	1-5	8
Disease	2.3	1.9	1	1-5	4
Competition	2.0	0.8	2	1-3	7
Shoreline construction	1.9	1.1	1	1-4	9
Tribal / First Nations fisheries	1.7	0.8	1	1-3	10
Non-indigenous species	1.7	0.8	1	1-3	6
Recreational harvest	1.4	0.9	1	1-3	9

Table 11. Results of qualitative ranking by the eulachon BRT of severity of threats for Columbia River eulachon. Threats were scored as: 1 – very low, 2 – low, 3 – moderate, 4 – high, and 5 – very high. N = number of BRT members voting; members not voting marked severity of threat as either "unknown" or "not/applicable."

	Mean	SD	Mode	Range	N
Climate change impacts on ocean conditions	4.3	0.7	4	3-5	10
Eulachon by-catch	3.8	0.7	4	3-5	9
Climate change impacts on freshwater habitat	3.4	0.5	3	3-4	10
Dams / water diversions	3.3	1.1	3	2-5	9
Water quality	3.0	0.7	3	2-4	10
Dredging	2.9	0.6	3	2-4	9
Predation	2.9	0.8	3	1-4	9
Catastrophic events	2.8	1.5	2	1-5	8
Commercial harvest	2.5	1.0	2	1-4	10
Shoreline construction	2.4	1.0	3	1-4	9
Disease	2.3	1.9	1	1-5	4
Competition	2.0	0.8	2	1-3	7
Recreational harvest	1.8	0.8	2	1-3	10
Tribal / First Nations fisheries	1.7	0.8	1	1-3	10
Non-indigenous species	1.7	0.8	1	1-3	6
Scientific monitoring	1.2	0.4	1	1-2	10

Table 12. Results of qualitative ranking by the eulachon BRT of severity of threats for Fraser River eulachon. Threats were scored as: 1 – very low, 2 – low, 3 – moderate, 4 – high, and 5 – very high. N = number of BRT members voting; members not voting marked severity of threat as either "unknown" or "not/applicable."

	Mean	SD	Mode	Range	N
Climate change impacts on ocean conditions	4.1	0.6	4	3-5	9
Eulachon by-catch	3.7	0.7	3	3-5	9
Predation	3.1	0.4	3	3-4	8
Climate change impacts on freshwater habitat	3.1	0.6	3	2-4	9
Water quality	2.7	0.7	3	2-4	9
Commercial harvest	2.7	0.9	2	2-4	9
Dredging	2.6	0.7	2	2-4	8
Dams / water diversions	2.5	1.6	1	1-5	6
Shoreline construction	2.3	1.0	3	1-4	9
Catastrophic events	2.3	1.8	1	1-5	8
Disease	2.3	1.9	1	1-5	4
Competition	2.0	0.8	2	1-3	7
Tribal / First Nations fisheries	1.8	0.8	1	1-3	9
Recreational harvest	1.7	0.9	1	1-3	9
Non-indigenous species	1.7	0.8	1	1-3	6
Scientific monitoring	1.2	0.4	1	1-2	9

Table 13. Results of qualitative ranking by the eulachon BRT of severity of threats for eulachon in mainland British Columbia Rivers south of the Nass River. Threats were scored as: 1 – very low, 2 – low, 3 – moderate, 4 – high, and 5 – very high. N = number of BRT members voting; members not voting marked severity of threat as either "unknown" or "not/applicable."

	Mean	SD	Mode	Range	N
Climate change impacts on ocean conditions	4.1	0.6	4	3-5	9
Eulachon by-catch	3.6	0.9	4	2-5	9
Predation	3.1	0.4	3	3-4	8
Climate change impacts on freshwater habitat	2.9	1.2	3	1-4	9
Catastrophic events	2.4	1.7	2	1-5	8
Shoreline construction	2.3	0.9	2	1-4	8
Disease	2.3	1.9	1	1-5	4
Water quality	2.1	1.0	2	1-4	8
Competition	2.0	0.8	2	1-3	7
Tribal / First Nations fisheries	1.9	0.8	2	1-3	9
Dams / water diversions	1.8	1.2	1	1-4	6
Dredging	1.7	1.0	1	1-4	9
Non-indigenous species	1.5	0.8	1	1-3	6
Recreational harvest	1.4	0.9	1	1-3	9
Scientific monitoring	1.2	0.4	1	1-2	9

Table 14. Description of reference levels for the Biological Review Team’s assessment of the species’ or Distinct Population Segment’s (DPS) extinction risk.

	Qualitative “Reference Levels” of Relative Extinction Risk
Continuum of decreasing relative risk of extinction	(1) Moderate Risk: a species or DPS is at moderate risk of extinction if it exhibits a trajectory indicating that it is more likely than not to be at a high level of extinction risk (see description of “High Risk” below). A species/DPS may be at moderate risk of extinction due to projected threats and/or declining trends in abundance, productivity, spatial structure or diversity. The appropriate time horizon for evaluating whether a species or DPS is more likely than not to be at high risk depends on various case- and species-specific factors. For example, the time horizon may reflect certain life-history characteristics (e.g., long generation time or late age-at-maturity) and may also reflect the timeframe or rate over which identified threats are likely to impact the biological status of the species or DPS (e.g., the rate of disease spread). The appropriate time horizon is not limited to the period that status can be quantitatively modeled or predicted within predetermined limits of statistical confidence. Please explain the time scale over which the BRT has confidence in evaluating moderate risk.
	(2) High Risk: a species or DPS with a high risk of extinction is at or near a level of abundance, productivity, spatial structure, and/or diversity that place its persistence in question. The demographics of a species/DPS at such a high level of risk may be highly uncertain and strongly influenced by stochastic and/or depensatory processes. Similarly, a species/DPS may be at high risk of extinction if it faces clear and present threats (e.g., confinement to a small geographic area; imminent destruction, modification, or curtailment of its habitat; or disease epidemic) that are likely to create such imminent demographic risks.
EXTINCT	A species or DPS is extinct when there is no longer a living representative.

Table 15. Example worksheet and results of the evaluation of the overall level of extinction risk for the Southern Eulachon (*Thaleichthys pacificus*) DPS using the "likelihood point" method (FEMAT 1993)

	Overall Extinction Risk Category [1]		
	Not at risk	Moderate Risk	High Risk
Number of likelihood points[2]	8	60	32
Comments:			

[1] These evaluations do not consider protective efforts, and therefore are not recommendations regarding Endangered Species Act listing status.

[2] Each Biological Review Team member distributes ten likelihood points among the three overall extinction risk categories. Placement of all ten points in a given risk category reflect 100% certainty that level of risk reflects the true level of extinction risk for the species. Distributing points between risk categories reflects uncertainty in whether a given category reflects the true species status.

FIGURES

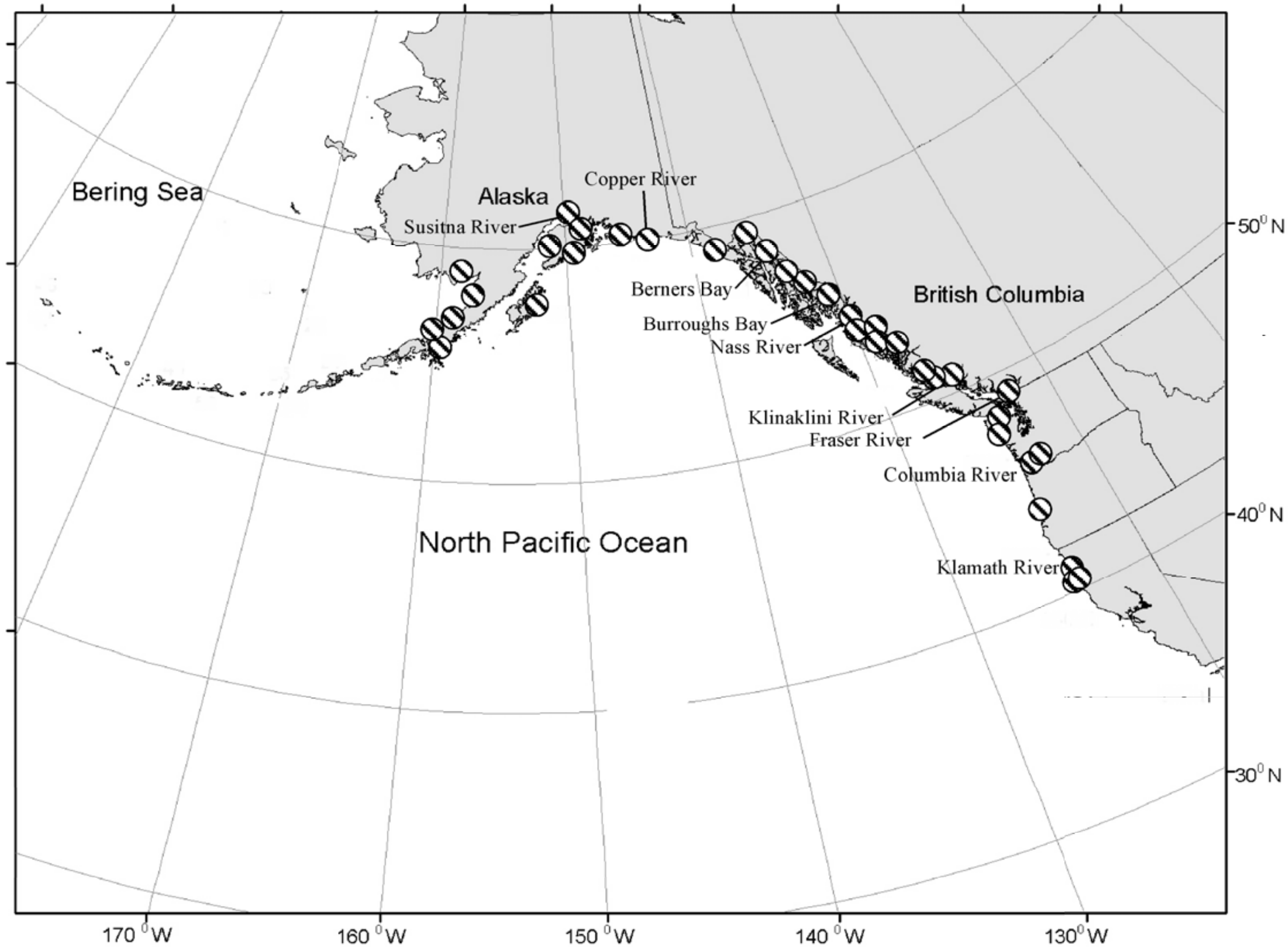

Figure 1. Distribution of eulachon spawning rivers in the Northeast Pacific.

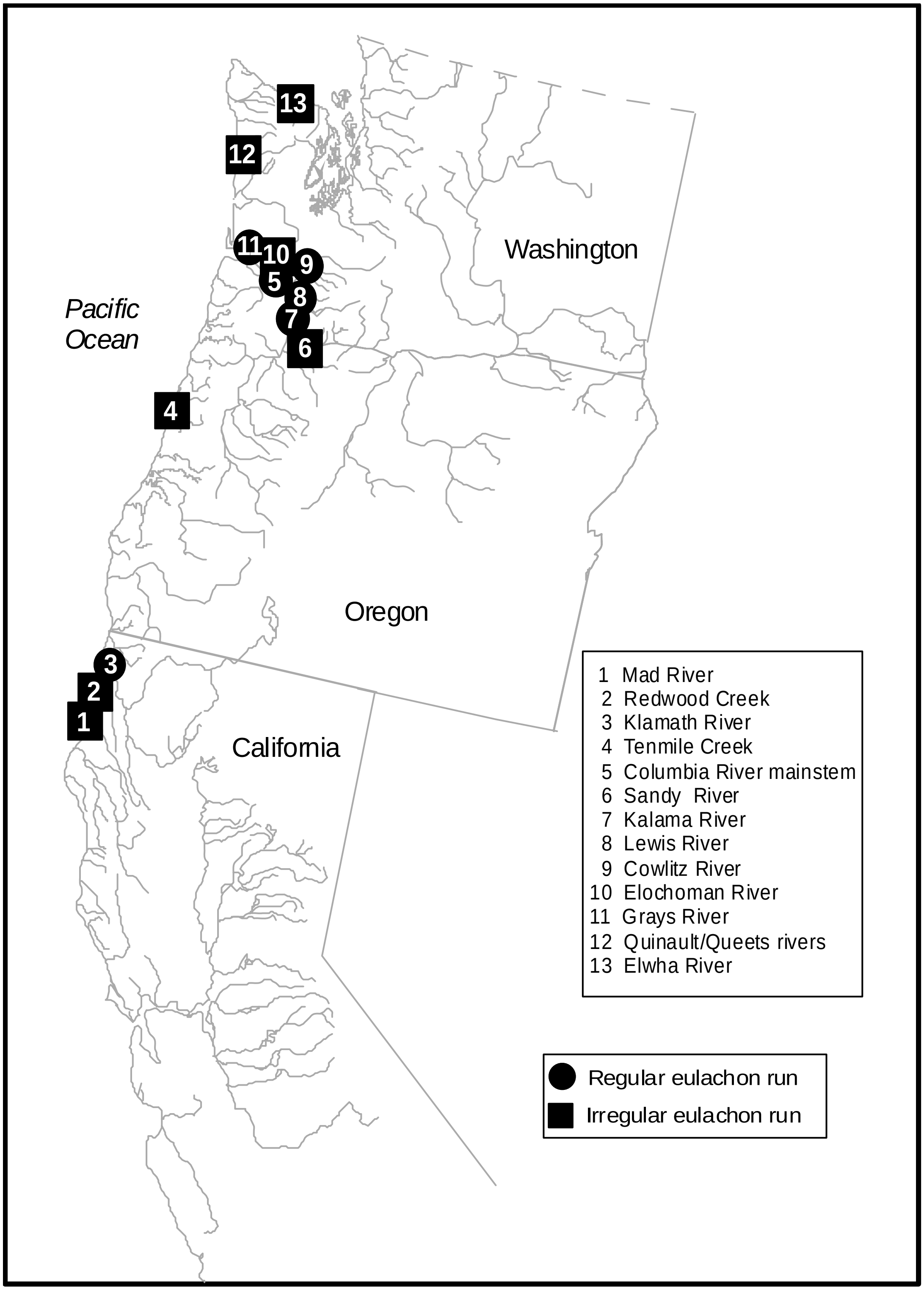

Figure 2. Eulachon spawning areas mentioned in the text in the conterminous United States.

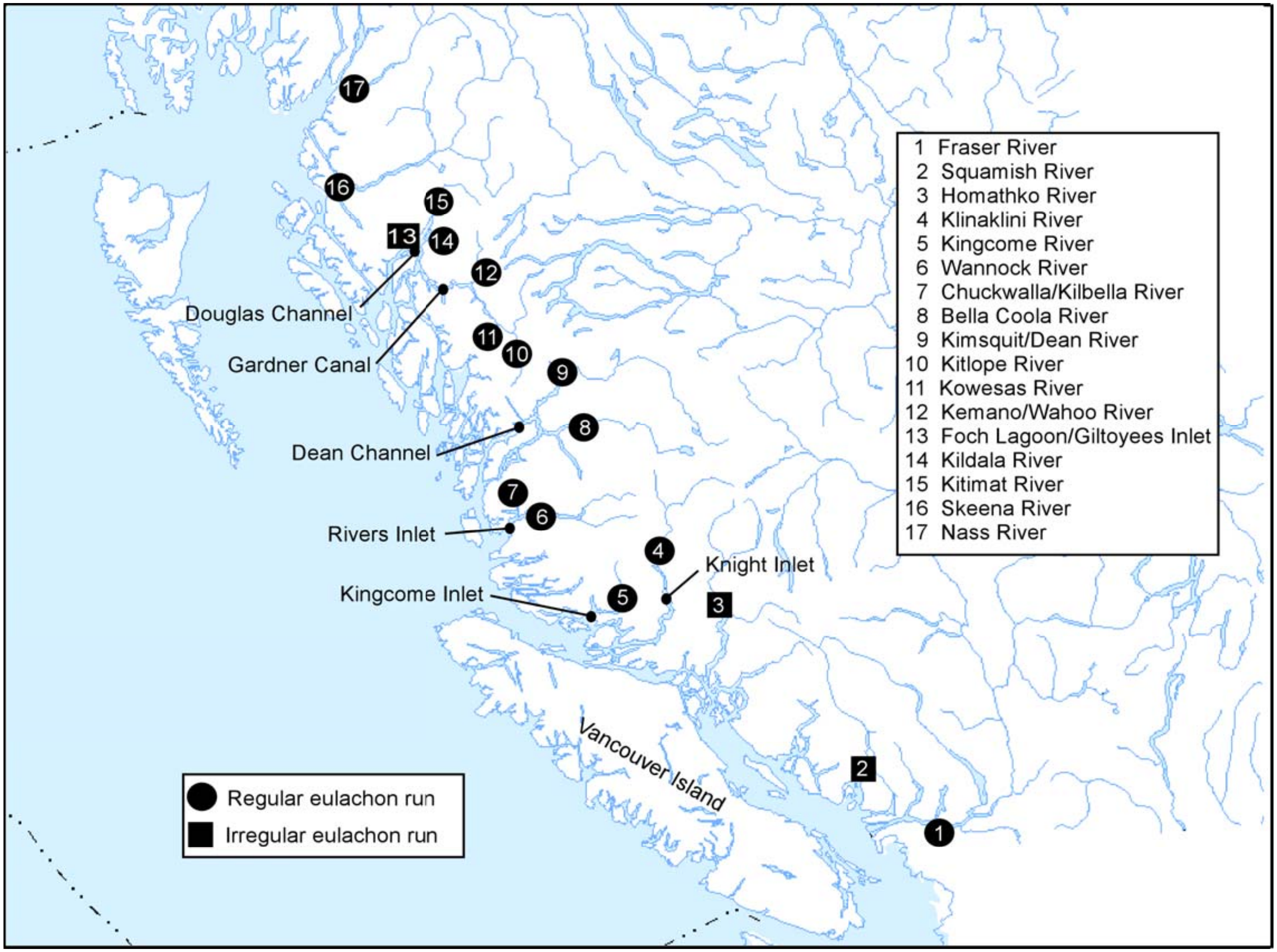

Figure 3. Major known eulachon spawning rivers in British Columbia (based on Hay and McCarter 2000 and Hay 2002).

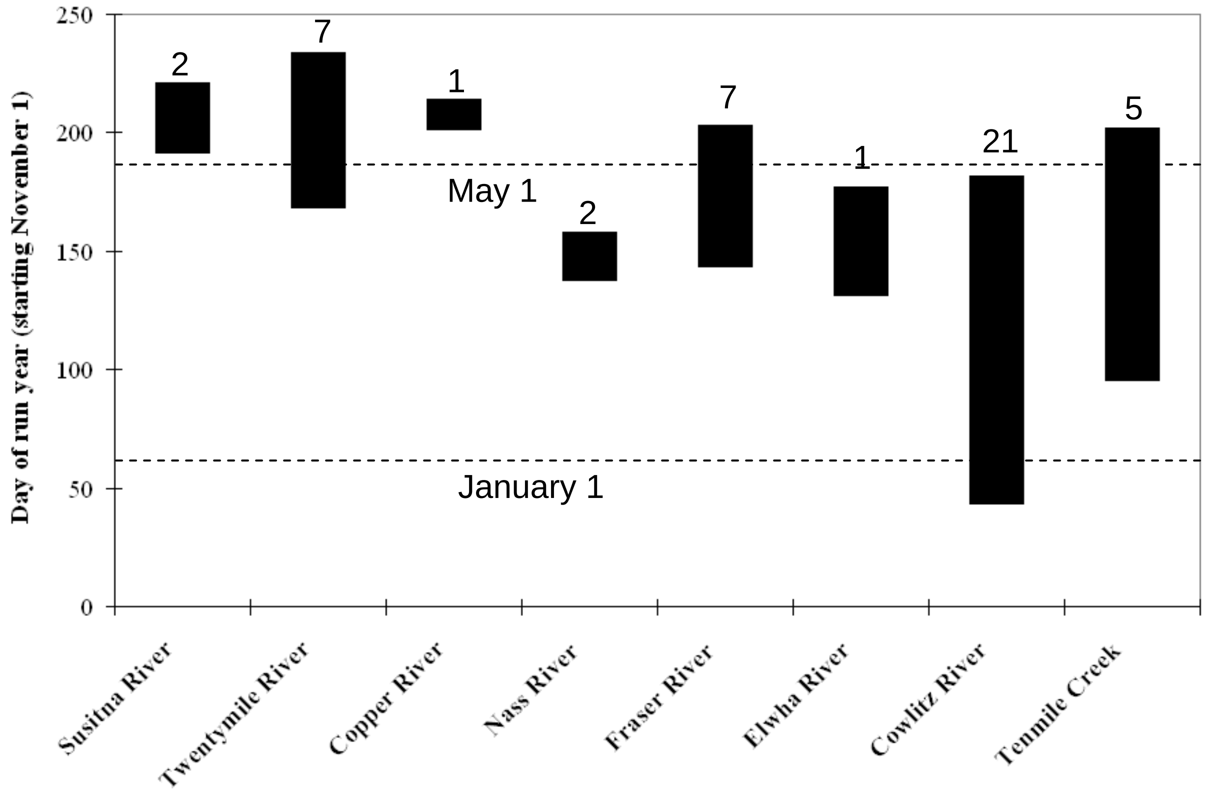

Figure 4. Duration of reported eulachon spawn timing in various river systems arranged north to south from left to right on the x-axis. Dates of spawn timing have been converted relative to the day of the run-year beginning on November 1st. Numbers above plots indicate the total years of data available for each system.

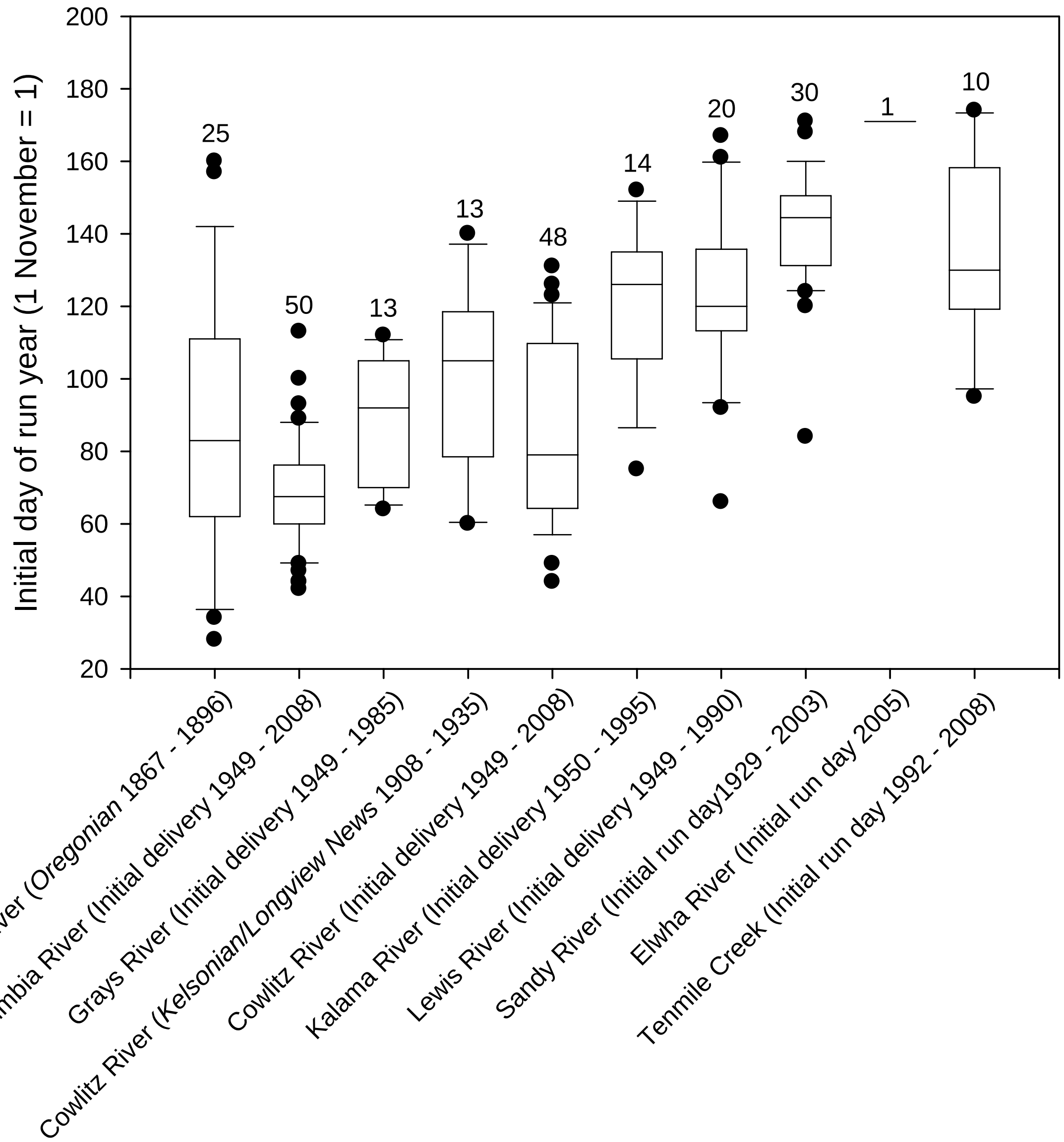

Figure 5. Box plots of the initial day of river entry in various river systems as reported in local newspapers (see Appendix A and Smith et al. 1953), commercial fishery deliveries (Brad James, WDFW, pers. comm.), Shaffer et al. (2007), and WDFW and ODFW (2008). Dates of initial river entry, or fishery delivery, have been converted to the day of the run-year beginning on November 1st. Numbers above plots indicate the total years of data available for each data set.

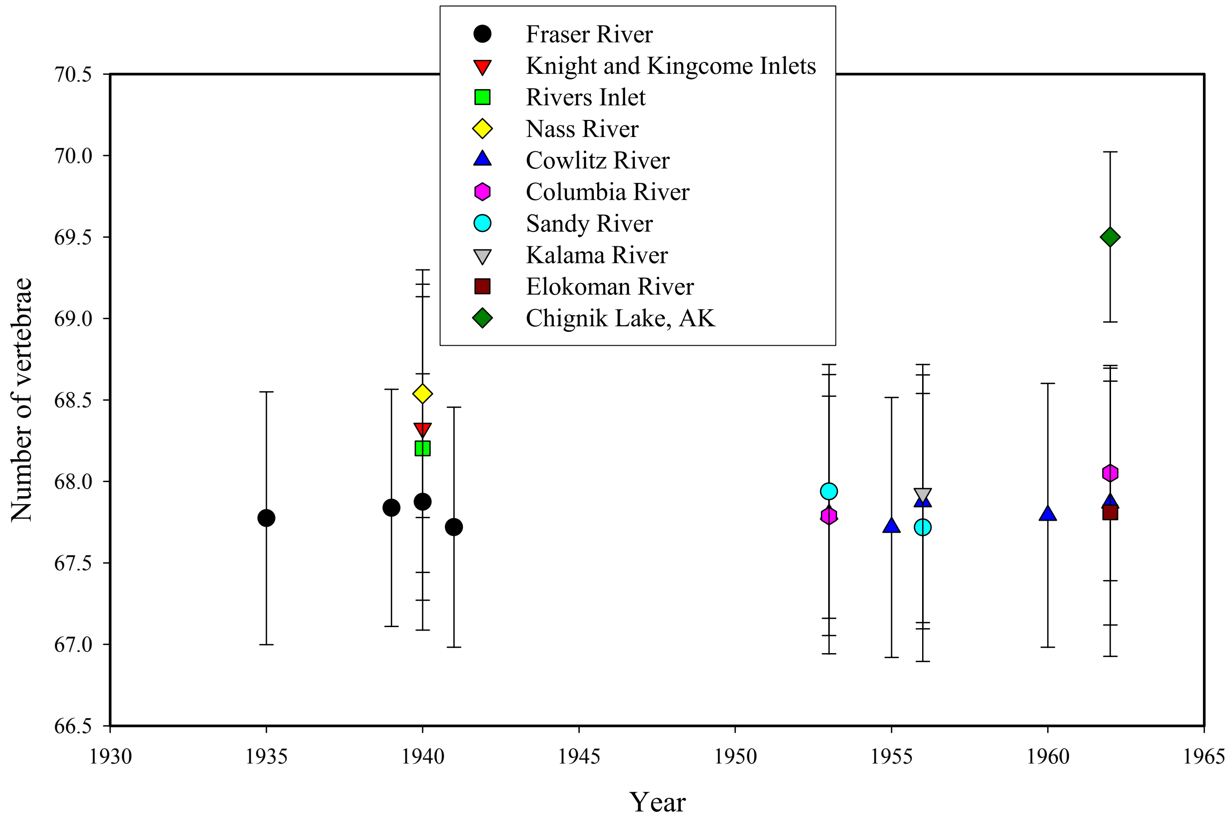

Figure 6. Comparison of mean and standard deviations of eulachon vertebral counts in various rivers. Data from DeLacy and Batts (1963) for the Columbia River and Chignik Lake, and Hart and McHugh (1944) for rivers in British Columbia.

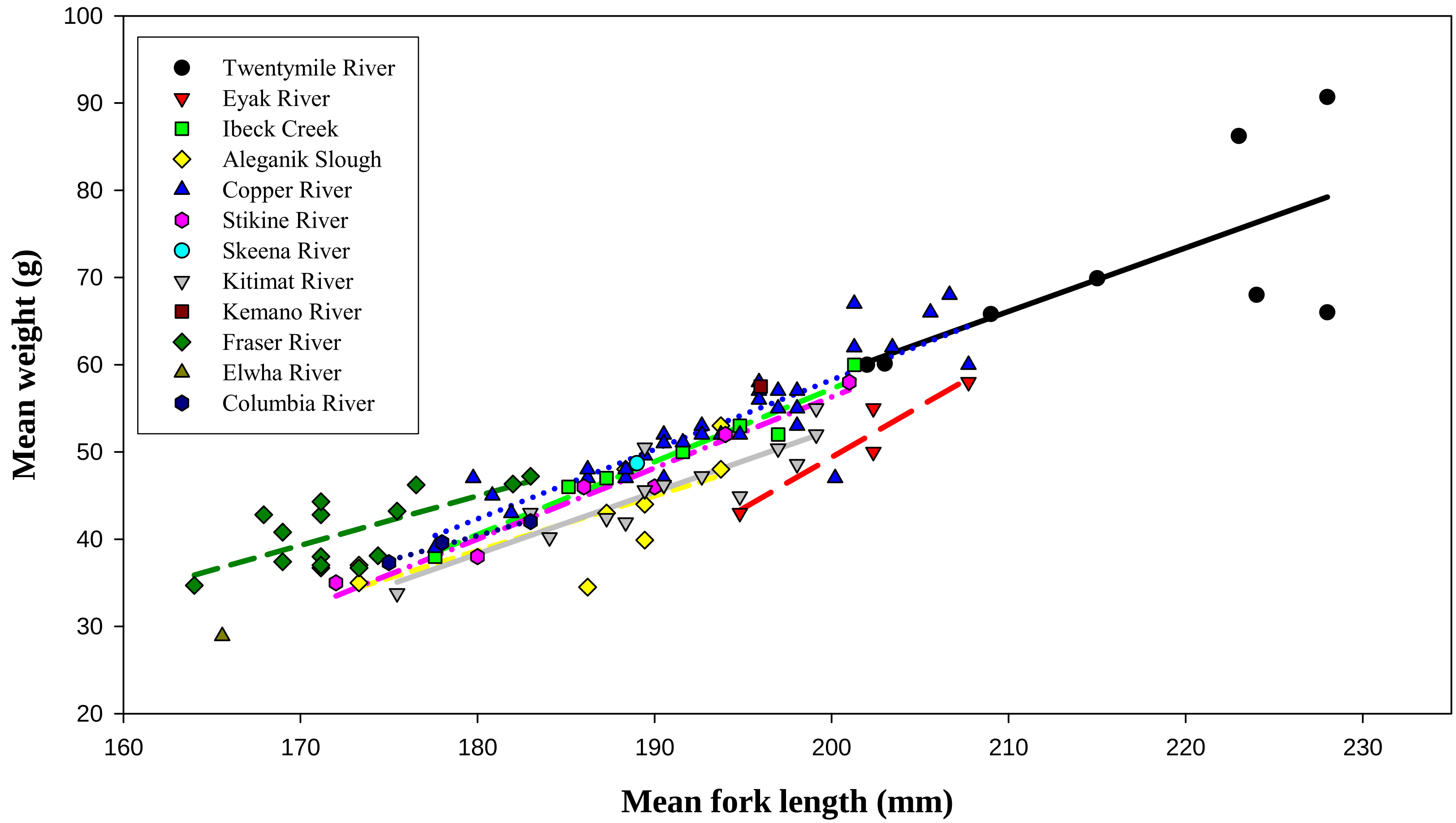

Figure 7. Length – weight relationship of eulachon from various rivers. Standard lengths and total lengths have been converted to fork length using equations published in Buchheister and Wilson (2005).

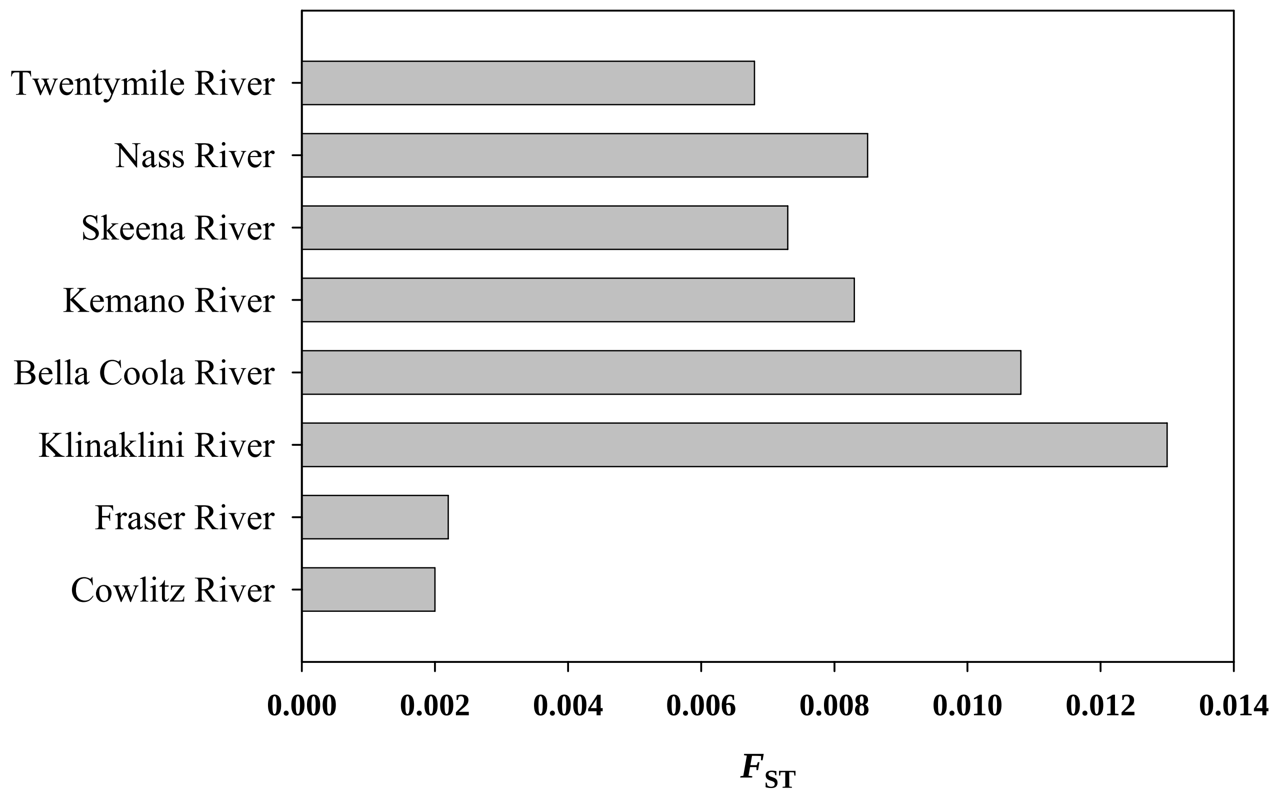

Figure 8. Comparison of F_{ST} (a measure of genetic distance) values of the Columbia River eulachon sample to other samples. Data are from Beacham et al. (2005; their Table 4). See Beacham et al. (2005; their Fig. 1) for sampling locations.

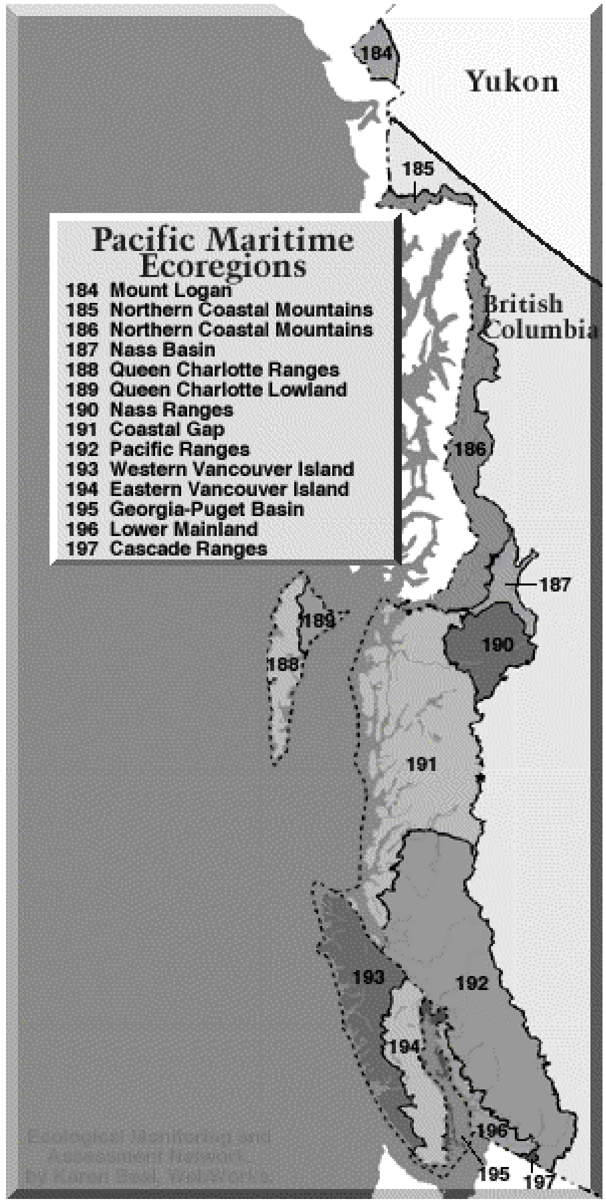

Figure 9. Ecoregions in the Pacific Maritime Ecozone of British Columbia. Map retrieved from online source: http://www.ec.gc.ca/soer-ree/English/Framework/NarDesc/pacmar_e.cfm.

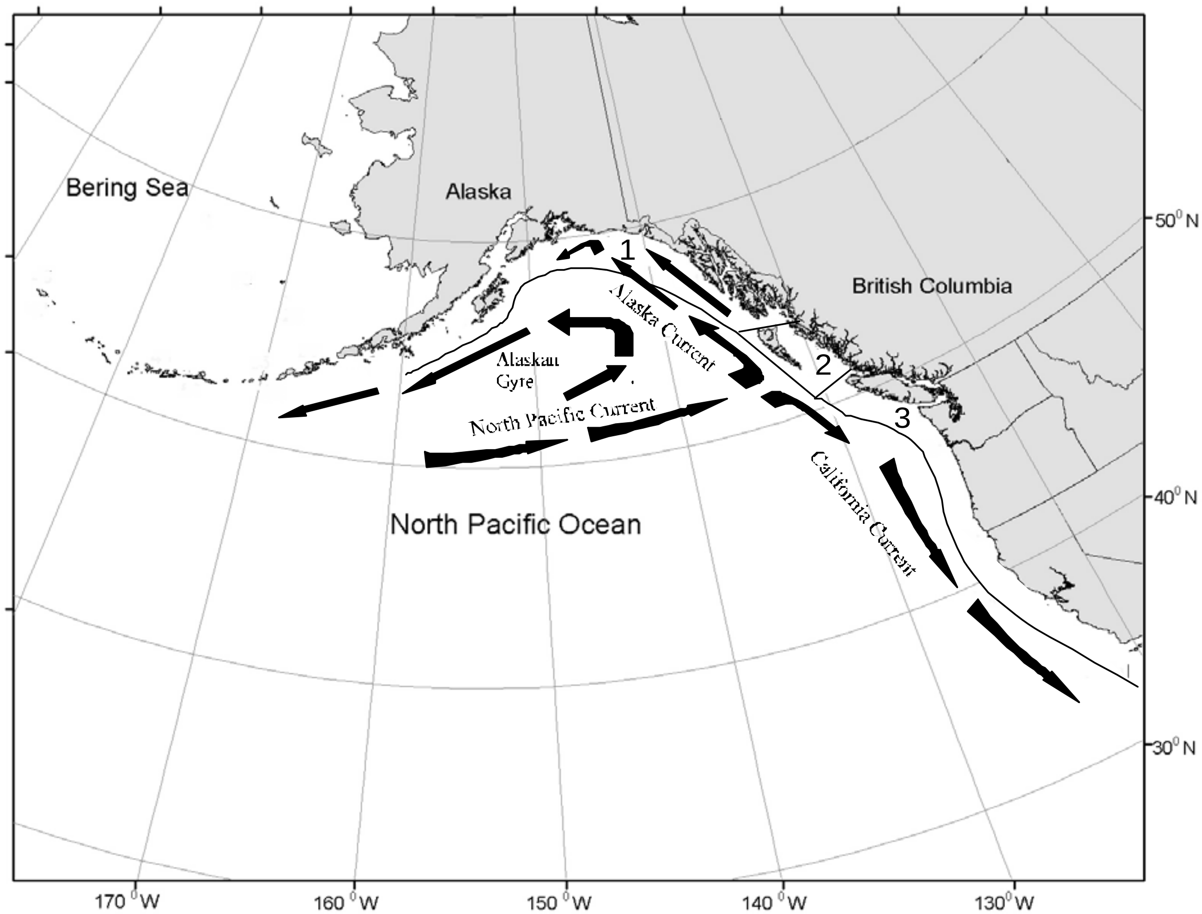

Figure 10. Approximate locations of oceanographic currents, Oceanic Domains (Ware and McFarlane 1989), and Coastal Provinces (Longhurst 2006) in the Northeast Pacific. 1 – Alaska Coastal Downwelling Province (aka, Coastal Downwelling Domain), 2 – Transition Zone, and 3 – California Current Province (aka, Coastal Upwelling Domain).

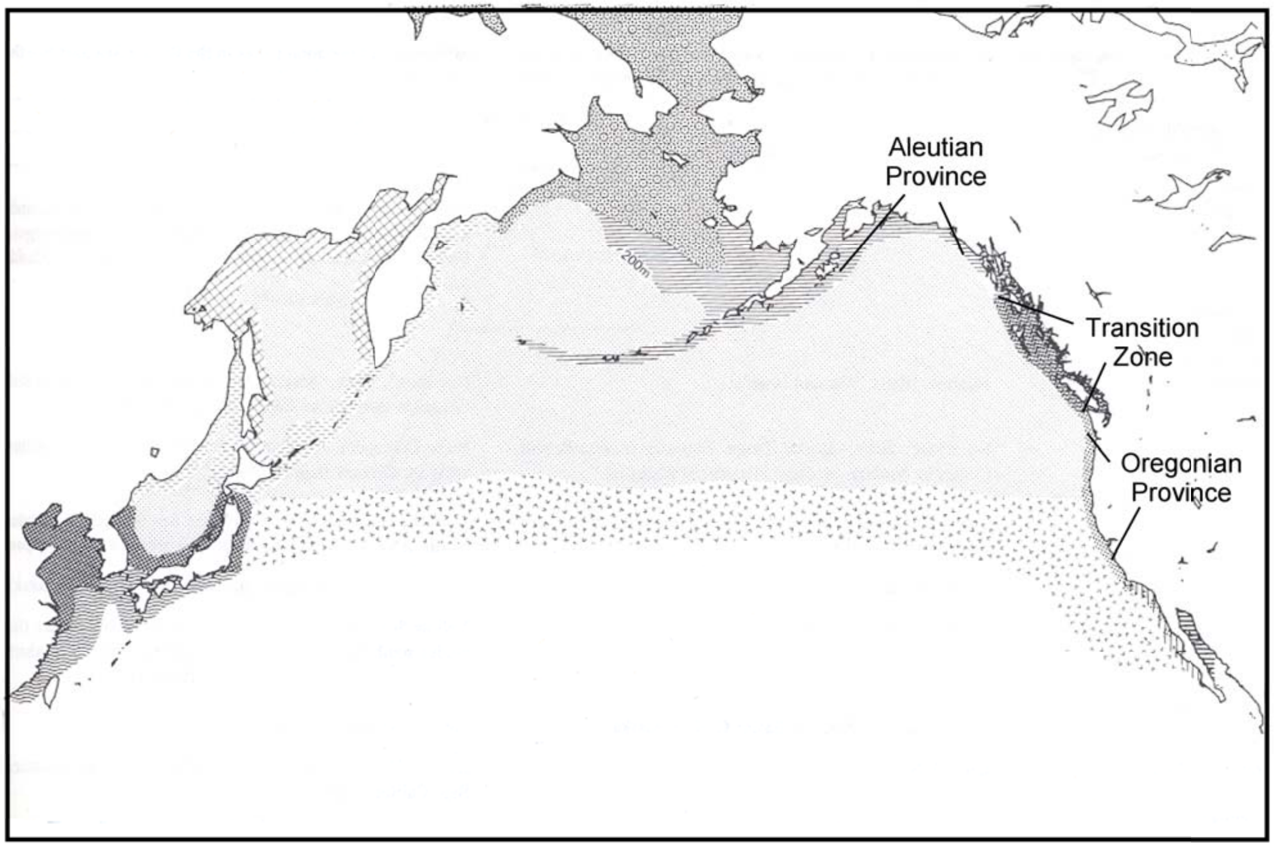

Figure 11. Marine zoogeographic provinces of the North Pacific Ocean. Modified after Allen and Smith (1988).

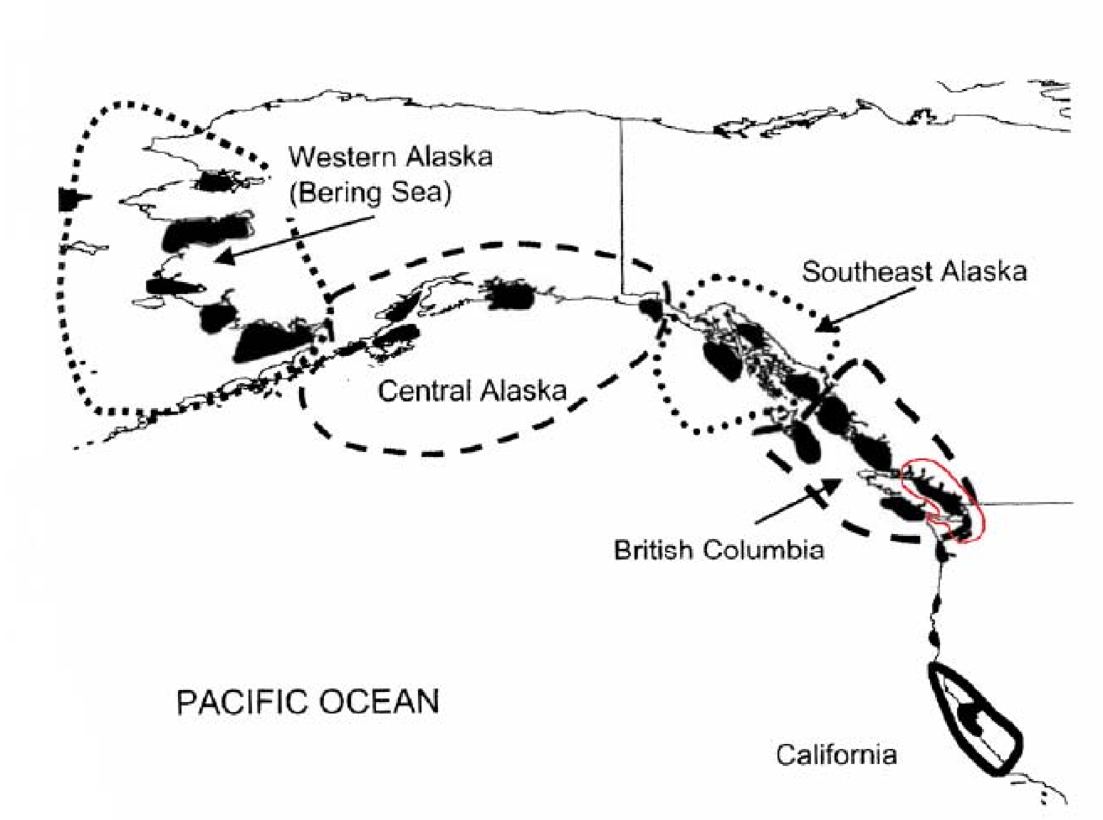

Figure 12. Major stocks of Pacific herring in the Northeast Pacific in relation to the Georgia Basin pacific herring DPS (area outlined in red) (Stout et al. 2001a, Gustafson et al. 2006) and the Southeast Alaska Pacific herring DPS (coincident with Southeast Alaska stock boundary) (Carls et al. 2008).

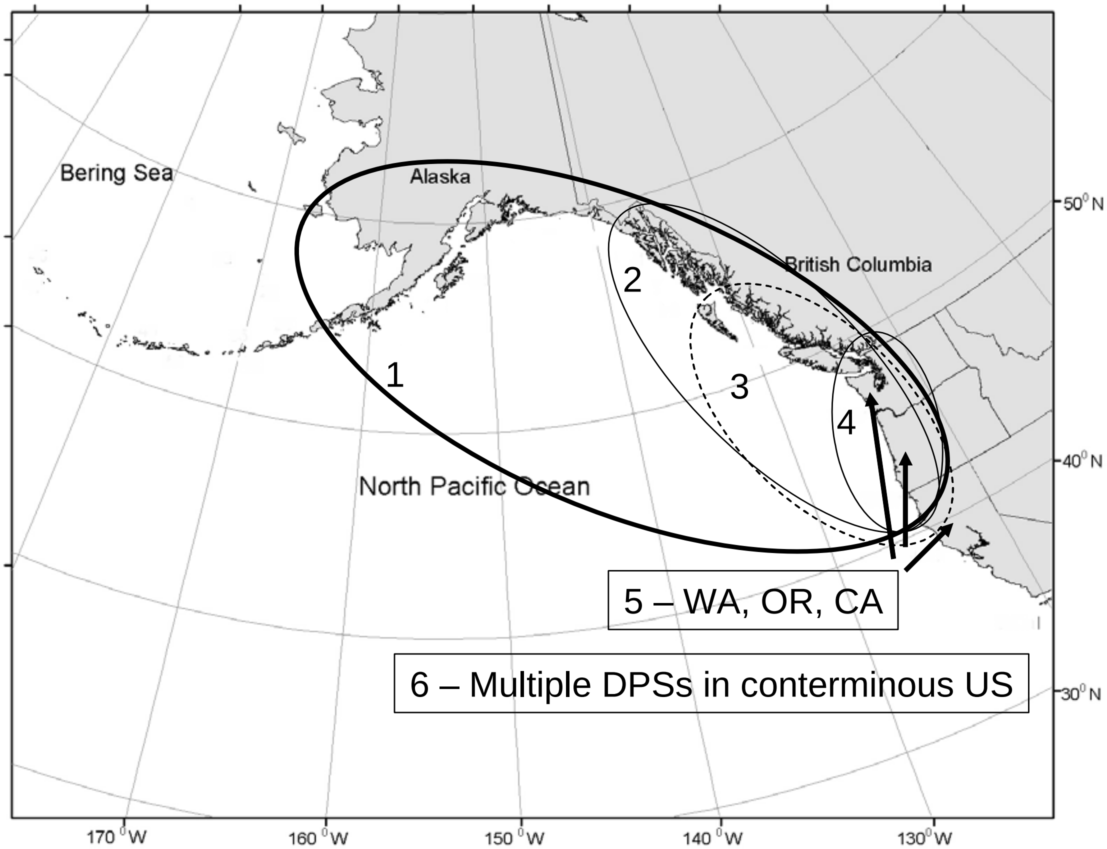

Figure 13. Geographic boundaries of possible eulachon DPSs considered by the BRT: 1) The entire biological species is one DPS; 2) One DPS south of the Yakutat Forelands (Southeast Alaska to Northern California); 3) One DPS south of the Nass River (i.e., south of Dixon Entrance); 4) One DPS that includes the Fraser River and south; 5) One DPS south of the Fraser River (i.e., one DPS in Washington, Oregon, and California); and 6) Multiple DPSs of eulachon in Washington, Oregon, and California.

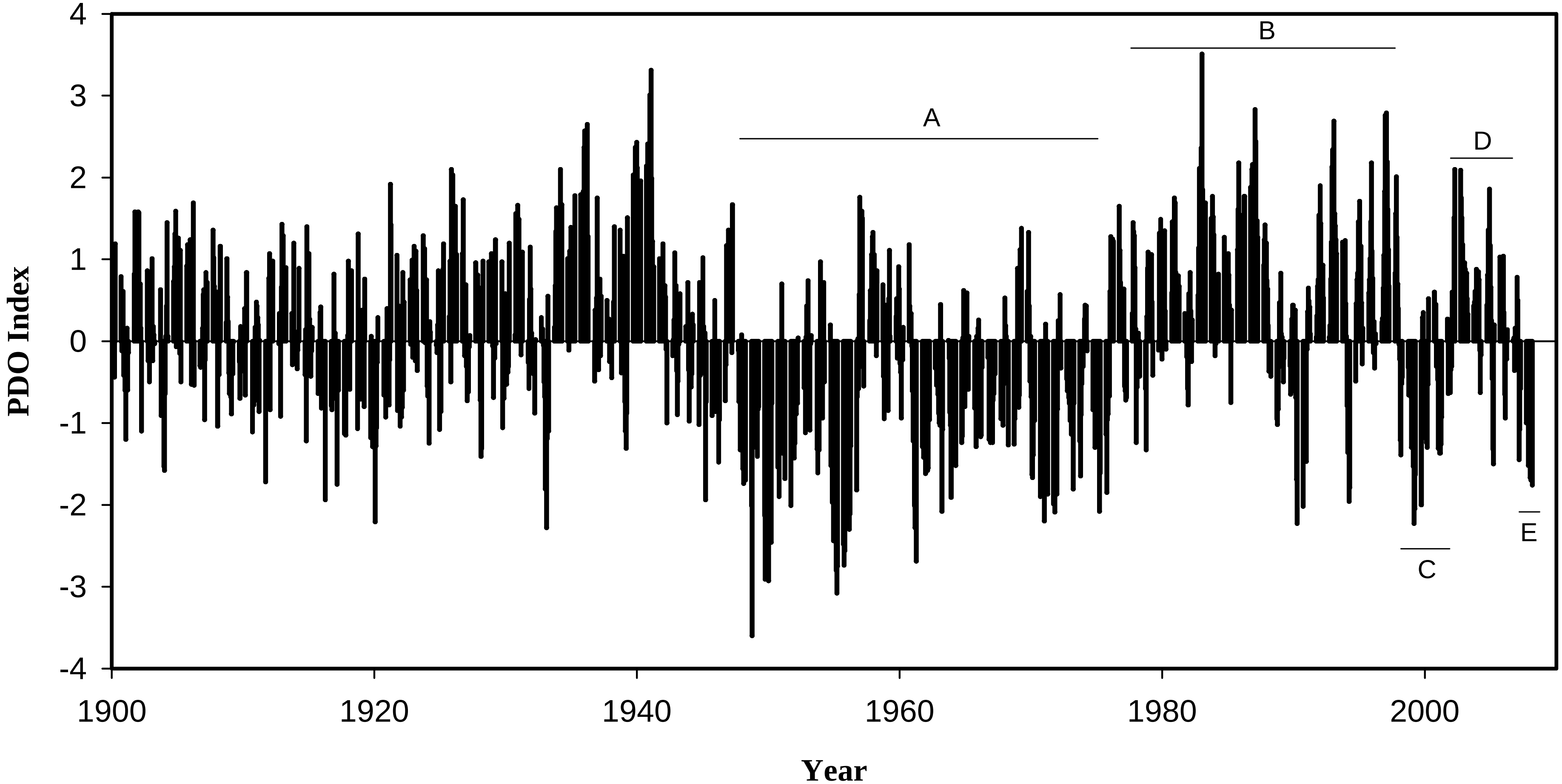

Figure 14. Monthly values for the Pacific Decadal Oscillation (PDO) index, which is based on sea surface temperatures in the North Pacific Ocean, poleward of 20N. See text for discussion of time periods A to E. Data source: Online at http://jisao.washington.edu/pdo/PDO.latest.

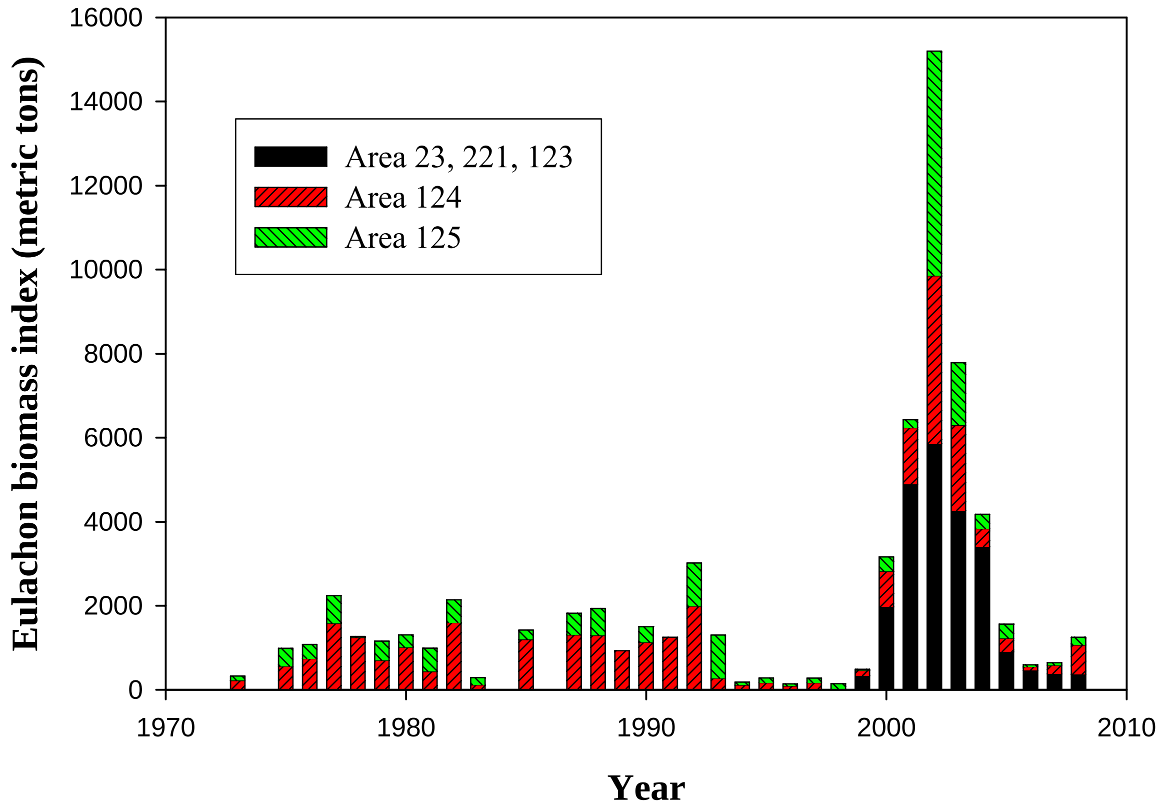

Figure 15. West Coast Vancouver Island offshore eulachon biomass index. Data from Hay et al. (2003) and DFO West Coast Vancouver Island Shrimp Survey Bulletins (2000-2008) available online at http://www-ops2.pac.dfo-mpo.gc.ca/xnet/content/Shellfish/shrimp/surveys/surveys.htm?

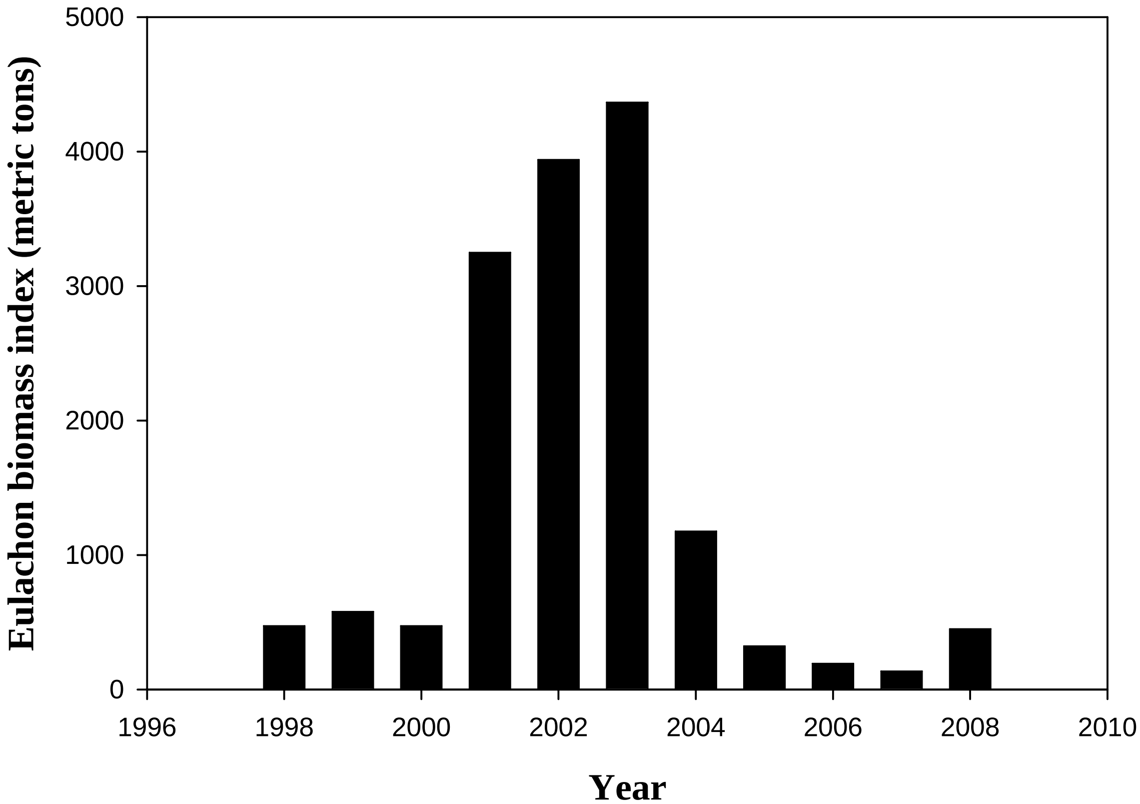

Figure 16. Queen Charlotte Sound offshore eulachon biomass index. Data from DFO Queen Charlotte Sound Shrimp Survey Bulletins (2000-2008) available online at http://www-ops2.pac.dfo-mpo.gc.ca/xnet/content/Shellfish/shrimp/surveys/surveys.htm?

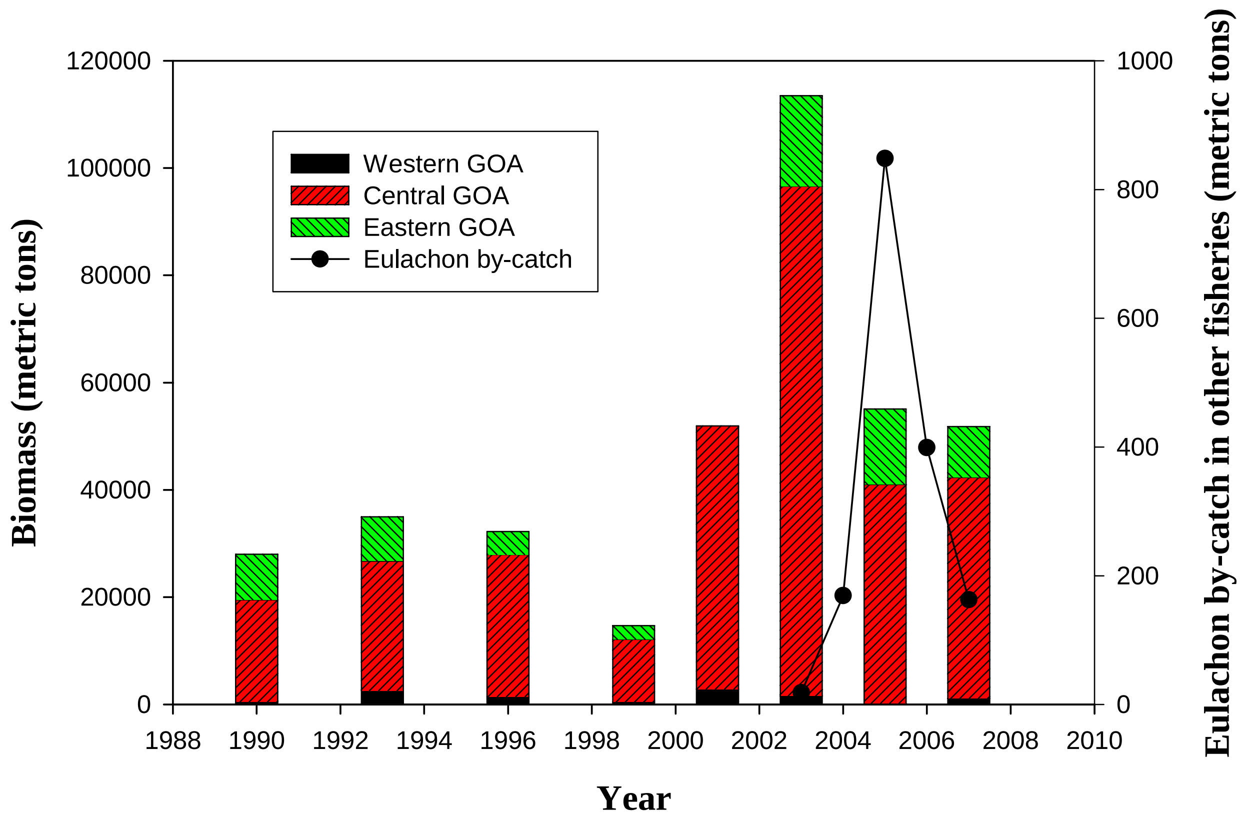

Figure 17. Alaska Fisheries Science Center Gulf of Alaska bottom trawl survey biomass estimates for eulachon and fishery incidental catch (by-catch) of eulachon in Alaska. Data from Ormseth and Vollenweider (2007).

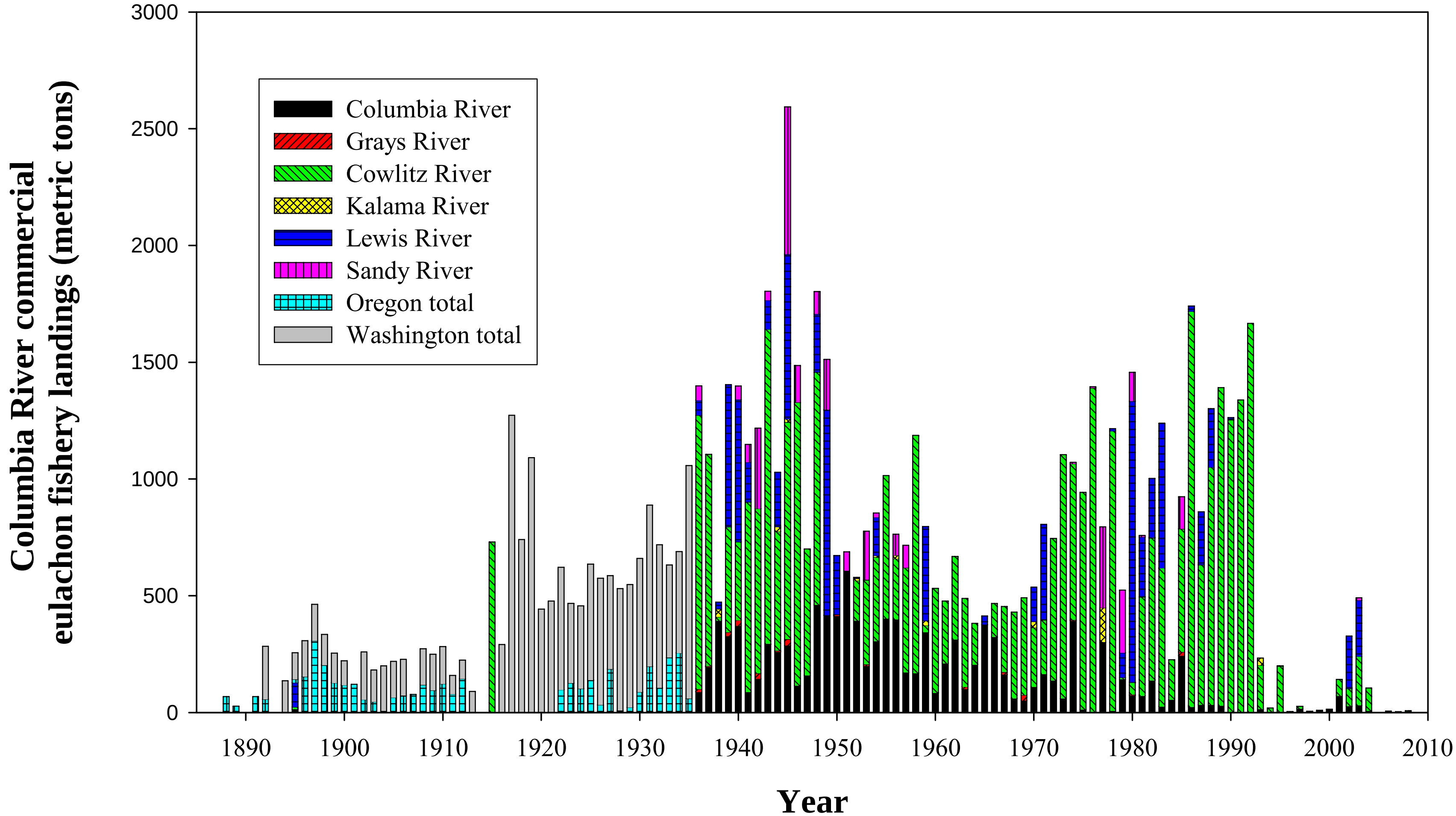

Figure 18. Commercial eulachon fishery landings in the Columbia River and tributaries from 1888 to 2008. Data sources listed in Table 2.

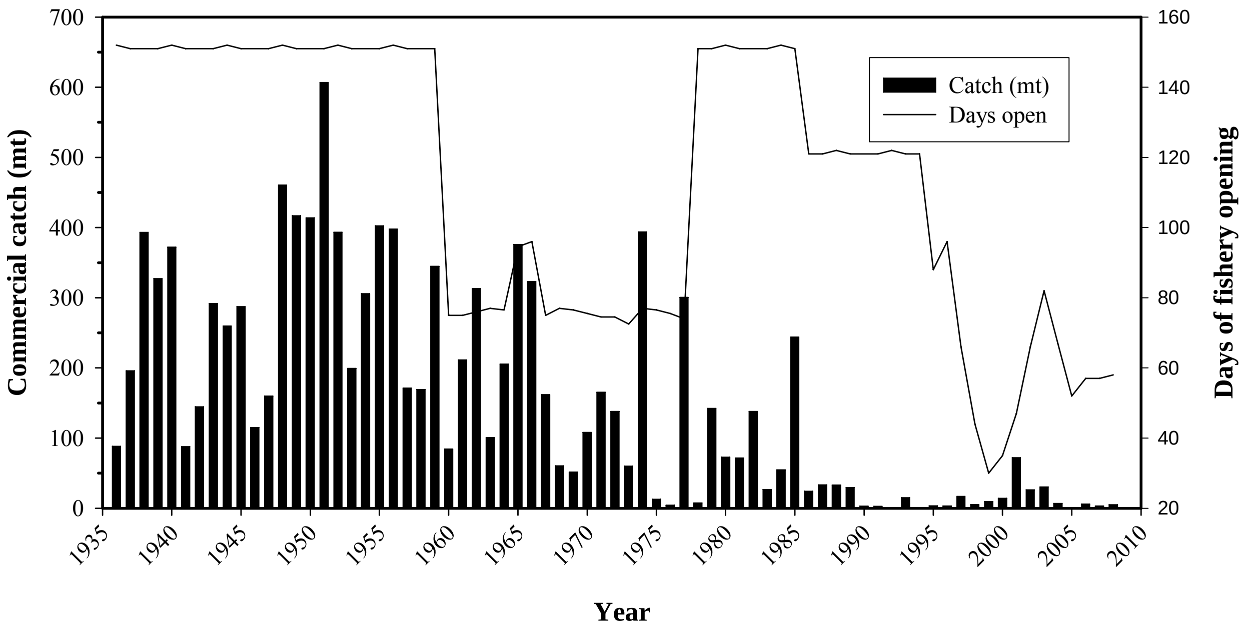

Figure 19. Commercial landings of eulachon and estimated total number of days the fishery was open in the Columbia River from 1935 to 2008.

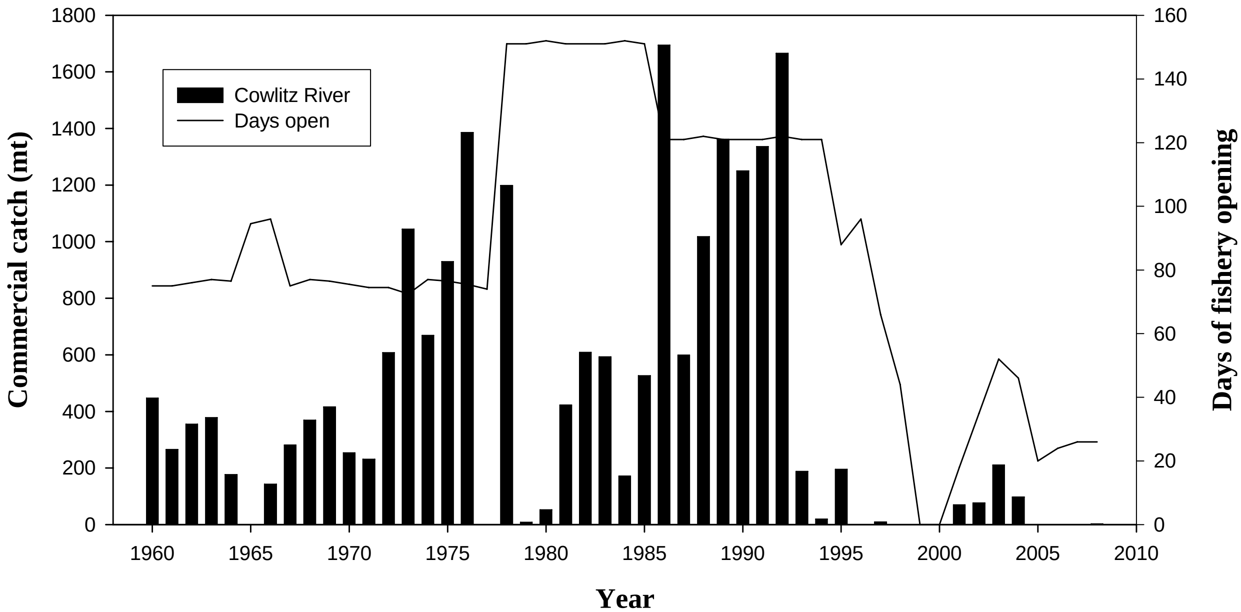

Figure 20. Commercial landings of eulachon and estimated total number of days the fishery was open in the Cowlitz River from 1960 to 2008.

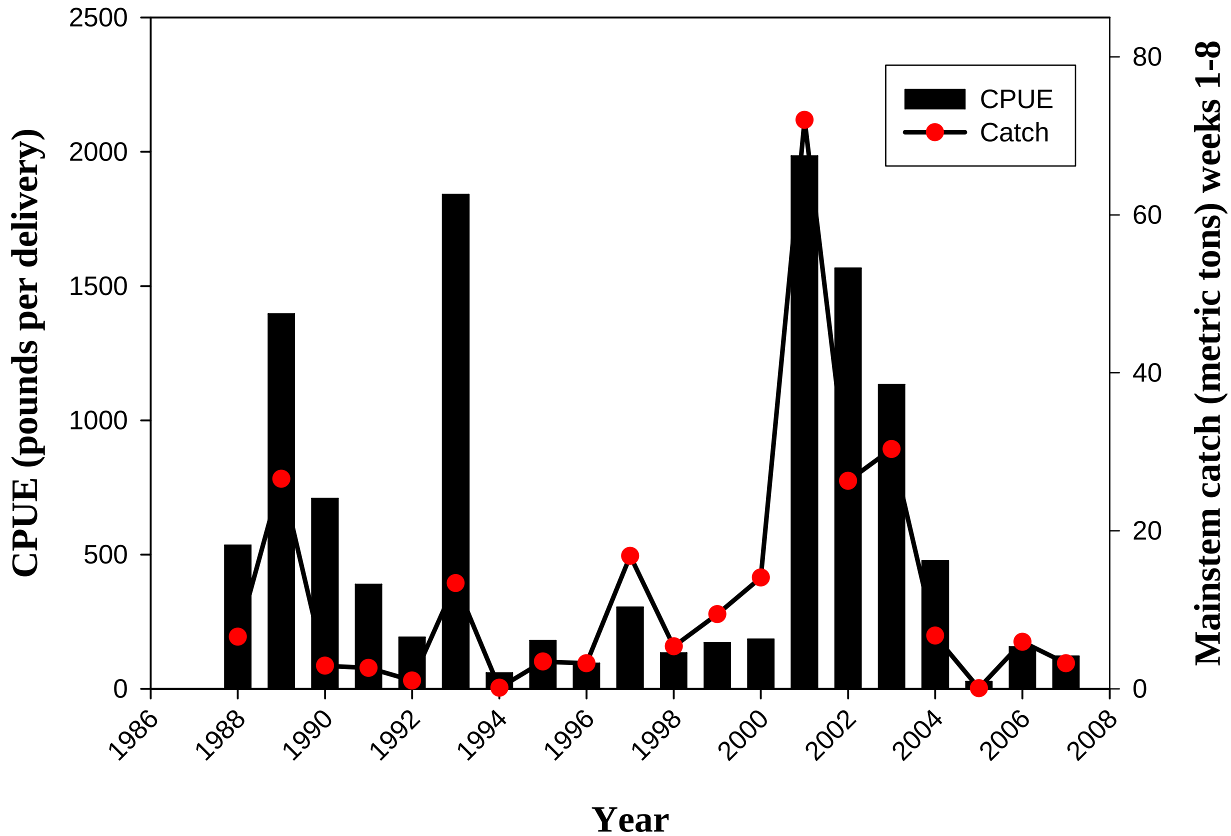

Figure 21. Columbia River commercial eulachon catch (season total may include catch during the previous December) and CPUE as pounds per delivery. Data from JCRMS (2007; their Table 17).

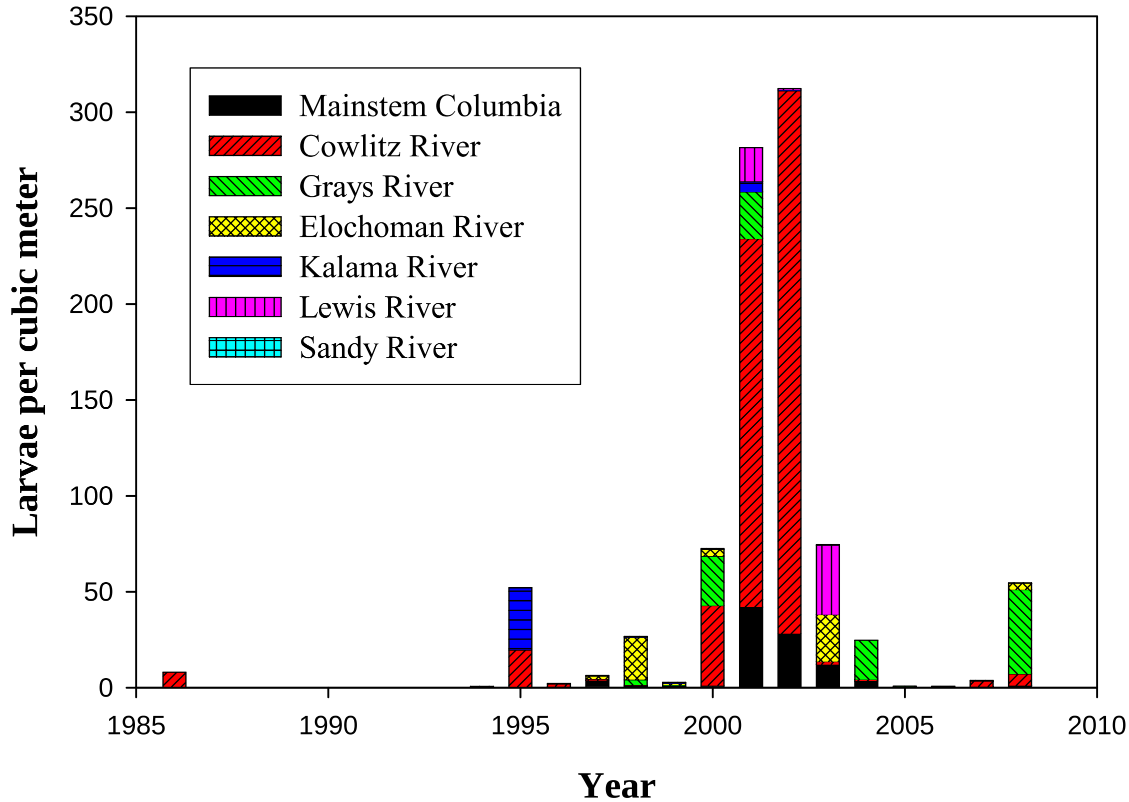

Figure 22. Columbia River larval eulachon (*Thaleichthys pacificus*) sampling. Inter-annual comparisons are problematic due to inconsistent effort and methods from year to year. Data from JCRMS (2007) and O. Langness (WDFW, pers. comm., August 2008).

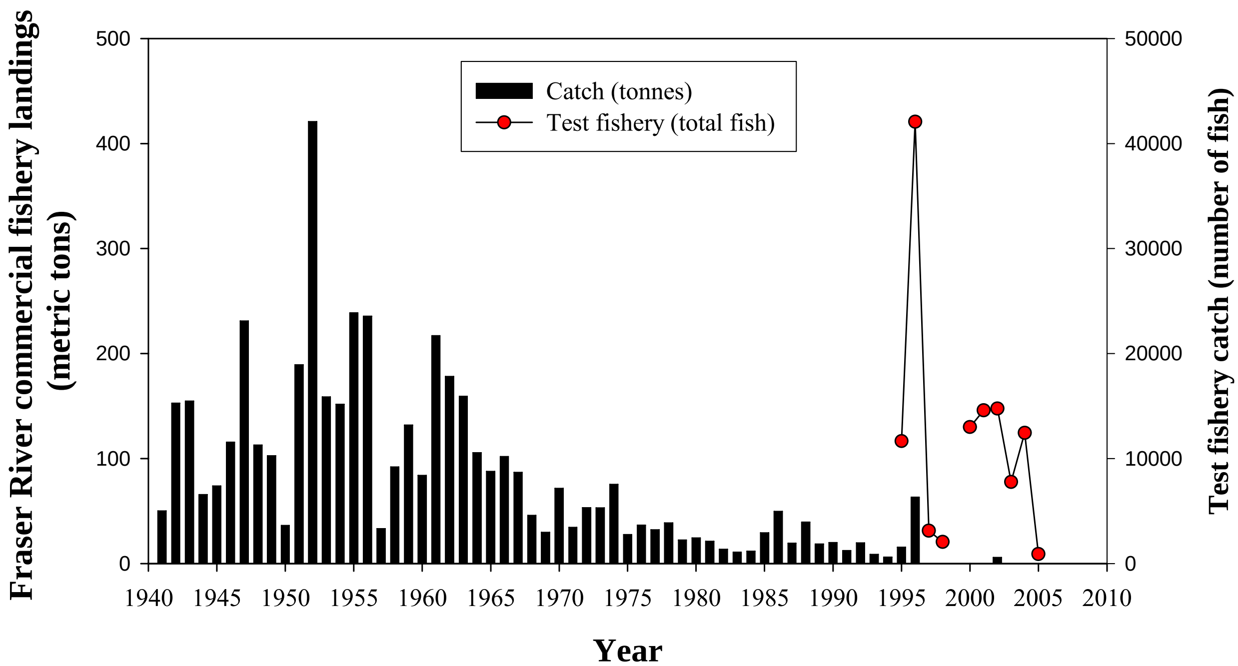

Figure 23. Eulachon landings (metric tons) in Fraser River commercial fishery (1940-2008) and total fish landed in Fraser River test fishery (1995-2005). Commercial fishery was closed in 1997-2001, 2003, and 2005-2008. Data from Hay (2002) and DFO (2008a).

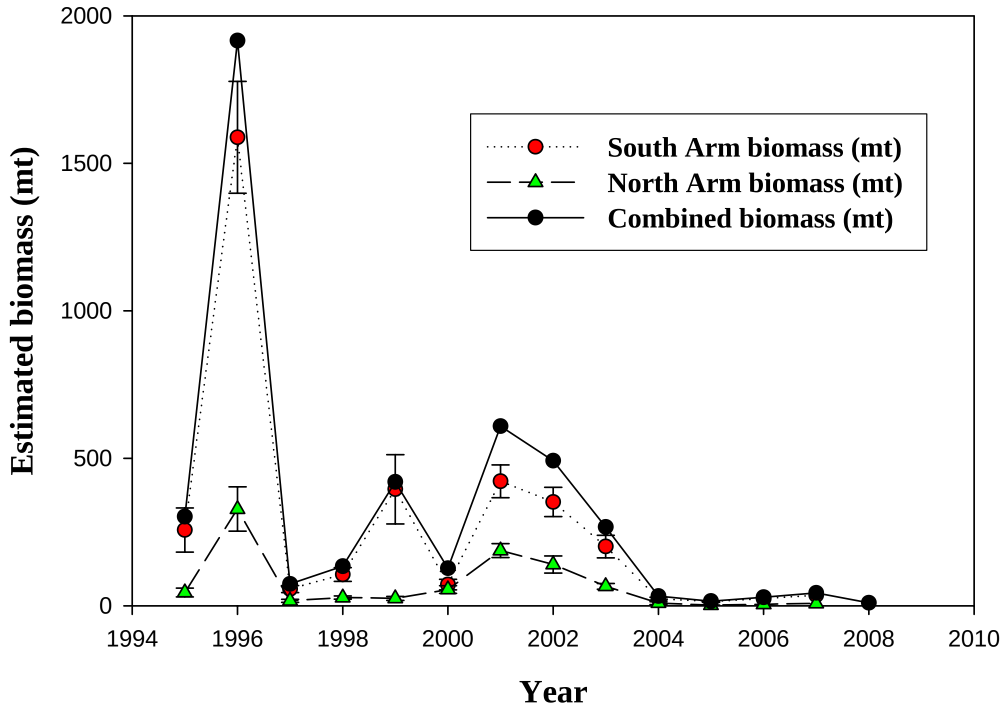

Figure 24. Fraser River eulachon spawning stock biomass 1995 to 2008 (estimated from egg and larval surveys). Data from DFO (2008a) and data online at http://www-sci.pac.dfo-mpo.gc.ca/herring/herspawn/pages/river1_e.htm.

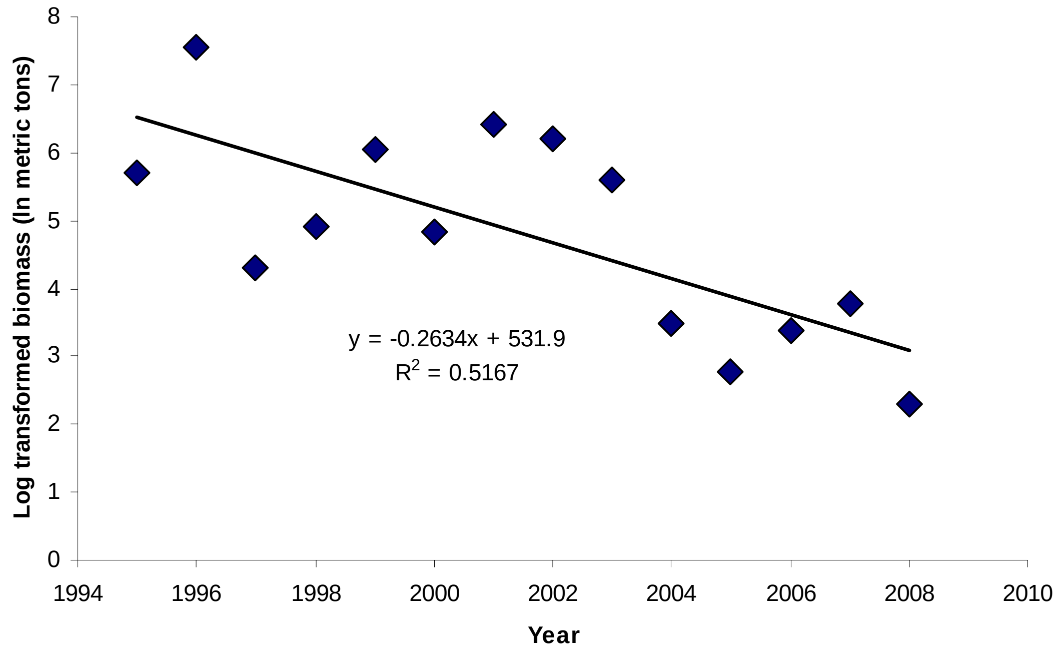

Figure 25. Trend of Fraser River eulachon spawner abundance (metric tons) from 1995 to 2008. Trend calculated from data in Figure 24.

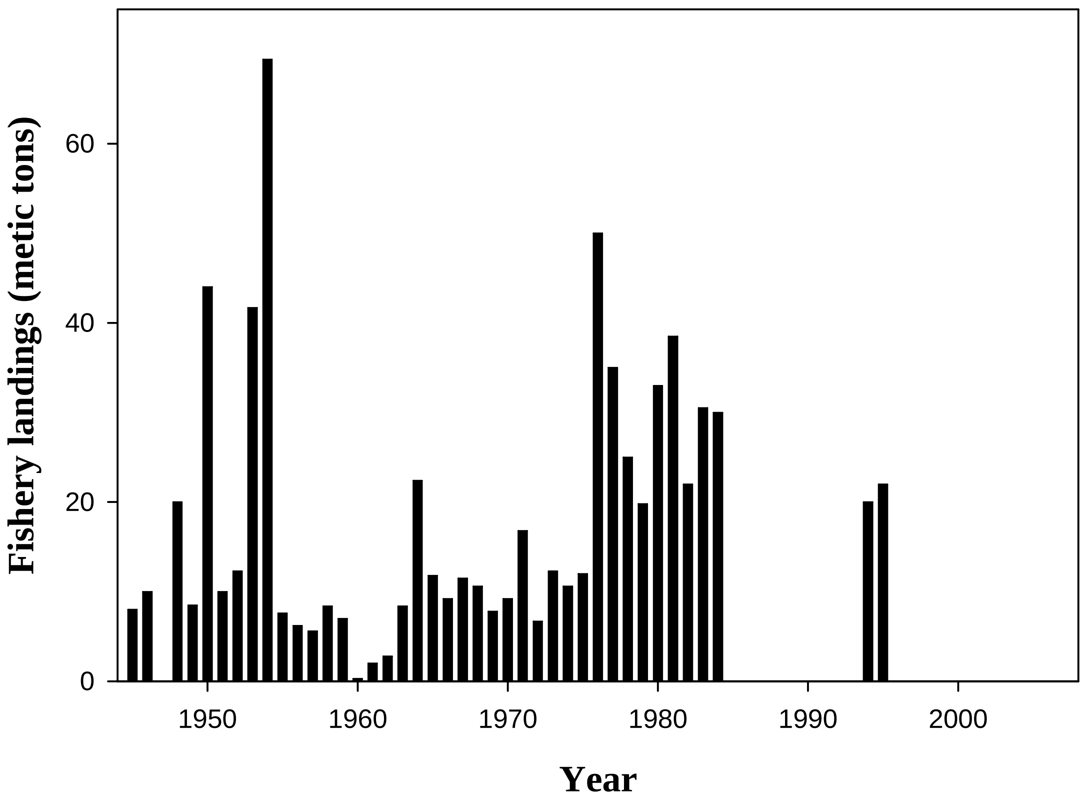

Figure 26. Estimated eulachon First Nations fishery landings (metric tons) on the Bella Coola River (data from Hay 2002). Catch of unknown size occurred from 1985 to 1993 and from 1996 to 1998 (Hay 2002). No fishery has occurred on the Bella Cool River since 1999.

APPENDIX A: LIFE HISTORY TABLES

Table A-1. List and classification of known and possible eulachon spawning areas and estuarine areas as given in Hay and McCarter (2000), Hay (2002), and Willson et al. (2006). Spawning regularity is categorized as mainly regular (occurring most years), irregular, occasional, rare, one-time (one-time observation), anecdotal, or unknown.

Eulachon spawning areas	Spawning regularity	Estuary	Reference
California			
Sacramento River	Single fish		Vincik and Titus (2007)
Gualala River	Anecdotal		Fry (1979)
Jacoby and Jolly Giant creeks	Rare	Humboldt Bay	Jennings (1996)
Mad River	Irregular		Moyle et al. (1995); Moyle (2002)
Redwood Creek	Irregular		Moyle et al. (1995); Moyle (2002)
Klamath River	Regular		Moyle et al. (1995); Moyle (2002)
Smith River	Rare		Moyle et al. (1995); Moyle (2002)
Oregon			
Chetco River	Rare	Chetco Estuary	WDFW and ODFW (2008)
Umpqua River	Rare	Umpqua Estuary	OFC (1970)
Tenmile Creek	Irregular		WDFW and ODFW (2008)
Sandy River	Irregular	Columbia River	WDFW and ODFW (2008)
Tanner Creek	One-time	Columbia River	WDFW and ODFW (2008)
Hood River	Anecdotal	Columbia River	Smith and Saalfeld (1955)
Washington			
Columbia River mainstem	Regular	Columbia River	Smith and Saalfeld (1955); WDFW and ODFW (2001, 2008)
Grays River	Regular	Columbia River	WDFW and ODFW (2001, 2008)
Skamokawa Creek	Rare	Columbia River	WDFW and ODFW (2001, 2008)
Elochoman River	Irregular	Columbia River	WDFW and ODFW (2001, 2008)
Cowlitz River	Regular	Columbia River	Smith and Saalfeld (1955); WDFW and ODFW (2001, 2008)
Toutle River	Rare	Columbia River	WDFW and ODFW (2008)
Kalama River	Regular	Columbia River	WDFW and ODFW (2001, 2008)
Lewis River	Regular	Columbia River	WDFW and ODFW (2001, 2008)
Washougal River	Rare	Columbia River	WDFW and ODFW (2008)
Klickitat River	Anecdotal	Columbia River	Smith and Saalfeld (1955)
Bear River	Occasional	Willapa Bay	WDFW and ODFW (2001, 2008)
Naselle River	Occasional	Willapa Bay	WDFW and ODFW (2001, 2008)
Nemah River	Rare	Willapa Bay	Smith (1941); WDFW and ODFW (2001, 2008)
Wynoochie River	Rare		WDFW and ODFW (2001, 2008)
Quinault River	Occasional		WDFW and ODFW (2001, 2008)
Queets River	Occasional		WDFW and ODFW (2001, 2008)
Quillayute River	Rare		WDFW and ODFW (2008)
Elwha River	Occasional		Shaffer et al. (2007)
Puyallup River	Rare		Miller and Borton (1980)
British Columbia			
Fraser River	Regular	Fraser Estuary	Hay and McCarter (2000); Hay (2002)
Squamish River	Irregular	Howe Sound	Hay and McCarter (2000); Hay (2002)
Homathko River	Irregular	Bute Inlet - Johnstone Strait	Hay and McCarter (2000); Hay (2002)
Stafford/Apple rivers	Unknown	Loughborough Inlet	Hay and McCarter (2000); Hay

Eulachon spawning areas	Spawning regularity	Estuary	Reference
			(2002)
Port Neville	Unknown	Johnstone Strait	Hay and McCarter (2000); Hay (2002)
Franklin River	Unknown	Knight Inlet	Hay and McCarter (2000); Hay (2002)
Klinaklini River	Regular	Knight Inlet	Hay and McCarter (2000); Hay (2002)
Kakweiken River	Unknown	Thompson Sound - Johnstone Strait	Hay and McCarter (2000); Hay (2002)
Kingcome River	Regular	Kingcome Inlet	Hay and McCarter (2000); Hay (2002)
Nekite River	Unknown	Smith Inlet	Hay and McCarter (2000); Hay (2002)
Hardy Inlet	Unknown	Rivers Inlet	Hay and McCarter (2000); Hay (2002)
Clyak River	Unknown	Rivers Inlet-Moses Inlet	Hay and McCarter (2000); Hay (2002)
Wannock/Oweekeno rivers	Regular	Rivers Inlet - Queen Charlotte Strait	Hay and McCarter (2000); Hay (2002)
Chuckwalla/Kilbella rivers	Regular	Rivers Inlet - Queen Charlotte Strait	Hay and McCarter (2000); Hay (2002)
Kwatna River	Unknown	Burke Channel	Hay and McCarter (2000); Hay (2002)
Cascade Inlet	Unknown	Dean Channel	Hay and McCarter (2000); Hay (2002)
Skowquiltz River	Unknown	Dean Channel	Hay and McCarter (2000); Hay (2002)
Taleomy River	Unknown	Dean Channel -South Bentinck Arm	Hay and McCarter (2000); Hay (2002)
Noeick River	Unknown	Dean Channel -South Bentinck Arm	Hay and McCarter (2000); Hay (2002)
Kimsquit/Dean rivers	Regular	Dean Channel	Hay and McCarter (2000); Hay (2002)
Bella Coola River	Regular	Dean Channel -North Bentick Arm	Hay and McCarter (2000); Hay (2002)
Kainet or Lard Creek	Unknown	Kynoch Inlet - Mathieson Channel	Hay and McCarter (2000); Hay (2002)
Aaltanhash River	Unknown	Princess Royal Channel - Aaltanhash Inlet	Hay and McCarter (2000); Hay (2002)
Khutze River	Unknown	Princess Royal Channel - Khutze Inlet	Hay and McCarter (2000); Hay (2002)
Kemano/Wahoo River	Regular	Gardner Canal - Kemano Bay	Hay and McCarter (2000); Hay (2002)
Kowesas River	Regular	Gardner Canal - Chief Matthew's Bay	Hay and McCarter (2000); Hay (2002)
Kitlope River	Regular	Gardner Canal	Hay and McCarter (2000); Hay (2002)
Foch Lagoon	Irregular	Douglas Channel	Hay and McCarter (2000); Hay (2002)
Giltoyees Inlet	Irregular	Douglas Channel	Hay and McCarter (2000); Hay (2002)

Eulachon spawning areas	Spawning regularity	Estuary	Reference
Kildala River	Regular	Douglas Channel - Kitimat Arm	Hay and McCarter (2000); Hay (2002)
Kitimat River	Regular	Douglas Channel - Kitimat Arm	Hay and McCarter (2000); Hay (2002)
Skeena River	Regular	Chatham Sound	Hay and McCarter (2000); Hay (2002)
Nass River	Regular	Portland Inlet	Hay and McCarter (2000); Hay (2002)
Southeast Alaska			
Wilson / Blossom rivers		Smeaton Bay	Willson et al. (2006)
Chickamin River			Willson et al. (2006)
Unuk / Klahini / Eulachon rivers		Burroughs Bay	Willson et al. (2006)
Stikine River			Womble (2003); Willson et al. (2006)
Hulakon River, Grant Creek		Bradfield Canal	Willson et al. (2006)
Bradfield River			Willson et al. (2006)
Speel / Whiting rivers		Port Snettisham	Womble (2003); Willson et al. (2006)
Taku River			Womble (2003); Willson et al. (2006)
Mendenhall River			Willson et al. (2006)
Eagle River			Willson et al. (2006)
Berners / Lace / Antler rivers		Berners Bay	Womble (2003); Willson et al. (2006)
Katzehin River			Womble (2003); Willson et al. (2006)
Skagway River			Willson et al. (2006)
Taiya River			Womble (2003); Willson et al. (2006)
Chilkoot / Ferebee rivers		Lutak Inlet	Womble (2003); Willson et al. (2006)
Chilkat River			Womble (2003); Willson et al. (2006)
Endicott River			Womble (2003); Willson et al. (2006)
Excursion River			Womble (2003); Willson et al. (2006)
Adams Inlet		Glacier Bay	Womble (2003); Willson et al. (2006)
Yakutat area, Alaska			Willson et al. (2006)
Dixon River			Womble (2003); Willson et al. (2006)
Fairweather Slough			Willson et al. (2006)
Sea Otter Creek			Willson et al. (2006)
Doame River			Willson et al. (2006)
Alsek River, Clear Creek		Dry Bay	Womble (2003); Willson et al. (2006)
Dangerous / Italio / Akwe rivers			Willson et al. (2006)
Situk / Ahrnklin rivers / Tawah Creek			Willson et al. (2006)
Lost River			Willson et al. (2006)

Eulachon spawning areas	Spawning regularity	Estuary	Reference
South-Central Alaska			
Pillar Creek, Kalsin River (Kodiak Island)			Willson et al. (2006)
Martin R., Alaganik Slough, Ibeck Slough, Eyak R., Scott R., Copper R. (Copper River Delta)			Willson et al. (2006)
Resurrection River		Resurrection Bay	Willson et al. (2006)
Twentymile R., Portage Cr., Placer R., Chickaloon R., Virgin Cr.		Turnagain Arm	Willson et al. (2006)
Susitna R., Yentna R., Beluga R., Kenai R.		Cook Inlet	Willson et al. (2006)
Western Alaska			
Kametolook River (Gulf of Alaska)			Willson et al. (2006)
Three Star River (Gulf of Alaska)			Willson et al. (2006)
Meshik R., Sandy R., Bear R., Milky R. (Bristol Bay; western Alaska Peninsula)			Willson et al. (2006)
King Salmon River		Bristol Bay	Willson et al. (2006)
Nushagak River		Bristol Bay	Willson et al. (2006)

Table A-2. Eulachon distribution information in West Coast estuaries as compiled by Monaco et al. (1990).

Estuary	Reference # and occurrence	Personal communication	Reference source
Skagit Bay	260 rare	Penttila, D. - Washington Department of Fisheries, Seattle, WA.	260. Miller, B. S., and S. F. Borton. 1980. Geographical distribution of Puget Sound fishes: maps and data source sheets. 3 Volumes. Wash. Sea Grant Prog. and Wash. State Dept. Ecol., Seattle, WA.
Hood Canal	260 not found	Penttila, D. - Washington Department of Fisheries, Seattle, WA.	260. Miller, B. S., and S. F. Borton. 1980. Geographical distribution of Puget Sound fishes: maps and data source sheets. 3 Volumes. Wash. Sea Grant Prog. and Wash. State Dept. Ecol., Seattle, WA.
Puget Sound	260, 452 rare		260. Miller, B. S., and S. F. Borton. 1980. Geographical distribution of Puget Sound fishes: maps and data source sheets. 3 Volumes. Wash. Sea Grant Prog. and Wash. State Dept. Ecol., Seattle, WA. 452. Wydoski, R. S. and Whitney R. R. 1979. Inland fishes of Washington, Univ. Wash. Press, Seattle.
Grays Harbor	96	Brix, R. - Washington Department of Fisheries, Montesano, WA.	96. Deschamps, G., S. G. Wright, and R. E. Watson. 1971. Fish migration and distribution in the lower Chehalis River and upper Grays Harbor. *In* Grays Harbor cooperative water quality study 19641966, p. 1-55. Tech. Rept. No.7, Wash. Dept. Fish., Olympia.

Estuary	Reference # and occurrence	Personal communication	Reference source
Willapa Bay		Brix, R. - Washington Department of Fisheries, Montesano, WA.	
Columbia River	118, 269	McConnell, R. - National Marine Fisheries Service, Hammond, OR.	118. Environmental Protection Agency. 1971. Columbia River thermal effects study. Volume 1: biological effects studies. U.S. Environ. Prot. Agency, U.S. Atomic Energy Comm., and Natl. Mar. Fish. Serv., 102 p. 269. Misitano, D. A. 1977. Species composition and relative abundance of larval and post-larval fishes in the Columbia River estuary, 1973. Fish. Bull., U.S. 75(1):218-222.
Nehalem Bay	0, not found		
Tillamook Bay	39, 131 not found		39. Bottom, D. L., and B. Forsberg. 1978. The fishes of Tillamook Bay. Fed. Aid Prog. Rept., Fish., Oregon Dept. Fish Wildl., Corvallis, 55 p. 131. Forsberg, B. O., J. A. Johnson, and S. M. Klug. 1977. Identification, distribution, and notes on food habits of fish and shellfish in Tillamook Bay, Oregon. Fed. Aid Prog. Rept., Fish., Oregon Dept. Fish WildI., Corvallis, 117 p.
Netarts Bay	399 not found	Chung, A. - Oregon State University, Corvallis, OR.	399. Stout, H. (editor) 1976. The natural resources and human utilization of Netarts Bay, Oregon. Oregon State Univ., Corvallis, 247 p.

Estuary	Reference # and occurrence	Personal communication	Reference source
Siletz River	384 not found	Stewart, G. - Oregon Department of Fish and Wildlife, Newport, OR.	384. Starr, R. 1979. Natural resources of Siletz estuary. Oregon Dept. Fish Wildl., Corvallis, 44 p.
Yaquina Bay	Not found	Butler, J. - Oregon Department of Fish and Wildlife, Newport, OR. DeBen, W. - U.S. Environmental Protection Agency, Newport, OR. Stewart, G. - Oregon Department of Fish and Wildlife, Newport, OR.	
Alsea River	Not found	Butler, J. - Oregon Department of Fish and Wildlife, Newport, OR. Stewart, G. - Oregon Department of Fish and Wildlife, Newport, OR.	
Siuslaw River	197 rare	McCleod, J. - Oregon Department of Fish and Wildlife, Florence, OR.	197. Hutchinson, J. M. 1979. Seasonal distribution of fishes in Siuslaw Bay. Oregon Dept. Fish Wildl. Corvallis, 55 p.

Estuary	Reference # and occurrence	Personal communication	Reference source
Umpqua River	200, 277, 323	Johnson, J. - Oregon Department of Fish and Wildlife, Reedsport, OR.	200. Johnson, J., D. P. Liscia, and D. M. Anderson. 1986. The seasonal occurrence and distribution of fish in the Umpqua estuary April 1977 through January 1986. Info. Rept. 86-6, Oregon Dept. Fish Wildl., Corvallis, 10 p. 277. Mullen, R. E., 1977. The occurrence and distribution of fish in the Umpqua River estuary, June through October 1972. Info. Rept. 77-3, Oregon Dept. Fish Wildl., Corvallis, 39 p. 323. Ratti, F. 1979b. Natural resources of Umpqua estuary. Est. Inven. Rept. 2(5), Oregon Dept. Fish Wildl, Corvallis, 55 p.
Coos Bay	91, 193, 337, 429 rare	Mullarkey, W. - Oregon Department of Fish and Wildlife, Charleston, OR.	91. Cummings, E, and E Schwartz. 1971. Fish in Coos Bay, Oregon, with comments on distribution, temperature, and salinity of the estuary. Info. Rept. 70-11, Oregon Fish Comm., Portland, 22 p. 193. Hostick, G. A 1975. Numbers of fish captured in beach seine hauls in Coos River estuary, Oregon, June through September 1970. Info. Rept. 74-11, Fish Comm. of Oregon, Portland, 22 p. 337. Roye, C. 1979. Natural resources of Coos Bay estuary. Oregon Dept. Fish Wildl, Corvallis, 87 p. 429. Wagoner, L. J., K. K. Jones, R. E. Bender, J. A. Butler, D. E. Demory, T. F. Gaumer, W. G. Mullarkey, N. T. Richmond, and T. J. Rumreich. 1988. Coos Bay fish management plan. Draft No.3, Oregon Dept. Fish Wildl., Corvallis, 127 p.

Estuary	Reference # and occurrence	Personal communication	Reference source
Rogue River	322 rare	Riikula, A. - Oregon Department of Fish and Wildlife, Gold Beach, OR.	322. Ratti, F. 1979a. Natural resources of Rogue estuary. Est. Inven. Rept. 2(3), Oregon Dept. Fish Wildl, Corvallis, 33 p.
Klamath River	138	Kisanuki, T. - U.S. Fish and Wildlife Service, Arcata, CA. Orcutt, M. - Hoopa Valley Tribe, Hoopa, CA. Pisano, M. - California Department of Fish and Game, Arcata, CA. Warner, R. - California Department of Fish and Game, Eureka, CA.	138. Fry, D. H., Jr. 1979. Anadromous fishes of California. Calif. Dept. of Fish and Game, Sacramento, 112 p.
Humboldt Bay	165, 454 rare	Barnhart, R. - U. S. Fish and Wildlife Service, Coop. Fish. Research Unit, Arcata, CA. Toole, C. - University of California Cooperative Extension, Eureka, CA. Warner, R. - California Department of Fish and Game, Eureka, CA.	165. Gotshall, D. W., G. H. Allen, and R. A. Barnhart. 1980. An annotated checklist of fishes from Humboldt Bay, California. Calif. Fish Game 66(4):220-232. 454. Young, J. S. 1984. Identification of larval smelt (Osteichthes: Salmoniformes: Osmeridae) from northern California. M. S. thesis. Humboldt State Univ., Arcata, CA, 90 pp.

Estuary	Reference # and occurrence	Personal communication	Reference source
Eel River	270, 313 not found		270. Monroe, G. W., F. Reynolds, B. M. Browning, and J. W. Speth. 1974. Natural resources of the Eel River delta. Coast. Wetl. Ser. No. 9, Calif. Fish and Game, Sacramento, 108 p. 313. Puckett, L. K. 1977. The Eel River estuary observations on morphometry, fishes, water quality and invertebrates. Memo. Rept., 26 p. plus appendix, Calif. Dept. Fish Game, Sacramento.
Tomales Bay	22, 264, 292 not found		22. Bane, G. W., and A. W. Bane. 1971. Bay fishes of northern California with emphasis on the Bodega Tomales Bay area. Mariscos Publ., Hampton Bays, NY, 143 p. 264. Miller, D. J.,and R. N. Lea. 1972. Guide to the coastal marine fishes of California. Calif. Fish Game. Fish Bull. 157, 235 p. 292. Odemar, M. W. 1964. Southern range extension of the eulachon, *Thaleichthys pacificus.* Calif. Fish Game 50(4):305-307.
Central San Francisco / Suisun / San Pablo Bays	264, 292 not found		264. Miller, D. J., and R. N. Lea. 1972. Guide to the coastal marine fishes of California. Calif. Fish Game Fish Bull. 157, 235 p. 292. Odemar, M. W. 1964. Southern range extension of the eulachon, *Thaleichthys pacificus.* Calif. Fish Game 50(4):305-307.

Estuary	Reference # and occurrence	Personal communication	Reference source
South San Francisco Bay	not found, 292, 294		292. Odemar, M. W. 1964. Southern range extension of the eulachon, *Thaleichthys pacificus*. Calif. Fish Game 50(4):305-307. 294. Oregon Department Fish and Wildlife, and Washington Department of Fisheries. 1987. Status report: Columbia River fish runs and fisheries 1960-1986. Oregon Dept. Fish Wildl., Portland, and Wash. Dept. Fish., Olympia, 78 p.
Elkhorn Slough	not found, 264, 292		264. Miller, D. J., and R. N. Lea. 1972. Guide to the coastal marine fishes of California. Calif. Fish Game Fish Bull. 157, 235 p. 292. Odemar, M. W. 1964. Southern range extension of the eulachon, *Thaleichthys pacificus*. Calif. Fish Game 50(4):305-307.
Morro Bay	not found, 264, 292		264. Miller, D. J., and R. N. Lea. 1972. Guide to the coastal marine fishes of California. Calif. Fish Game Fish Bull. 157, 235 p. 292. Odemar, M. W. 1964. Southern range extension of the eulachon, *Thaleichthys pacificus*. Calif. Fish Game 50(4):305-307.
Santa Monica Bay	not found, 264		264. Miller, D. J., and R. N. Lea. 1972. Guide to the coastal marine fishes of California. Calif. Fish Game Fish Bull. 157, 235 p.
San Pedro Bay	not found, 264		264. Miller, D. J., and R. N. Lea. 1972. Guide to the coastal marine fishes of California. Calif. Fish Game Fish Bull. 157, 235 p.

Estuary	Reference # and occurrence	Personal communication	Reference source
Alamitos Bay	not found, 264		264. Miller, D. J., and R. N. Lea. 1972. Guide to the coastal marine fishes of California. Calif. Fish Game Fish Bull. 157, 235 p.
Anaheim Bay	not found, 264		264. Miller, D. J., and R. N. Lea. 1972. Guide to the coastal marine fishes of California. Calif. Fish Game Fish Bull. 157, 235 p.
Newport Bay	not found, 264		264. Miller, D. J., and R. N. Lea. 1972. Guide to the coastal marine fishes of California. Calif. Fish Game Fish Bull. 157, 235 p.
Mission Bay	not found, 264		264. Miller, D. J., and R. N. Lea. 1972. Guide to the coastal marine fishes of California. Calif. Fish Game Fish Bull. 157, 235 p.
San Diego Bay	not found, 264		264. Miller, D. J., and R. N. Lea. 1972. Guide to the coastal marine fishes of California. Calif. Fish Game Fish Bull. 157, 235 p.
Tijuana Bay	not found, 264		264. Miller, D. J., and R. N. Lea. 1972. Guide to the coastal marine fishes of California. Calif. Fish Game Fish Bull. 157, 235 p.

Table A-3. Range (gray shading) and peak (black shading) timing of documented river-entry and/or spawn-timing for eulachon.

Basin	Source	December	January	February	March	April	May	June
California								
Mad River								
Redwood Creek								
Klamath River	1							
Oregon								
Tenmile Creek, OR	7							
Columbia Basin								
Columbia River	10							
Cowlitz River	10							
Sandy River	7							
Washington								
Elwha River, WA	2							
British Columbia								
Fraser River	4, 13							
Kemano River	8							
Bella Coola River	15							
Kitimat River	3, 9							
Skeena River	16							
Nass River	6							
Alaska								
Copper River	11, 12							
Alaganik River	11, 12							
Eyak River	11							
Ibeck Creek	11, 12							
Twentymile River	5							
Susitna River	14							

1 – Larson and Belchik (1998); 2 – Shaffer et al. (2007); 3 – Pedersen et al. (1995); 4 – Ricker et al. (1954); Hart and McHugh (1944); 5 – Kubik and Wadman (1977, 1978); Spangler et al. (2003); 6 – Langer et al. (1977); 7 – WDFW and ODFW (2008); 8 - Lewis et al. (2002, as cited in Moody 2008); 9 – Kelson (1996, as cited in Moody 2008); 10 – WDFW and ODFW (2001); 11 – Joyce et al. (2004); 12 – Moffitt et al. (2002); 13 – Hart (1943); 14 - Barrett et al. (1984, cited in Spangler et al. 2003); 15 – Moody (2008); 16 – Lewis (1997).

Table A-4. Temperatures at the time of river entry and spawning for eulachon in different river systems.

Location	Temperature	Incubation time	Reference
Columbia River	6.5˚ – 9.0˚ C	~ 21 days	Parente and Snyder (1970)
Cowlitz River	4.5˚ – 7.0˚ C	30 – 49 days	Smith and Saalfeld (1955)
Fraser River	4.0˚ – 5.0˚ C	~ 28 days	Hay and McCarter (2000)
Fraser River	4.4˚ – 7.2˚ C	30 – 40 days	Hart (1973)
Kitimat River	4.0˚ – 7.0˚ C	~ 42 days	Willson et al. (2006; their Table 4)
Nass River	0.0˚ – 2.0˚ C	unknown	Langer et al. (1977)

Table A-5. Mean length of adult eulachon for selected river basins for individual years, sex, and age. Dashes indicate data were unavailable. Methods of length measurement are: FL = fork length, SL = standard length, TL = total length. SD = standard deviation, SE = standard error.

Location				Male Length (mm)					Female Length (mm)				
(River basin)	Date	Age	Method	Mean	SD	SE	Range	N	Mean	SD	SE	Range	N
Alaska													
Susitna River	1982												
	1983												
Twentymile River	1976[a]	--	--	228	--	--	202-249	22	224	--	--	210-246	40
	1977[b]	--	--	228	--	--	162-270	--	223	--	--	202-255	408 total
Copper River Delta													
	2000[c]	--	FL	215	--	0.9	166-242	222	202	--	3.0	143-234	49
	2001[c]	--		209	--	0.5	100-241	585	203	--	0.6	99-253	425
Eyak River	2002[i]	3	SL	180	--	4	--	4	--	--	--	--	---
		4		187	--	0	--	430	187	--	12	--	2
		5		192	--	3	--	9	--	--	--	--	--
Ibeck Creek	2001[i]	3	SL	180	--	2	--	40	164	--	4	--	2
		4		177	--	0	--	1089	171	--	1	--	75
		5		186	--	3	--	5	--	--	--	--	--
		6		182	--	3	--	4	--	--	--	--	--
	2003[j]	--	SL	179	--	10	138-207	1249	173	--	9	154-206	101
Alaganik Slough	1998[i]	3	SL	179	--	3	--	6	--	--	--	--	--
		4		175	--	2	--	35	172	--	2	--	2
		5		179	--	0	--	377	175	--	2	--	40
	2000[i]	3	SL	160	--	1	--	47	160	--	2	--	25
		4		174	--	3	--	21	173	--	9	--	6
Copper River													
Flag Point channel	1998[i]	3	SL	179	--	3	--	7	181	--	1	--	2
		4		182	--	1	--	151	175	--	1	--	96
		5		183	--	0	--	1848	177	--	0	--	478
		6		176	--	2	--	7	186	--	10	--	2
	2000[i]	2	SL	182	--	--	--	1	--	--	--	--	--
		3		174	--	0	--	534	168	--	1	--	109
		4		176	--	0	--	547	172	--	1	--	99
		5		183	--	2	--	43	164	--	5	--	5
		6		192	--	--	--	1	--	--	--	--	--
	2001[i]	2	SL	--	--	--	--	--	154	--	n/a	--	1

Location				Male Length (mm)					Female Length (mm)				
(River basin)	Date	Age	Method	Mean	SD	SE	Range	N	Mean	SD	SE	Range	N
		3		174	--	0	--	643	167	--	1	--	306
		4		180	--	0	--	571	172	--	1	--	155
		5		179	--	2	--	21	166	--	3	--	2
	2002[i]	3	SL	178	--	3	--	16	185	--	6	--	2
		4		183	--	0	--	1081	178	--	1	--	175
		5		188	--	3	--	15	190	--	n/a	--	1
60 km bridge	2002[i]	3	SL	181	--	8	--	3	176	--	4	--	7
		4		186	--	0	--	575	181	--	1	--	218
		5		191	--	3	--	9	--	--	--	--	--
Southeast Alaska													
Stikine River[e]	1979	2	FL	180	--	--	141-197	--	--	--	--	--	--
		3		190	--	--	165-210	--	--	--	--	--	--
		4		194	--	--	173-211	--	--	--	--	--	--
	1980	2		172	--	--	155-179	--	--	--	--	--	--
		3		186	--	--	162-208	--	--	--	--	--	--
		4		201	--	--	195-208	--	--	--	--	--	--
British Columbia													
Nass River[d]	1970	3	SL	173	11.3	--	--	87	171	16.2	--	--	11
		4		179	11.2	--	--	123	181	11.8	--	--	19
		5		188	6.1	--	--	12	192	3.5	--	--	4
	1971	2		155	10.9	--	--	5	144	6.9	--	--	9
		3		167	52.3	--	--	74	157	16.2	--	--	183
		4		174	10.2	--	--	33	171	10.3	--	--	60
		5		188	19.8	--	--	7	183	11.3	--	--	7
Skeena River	2003[l]	--	FL Not sexed	189	--	2	--	52					
Kitimat River	1993[e]	3	SL	--	--	--	--	--	169	--	1.5	149 – 187	44
		4		--	--	--	--	--	175	--	1.5	165 – 181	12
		5		--	--	--	--	--	184	--	n/a	n/a	1
		6		--	--	--	--	--	170	--	9.5	160 - 189	2
	1997[q]	2	SL	173	9.9	--	--	2	162	0.0	--	--	1
		3		176	14.4	--	--	28	180	9.9	--	--	25
		4		175	12.9	--	--	16	174	11.6	--	--	37
		5		184	15.6	--	--	13	183	12.7	--	--	10
		6		182	0.0	--	--	1	178	17.7	--	--	2
Kemano River	1988 [r]	3	FL	168	--	--	--	--	165	--	--	--	--
		4		175	--	--	--	--	174	--	--	--	--

Location (River basin)	Date	Age	Method	Male Length (mm) Mean	SD	SE	Range	N	Female Length (mm) Mean	SD	SE	Range	N
		5		187	--	--	--	--	186	--	--	--	--
		6		195	--	--	--	--	196	--	--	--	--
	1989 [r]	2	FL	190	--	--	--	--	181	--	--	--	--
		3		188	--	--	--	--	181	--	--	--	--
		4		189	--	--	--	--	184	--	--	--	--
		5		189	--	--	--	--	181	--	--	--	--
		6		183	--	--	--	--	176	--	--	--	--
	1990 [r]	3	FL	177	--	--	--	--	182	--	--	--	--
		4		188	--	--	--	--	187	--	--	--	--
		5		196	--	--	--	--	194	--	--	--	--
		6		206	--	--	--	--	194	--	--	--	--
	1992 [r]	3	FL	177	--	--	--	--	173	--	--	--	--
		4		187	--	--	--	--	182	--	--	--	--
		5		196	--	--	--	--	198	--	--	--	--
		6		207	--	--	--	--	214	--	--	--	--
	1993 [r]	3	FL	176	--	--	--	--	170	--	--	--	--
		4		187	--	--	--	--	186	--	--	--	--
		5		198	--	--	--	--	195	--	--	--	--
		6		207	--	--	--	--	--	--	--	--	--
	1994 [r]	3	FL	169	--	--	--	--	166	--	--	--	--
		4		182	--	--	--	--	181	--	--	--	--
		5		186	--	--	--	--	186	--	--	--	--
	1995 [r]	3	FL	171	--	--	--	--	174	--	--	--	--
		4		181	--	--	--	--	182	--	--	--	--
		5		183	--	--	--	--	181	--	--	--	--
		6		190	--	--	--	--	195	--	--	--	--
		7		201	--	--	--	--	--	--	--	--	--
	1996 [r]	3	FL	188	--	--	--	--	185	--	--	--	--
		4		192	--	--	--	--	185	--	--	--	--
		5		195	--	--	--	--	186	--	--	--	--
		6		193	--	--	--	--	195	--	--	--	--
	1998 [r]	2	FL	--	--	--	--	--	175	--	--	--	--
		3		177	--	--	--	--	172	--	--	--	--
		4		174	--	--	--	--	172	--	--	--	--
		5		181	--	--	--	--	174	--	--	--	--
	2003 [1]	--	FL	196	--	3	--	36					
			Not sexed										

Location (River basin)	Date	Age	Method	Male Length (mm) Mean	SD	SE	Range	N	Female Length (mm) Mean	SD	SE	Range	N
Fraser River	1986[f]	--	FL	182	13.3	--	129-212	325	164	21.6	--	124-200	95
	1995[g]	--	SL	158	11.0	--	--	311	158	10.4	--	--	352
	1996[g]	--		156	10.4	--	--	241	155	10.7	--	--	218
	1997[g]	--		161	12.0	--	--	254	158	10.4	--	--	259
	1998[g]	--		158	12.6	--	--	260	158	15.6	--	--	156
	2000[g]	--		162	10.4	--	--	108	163	9.3	--	--	93
	2001[g]	--		160	6.4	--	--	50	156	5.3	--	--	50
	4/25/2001[o]	--	FL	171	7.2	--	117-186	138	--	--	--	--	--
	5/2/2001[o]	--	Not sexed	171	7.4	--	154-195	47	--	--	--	--	--
	5/3/2002[o]	--		181	22.0	--	116-206	20	--	--	--	--	--
	2003[l]	--	FL	183	--	3	--	45					
			Not sexed										
Washington													
Columbia River	1968	--	FL	153	--	--	--		--	--	--	--	--
	1969	--	Not sexed	161	--	--	--		--	--	--	--	--
	1978[m]	--	FL	183	13.1	--	142-250	674	178	12.9	--	153-205	59
	1984[n]	3	FL				134-158	11	--	--	--	--	--
		4	Not sexed	--	--	--	125-167	52	--	--	--	--	--
		5		--	--	--	115-185	28	--	--	--	--	--
		6		--	--	--	156-189	8	--	--	--	--	--
		7		--	--	--	148-191	5	--	--	--	--	--
	1985	3	FL	--	--	--	148-150	2	--	--	--	--	--
		4	Not sexed	--	--	--	153-183	25	--	--	--	--	--
		5		--	--	--	156-196	48	--	--	--	--	--
		6		--	--	--	170-204	20	--	--	--	--	--
		7		--	--	--	178-188	3	--	--	--	--	--
		8		--	--	--	192-203	2	--	--	--	--	--
	1986	2	FL	--	--	--	134-145	5	--	--	--	--	--
		3	Not sexed	--	--	--	133-198	50	--	--	--	--	--
		4		--	--	--	125-201	50	--	--	--	--	--
		5		--	--	--	165-211	22	--	--	--	--	--
		6		--	--	--	182-220	14	--	--	--	--	--
		7		--	--	--	201-209	2	--	--	--	--	--
		8		217	--	--	--	1	--	--	--	--	--
	1992[p]	3	FL	169.4	--	--	--	--	--	--	--	--	--
		4	Not sexed	189.3	--	--	--	--	--	--	--	--	--

Location (River basin)	Date	Age	Method	Male Length (mm) Mean	SD	SE	Range	N	Female Length (mm) Mean	SD	SE	Range	N
		5		190.8	--	--	--	--	--	--	--	--	--
	1993 [p]	3	FL	164.4	--	--	--	--	--	--	--	--	--
		4	Not sexed	159.4	--	--	--	--	--	--	--	--	--
		5		149	--	--	--	--	--	--	--	--	--
	1994 [p]	3	FL	178.7	--	--	--	--	--	--	--	--	--
		4	Not sexed	177.4	--	--	--	--	--	--	--	--	--
		5		164.8	--	--	--	--	--	--	--	--	--
	1994 [m]	2	FL	181	16.8	--	151-201	12	--	--	--	--	--
		3		181	11.6	--	163-205	25	179	13.2	--	163-193	7
		4		179	15.8	--	156-209	16	168	10.6	--	160-175	2
		5		168	7.5	--	160-178	5	150	--	--	--	1
	1995 [p]	3	FL	171.3	--	--	--	--	--	--	--	--	--
		4	Not sexed	181	--	--	--	--	--	--	--	--	--
		5		197.5	--	--	--	--	--	--	--	--	--
	1996 [p]	3	FL	168.5	--	--	--	--	--	--	--	--	--
		4	Not sexed	179.4	--	--	--	--	--	--	--	--	--
		5		170.2	--	--	--	--	--	--	--	--	--
	1997 [p]	3	FL	165.4	--	--	--	--	--	--	--	--	--
		4	Not sexed	170.5	--	--	--	--	--	--	--	--	--
		5		162.8	--	--	--	--	--	--	--	--	--
	1998 [p]	3		173.5	--	--	--	--	--	--	--	--	--
		4		181.5	--	--	--	--	--	--	--	--	--
		5		175.9	--	--	--	--	--	--	--	--	--
	2003 [l]	--	FL Not sexed	175	--	3	--	25	--	--	--	--	--
Elwha River [k]	2005	--	TL	180	10.1	--	171-195	7	166	28.5	--	125-250	18
Oregon													
Tenmile Creek [h]	1992	--	FL	189	--	--	--	24	--	--	--	--	--
	1993	--	Not sexed	170	--	--	--	6	--	--	--	--	--
	1994	--		155	--	--	--	1	--	--	--	--	--
	2001	--		177	--	--	--	23	--	--	--	--	--
	2003	--		208	--	--	--	3	--	--	--	--	--
	2005	--		165	--	--	--	7	--	--	--	--	--
	2007	--		170	--	--	--	1	--	--	--	--	--
	2008	--		182	--	--	--	1	--	--	--	--	--

a – Kubik and Wadman (1977); b - Kubik and Wadman (1978); c – Spangler (2002); d – Langer et al. (1977); e - Franzel and Nelson (1981 in Willson et al. 2006 Table 2b); f – Higgins et al. (1987); g – Hay et al. (2002) (table 3); h – WDFW and ODFW (2008); i – Moffitt et al. (2002); j – Joyce et al. (2004); k – Shaffer et al. (2007); l – Clarke et al. (2007); m – Data provided by Brad James (WDFW); n – Dammers (1988); o – Stables et al. (2005); p – WDFW and ODFW (2001); q – Kelson (1997); r – Lewis et al. (2002).

Table A-6. Mean weight of adult eulachon for all available river basins for individual years, sex, and age. Dashes indicate data were unavailable. SD = standard deviation, SE = standard error.

Location (River basin)	Year	Age	Male weight (g) Mean	SD	SE	Range	N	Female weight (g) Mean	SD	SE	Range	N
Alaska												
Susitna River	1982											
	1983											
Twentymile River	1976[a]	--	66	--	--	41-91	200	68	--	--	45-95	40
	1977[b]	--	90.7	--	--	45.4-127	--	86.2	--	--	54.4-127	408 total
	2000[c]	--	69.9	--	1.0	26.5-104	222	60.0	--	2.8	29-101	49
	2001[c]	--	65.8	--	0.5	6-106	585	60.1	--	0.5	28-122	425
Copper River Delta												
Eyak River	2002[h]	3	43	--	2	--	4	--	--	--	--	--
		4	55	--	0	--	430	50	--	10	--	2
		5	58	--	2	--	9	--	--	--	--	--
Ibeck Creek	2001[h]	3	53	--	2	--	40	38	--	2	--	3
		4	50	--	0	--	1089	46	--	1	--	75
		5	60	--	5	--	5	--	--	--	--	--
		6	52	--	4	--	4	--	--	--	--	--
	2003 [i]	--	56	--	10	23-89	1249	47	--	9	31-82	101
Alaganik Slough	1998 [h]	3	53	--	4	--	6	--	--	--	--	--
		4	44	--	1	--	35	34.5	--	1	--	2
		5	48	--	0	--	377	39.9	--	1	--	40
	2000 [h]	3	37	--	1	--	47	35	--	2	--	25
		4	48	--	3	--	21	43	--	6	--	6
Copper River												
Flag Point channel	1998[i]	3	52	--	2	--	7	56	--	8	--	2
		4	57	--	1	--	151	49.6	--	1	--	96
		5	55	--	0	--	1848	51.1	--	0	--	478
		6	52	--	3	--	7	67	--	14	--	2
	2000[i]	2	55	--	--	--	1	--	--	--	--	--
		3	47	--	0	--	534	43	--	1	--	109
		4	47	--	0	--	547	47	--	1	--	99
		5	53	--	2	--	43	39	--	3	--	5

Location (River basin)	Year	Age	Male weight (g) Mean	SD	SE	Range	N	Female weight (g) Mean	SD	SE	Range	N
		6	60	--	--	--	1	--	--	--	--	--
	2001[i]	2	--	--	--	--	--	37	--	n/a	--	1
		3	48	--	0	--	643	45	--	1	--	306
		4	52	--	0	--	571	48	--	1	--	155
		5	52	--	2	--	21	47	--	3	--	2
	2002[i]	3	53	--	3	--	16	47	--	2	--	2
		4	57	--	0	--	1081	52	--	1	--	175
		5	62	--	3	--	15	66	--	n/a	--	1
60 km bridge	2002[i]	3	57	--	7	--	3	51	--	3	--	7
		4	62	--	0	--	575	58	--	1	--	218
		5	68	--	3	--	9	--	--	--	--	--
South East Alaska												
Stikine River[d]	1979	2	38	--	--	18-50	--	--	--	--	--	--
		3	46	--	--	28-60	--	--	--	--	--	--
		4	52	--	--	34-58	--	--	--	--	--	--
	1980	2	35	--	--	30-42	--	--	--	--	--	--
		3	46	--	--	32-60	--	--	--	--	--	--
		4	58	--	--	52-64	--	--	--	--	--	--
British Columbia												
Skeena River	2003[l]	--	48.7	--	1.7	--	52	--	--	--	--	--
	Not sexed											
Kitimat River	1993[e]	3	--	--	--	--	--	43	--	1.5	27-71	44
		4	--	--	--	--	--	50.5	--	2	40-60	12
		5	--	--	--	--	--	52	--	n/a	--	1
		6	--	--	--	--	--	40.2	--	7.8	48-80	2
	1997[m]	2	42.4	5.9	--	--	2	33.8	n/a	--	--	1
		3	46.2	11.3	--	--	28	44.9	10.5	--	--	25
		4	45.6	11.0	--	--	16	41.9	9.1	--	--	37
		5	55.0	16.6	--	--	13	48.6	12.6	--	--	10
		6	50.4	n/a	--	--	1	47.2	19.7	--	--	2
Kemano River	1988-1998[n]	--	47.5	10.9	--	--	1110	44.2	10.7	--	--	1433
	2003[l]	--	57.5	--	2.3	--	36	--	--	--	--	--
	Not sexed											
Fraser River	1986[f]	--	46.3	10.7	--	13.8-81	325	34.7	14.5	--	12.9-63.7	95
	1995[g]	--	42.8	10.9	--	--	311	44.3	9.6	--	--	352
	1996[g]	--	40.8	9.5	--	--	241	42.8	9.9	--	--	218
	1997[g]	--	38.1	9.1	--	--	254	38.0	7.1	--	--	259

Location (River basin)	Year	Age	Male weight (g) Mean	SD	SE	Range	N	Female weight (g) Mean	SD	SE	Range	N
	1998 [g]	--	36.7	8.6	--	--	260	37.0	9.9	--	--	156
	2000 [g]	--	43.2	9.0	--	--	108	46.2	8.4	--	--	93
	2001 [g]	--	36.7	5.0	--	--	50	37.4	3.5	--	--	50
	2003 [l] Not sexed	--	47.2	--	1.6	--	45	--	--	--	--	--
Washington												
Columbia River	1978 [k]	--	42.0	9.9	--	20-76.1	674	39.6	10.6	--	20.5-64.3	59
	2003 [l] Not sexed	--	37.3	--	1.8	--	25	--	--	--	--	--
Elwah River [j]	2005	--	40.3	5.8	--	36-49	7	28.9	12.2	--	11-58	18

a - Kubic and Wadman (1977); b - Kubik and Wadman (1978); c - Spangler (2002); d - Franzel and Nelson (1981 in Willson et al. 2006 Table 2b); e – Pedersen et al. (1995); f – Higgins et al. (1987); g – Hay et al. (2002) (table 3); h – Moffitt et al. (2002); i – Joyce et al. (2004); j – Shaffer et al. (2007); k – Data from Brad James (WDFW); l – Clarke et al. (2007); m – Kelson (1997); n – Lewis et al. (2002).

APPENDIX B: SELECTED ACCOUNTS OF EULACHON IN LOCAL NEWSPAPERS

Oregon

[The Morning Oregonian (Portland, OR), Saturday, April 6, 1867, p. 4, col. 2]

Smelt.—Holman & Co. of the Union Fish Market, have just received a fine lot of smelt, halibut, etc. They keep on hand the best and freshest fish of the season. Call on them on Washington street near second.

[The Morning Oregonian (Portland, OR), Thursday, April 9, 1868, p. 4, col. 6]

Fish! Fish!
At the
Franklin Fish Market!
134 First St., Portland.
Just received fresh from the fisheries
Smelt by the Million

[The Morning Oregonian (Portland, OR), Friday, January 15, 1869, p. 2, col. 4]

New Today
Oak Point Smelt!
At the
Franklin Fish Market
134 First Street.
Just Received by the Str. Ranger – large supply.
Jan 15 1869

[The Morning Oregonian (Portland, OR), Thursday, January 21, 1869, p. 2, col. 4]

Fresh Oak Point Smelt
At the
Franklin Fish Market
By the Steamer "Okanagan"

[The Morning Oregonian (Portland, OR), Tuesday, January 25, 1870, p. 2, col. 4]

New To-Day.
Fresh Smelt.
Three pounds for 25 cents.

Arrived last night at the "Union Fish Market," Washington street between First and Second. Hotels and Restaurants supplied cheap

J. Quinn.

[The Daily Oregonian (Portland, OR), Saturday, January 28, 1871, p. 2, col. 3]

New To-Day.
Fresh Smelt.
A fresh lot, arrived last night for sale at
Quinn's Union Fish Market,
On Waddington street.
Hotels and Restaurants supplied at low rates.

[The Daily Oregonian (Portland, OR), Wednesday, February 1, 1871, p. 4, col. 1]

Local Brevities

Six tons of smelt arrived from down the river on Monday night, and the market may be said to be full and terms in favor of the buyer.

[The Daily Oregonian (Portland, OR), Saturday, January 20, 1872, p. 3, col. 2]

Local Brevities

The first smelt of the season appeared in the market last evening.

The First Smelt at Quinn's—Quinn, of the Union Market, Washington street, is, as usual, the first on hand with the delicacies of the season. This time he has the first catch of smelt. Call early, if you would make sure of a mess.

[The Daily Oregonian (Portland, OR), Friday, February 16, 1872, p. 3, col. 3]

SMELT—Quinn, of the Union Fish Market, has sufficient quantity of smelt now to supply all demands. The Prices are so low that everybody can eat 'em. … Don't go home without a mess of smelt.

[The Daily Oregonian (Portland, OR), Tuesday, December 8, 1874, p. 2, col. 2]

First Smelt!
The First
Lot of Smelt of the Season!
At Quinn's
3 lbs. for 25 Cents.

[The Daily Oregonian (Portland, OR), Wednesday, March 17, 1875, p. 3, col. 3]

Smelt—the first of the season—from the Columbia river in large quantities at Malarkey's, Second street, between Stark and Washington. Get a mess.

[The Daily Oregonian (Portland, OR), Tuesday, February 22, 1876, p. 2, col. 5]

Columbia River Smelt!
First of the Season of 1876.
At C. A. Malarkey's New York Market.
S. E. Cor. Stark and Second streets.

[The Daily Oregonian (Portland, OR), Friday, February 25, 1876, p. 3, col. 3]

1000 Pounds Fresh Columbia River Smelt, for sale Wholesale and Retail by C. A. Malarkey, S. E. corner Stark and Second streets.

[The Daily Oregonian (Portland, OR), Wednesday, March 1, 1876, p. 2, col. 4]

Fresh Columbia River Smelt. I received last night the largest lot that has come to market this season. 3 lbs. for 25 cts. C. A. Malarkey New York Market, S. E. cor. Stark and Second streets.

[The Daily Oregonian (Portland, OR), Saturday, March 4, 1876, p. 2, col. 3]

Caution.

Fresh Columbia River Smelt. The public are cautioned against buying Puget Sound Smelt for Columbia River Smelt. Come to headquarters for the latter. Large lot received again last night. C. A. Malarkey, New York Market, S. E. cor. Stark and Second.

[The Daily Oregonian (Portland, OR), Saturday, February 2, 1878, p. 2, col. 3]

Columbia River
Smelt!
First of the Season of 1878!
Wholesale and Retail
At
Chas. A. Malarkey's
New York Market,
S. E. Cor. Stark and Second Sts., Portland.

[The Daily Oregonian (Portland, OR), Saturday, February 2, 1878, p. 2, col. 3]

HURRA! HURRA!
First Columbia River Smelt
of the Season
Smelt! SMELT! Smelt!
At 5 Cents per Pound
Wholesale and Retail
At Dougherty & Browne's
Washington Market,
Corner Fourth and Washington Streets

[The Daily Oregonian (Portland, OR), Thursday, January 22, 1880, p. 2, col. 3]

SMELT, SMELT
Columbia River Smelt
First of the season 1880
At
C. A. Malarkey's
New York Market
Stark street between First and Second

[The Morning Oregonian (Portland, OR), Thursday, February 5, 1880, p. 1, col. 4]

Smelt fishermen are making good wages on the river now. Some make $40 a night with dip nets. Hapgood cannery, at Waterford has put up 8000 pounds. There is a big run.

[The Daily Oregonian (Portland, OR), Thursday, February 12, 1880, p. 3, col. 1]

Dead Smelt---A gentlemen who came up the river from Astoria yesterday, informs us that millions of smelt are dying from some unknown cause in the Columbia and floating ashore. In the vicinity of Pillar Rock the bank is lined with these little fish for some distance, and hundreds of voracious sea gulls are constantly devouring them.

[The Morning Oregonian (Portland, OR), Saturday, January 8, 1881, p. 2, col. 3]

SMELT
Columbia River Smelt
Season 1881
A fine lot just received by
C. A. Malarkey,
New York Market,
N. E. corner Oak and Second Street
Country orders promptly filled

[The Morning Oregonian (Portland, OR), Wednesday, February 27, 1882, p. 3, col. 1]

C. A. Malarkey, Second and Oak, will receive this morning a choice lot of Columbia river smelt.

[The Morning Oregonian (Portland, OR), Tuesday, March 6, 1883, p. 2, col. 4]

NEW TO-DAY
SMELT
First of the Season
At
Williams & Sons
General Market

[The Morning Oregonian (Portland, OR), Tuesday, March 13, 1883, p. 3, col. 7]

Smelt! Smelt!
Columbia River Smelt!
These most delicious fish are now being received by
C. A. Malarkey daily. Orders from the country
will be filled promptly.
C. A. MALARKEY,
….
New York Market,

N. E. corner Oak and Second St.

[The Morning Oregonian (Portland, OR), Monday, February 25, 1884, p. 1, col. 8]

SMELT SMELT
Columbia River Smelt!
First of the season of 1884 have now arrived.
Send your orders to
Chas. A. MALARKEY,
N. W. corner Fourth and Morrison Streets.

[The Morning Oregonian (Portland, OR), Tuesday, March 4, 1884, p. 2, col. 4]

SMELT SMELT
Columbia River Smelt!
The most delicious of all fish are now coming to
market …………
Country Customers will find it to their advantage to order from
C. A. MALARKEY,
Fourth and Morrison Sts.

[The Morning Oregonian (Portland, OR), Friday, February 13, 1885, p. 3, col. 1]

Columbia River Smelt

These delicious little fish have made their appearance at Astoria, and C. A. Malarkey corner of Fourth and Morrison has made arrangements to receive a full supply during the season. He expects the first lot to-day. Call early and leave your order.

[The Morning Oregonian (Portland, OR), Friday, February 13, 1885, p. 3, col. 3]

The Little Fish coming—Polish up your frying pan, for Malarkey says he is going to have Columbia river smelt to-day. These little fish have become of considerable importance to fishermen and several boats have been kept on the lookout for their advent for the past two weeks. The advance guard of the immigration came up the river a little way some days since, but smelling the snow in Eastern Oregon, took a wheel back. The ones behind are shoving on the ones before, and countless millions of smelt are crossing in over the bar, anxious to reach the Cowlitz or the Sandy.

[The Oregonian (Portland, OR), Wednesday, February 25, 1885, p. 3, col. 1]

Brief Mention

Considerable anxiety has been expressed about the Columbia river smelt fleet now overdue here and anxiously awaited by all good citizens. It is now stated that the smelt are hovering off the bar waiting for a pilot.

[The Oregonian (Portland, OR), Friday, February 27, 1885, p. 3, col. 2]

FISH IN SUPPLY. … The first box of Columbia river smelt, so long looked for, was received by J. W. and V. Cook last evening. It contained about twenty pounds—the result of a night's fishing by five men. There will be plenty in a few days, sure.

[Daily Oregonian (Portland, OR), Friday, March 13, 1885, p. 3, col. 2]

NO HOPE FOR SMELTS.—Fishermen generally have about given up hope of a smelt harvest this year. In speaking of the matter yesterday, a pioneer, who resided for many years on the lower Columbia, says that there were no smelt or oolachan, as they were called by Indians, in the Columbia from the time he came here till in 1863, when they appeared in vast numbers about the middle of February, and have been plentiful every season since. In Irving's "Astoria" mention is made of the great quantities of smelt in the Columbia in 1826. Shortly after they forsook the river entirely and did not return till 1863, having been absent nearly forty years. It would be interesting to know why the smelt deserted the river and in what ocean wilderness they wandered all these forty years. If they have gone again to stay forty years most of us may as well say good-bye to them for we'll eat no more Columbia river smelt unless the doctrine of transmogrification is true, in which case if a fellow is changed into a seal or a sturgeon he may have a chance at them once more.

[The Morning Oregonian (Portland, OR), Sunday, January 31, 1886, p. 5, col. 1]

There is a great rivalry just now among the fish dealers. The first smelt are now in the market. Malarkey went down the river yesterday, met the steamer as she was coming up and secured all the smelt, which were piled up last night triumphantly on his tables.

[The Morning Oregonian (Portland, OR), Tuesday, February 2, 1886, p. 3, col. 1]

Wm McGuire & Co. corner Third and Morrison streets corralled all of the smelt that came to town yesterday consequently they have the only fresh smelt in the city. They received twenty five large boxes—over 4000 pounds—and are prepared to furnish everybody at reasonable prices. They are prepared to fill all orders from the country at lowest rates and guarantee perfect satisfaction. Send in your orders. Telephone 371.

[The Morning Oregonian (Portland, OR), Sunday, February 7, 1886, p. 5, col. 6]

COLUMBIA RIVER SMELT

Wm McGuire & Co Third and Morrison, have made arrangements to receive large supplies of fresh smelt daily and are prepared to fill all orders from the country at lowest rates. Send in your orders early.

[The Morning Oregonian (Portland, OR), Tuesday, February 10, 1886, p. 2, col. 4]

SMELT AND SALMON

Columbia River Smelt and Genuine Chinook Salmon received daily and for sale in any quantity from one pound to one ton by C. A. Malarkey corner of Fourth and Morrison streets.

[The Morning Oregonian (Portland, OR), Saturday, December 11, 1886, p. 5, col. 1]

The first Columbia river smelt of the season came up yesterday to George Ginstin, of the Baltimore market, No.290 First.

[The Morning Oregonian (Portland, OR), Wednesday, January 19, 1887, p. 3, col. 2]

A Few Good Fish--…Vin Cook says they had a mess of Columbia river smelt down at Clifton the other day, but have not been able to catch any since. It will not be long till these delicious little fish are here.

[The Oregonian (Portland, OR), Friday, January 28, 1887, p. 3, col. 2]

FISH IN DEMAND. -- … while [another fisherman] proudly exhibited a sample of genuine Columbia river smelt. Vin Cook has a party on the lookout for the arrival of these anxiously awaited little fish, and they yesterday sent him up several pounds. The advance of the main school of smelt may be expected any day now. It was about this time last year that the first shipment came up.

[The Oregonian (Portland, OR), Thursday, February 24, 1887, p. 5, col. 2]

FISHING FOR SMELT.—No doubt many people once in a while give a thought to the Columbia river smelt, which would have been in market before now but for the cool spell, but probably very few have any idea of the number who are keeping a sharp lookout along the Columbia for the advent of these little fish. Although the Columbia from the mouth of the Willamette for a long way up has been frozen for some time and there has been snow all along down the river, not a day has passed for the last three weeks but what seines have been put out and dip nets plied at various points in vain search for the smelt. At Oak Point two men in the employ of a fish dealer here have been going out twice every day for the past three weeks and probing the Columbia with dip nets, but nary a smelt have they caught. As the ice is now going out the fish may be expected any day.

[The Morning Oregonian (Portland, OR), Monday, March 1, 1887, p. 3, col. 4]

Fish dealers wee all on hand when the [Steamer Ship] Telephone arrived yesterday, expecting to see a shipment of Columbia river smelt. They were disappointed, but the little fish will be here soon or not at all.

[The Morning Oregonian (Portland, OR), Saturday, March 5, 1887, p. 3, col. 3]

Brief Mention

The prospect is that we are to have no Columbia river smelt this season.

[The Oregonian (Portland, OR), Wednesday, March 9, 1887, p. 3, col. 3]

COMING UP ON THE RISE –People had about given up all idea of seeing any Columbia river smelt this season, but it appears that they have not deserted us but were only lying off the mouth of the river waiting for the water to become decently warm in order to swarm to their spawning place in the Cowlitz and Sandy. Deep sea fishermen at Astoria report that the cod and groupers caught by them of late have been literally filled with smelt and they predict a large run. The late heavy warm rains have put the schools a motion and in a few days it will perhaps be possible to walk across the Sandy on the backs of the smelt.

SMELT AT LAST –Late last night McGuire & Co., fish dealers, corner o' Third and Morrison streets, received a telegram from down the river stating that several boxes of Columbia river smelt would arrive on the [steamer ship] Telephone today for them. These will be the first smelt of the season and as the steamer will arrive about 2:30 everybody can have smelt for dinner by leaving orders early today.

[The Morning Oregonian (Portland, OR), Thursday, March 10, 1887, p. 5, col. 3]

THE SMELT HERE.—The first lot of smelt of the season arrived on the [steamer ship] Telephone yesterday, and very fine they were, being much larger and plumper than the first to arrive usually are. A number of them were evidently caught by Indians in the old-fashioned way by sweeping a stick armed with sharp pointed nails through the water and impaling the smelts thereon.

[The Morning Oregonian (Portland, OR), Friday, March 11, 1887, p. 3, col. 3]

And now the smelt come in earnest. C. A. Malarkey came up the river last evening having secured the entire catch of these delicious fish along the Columbia for the day some two tons in all. He is prepared to furnish all both great and small, and as he has the only smelt in the city orders should be left early this forenoon.

[The Sunday Oregonian (Portland, OR), February 26, 1888, p. 5, col. 3]

Fish and Fishing.

… The smelt season is about over apparently. They have not come above the Cowlitz as yet, and are not likely to visit the Sandy this season. They have gone so far up the Cowlitz now that there is trouble to get them and boxes of them which a few days ago could be bought for 50 cents, have jumped to $3. …

[The Sunday Oregonian (Portland, OR), March 11, 1888, p. 5, col. 2]

In and About Portland

Large quantities of smelt still continue to be sent up from the Cowlitz. Nothing has been heard of them reaching the Sandy yet.

[The Morning Oregonian (Portland, OR), Thursday, December 13, 1888, p. 8, col. 1]

The First, Lone Smelt.--Mr. Calper, who has a salmon fishery on Lewis river, a day or two since caught a fine large Columbia river smelt, which in some manner became entangled in his net. This is the first smelt of the season, and it comes to hand unusually early, as they generally put in an appearance some time in February. It is also a little strange that the first smelt heard from should be taken in Lewis river, as for the three past seasons the shoals of these fish have not come any farther up than the Cowlitz. It will hardly be worth while for our epicures to make up their mouths for smelt yet awhile. One swallow does not make it summer, nor does one smelt make it spring, and in all probability we shall have a cold snap before we shall see smelt in the market.

[The Morning Oregonian (Portland, OR), Thursday, December 27, 1888, p. 5, col. 2]

SMELT FOR CHRISTMAS DINNER.—Last evening a gentleman marched into the reporter's room of The Oregonian office and left a parcel with the compliments of Vin Cook. On opening the package it was found to be a cigar box filled with genuine Columbia river smelt, which glistened in the lamplight like silver. A short time since a notice was published in The Oregonian of a single smelt having been caught by Mr. Calper in his salmon seine in Lewis river. Mr. Cook, who is at Clifton, seeing this, sent out a boat to drift for smelt and enough was caught to make a course for the Christmas dinner for all hands at Clifton and some left to send to The Oregonian. It is hardly probable that any one in this region ever had Columbia river smelt for dinner on Christmas before. The smelt usually arrive in February and what they mean by coming so much earlier than usual this year it is impossible to say. They have some queer ways, as only a few years since they forgot to come up entirely. It may be that they have had some premonition that there would be no winter this time and if so the chances are ten to one that they will find themselves fooled. If the weather should "come off" warm with rain it is not unlikely that there will be smelt in the market very soon.

[The Morning Oregonian (Portland, OR), Saturday, January 12, 1889; p. 8, col. 1]

Gathered by Reporters
First Shipment for the Season of Columbia River
Smelt Quickly Disposed Of

Nothing Too Rich For Us—The first shipment of Columbia river smelt of this season arrived here yesterday. There were only thirty-five pounds of them, and they were all disposed of by McGuire & Co. before they arrived for 50 cents per pound, that being the price fixed by the fishermen, who have been out drifting for several nights in hopes of making a haul. The price made no difference, and many more could have been sold. Wealthy people at the East think nothing of paying a dollar a pound or more for the first salmon or trout of the season, and our wealthy people are not going to be left on the first Columbia river smelt, no matter what the price is.

[The Morning Oregonian (Portland, OR), Thursday, February 21, 1889, p. 5, col. 1]

COLUMBIA RIVER SMELT.—Columbia river smelt are coming in plentiful and Malarkey & Co., corner of Fourth and Morrison streets, have enough to supply everybody at cheaper prices than ever before. The run will not last long and if you want a mess of these delicious little fish now is the time to get them. This firm makes a specialty of shipping these fish and orders from the country for any quantity will be promptly filled.

[The Morning Oregonian (Portland, OR), Friday, February 22, 1889, p. 4, col. 3]

Smelt. Smelt.

Columbia River Smelt are now growing plentiful and cheap. Parties wishing to procure Smelt for salting down can buy them by the box at a low price. Remember that the run lasts but a short time.
Malarkey & Co.,
Fourth and Morrison sts.

[The Morning Oregonian (Portland, OR), Wednesday, December 18, 1889, p. 6, col. 7]

THE VERY FIRST OF THE SEASON

A Small Lot of Smelt Have Put in an Appearance in the City

A small lot of genuine Columbia river smelt were displayed at C. A. Malarkey & Co.'s market yesterday. They were, it is needless to say, the first of the season, and as the fisherman who sent them up wrote, "they are the earliest smelt that ever went into Portland market." J. B. Johnson captured them near Quinn's Landing, and the twenty-five pounds represent three night's work out in the cold. He has got ahead of Vin Cook this year, and broken the record, for no living man has ever seen Columbia river smelt here so early before. They generally arrive about the 1st of January, and when they come it is considered that winter is over. Many who saw the smelt yesterday, said "well winter is over," but it is more probable that the smelt have made a mistake. Many things have been mentioned as tending to indicate that we are to have a hard winter, but the arrival of these smelt is the first thing which seems to indicate that winter is over, and we might as well cling to the hope till it is dispelled.

[The Morning Oregonian (Portland, OR), Monday, December 23, 1889, p. 5, col. 1]

Something About Early Smelt.—Mr. James Quinn, formerly a well-known resident of this city, but for years a resident at Quinn's Landing on the lower Columbia, demurs to the statement published in these columns a few days since, to the effect that some Columbia river smelt received here on that day were as the man who caught them claimed the earliest smelt ever seen in the Portland market. Mr. Quinn says he had fresh Columbia river smelt in his market on Washington street, on the 8th of December, 1869. From this it appears that Mr. Johnson in 1889, was ten days behind Mr. Quinn in 1869, in getting smelt to this market. It is the belief of many fishermen that smelt and Chinook salmon both are in the river all winter, and could be taken if fished for, but the game would hardly be worth the candle.

[The Morning Oregonian (Portland, OR), Friday, January 22, 1892, p. 5, col. 2]

The Smelt as a Weather Prophet—The shoals of smelt which have been in the Columbia river for the past month or six weeks have struck into the Cowlitz. Over a ton of these fish were sent up from the Cowlitz Wednesday evening, and it was supposed that they would continue to be plentiful, but the next day only a small lot arrived, and it is feared that the shoals will soon go up the river out of reach, and the smelt season will be over. The fact that the smelt have started up for their spawning grounds is considered by many to indicate that winter is over. It is scarcely probable that there will be ant ice or snow this winter.

[The Morning Oregonian (Portland, OR), Monday, November 28, 1892, p. 6, col. 2]

Columbia Smelt. An Unusually Early Catch of the Dainty Little Fish

A lot of Columbia river smelt were received in this city Saturday, and very fine ones they were. This is the earliest time of year that smelt have ever been caught. They were taken by J. B. Johnson, near Eagle Cliff, and the first sales were made at 75 cents per pound, which is the highest price ever paid for the delicious little pan fish.

The Columbia river smelt did not put in an appearance formerly, as a general thing, [un]till about the 1st of February, and if there happened to be a cold winter and ice in the Columbia, they did not materialize until after the ice had gone out, when they arrived in the Cowlitz in immense shoals, and shortly after in the Sandy in like numbers. For several years past fishermen have been using deep nets in the Columbia, searching for smelt, and last year and the year before at Christmas time they caught small lots right along. The first man who got a shipment into market received a high price, as every market man was anxious to have the first lot, which he had no trouble in disposing of at 50 cents per pound. The price would soon drop to 25 cents, then to a bit, and when the shoals of fish got into the Cowlitz they would sell for 5 cents. Soon they would be shipped all over the country, and then there would be many more smelt than could be got rid of at any price.

The fact that the smelt were to be found in the river in December led some to imagine that they were there all winter, staying in deep water. If such is the case, Mr. Johnson, who made this early catch and broke the record, has probably found one of their haunts. Some people think that the freshet in the Columbia-if a rise of five feet at Vancouver can be called a freshet-has brought the fish up the river. There is no probability, however, of their going up the Cowlitz to their spawning grounds till the snow is gone out of the mountains at the headwaters of that stream.

The Columbia river smelt is what is called farther north the oolihan [sic], or candlefish, and is esteemed as one of the most delicious little fish caught. Salmon and trout have no superiors in their season, but the smelt comes at a season when other fish are scarce, and so is most esteemed. If it is going to come at this season and mix itself up with Sound smelt and all the other fish in the market, its good qualities will have to submit to the test of comparison.

[The Morning Oregonian (Portland, OR), Monday, January 1, 1893, p. 5, col. 1]

Smelt Have Returned—The Columbia river smelt, which arrived earlier this season than ever before so far as known, and were well along on their way up the Cowlitz river to their spawning grounds when the snow storm came on and drove them back, have re-entered the Cowlitz and will for a time be plentiful in the local market. They re-entered the Cowlitz last Friday, and a man who happened to be loafing along the bank of the river saw them pouring up the stream in a solid column about two feet in width. He hastily secured a dip net, worked with a will for two hours, caught the boat coming to this city and sold his catch for $25. He was much elated with his success, and expressed his intention of devoting the remainder of his life to fishing.

[The Morning Oregonian (Portland, OR), Wednesday, January 2, 1895, p. 9, col. 1-2]

Great Quantities of Smelt

The Columbia-river smelt, the most delicious of panfish, during the past year commenced coming to market in October, more than a month earlier than ever known before. Small quantities have been received almost daily ever since, but within the past week the shoals have entered the Cowlitz river, on their way to their spawning grounds, and they have been taken in large quantities. The change in the weather has been so slight as hardly to check them, although ice or snow might send them back into the deep waters of the Columbia. With the first rains, the immense shoals of these fish will swarm the Cowlitz and tons of them will be coming to market, and they will be shipped to all parts of the country. No method has yet been discovered of preserving the delicate flavor of these fish, which are so fat as to be known to the Indians as the candle fish. Large quantities might be put up yearly if any process could be discovered which would preserve their good qualities.

[The Morning Oregonian (Portland, OR), Thursday, March 28, 1895, p. 8, col. 3-4]

The Big Run of Smelt

The enormous run of smelt in the Sandy river is attracting wide attention. If all the statements of those who have been out there are true, and they seem to be verified by the wagon loads of smelt taken, the run is the biggest that has been seen in the Sandy for the past 15 years. When the O. R. & N. railroad was in course of construction, and there was a large encampment on the river, the water suddenly came alive with the fish, and the railroad employes [sic] feasted on smelt for several days. Great wagon loads were taken. The next run occurred six years ago, it is claimed by those who know, but the run was comparatively small, and was soon over. There are now hundreds of people catching smelt by the tons. A wagon may be filled in half an hour. The wagon is driven into the shallow water, and the fish are scooped into the wagon by means of a small scoopnet. It is stated some of the farmers are catching the fish in wagon loads and distributing them over their farms for fertilizing purposes, where some are smoking them, and many are being packed in salt. The fish move along close to the shore. The females come with the first run, and the males afterward. One can put his hands in the water and feel the fish bumping against them. Mr. Joseph Paquet was down the river several days ago, and saw indications that the fish were going up the river. They were followed by droves of seagulls, watching, apparently, to catch the fish which happen to come near the surface. They were on the way to spawning-ground. The habits of the smelt are rather peculiar. They have usually appeared in the Cowlitz river, and not in the Lewis river, but this year they have entered the Lewis and very few in the Cowlitz. The run went on past the Willamette and entered the turbid and always discolored waters of the Sandy river. W. F. Allen, who was on the Sandy in all the smelt runs for the past 30 years, will go out today, and see how the present run sizes up with what he saw in the long ago.

[The Morning Oregonian (Portland, OR), Monday, April 1, 1895, p. 5, col. 4-5]

All Fished for Smelt
Large Number of Portlanders Visit the Sandy to Enjoy the Sport

The banks of the Sandy river for many miles were the scene of great activity all day yesterday, made so by the presence of hundreds of pleasure-seekers, bent upon catching smelt or watching others catch them. A gentleman who has made a careful estimate, from personal observation, states that the catch during the week has fully averaged 100 tons per day. It is thought that this run is the greatest that has occurred for over 30 years, and of the longest duration. The runs do not usually last over five or six days, but the fish were still running very thick yesterday, the eighth day. It is thought the run will now dwindle down, as all fish now going up are males. The females go up to the spawning grounds first, and they are followed by the males. It is inferred that the run is almost over, as the males have already been running since the middle of the week. As far as could be ascertained yesterday no females were caught, all being males, very firm and plump. A few of the fish gave evidence of some hard knocks during their trip up the river. If the gentleman who estimated the catch at 100 tons a day is right the entire catch during the run will foot up a 1000 tons.

All yesterday vehicles of every sort, loaded with families, well supplied with boxes and sacks and dip nets, prepared to catch smelt, poured to the banks of the Sandy. The favorite place was at the county bridge. The river has here cut a deep channel through the slightly-wooded uplands, and winds its sinuous ways like a thread of silver to blend with the majestic Columbia, a few miles below. Where the bridge spans the river there is a sort of open space, and to the southeast the river makes a gentle curve, sweeping around a gravel and sandbar of about five acres in extent. A full view of the bridge and surroundings may be had from the county road to the westward, just before it plunges down a winding grade to the bridge. The gravel was covered with fishermen and women, both great and small. With long poles, on which were suspended dip nets made of most anything that will allow the water to run off, they were constantly dipping out the sluggish smelt. Toward the point of the gravel bank, which the water sweeps around swiftly, a dozen or more of wagons had been backed into the stream up to the hub, and these were being filled by means of nets of larger size. It was an interesting sight to see these wagons fill up and others take the place. The men swung the nets with monotonous regularity, and rarely ever failed to bring up from a dozen to half a dozen wriggling fish. The smelt seemed to run around this point in more condensed bunches than below, along the margin of the gravel bank. The experienced fisherman was provided with a sort of metal funnel, well perforated with holes, on the end of a light pole, about eight feet long. But it was comparatively an easy matter to catch in a few minutes all anyone would care to take of them.

From a sportsman's point of view the taking of fish in this manner cannot be regarded as very exhilarating exercise, still it is a sort of change. One good thing about it is that no one went home without a fine string, or rather sack of fish. The smelt caught in the Sandy were very plump and firm. At this time of year the river is very clear and cold. Evidence of prodigality and waste was apparent from the piles of half-dried fish near the bridge. And yet, with all the millions which were taken from the river, millions went on to the spawning ground. On their return trip they keep well in the center of the river and move faster than when on the way up.

A large number of people went out from the city in carriages and on bicycles merely to see the fishing. It was a day that will not soon be forgotten in the interior of the county, and if there is a family within 10 miles of the Sandy that has not had a feast of fish last week, it has not been because they could not be had in unlimited quantities.

[The Morning Oregonian (Portland, OR), Wednesday, December 4, 1895, p. 12, col. 3]

First Smelt Arrive
But They're Mighty Dear—Wait, and They'll Soon Be Cheaper.

Among the various species of fish which form the great harvest of the mighty Columbia, non is more eagerly looked for or more highly appreciated than the smelt, the Columbia river smelt, or "candle-fish," being considered by many people of this section the prince of all pan fish. Ten or a dozen years ago, they did no appear in this market as a general thing till after the cold weather was past, In February or March, or as soon as the main school began crowding up the Cowlitz and other tributaries of the Columbia to their breeding-grounds. Of late years fishermen have taken to fishing for them with seines in the Columbia, and it has been found that they are in the river nearly all winter, and year after year they have been coming earlier and earlier to market, the fishermen who gets in the first lot reaping a rich reward for his trouble. The first lots have sold for 50 cents per pound, and, as they become more plentiful, the price goes down to 25 cents, then to 15 cents, and finally to 5 cents, when they come in by scores of bushels at a time, till finally they are so plentiful that there is no sale for them.

Las year the smelt arrived just before Christmas, and the run lasted a long time, the quantity of little fish disposed of here being probably much greater than in any previous year and yielding a handsome return to the fishermen. This was the earliest the smelt ever came to market; but the record has been beaten this season, as a small lot, just a few pounds, were received here yesterday. This is positively the earliest arrival of smelt known, and unless freezing weather comes on and drives them back, or to the bottom, it may be expected that the fish will soon arrive in quantities. They were held at 75 cents per pound, as they were looked upon more as a curiosity than as an article of merchandise.

The sturgeon, which, until within the past year or two, thronged the Columbia and devoured enormous quantities of smelt, are now very scarce, and this will probably result in an increase in the shoals of smelt, which, however, have always been immense.

[The Morning Oregonian (Portland, OR), Tuesday, December 29, 1896, p. 9, col. 4]

The Story of Smelt
How it is mentioned by an Early Visitor to Oregon

A gentleman of this city, who has a copy of "Francheve's Narrative," which is the diary of Gilbert Francheve [Franchère], of Montreal, who was a clerk in the trading company of John Jacob Astor, and who visited the Columbia in 1811, is of the opinion that Francheve [Franchère] makes the first mention of the Columbia river smelt. He says:

"February brings a small fish about the size of a sardine. It has an exquisite flavor, and is taken in immense quantities by means of a scoop-net, which the Indians, seated in canoes, plunge into the schools, but the season is short, not even lasting two weeks."

The season for smelt has grown much longer within the past few years, since fishermen have made it a business of going out hunting for the advance guards of the schools. Some years since, they were seldom seen in market until February, when the great schools began pushing their way up the Cowlitz and Sandy to their spawning grounds, and in a short time the run was over, or the fish had become soft and not fit for food. Last year the first smelt caught in the Columbia in driftnets cane to market in December, and the season lasted nearly three months, the fish being good all the time till after they were well on their way to the spawning grounds.

It is probable that mention has been made of the vast schools of smelt entering the Columbia before Francheve [Franchère] wrote his diary, as the smelt were always here, and the earliest residents along the river have described how the Indians caught them by means of a long rod, through which nails had been driven, forming a sort of comb, or rake, which they moved swiftly through the schools of smelt, bringing up many impaled upon these nails. Smelt fishing now brings in considerable money to the fishermen, owing to the greater length of the season. Late in the season the price gets very low, but then the only limit to the catch is the amount that can be disposed of. Many are salted by farmers along the river, and some are smoked, but the fish is best in a fresh state, and for the pan has no superior on the coast.

[The Morning Oregonian (Portland, OR), Saturday, December 7, 1907, page 12, column 1-2]

GOOD THINGS IN PORTLAND MARKETS
BY LILIAN TINGLE

Columbia River smelt cost 50 cents [per pound]

[The Morning Oregonian (Portland, OR), Saturday, December 14, 1907, page 12, column 1-2]

GOOD THINGS IN PORTLAND MARKETS
BY LILIAN TINGLE

Columbia River smelt … are 20 to 25 cents per pound

[The Morning Oregonian (Portland, OR), Saturday, February 29, 1908, page 5, column 1-2]

GOOD THINGS IN MARKETS
BY LILIAN TINGLE

I saw even more varieties of fish in the market than there were last week. Columbia River smelt were 12½ cents a pound, and scarce at that, when I inquired about it, but more may be in today.

[The Morning Oregonian (Portland, OR), Saturday, March 7, 1908, page 12, column 1-2]

GOOD THINGS IN MARKETS
BY LILIAN TINGLE

Columbia River smelt was selling at two pounds for 25 cents …

[The Morning Oregonian (Portland, OR), Saturday, December 19, 1908, page 10, column 2]

WHAT THE MARKETS OFFER
BY LILIAN TINGLE

Columbia River smelt are more plentiful and are to be had at a reasonable price.

[The Morning Oregonian (Portland, OR), Saturday, December 24, 1908, page 15, column 2]

WHAT THE MARKETS OFFER
BY LILIAN TINGLE

The cold weather has kept the price of Columbia River smelt up to 30 and 35 cents a pound.

[The Morning Oregonian (Portland, OR), Saturday, January 9, 1909, page 8, column 2]

GOOD THINGS IN MARKETS

Columbia River smelt was about 10 cents a pound yesterday; but the supply is of course affected by the weather.

[The Morning Oregonian (Portland, OR), Tuesday, February 2, 1909, page 9, column 2]

THE RUN IS ON.—Fresh Columbia river smelt, 5 cents a pound. Maces Market, 151 Fourth street.

[The Morning Oregonian (Portland, OR), Saturday, February 13, 1909, page 12, column 4]

GOOD THINGS IN MARKETS

Columbia River smelt was selling at 4 and 5 cents a pound earlier in the week, but cost 7 to 10 cents when I inquired; and no man would risk a statement as to whether it was likely to be down again today or up higher.

[The Morning Oregonian (Portland, OR), Friday, December 24, 1909, page 10, column 2]

GOOD THINGS IN MARKETS

The fish market is exceedingly well supplied with the sea dainties for which Portland is famous … Columbia River smelt, 40 to 50 cents [per pound]

[The Morning Oregonian (Portland, OR), Saturday, February 12, 1910 page 12, column 2]

GOOD THINGS IN PORTLAND MARKETS
By Lillian Tingle

Columbia River smelt may be considered the most interesting feature of the market this week, of interest alike to epicure and economist. At 5 cents a pound, or six pounds for a quarter, this dainty fish is within the reach of every one. Many thrifty housekeepers take advantage of the season of plenty, and buying smelt by the box at about 3 cents a pound. Proceed to secure inexpensive future breakfast or luncheon dishes by salting, smoking, pickling or canning this "violet of the waters."

[The Sunday Oregonian (Portland, OR), February 13, 1910, page 9, column 4-5]

SMELT CANNERY OFFERED

KELSO OWNERS SEEK SOMEONE TO OPERATE PLANT

Heavy Catches Are Accompanied by No Diminution of Supply—Cowlitz Yields Well

Owners of an idle canning plant in Kelso are seeking someone who will engage in the packing of Columbia River smelt in that city.

F. L. Stewart, a banker of Kelso, who is in Portland, expresses the conviction that the opportunities are good for using the plant for smelt canning in Winter and fruit and vegetable canning in the Spring and Summer. The cannery was started as a co-operative venture, but has been idle about two years.

Although the smelt, now so generously in the Portland markets, bear the name "Columbia River," the great preponderance of them is taken in the vicinity of Kelso from the Cowlitz River. Kelso this season has shipped out approximately 15,000 boxes. Each box contains 50 pounds and the fish average eight to the pound. The catch, so far, therefore represents approximately 6,000,000 fish.

In spite of the heavy catches there is apparently no diminution in the yearly runs of fish and at the height of the season they get down to a low figure.

At the beginning of the present season fishermen got $3 a box for the first run, but the price, as the run increased, dropped rapidly until now the fishermen realize about 25 cents a box. Last year the price went as low as 15 cents. The largest catch reported this season was 45 boxes, taken between 7 and 11 A.M., by two men in one boat.

Some of the residents of Kelso smoke the fish as they would herring and find that smoked smelt are a delicacy. The cannery plan, however, would be to put them up in form similar to sardines.

[The Morning Oregonian (Portland, OR), Thursday, February 17, 1910, page 8, column 4]

COWLITZ FULL OF SMELT

Big Run May Presage Prosperous Salmon Season Later On

ASTORIA, Or., Feb. 16.—The largest run of smelt for years in the Cowlitz River is now in progress. The river has never been known to contain so many smelt in the memory of the oldest fisherman.

This may bode good for the coming fishing season in the Columbia, as it is said that a good run of smelt has always been followed by a good run of salmon.

[The Sunday Oregonian (Portland, OR), February 27, 1910, Section 5, page 8]

SMELT FISHING ON THE COWLITZ

How an Army of Men Catch the Biggest Run Known in the Last Twenty Years

By R. G. Callvert

A hobo the other day wandered along the fringe of river bank that lies between the floating docks and the railroad track at Kelso, picking up discarded smelt for an easy meal.

"Here, drop those rotten fish and come down and get some fresh ones" shouted a fisherman from a float where smelt were being packed into boxes for shipment.

Discarded fish may look good to a tramp in most countries, but in Kelso during the smelt run only a stranger with a most aggravated antipathy to exertion need go without the freshest product of the Cowlitz River.

Had the tramp known it and been inclined toward the effort, an old can tied at the end of a stick plunged into the water from a nearby log boom would have brought him up in one sweep all the smelt he could eat in a day. Or by lying on the log boom he could have pulled out enough fish with his bare hands for a square meal.

There is not much romance connected with the taking of the smelt that are so plentiful in the markets of Portland and the Northwest during four or five months of each Winter. There is no battling with waves and storms such as are encountered by the hardy herring fishermen of the Atlantic. For the sportsman, smelt fishing would be just about as exciting as clam digging and the amount of skill required about the same. Smelt fishing furnishes tales, however, that are novelties among fish stories in that while almost unbelievable they are nevertheless true.

During the smelt runs fish are so plentiful that even the voracious sea gull becomes almost sated. When the gulls are at all hungry the fishermen sometimes find amusement tossing smelt into the air, which the birds catch before they reach the water.

A sea gull, on the wing, will seize a fish perhaps by the tail and reverse it with a toss in the air and gulp it head first in the twinkling of an eye.

So plentifully do the smelt run that frequently children bail them out of the water with tin cans securing half fish and half water. When the water is shallow enough the smelt can be taken with the bare hands for the skin of the fish is not slimy when in the water.

While the Cowlitz River is the only known spawning ground for smelt where the fish may be taken year by year, they have been known to run up the Lewis River and also up the Sandy. At the time the smelt ran up the Lewis River, 14 years ago, there was only a small run of male smelt in the Cowlitz and the fishermen transferred their operations to the Lewis. When smelt run in numbers up the River it is apparently independently of the Cowlitz run and it is said to occur in the Sandy about once in eight years. It is truthfully related that at the time of the last run up the Sandy a party of Portland young men went out with dip nets on a fishing expedition. One man lost his dip net, but luckily found an old, rusty, discarded bird cage. This he attached to the end of a pole and successfully kept pace with his more fortunate companions. The is the only record in fishing annals of successful fishing with a bird cage although if the novelty of the experiment invites one it can undoubtedly be successfully duplicated in the Cowlitz River any day between now and April 1.

During the last big smelt run in the Sandy farmers drove their wagons to stream, filled them with dip nets and used the fish for fertilizing fruit trees. An unusually large quantity of pork with a fishy taste sold in the markets some months afterwards revealed the fact that some of the farmers had utilized the fish surplus in feeding their hogs.

This season the Cowlitz River is the spawning ground of the greatest run of smelt ever known by fishermen who have been engaged in the business for 20 years. It is now estimated that by the close of the season the river will have yielded 300,000 boxes of smelt, each box weighing 50 pounds. This will represent an output of 10,000,000 pounds or 5000 tons and a smelt average about eight fish to the pound it means the marketing of 80,000,000 fish.

The smelt has peculiarities of his own, as pronounced as those of the salmon. What is known commercially as the "Columbia River smelt" is caught in paying quantities regularly year by year only in Cowlitz River, which is a tributary of the Columbia River rising in the State of Washington.

The main fishing grounds of the river extend over an area during the season of not more than eight or 10 miles as a rule. Like those of the salmon the smelt runs come in from the sea through the mouth of the Columbia River. In the earliest catches, when smelt bring from $3.50 to $3 per box, the fish are taken in limited numbers in the Columbia.

In the Columbia some fish are caught in the early season by gill netters, but when the season is well along the gill netter cannot compete with the regular smelt fisherman, for the former has to pick the fish out one by one from the meshes of his net. The latter uses a dip-net attached to a long pole, and after locating a school of fish simply bail them out of the river and into his boat, sometimes getting as many fish as he can lift out of the water.

The smelt lie in schools close to the bottom of the river, and are therefore found at varying depths. The fishermen prospects for the schools with the reverse end of his pole, and if the end of the pole is plunged into an accumulated number of fish the wriggles of the small bodies that results is communicated to the hands of the fisherman.

Most of the fishing is done at night, for the light of day seems to scatter the fish, yet even in daylight hours the fishermen are able to pursue their occupation with good results.

Before Kelso accumulated a variety of industries along its waterfront, one of the best fishing points was opposite the Northern Pacific depot, from where on e can toss a stone into the water. The driving of piles, however, seems to have driven the fish father up the stream, and this season they have been found most plentifully about one and one-half miles above the town. Between the small floating docks and the fishing grounds boats are continually plying, going up stream empty and returning ladened with fish. Fully 500 boats are utilized in the industry and of these about 75 are power boats.

As a rule there are two men to each boat and the crafts are filled in almost an incredibly short space of time. Last Tuesday night J. A. Sprague, one of the principal shippers of Kelso, and one companion, loaded his launch to its capacity in 45 minutes. This represents a catch of 45 boxes, or one 50-pound box a minute. Last year a catch of 125 boxes for two men held the record for a night's fishing. This year there have been frequent occasions when two men brought in 200 boxes to represent a day's work.

To the ordinary fisherman who has no regular market to supply, a catch of 200 boxes of smelt in the height of the season is worth about $50. On the Cowlitz River; however, there are a number of men who ship direct to retail markets, maintain boats of their own and buy from other fishermen. Portland wholesalers have buyers at Kelso and probably the greater portion of the retail trade is supplied through Portland. At Kelso, however, smelt have been shipped direct as far East as Wisconsin.

The output of the river, say the fishermen, could be greatly increased if the market demands were sufficient to justify more men engaging in the industry. Kelso has no facilities for shipping fish in cold storage. A cold storage plant is one of the enterprises the town wants, for it is believed that the market can be broadened and a demand created in the Far Eastern states. Canning in the form of sardines is also suggested, and in Kelso there is a cannery that was utilized as a co-operative plant by fruit and vegetable-growers until last year, that will be turned over to any experienced man who will engage in the business.

Kelso has a group of enterprising citizens who have done much to build up the town to its present population of 2800. Practically the same group of business men established the electric light plant and city water works, built a $15,000 opera-house erected a drawbridge across the Cowlitz River, which they afterwards sole to the county, established a newspaper office, invested in the co-operative cannery mentioned and have aided and encouraged several other enterprises.

They are now seeking to put the smelt fishing on a basis where it will pay better returns to the fishermen and increase the number of men engaged in the industry. This effort is apparently justified, for though the output of smelt is slowly growing year by year, the increasing inroads upon the schools of fish do not seem to diminish their number.

Cowlitz River fishermen are now advocating the licensing of persons engaged in commercial smelt fishing. Frequently, during the season, schoolboys will go out, load up a few boats with fish and become easy marks for the buyers. The result is a demoralizing market, the boys being content with enough money to buy candy or a few toys. Often too, groups of Greeks or Italians will come up the Cowlitz in boats, remain at the fishing grounds for a few days and sell their catches for whatever they can get, again upsetting the prices paid the regular fishermen. The men who are regularly engaged in the industry want the protection of a reasonable license, which, they believe, will cut out the itinerant fisherman.

It is a saying among fishermen that a big run of smelt presages a big run of salmon. If this is true, the salmon fisheries of the Columbia should have a prosperous season this year, for the smelt run is unprecedented in volume.

[The Morning Oregonian (Portland, OR), Thursday, December 8, 1910, page 21, column 6]

SMELT IN THE RIVER

GOOD HAULS LOOKED FOR IN ABOUT TEN DAYS

…

ASTORIA, Or., Dec. 7.

…

Two days ago a few smelt were seen at the mouth of Grays river, showing that they are beginning to come in, and good hauls of this class of fish may be looked for in about ten days or two weeks.

[The Morning Oregonian (Portland, OR), Thursday, January 5, 1911, page 21, column 1]

Run of Smelt is Small

ASTORIA, Or., Jan 4.—(Special)—Quite a few smelt have been caught during the last few days in the vicinity of Clifton, but none has been taken as yet in the Grays River. It is said the water in that stream is too low and a freshet must come before the smelt will be attracted that way.

[The Morning Oregonian (Portland, OR), Saturday, January 7, 1911, page 12, column 4]

GOOD THINGS IN MARKETS

Columbia River smelt, though less costly than on its first appearance, sold yesterday at 25 cents a pound, but will probably soon reach the lower prices we are accustomed to.

[The Morning Oregonian (Portland, OR), Saturday, February 11, 1911, page 8, column 4]

GOOD THINGS IN MARKETS

The day of very cheap Columbia River smelt is not yet, though any market man will tell you it may be expected at any time now. Smelt were selling yesterday at 10 to 12½ cents a pound, and were quite scarce at that, though earlier in the week they were to be had at three pounds for 25 cents.

[The Morning Oregonian (Portland, OR), Friday, February 18, 1911, page 10, column 3]

GOOD THINGS IN THE MARKET

The smelt are here! The run is sufficiently strong to reduce the price to 5 cents a pound, and at every dealer's the fish are on hand in boxfuls.

[The Morning Oregonian (Portland, OR), Wednesday, February 22, 1911, page 18, column 2]

Marine Notes.

First of the season's catch of smelt in the Cowlitz River, amounting to 35 tons was brought to Portland on the steamer Lurline. Another consignment was transported by the steamer Joseph Kellogg.

[The Morning Oregonian (Portland, OR), Saturday, February 25, 1911, page 12, column 2]

GOOD THINGS IN MARKETS
BY LILIAN TINGLE

The heavy run of Columbia River smelt has come in earnest this week. The delicious little fish are selling at three pounds for a dime, 10 pounds for a quarter, or one dollar a box, and there is enough for every one.

[The Morning Oregonian (Portland, OR), Saturday, December 2, 1911, page 11, column 2]

First Columbia River smelt of the season at Mace's Market.

[The Morning Oregonian (Portland, OR), Saturday, January 27, 1912, page 4, column 3]

GOOD THINGS IN MARKETS

Columbia River smelt is not really plentiful, but is to be had at 6 to 8 cents a pound.

[The Morning Oregonian (Portland, OR), Saturday, February 10, 1912, page 12, column 4]

GOOD THINGS IN MARKETS
BY LILIAN TINGLE

Columbia River smelt are still the leading feature in the fish markets, and are selling at about 8 cents a pound.

[The Morning Oregonian (Portland, OR), Tuesday, April 2, 1912, page 7, column 3]

SMELT RUN NOW ON

Millions of Small Fish Enter the Sandy River

SUNDAY CROWDS ACTIVE

Troutdale, Or., April 1.—(Special)—This thriving little city should have been named Smeltdale, as there isn't a trout anywhere near it. But the dainty little smelt is just now the attraction that has made the town the Mecca of thousands who are all returning home laden down with all the fish they care to take away with them.

The great run of smelt from the Columbia River began on Thursday last and was at its greatest yesterday. An ideal day and the prospect of unlimited catches, together with the exciting sport of taking them, brought people from every direction. The banks were lined with teams from all over the county and automobiles from the city, and the entire day was spent in a vain effort to deplete the Sandy River of its finny denizens.

Millions Will Die

Thousands were caught but millions got away, only to swim against the strong current for a few days longer and then float back dead, dying or exhausted, when the greatest run known will all be over.

Nine years ago there was a similar run of smelt in the Sandy. This is the only river, excepting the Cowlitz that is ever entered by them from the Columbia. No one can ever predict when they are coming. It is only when the water is seen to be fairly alive with them that the word goes out and for a few days all other business is suspended while the people from far and near lay in a big supply.

Bird Cages Used as Nets

Yesterday's sport was exciting enough. It was attended with many involuntary baths and much mirth. The fishing appliances consisted of nets tied to long poles and every scoop into the water brought up fish.

In place of the regulation net there were to be seen improvised scoops made of wire gauze, coal-oil cans and even bird cages. A motion picture outfit made films and every sort of a water craft did a rushing business all day long.

The great run will cease as suddenly as it began.

[The Morning Oregonian (Portland, OR), Saturday, November 23, 1912 page 16, column 4]

SMELT ARE RUNNING EARLY

Fish Caught Close to Ocean Bring Fancy Prices

ASTORIA, Or., Nov. 22—(Special)—Smelt are entering the river earlier this year than ever before. Last night one man who was fishing for herring in the lower river not far from Sand Island caught a pound and a half of smelt in his net, and as a result he is going out with a regular smelt net.

Columbia River smelt are considered the most toothsome fish found on the Coast, and when caught close to the ocean are exceptionally fine, those taken early in the season often selling as high as a dollar a pound.

[The Sunday Oregonian (Portland, OR), December 15, 1912, page 14, column 4]

GOOD THINGS IN MARKETS

Columbia River smelt is the "newest thing" in the fish market and is available, in small quantities only, at 25 cents a pound.

[The Sunday Oregonian (Portland, OR), February 2, 1913, page 16, column 5]

GOOD THINGS IN MARKETS

Columbia River smelt again is in the market, in generous supply, and can now be had at six pounds for 25 cents.

[San Jose Evening News (San Jose, CA), Monday, April 14, 1913, page 5, column 4-5]

UNUSUAL RUN OF SMELT NEAR PORTLAND—FARMERS CARRY FISH BY WAGONLOADS FOR FERTILIZER

Portland, Or., April 14. – A run of smelt which promises to break all records has come into the Sandy river, a tributary of the Columbia, 12 miles from Portland.

An army of farmers and people from the city are busy scooping out the little fish in water buckets, dip nets, inverted bird cages and with pitchforks. The supply is so far beyond the demands of the markets that farmers are hauling them off by the wagonload and distributing them over their plowed lands as fertilizer.

One cent a pound is the market price for smelt along the Sandy, with but scant demand, since people there and in Portland have become surfeited with them.

Heavy runs of smelt in the Sandy appear at intervals of several years, but this one is denominated a freak. The run is both ahead of time and unusually heavy.

[The Morning Oregonian (Portland, OR), Saturday, November 29, 1913, page 12, column 1]

GOOD THINGS IN PORTLAND MARKETS

The first Columbia River smelt of the season is on the market this week at $1 a pound …

[The Morning Oregonian (Portland, OR), Friday, December 5, 1913 page 14, column 4]

COLUMBIA SMELT ON SALE

Weather Makes Fish Scarce and Retail Price is 25 Cents a Pound

Columbia River smelt have appeared in the market. The run, so far, has been a small one, and as long as the present kind of weather continues, the fish will not be plentiful, but warm rains and higher water in the river will bring them in abundance.

The big run, which is due later, will be in the Cowlitz River. Smelt are retailing in the markets at 25 cents a pound.

[The Morning Oregonian (Portland, OR), Wednesday, January 14, 1914, page 14, column 2]

Marine Notes

First of the smelt caught this season in the Cowlitz River arrived yesterday on the steamer Joseph Kellogg, the shipment consisting of 60 boxes. Owing to high water in that stream the catch is regarded as light.

[The Sunday Oregonian (Portland, OR), January 18, 1914 page 6, column 6]

Columbia River smelt are so plentiful as to confound the price jugglers.

[The Morning Oregonian (Portland, OR), Thursday, February 5, 1914, page 16, column 6]

Marine Notes

It was estimated that the deliveries of smelt from the Cowlitz River and Lower Columbia district yesterday were between 1200 and 1500 boxes. The launch Frolic brought 425 cases from the Cowlitz.

[The Morning Oregonian (Portland, OR), Friday, February 27, 1914, page 14, column 3-4]

GOOD THINGS IN MARKETS

Columbia River smelt is still at flood tide and is expected to be abundant [in the fish market] until possibly the middle of March.

[The Morning Oregonian (Portland, OR), Tuesday, March 31, 1914, page 10, column 6]

SMELT ARE DESTOYED

PROSECUTIONS MAY FOLLOW USE OF FISH AS FERTILIZER

Mr. Finley Says Law Against Wanton Waste of Food Will Be Enforced Against Sandy River People

The smelt running in the Sandy River are attracting many people to that locality. Inasmuch as the fish are extremely plentiful, it is no trouble at all to catch them in nets or makeshift scoops. The fact that the fish are so abundant has led many persons to catch them without limit.

"The State Board of Fish and Game Commissioners desire to give public notice that the law passed as the last session of the Legislature concerning the wanton waste of fish will be strictly enforced" said William L. Finley. "The Columbia River smelt is one of our most valuable commercial fish. The fact that it comes in great numbers into Cowlitz, the Sandy and certain other streams at about this time of the year, leads some people to believe that the supply is inexhaustible.

"These fish come in from the sea and go into the rivers to spawn. We have to depend upon our future supply from the natural spawning of these fish. At the present time many people living in the vicinity of Troutdale are catching far greater numbers of these fish than they have any use for; in fact, they are loaded into gunny sacks and into wagons and not used in any way except as a fertilizer.

"It is an economic waste and an outrage that such a fine pan fish as the smelt should be wantonly destroyed and wasted. There is nothing governing the amount of these fish that can be caught or the method of catching them, yet there is a strict law against the wanton waste of food of this kind. If it is not observed, complaints will be sworn out and arrests will follow."

[The Morning Oregonian (Portland, OR), Saturday, January 2, 1915 page 5, column 4]

Kelso Prepares for Smelt Run

KELSO, Wash., Jan. 1—(Special)—The Columbia River Smelt Company is erecting a new dock near the depot at Kelso to facilitate the work of handling and shipping the smelt catch during the approaching season. It is now almost time for the arrival of the fish and old fishermen expect the run to start as soon as the river rises. The fish never start their run until the river is muddied by rains. Plans are being made to open an Eastern market on a more extensive scale than last year when shipments in refrigerator cars were made for the first time.

[The Morning Oregonian (Portland, OR), Saturday, January 9, 1915, page 8, column 6-7]

GOOD THINGS IN MARKETS

In the fish market: Variety is considerable this week still and the ripple on the surface is caused by a run of smelt up the Columbia River. They are in the Cowlitz strong and here in Portland are selling at two pounds for 25 cents, with every prospect of rapid descent in price

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[The Morning Oregonian (Portland, OR), Monday, February 15, 1915 page 9, column 6-7]

Cowlitz Has No Smelt

VANCOUVER, Wash., Feb. 14—(Special)—That some person desiring to keep the smelt from running up the Cowlitz River at Kelso dumped several barrels of lime in the mouth of the river, just as the smelt were beginning to run, is a story told at Kelso.

It is known that for two or three days the smelt passed the Cowlitz River and went into the Kalama River, the first time since 1847. There is not a great deal of current at the mouth of the river where it is said the lime was dumped into the river. Many persons say, however, that it was just a whim of the smelt themselves to select the Kalama River. It is reported that another big run of smelt has started in at the mouth of the Columbia River.

[The Morning Oregonian (Portland, OR), Wednesday, March 8, 1915, page 11, column 1]

New run fresh Columbia River smelt. 75c for 50-lb box. Order shipped promptly. Sanitary Fish Co., First and Washington—Adv.

[The Morning Oregonian (Portland, OR), Tuesday, March 9, 1915, page 5, column 4-5]

SMELT IN LEWIS ON WANE

Gulls Prey on Third Run That Is Wakened by Swift Current

VANCOUVER, Wash., March 8.—(Special)—The third run of smelt in the Lewis River at Woodland is beginning to wane and the price has dropped. The smelt, which are said not to eat after they leave salt water, are dying by thousands, and may be seen floating down stream. Many are weak and cannot swim against the current.

Seagulls by the thousands hover over the Columbia River and follow the smelt from the time the smelt enter the mouth of the Columbia River. They refuse to eat the dead smelt. So thick are the smelt in the Lewis River that they are dipped out in bunches from 50 to 75 pounds. One man made a dip yesterday that weighed 68 pounds.

[The Morning Oregonian (Portland, OR), Friday, December 31, 1915, page 9, column 4]

Smelt Are Becoming Plentiful

KELSO, Wash., Dec. 20.—(Special)—Columbia River smelt are being taken in increasing numbers in the mouth of the Cowlitz and along the Columbia by the gillnetters, and fishermen are expecting a large enough supply of the fish so as to permit of dipnet fishing at almost any time. Many boxes of smelt are leaving the Kelso depot daily, and the fishermen are securing good prices for their catches.

[The Morning Oregonian (Portland, OR), Friday, December 31, 1915, page 12, column 3-4]

GOOD THINGS IN THE MARKET

The fish market is enlivened by the intelligence that a considerable run of Columbia River smelt appeared in the Cowlitz on Wednesday, and consequently the price has dropped to 15 cents a pound.

[The Morning Oregonian (Portland, OR), Friday, January 28, 1916, page 11, column 1-2]

GOOD THINGS IN THE MARKET

[The Morning Oregonian (Portland, OR), Tuesday, March 7, 1916, page 16, column 6]

Marine Notes.

Smelt shipments delivered here yesterday aboard the launch Beaver, which came from the Cowlitz River, numbered 212 boxes.

[The Morning Oregonian (Portland, OR), Saturday, December 21, 1918, page 18, column 7]

COLUMBIA RIVER SMELT 15c per lb. Single frozen, properly packed to arrive in good condition in 5-pound to 15-pound lots, within 150 miles of Portland. Write for quotations on larger quantities. NORTHWEST FISH PRODUCTS CO., 205 Yamhill St., Portland, Or. Phone Main 4760.

[The Morning Oregonian (Portland, OR), Wednesday, February 5, 1919, page 13, column 6]

RUN OF SMELT BEGINS

Farmers Join Fishermen in Cowlitz River Catches

The annual run of smelt in the Cowlitz River has started, according to reports received in Portland yesterday. Farmers and people living in the vicinity of the river have joined with the smelt fishermen in catching the fish, which are said to be running in large schools.

As a result of the commencement of the run, prices of Columbia River smelt dropped to 4 and 5 cents per pound in Portland. It will be several months before the smelt can be expected in the Sandy River, although the fish do not ply through this stream every year. However, for the past two years Portland people have made large smelt catches in the Sandy.

[The Morning Oregonian (Portland, OR), Monday, February 17, 1919, page 8, column 6]

DISAPPEARANCE OF SMELT FEARED

Pioneer Cowlitz Fishermen Deplores Lack of Protective Laws

KALAMA, Wash., Feb. 13.—(To the Editor.)—I have been fishing smelt since 1879 and for over 25 years after that date never saw the Cowlitz river without a big run of smelt. Some winters they would come as early as January and sometimes as late as March. Then they would come so thick that a fish boat could be loaded with a small dipnet in a few hours.

For the last eight years I have noticed the large runs have disappeared; for three years, or three winters, the most smelt have been caught in the Kalama, Lewis and Sandy rivers, and it looks like the smelt were done for in the Cowlitz forever.

This winter we got a surprise. A big run of smelt entered the Cowlitz after the markets had been well supplied from the smelt caught by gillnets in the lower Columbia. As soon as the smelt entered the Cowlitz several hundred launches loaded up. My boy caught a ton and one-half in five or six hours and expected to make a stake out of it. He went over to Rainier, but the smelt buyers were blocked, and also in Kelso. At least 150 fish boat-loads at two tons each have been dumped overboard inside of three days and a big troller loaded and bound for a lower river port with seven tons of smelt got foul of a bootlegger just after being loaded and bound out of the Cowlitz, and struck the sandbar in the mouth of the Cowlitz. He kept driving ahead and drove her high and dry. The river falling about his launch, he was compelled to jettison his cargo overboard, as nobody wanted his smelt for nothing.

The whole thing is a disgrace. Every fisherman and cannery man knows that the smelt is the natural food for the Chinook salmon. The young salmon, after leaving the spawning ground and hatcheries, feed on the young smelt, and the large salmon fatten on the grown smelt. This run of smelt, most likely the last big run ever to come into the Cowlitz, will be followed up by launches to the very spawning grounds. My boy was offered a contract by one of our big smelt merchants at $8 per boatload of 2⅓ tons, a trifle over ⅛ of a cent per pound.

There is no law against dumping a few hundred tons of these fine fish overboard, but we should have a law to protect the smelt, as well as the salmon. Our lawmakers in Salem and

Olympia are not all to blame, but the fish law agitators in both houses, who fight all kinds of battles between themselves on how to protect the salmon, let the salmon starve and don't think of feeding this royal fish. I am sure that in less than 15 years from now smelt will be as scarce as the elk in the mountains. These plentiful launches with the big scoopnets will soon finish the smelt business. I am able to see it. It is my trade and business. The smelt-buying merchants about Kelso and Kalama consist of about a dozen, and get discharged sailors and soldiers to dip the smelt at from $3 to $5 a ton. They get fat on the destruction of the smelt. Whatever can be dumped fresh on the market at 75 cents to $1 a box goes. Several hundred tons may go into cold storage and be retailed later from 10 to 12½ cents per pound. It would be wise and easy to draft a law that would be of benefit to the salmon, the fishermen and the children.

Charles Wood

[The Morning Oregonian (Portland, OR), Tuesday, April 1, 1919, page 10, column 5]

Those Who Come and Go

Run of smelt in the Sandy river attracted scores of guests from the hotels yesterday. To the easterners and people from California the sight was wonderful. "About everyone in the hotels has gone out to the Sandy river," said Clerk J. J. O'Brien, at the Hotel Portland. "Those who went yesterday came back so excited and talked so much about the fish that they caused others to go out today. One easterner declared there was more fish than water in the river."

[The Morning Oregonian (Portland, OR), Tuesday, April 27, 1920, page 10, column 6]

Those Who Come and Go

When A. N. Ward gets back to the Hot Stove club at Malden, Mass., [he] will have a fish story to tell that his fellow townsmen will probably not believe and will stamp it as a traveler's tale. When Mr. Ward recounts that he saw a river so filled with fish that the stream was virtually one solid mass of fish for miles, and contained millions of smelt, the Maldenites will sniff with suspicion. When he says that in five minutes he, or anyone, could gather enough fish from the Sandy river with his coat, or auto robe, or any old thing, to fill a car to overflowing, they'll be certain that he is drawing the long bow. And yet, those were the things which Mr. Ward saw when he toured the Columbia river highway yesterday. He saw the great smelt run and saw miles upon miles of parked cars, while their drivers were filling gunny sacks, cans, buckets, tubs, boxes and any container they could secure, with smelt. At home Mr. Ward is an undertaker, and with his wife he is at the Multnomah, returning from the profiteer belt of California.

[The Morning Oregonian (Portland, OR), Wednesday, April 28, 1920, page 15, column 4-5]

SMELT RUN BIGGEST EVER

Prow of Boat Turns Up Hundreds All Night Long

"My observation is that this is the biggest smelt run that has ever come up the Columbia river," was the statement made yesterday by State Game Warden Carl D, Shoemaker after he spent Monday night on the river in a motorboat. "We found early this morning that the seagulls are following the smelt all the way from Vancouver bridge to the mouth of Sandy and that a solid wave of smelt is coming upstream between these points, or a distance of about ten miles. The prow of our boat turned up hundreds of them all night long."

Mr. Shoemaker says there are no indications of the run slacking and that tons of fish are being shipped to Oregon and Washington points and many are going into local cold-storage plants. It is found that female smelt predominate over males in the present run, indicative of another heavy one next year.

[The Morning Oregonian (Portland, OR), Monday, May 3, 1920 page 4, column 2]

SMELT RUN NEARS END

SCHOOL IN SANDY KEEPS OVER SPAWNING BEDS

WITHIN NEXT FEW DAYS DIP-NETTERS WILL BE HARD PUT TO GET A MEAL FROM WATERS

The record run of smelt, so far as the Sandy river is concerned, is all but over. Within the next few days the gulls and the dip-netters will be hard put to find a meal in the deeps and shallows that aforetime held smelt by the billion. But few fish were obtained yesterday and the disappointments were in keeping—for not more than 50 fishermen were congregated at the Troutdale bridge at any one time during the day.

Most of the dip-netters, however, managed to get a sack or so, by watching for the stray fringes of the now depleted and rapidly vanishing school. The main body of the run held well to the center of the stream, over the spawning beds, and only the commercial fishermen, with improvised piers and rowboats, were able to reach the profitable coigns of vantage.

The Sandy river smelt run, more than a month overdue by comparison with previous seasons, began ten days ago and within half a week had attained unheard of proportions. Launches in the Columbia river outside, near the mouth of the Sandy, ploughed through pools of smelt so dence [sic] that the curving wave at the bow was a cascade of shining fish. The smelt even drove far past the Sandy and as far up the river as Bonneville.

[The Morning Oregonian (Portland, OR), Saturday, January 1, 1920 page 1, column 2]

SMELT ON MARKET HERE
First Shipments of Cowlitz River Run Are Received

Portland markets yesterday were selling the first of the new run of Columbia river smelt, the fish having been shipped from Cowlitz river, where the run is said to be quite heavy. The fish are what is known as the "widow" run, being the forerunners of the main run, which starts generally in February. About 20 boxes of the fish were received yesterday from the Cowlitz by the Portland Fish company, which reports that they will continue to receive consignments daily until the run ceases. Heavy catches generally reduce the "widow" run within a short time, it is stated, and smelt are off the market until the main run starts.

The wholesale price for the smelt yesterday was 13 cents a pound, and the retail price at most of the markets was 20 cents. When the main run begins the fish are caught in such quantities that the price generally drops much lower.

[The Morning Oregonian (Portland, OR), Wednesday, May 5, 1920, page 10, column 2]

LIKE THE SANDS OF THE SEA

Take all the hyperbolic similes expressive of vastitude of numbers, stir them well together, segregate the triple-extracted essence and confine it in a humdinger of extravagant comparison, and one will but have paid tribute to the fringes of the Columbia river smelt run. Naught save deity could give it census, for the count would worst mortal mathematics as that science is ordinarily employed. These observations are by way of preface to the statement that a Portland resident has been arrested on the count of wasting food fish, because he sought to fertilize his fruit trees with passé smelt.

There are those who will charge the game department with mulish conformance to law, asserting that the statute invoked was never intended to deal with billions upon billions of silver "hooligans,' swimming up the Columbia just as they did on the morning Captain Gray's visit, ever and ever so long ago. To chirk up a cherry tree or two with half a peck from that seemingly inexhaustible measure, the sea, would to many commend itself not only as a trifling tithe on nature's largess but as a most sensible procedure.

When the grandfathers of the present were the boys of yesterday, back in Ohio, and Michigan, and Minnesota, and Wisconsin, and New York, along the entire Atlantic coast and well into the middle-west, the flight of passenger pigeons was an annual event comparable to the smelt run of the Columbia. On sunny days, with the spring mornings all golden and green, when those epochal pilgrimages were on the wing, it is recorded that the face of the sky was darkened as by a heavy cloud—a living veil of plumage that swept on and on, and endured till dusk. And thus for many days. They narrate, those same grandsires, that one might feed a bullet to the muzzle-loading squirrel rifle and fire at random upward, through the hurtling avalanche of pigeons. Not one but several birds would fall to that hazard, it is recounted. Yet the passenger pigeon is gone, and wealth would reward the man who could prove the existence of a single flock, a single bird. The species is with the great auk and the dodo, and while it may have perished in some stormy passage between the northern and southern continents, there is abundant evidence against the market hunter and the game assassin.

Natural history is replete with tragedies in which man plays the role of villain. Ethically and economically—and merely, for an additional reason, because all waste is wicked—the game department is fortified in its enforcement of the law with respect to the smelt run.

[The Morning Oregonian (Portland, OR), Friday, May 7, 1920, page 10, column 7]

HABITS OF SMELT LITTLE KNOWN

Study Made of Fish Which Authorities Know Under Several Names.

PORTLAND, May 6.—(To the Editor.)—Please publish the follow [sic] information, and any other interesting facts, about the smelt.
How long until they hatch, and how long do they stay in fresh water after hatching?
How long before they come back to spawn?
Do all that come up the river die, and what becomes of them when dead?
What is their correct name?
Are there such fish other places than the Columbia river?
A SUBSCRIBER.

The scientific name of the Columbia river smelt is Thaleichthys Pacificus [sic]. It is described in encyclopedias and dictionaries under "candlefish." The Indians called it "oolachan," sometimes spelled "eulachon," which has been corrupted by whites into "hooligan." It is common in Alaskan and British Columbia streams, as well as in the Columbia.

R. E. Clanton, master fish warden, is authority for the statement that the longevity and habits of the Columbia river smelt have never been made the subject of exhaustive study, and that this season is the first in which trained observation has been directed.

The present attempt includes a study of the reproductive organs of the female smelt, to discover whether nature has provided for a second spawning. It is not known at present whether smelt return to the ocean or perish in the rivers—as does the salmon after visiting the spawning beds.

If the billions of smelt in an ordinary run were to die in fresh water, it is contended, the evidence of such demise would be prevalent, even to the point of pollution, of so mighty a stream as the Columbia. On the other hand, the return of the smelt run to salt water, if it does return, never has been observed. Fish commission officials, including Master Warden Clanton and Secretary Carl Shoemaker, of the fish commission, expect to make tests this week toward solving the riddle.

The journey of the smelt fry to the ocean is another phase of the life cycle that is darkness. None has seen, so far as the records show, the migration of the infant fish from the birthplace river to salt water. Their numbers must be uncounted myriads, and even if the fry were even an inch in length the passage of the infant smelt would be plainly discernible. It is conjectured that the fry run to sea when extremely small.

But all this is guess work. An attempt is now launched to learn more of the actual life history of the Columbia river smelt. Specimens now held at Bonneville hatchery will be kept under observation to determine whether they are subject to demise after spawning, while an attempt will also be made, with nets, to discover whether any portion of the recent heavy run has retraced its course to the Pacific.

[The Morning Oregonian (Portland, OR), Thursday, January 20, 1921 page 4, column 2]

Smelt Enter Cowlitz River.

KELSO, Wash., Jan. 19.—(Special)—For the first time this season smelt were dipped in the Cowlitz river today. A few smelt had been gillnetted in the Cowlitz earlier this winter before the freshet, and for the last two weeks the Columbia River gill netters have been getting smelt on the lower Columbia. It is thought that the present run is what is known as the early winter run and that the main run of the little fish will not be here for several weeks more.

[The Morning Oregonian (Portland, OR), Friday, February 18, 1921, page 11, column 1]

Lewis River Rises.

WOODLAND, Wash., Feb. 17.—(Special.)—Warm winds and melting snow in the mountains have caused a decided rise in the Lewis river. The water has already reached within a foot of the high-water record. Muddy water is driving the run of smelt out of the river into the Columbia.

[The Morning Oregonian (Portland, OR), Saturday, February 19, 1921, page 13, column 1-2]

MANY FRUITS IN SEASON

Columbia river smelt retailed at two pounds for 15 cents yesterday.

[The Morning Oregonian (Portland, OR), Saturday, March 19, 1921, page 13, column 2]

FISH FOR LENT PLENTY

Prices will cover all the stages between 5 cents a pound for Columbia river smelt to 50 cents a pound for lobster shipped from the Atlantic seaboard.

[The Morning Oregonian (Portland, OR), Saturday, December 24, 1921, page 12, column 1]

Smelt Put in Appearance

Columbia river smelt have appeared for the holiday season in large quantities. They are being dipped up with nets are selling retail here at 15 cents a pound, in comparison with 25 cents a pound, which was the price until yesterday.

[The Morning Oregonian (Portland, OR), Saturday, January 14, 1922, page 10, column 2-3]

DID THE SMELT NEGLECT THEIR TRYST?

If nature forgot us for a single season, in all her bounties, we should be like so many children squalling in the dark. Quite helpless, very hungry and probably petulant. Occasionally the good dame does forget, neglecting some customary gift, and men puzzle themselves to discover the reason. They do not always find an answer. Why was it, as was recorded twenty-five years ago, that there had been noted long periods during which the smelt run deserted the Columbia river? For twenty years, so these observers asserted, the pleasing little eulachon was—to put it tritely—conspicuous by his absence.

The drying racks of the Indians were not laden, and the residents along the great river and its tributaries scanned the streams vainly for the return of their favorite fish, who was wont to be as punctual as April. There is no record of the year in which the run reappeared, nor is there more than the testimony of a few individuals, as preserved in news reports, to substantiate the disappearance. Undoubtedly it was the ancient and continuous custom of the smelt to frequent the Columbia as spawning time. Captain Robert Gray, whose good ship lent its name to the river, found them plentiful in 1792, and did not neglect to pay his compliments. It is to be regretted that the record of their truancy is not more specific, better verified, for instances in which anadromous fish fail to keep their natural appointments are more than rare.

Regarded across a third of a century, the claim is doubtful, and one cannot but incline to an opinion that the smelt were punctual, but unobserved. It might have been that the run, lengthy as it is, passed the specific points of observation at periods of high and murky water, to spawn far up-stream. The weakness of this theory, which is otherwise entirely tenable, is that such conditions would scarcely be repeated annually over a long period of years. An instance that proves how easy it is to overlook the presence of the run is that of the appearance of the smelt in the Sandy river last spring. Unusually high water prevailed at the time the run was expected, and all observers were confident that the hordes of smelt had not entered the stream. Later they revised their opinion, for schools of infant smelt were noticed in early summer, and it became apparent that the fish had arrived and fulfilled their destiny without a single person glimpsing the millions of adult fish in the muddy current. Yet, as has been said, it is a bit far-fetched to fancy that such conditions could be indefinitely repeated.

The habits of anadromous fish are definite and precise. They return from the sea at well-established seasons to the waters of their own birth to deposit their eggs. In this impulse the smelt are one with the salmon, whose cousins they are, and the confirmed belief is that such runs do not fail until the run itself is obliterated. With salmon this has repeatedly been proved. It is logical to assume that the multitudinous smelt conform to the same law, and that those early observers confused loose report and limited observation with fact until they had for themselves established a tradition. This may not be true, but if it is not true one of ocean's mysteries remains unsolved, and it is to be regretted that the record is so imperfectly preserved.

[The Morning Oregonian (Portland, OR), Monday, February 6, 1922, page 6, column 2]

Smelt Run in Cowlitz Small.

KELSO, Wash., Feb. 5.—(Special.)—A small run of Columbia river smelt is in the Cowlitz river and the fishermen are making small catches of the little fish, which are a great table delicacy throughout the northwest. Boats can get but three or four boxes a night. It may be several weeks before a heavier run arrives, say those familiar with smelt fishing operations, as few fish have been caught by the Columbia river gill netters.

[The Morning Oregonian (Portland, OR), Saturday, February 11, 1922, page 12, column 1]

A large supply of Columbia river smelt is available at 15 cents a pound, and in some places at two pounds for 25 cents.

[The Morning Oregonian (Portland, OR), Tuesday, February 21, 1922, page 7, column 6]

Smelt Run Again Enters Cowlitz

KELSO, Wash., Feb. 20.—(Special)—What is thought to be the main run of Columbia river smelt entered the Cowlitz river last night and large catches of smelt were made by the fishermen. Later, however, the run decreased, and there is some doubt whether or not this is the main run. The fish have been late in coming up the river this year, although there have been small runs in the Cowlitz several times during the winter.

[The Morning Oregonian (Portland, OR), Saturday, February 25, 1922, page 12, column 1]

COLUMBIA SMELT PRICE IS REDUCED

Fresh Seafood Sells Three Pounds for 25 Cents.

LARGE SUPPLY ON HAND

Smelt Prices Cut.

The price of a popular seafood that is recognized in Portland as a real delicacy was cut almost in two when dealers reduced prices of Columbia river smelt. These tasty, silvery fish are now available at three pounds for 25 cents. The price a week ago was 15 cents a pound. Dealers report a good supply on hand to supply a brisk popular demand. The smelt are fresh from the Columbia river.

[The Morning Oregonian (Portland, OR), Saturday, March 4, 1922, page 15, column 1]

Smelt Also Take Fall.

Another popular product that has dropped in price is Columbia river smelt. These tasty little fish may be had at two pounds for 15 cents or four pounds for a quarter. In some stores the price is three pounds for 15 cents. These prices are the lowest of the season so far and caused a heavy demand.

[The Morning Oregonian (Portland, OR), Wednesday, April 12, 1922, page 13, column 3]

SMELT REPORTED RUNNING IN SANDY

Fish Keeping to Middle of Stream, It Is Said

LICENSES NOT NEEDED

Nets, sieves, baskets and dippers of various kinds will be at a premium for a few days, and many thousand gallons will be consumed along the Columbia river highway route between Portland and the Sandy River, for the smelt are running again.

A silvery phalanx 15 feet wide and six inches deep is flowing upstream in the Sandy for the first time in two years, the dainty little fish completely ignoring the stream last year. By the millions, the tiny smelt are seeking the headwaters, a phenomenon which will attract thousands to the river banks and flood Portland homes with the toothsome little delicacy for many days.

For the true fisherman there is no sport in catching smelt during a run, for it requires no more effort than the dipping of a net into the water and removing it filled to the brim with flopping, silver fish, but the run has a great attraction for the fireside fisherman who desires great results from a minimum of effort.

Length of Run Uncertain

How long will the run last? This is a question which cannot be answered with any degree of certainty. Runs have been known to last from two days to 24 days. A good deal depends on the weather. Should conditions moderate and a heavy, warm rain develop, high water in the Sandy will prove too great an obstacle for the small fish to negotiate. They have traveled a long distance by the time they arrive in the Sandy and are tired.

On the other hand, should the weather continue cool, with little rain, a long run can be anticipated. Indications are that there still will be a considerable run next Sunday to accommodate the holiday flow of autoists.

Though the smelt have been known to ignore the Sandy for as high as eight consecutive years, of late the runs have been quite constant, the failure of the fish to appear last year being quite out of the ordinary. A late spring usually presages a heavy smelt run, according to Lou Karlow, deputy county clerk, whose home is on the banks of the river and whose wife telephoned to Portland the first news of the run yesterday morning.

Run Appears Big

The run looks like a big one, similar to that of two years ago, according to Carl Shoemaker, master fish warden, although he said yesterday the fish were keeping to the middle of the stream. However, he expected the run would reach such proportions, probably by today, that the merest tyro fisherman can stand on the bank of the stream and dip up all he wants.

No fishing license will be required, said Mr. Shoemaker, for persons who desire only to take smelt for their own use. Those who operate commercially, however, and sell their catch, must provide themselves with a dipnet or dragnet license. No waste will be tolerated, said Mr. Shoemaker.

[The Morning Oregonian (Portland, OR), Thursday, April 13, 1922, page 8, column 2]

SMELT THICK IN SANDY

AUTOISTS CONGEST HIGHWAY IN RUSH FOR FISH.

Calls for Assistance Cause Sheriff to Dispatch Entire Motorcycle Squad to District.

Smelt scouts up the Sandy river evidently reported favorably concerning that stream as a spawning ground, for millions of the silvery little fish reached from bank to bank yesterday by the time autoists in any number began to gather in the vicinity of Troutdale.

More than 2000 automobiles congested the Columbia river highway near the Sandy before noon and calls for assistance caused Sheriff Hurlburt to dispatch his entire motorcycle squad of six men and machines to the district to direct traffic and break the jam which had ensued.

Bird cages, lace curtains and many other substitutes for fish nets, made their appearance and only a few minutes in the stream sufficed to supply any family with enough smelt for a re-union. All indications are that the run will last for a week or more and it is expected that the traffic will attain proportions by next Sunday which may make it necessary to employ traffic officers in addition to the sheriff's complement.

It is not necessary to have a fishing license if the smelt are dipped out of the river for the use of oneself and family.

[The Morning Oregonian (Portland, OR), Thursday, April 13, 1922, page 10, column 7]

Those Who Come and Go.

Tales of Folks at the Hotels.

Smelt in the Sandy river, out near Troutdale, are as interesting to tourists at the hotels as they are to the householders of Portland. News of the annual run of smelt in the Sandy was received at the hotels yesterday and many persons chartered automobiles to go out and see this famous run. To the easterner who is not familiar with a run of fish and particularly to people who live in the interior, the smelt are a wonderful attraction. The march of millions of these silver fish swarming up the confines of the glacial waters of the Sandy river toward their spawning grounds never fails to evoke exclamations of astonishment. Hotel clerks have learned that they can recommend a real attraction to visitors by sending them out the highway to see the run of smelt. Tourists yesterday were so notified and they were also advised to equip themselves with nets or buckets or something with which to scoop up the fish, for no one can stand on the bank of the stream and see the myriad of fish passing them without a wild desire to go fishing on the spot. The trouble with catching smelt is that the fisher gets more than he needs or can use, so he brings back a gunnysack or two with the fish and inflicts them on everyone who can be induced to accept them. Smelt are as fine eating fish as can be found when scooped from the Sandy waters, but a person cannot eat more than several dozen.

[The Sunday Oregonian (Portland, OR), April 16, 1922, page 3, column 2]

Smelt Season Ends at Kelso.

KELSO, Wash., April 15.—(Special.)—Final shipment of smelt was made by Kelso fishermen this week, and they will be busy the rest of this month getting their salmon fishing equipment ready for the spring season and moving their outfits to drifts along the Columbia river. This has been a very good smelt season, the prolonged cold weather being a benefit to the industry.

[The Morning Oregonian (Portland, OR), Tuesday, April 18, 1922, page 1, column 2]

LOCKS BLOCK SMELT RUN

Millions of Tiny Fish Caught at Cascades of Columbia

Hood River, Or., April 17.—(Special)—The run of smelt has reached the Cascades of the Columbia, where they are blocked. Millions of the fish are trying to get to the headwaters by way of the government locks. Deputy Sheriff Meyers today telephoned to Sheriff Johnson that residents of Cascade Locks, utilizing as various an assortment of improvised nets as one sees at the Sandy, are taking fish by the boxfuls at the lower end of the locks.

Schools of smelt appeared at Eagle creek Saturday.

[The Morning Oregonian (Portland, OR), Monday, May 1, 1922, page 4, column 2]

Pantries Stocked With Smelt

HOOD RIVER, Or., April 30.—(Special)—Residents of Cascade Locks and Stevenson, Wash., made the most of the recent smelt run up the Columbia to the foot of the rapids below the Cascades, and many pantries have been stocked with dried and salted fish. A. J. Pratt, a Stevenson, Wash. man, who captured 1600 pounds of smelt, salted and smoked them. His shrinkage, he reports was 66 percent, as he now has left 575 pounds of kippered smelt.

[The Morning Oregonian (Portland, OR), Monday, May 1, 1922, page 8, column 3]

MARVEL OF THE SMELT

The Eugene register has printed what we think is a timely warning concerning smelt. It predicts that unless there is some curb on the taking of this variety of fish, smelt will go the way of the passenger pigeon and the buffalo.

Probably the fact made impressive by these early tragedies that wild life cannot long maintain itself against man's unrestrained rapacity, will cause us to take heed before the smelt have disappeared. But why not for once depart from the usual custom of delaying regulation until scarcity is upon us?

Smelt fishing in the Sandy river is an asset to Portland whose importance is hardly realized. The incidents of the spring run have no counterpart anywhere. The Sandy is not the only stream in which smelt appear in vast numbers, but it is the one stream in which they swarm that is readily accessible from a populous community.

Sandy river is a stream worth visiting for its scenic beauty alone. The point where the Columbia highway crosses it is within less than an hour's automobile ride from Portland over a paved road. It happens that the reaches of the stream directly above and below the highway bridge are the smelt fishing grounds.

There, in beautiful surroundings and without license, hindrance or limit, the Portland citizen, one hour's journey from home, may with the crudest of home-made appliance dip out and take away as many delectable food fishes as the novelty of the occasion impels him to take. It is as the Eugene paper remarks—the rule is to take more than one can possibly use or give away. Smelt-taking in the Sandy, in which thousands of persons—rich and poor—participate annually, is one of the spectacles, one of the marvels, of the northwest and of the Columbia highway.

The habits of the smelt, or candlefish as it is properly called, are little understood. Presumably they return to the stream in which they were spawned. If that be true, whatever protection given them elsewhere will not restock Sandy river if it is once fished out. As an important contribution to the food supply and as an advertisement for this community, smelt runs are worthy of scientific study and of protection, if need be, from greed and waste.

[The Morning Oregonian (Portland, OR), Tuesday, May 9, 1922, page 10, column 8]

HOW INDIANS ONCE TOOK SMELT

Nails in Canoe Paddles Impaled Fish, Recalls Captain Gray

PASCO, Wash., May 7.—To the Editor)—The Oregonian's editorial "Marvel of the Smelt," reminds me of the first runs of smelt in the Cowlitz river. The Indians drove sharp pointed nails through thin paddles, and as they forced their canoes upstream
Through the school, or rather stream of smelt, would soon fill their canoes by shaking the smelt from the nails in their paddles.

I have not been on the Cowlitz for many years, but understand that the smelt runs on that river do not compare with the runs of the '60s, when steamboats did not run above Monticello or Freeport-they now run to Kelso. Did steamboats on the Columbia or log booms at its mouth check its smelt run? If so your Sandy river runs are safe, as steamboats cannot disturb them.

We used to know when the smelt were in the Columbia by the number of seagulls that followed the schools.

Another thought: Is there not a danger of "overpopulation" of smelt if their taking is restricted? Hundreds of millions of eggs are deposited every year. Will the few thousands of fish captured relieve a congestion that would drive the smelt to some other stream? You are in error in saying the smelt is properly called a candle fish. The candle fish is only taken in salt waters like Puget sound, and takes its name from the fact that when it is dried its mouth opens wide and makes a base to support the greasy bones that stand upright. A lighted match touched to the tail of the dried fish makes a perfect candle. The flesh of the candle fish is far inferior to the smelt.

The Columbia seems to be the only river that has the two distinct varieties of the best of fish, salmon and smelt.

The Yukon river salmon is larger and compares in flavor with our Columbia river variety, but there are no smelt to compare with the genuine Columbia river variety, which seek the Cowlitz, Kalama, Sandy and other small streams every spring to spawn.

W. P. Gray

[The Morning Oregonian (Portland, OR), Friday, December 29, 1922, page 12, column 5]

New Today in the Markets.

A few smelt made their appearance on the Portland market yesterday, bringing the price, which was formerly about 35 cents, down to 30 cents. Marketmen state that fishermen have discovered a school of the fish making their way up the Columbia river.

Washington

[Kalama Beacon, (Kalama, Washington Territory), Friday, March 1, 1872, page 1, col. 1]

A PISCATORIAL EXPLOIT.—A few days ago, at Camp Enterprise on the Cowlitz, Johnny McGrath, who "runs" things there, performed a feat at smelt-catching that places him in the van of fishers. With a little dip-net of only sixteen inches diameter across the open end, he stood on the river bank and caught by scooping two barrels of fish within half an hour! In the lower Columbia river tributaries this species of herring are now running in schools of myriads, and literally fill the Cowlitz in shoals that occupy the entire space of the stream; and what is singular, although apparently moving forward up the river, there is at present no diminution of their volume.

[Kalama Beacon, (Kalama, Washington Territory), Friday, March 22, 1872, page 1, col. 1]

THE SMELTS.—These piscatory phenomenon seemed to pass the rear of their column up the Cowlitz and tributaries last week. There seems to be no return of any portion of them down stream; and whither they are tending, and where can such myriads find room at the head of the Cowlitz, is something that would not be an inappropriate study for an Agassiz, or some other piscatorial student.

[Kalama Beacon, (Kalama, Washington Territory), Saturday, February 8, 1873, page 1, col. 2]

A PISCATORY ADVENT.—The annual return to the Cowlitz river of that delicious little fish called the smelt, commenced a couple of weeks ago, and the river is literally alive with them. With a scoop-net of about fifteen to twenty inches in diameter, it is practicable to stand anywhere on the bank and scoop a barrel full in ten or fifteen minutes. The run will last about a month longer, but toward the latter end of the season they are pronounced inferior and the catch is abandoned. A few days ago, the steamer Rescue transported *seven* tons of these fish at once to fill orders from Portland.

[Kalama Beacon, (Kalama, Washington Territory), Tuesday, February 10, 1874, page 1, col. 1]

THE SMELT RUN.—That delicious little fish is playing truant this season, so far. According to the period of their annual visits heretofore, they have been due in the Cowlitz for two or three weeks past; but they have not yet put in an appearance, and may fail altogether, as they do sometimes in streams frequented by them.

[Daily Olympian (Olympia, WA), Monday, March 16, 1896, page 3, column 4]

FRESH SUPPLY OF FISH

The Columbia Market today received a fresh supply of … Columbia river smelt … All fresh and nice. Columbia foot of Sixth.

[Daily Olympian (Olympia, WA), Wednesday, February 2, 1898, page 3, column 1]

BREVITIES OF THE DAY

M. Giles of the Main street market has just received an invoice of fine Columbia river smelt.

[Centralia Daily Chronicle (Centralia, WA), Wednesday, February 3, 1909, p.3, col. 1]

Fresh Columbia River smelts, 5 c per pound at Kent's Fish Market, Tower avenue. Phone 613 and your order will be promptly delivered.

[Centralia Daily Chronicle (Centralia, WA), Tuesday, March 16, 1909, p. 3, col. 2]

The last run of fresh smelts is on and will last only a few days longer. A good supply at Kent's Fish Market on Tower avenue, 5 cents per pound. Phone 613.

[Centralia Daily Chronicle (Centralia, WA), Tuesday, February 8, 1910, p. 3, col. 2]

The Columbia River smelt are now in. Get them at the Main Street Fish Market.

[Centralia Daily Chronicle (Centralia, WA), Thursday, February 23, 1911, p. 3, col. 1]

Columbia river smelt can be had at the Main St. Fish Market and the Centralia Fish Market on North Tower Ave. 5 cents per pound

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[Centralia Daily Chronicle (Centralia, WA), Thursday, February 1, 1912, p. 3, col. 5]

Centralia Fish Market
Columbia River Smelts, Per lb. 5c

[Centralia Daily Chronicle-Examiner (Centralia, WA), Thursday, January 16, 1913, p. 6, col. 6]

Columbia River Smelts, 5c per pound. City Fish Market, Carsten Building.

[Centralia Daily Chronicle-Examiner (Centralia, WA), Friday, January 17, 1913, p. 6, col. 2]

SMELT RUN IS ON IN ERNEST [sic]

KELSO, Jan. 17—Columbia River smelt, or Cowlitz River smelt, as they should be called, have come into the Cowlitz in ever increasing numbers since the fag end of last week, and fishermen now report that the run is a satisfactory one, although not extremely large. Monday saw the first large catch, more than one thousand boxes of fifty pounds each, or 50,000 pounds, being caught and shipped from Kelso. The gill nets have been discarded for the nets of the dip variety, and a force of a score or more of boats has been busy in midstream.

[Centralia Daily Chronicle (Centralia, WA), Friday, January 31, 1913, p.3, col. 6]

We are now well supplied with Choice Columbia River Smelt. Shipments daily; 5 cents a pound. City Fish Market, Carstens Building.

[Centralia Daily Chronicle-Examiner (Centralia, WA), Monday, February 10, 1913, p. 6, col. 6]

1,200,000 smelt were caught in the Cowlitz river last Sunday.

[Olympia Daily Recorder (Olympia, WA), Wednesday, January 14, 1914, page 2, column 7]

RUN OF SMELT LARGEST EVER IN THE COLUMBIA

PORTLAND, Ore., Jan. 14.—The greatest run of smelt ever in the Columbia river is now being harvested. Fresh offerings of Columbia river smelt were quoted at 5 cents a pound today by the wholesale fish trade and there were indications that even this low price would be cut. The market is glutted.

Such heavy catches by gillnetters of the lower Columbia river were never before seen in this market. As a rule the gillnetters catch only limited supplies before the fish enter the Cowlitz, when they are caught in abundance with dip nets.

[Centralia Daily Chronicle-Examiner (Centralia, WA), Tuesday, February 23, 1915, p. 3, col. 3]

HEAVY SMELT RUN IN LEWIS

KELSO, Feb. 23.—That the heavy run of smelt have passed up the Cowlitz river for this season seems certain from the enormous numbers of the tiny fish which have poured up the Lewis river during the past few days. Not satisfied with the Kalama river, which they first entered, the main run of the fish went into the Lewis river, and at the present time that streams looks like the Cowlitz at this season of other years. Smelt everywhere in the waters, filling it from bank to bank and all the way from the mouth far above Woodland.

[Centralia Daily Chronicle (Centralia, WA), Wednesday, March 17, 1915, p. 3, col. 4]

Big Smelt Run

WOODLAND, Wash., March 17.—The great run of smelt in the Lewis river during the past month and which seemed to be decreasing last week has been increased by another run which started yesterday, and the fish coming now are of as good quality as have ever been caught here, but the price has ruled so low that there are not many fishermen taking them. Seagulls and other fish-eating birds are doing their best to clean them up. The gulls are on the river by the hundreds of thousands, their flight being almost solid at times, and the sand bars when covered by them look like a snow bank. Immense numbers of the little fish are lying dead in the river and a good rain, with a rise in the river, would be a great help, as it would wash the dead fish out. This is the first season in seven years the fish have come in here.

[Centralia Daily Chronicle-Examiner (Centralia, WA), Wednesday, March 31, 1915, p. 1, col. 3]

Smelt Come Too Late

KELSO, March 31.—Too late to do the fishermen of the Cowlitz river any good, because the market is already loaded up and the price down, large numbers of smelt came into the river some time last week. For some unknown reason the smelt this year wandered everywhere except into the Cowlitz, which in seasons past has been their regular abode. This is the first run of smelt of any size in the Cowlitz this year.

[Centralia Daily Chronicle-Examiner (Centralia, WA), Friday, December 17, 1915, p. 2, col. 2]

SMELT COMING IN

KELSO, Dec. 17—Smelt are coming into the Cowlitz river in increasing numbers, as shown by growing catches of the gillnetters. Gillnetting for smelt at this season of the year is profitable, as the fish bring 20 cents a pound. Later on the fishermen will be lucky to get that much a box.

[Centralia Daily Chronicle-Examiner (Centralia, WA), Friday, December 31, 1915, p. 7, col. 5]

MANY SMELT CAUGHT

KELSO, Dec. 31.—Since the drop in the Cowlitz river smelt have been plentiful in the stream and gillnetting for them has been going on merrily. Many boxes of fish are being caught daily in this manner and the fishermen are getting good prices for them.

[Centralia Daily Chronicle (Centralia, WA), Wednesday, February 12, 1920, p. 8, col. 4]

WAIT FOR SMELT

Kelso, Feb. 12—A few smelt have been caught in the Cowlitz river the past two years and fishermen are hopeful that a heavy run of the fish will soon appear in the stream. Smelt in large numbers were reported to be nearing the mouth of the Cowlitz just before the recent cold weather and fishermen think that they may soon be in the stream now that the ice is gone. Last year was the only one in the last three years that the smelt came into the Cowlitz, the main run going up the Lewis river in 1927 and 1928.

[Centralia Daily Chronicle (Centralia, WA), Friday, January 25, 1929, p. 2, col. 5-6]

SMELT RUNNING

Longview, Jan. 25—The annual horde of smelt is coming up the Columbia river. The run is at present in the vicinity of Cathlamet, about 40 miles west of here, according to local fishermen. There is considerable conjecture here as to whether the shining silvery millions of little fish will journey up the Cowlitz or the Lewis rivers. The Cowlitz was the usual habitat until two years ago when they selected the Lewis, 30 miles further up stream. It was thought to be an "off year," which occurred once in about seven years previous. But last season the smelt passed by the Cowlitz and went up the Lewis again. Fishermen are scratching their heads and wondering which stream will be selected this year.

[Centralia Daily Chronicle (Centralia, WA), Saturday, February 23, 1929, p. 4, col. 4]

SMELT OVERDUE

KELSO, Feb. 23.—The main run of Columbia river smelt into the Cowlitz or Lewis river is considerably past due and fishermen are waiting for the run to enter one of the streams. The run has gone up the Lewis river for the past two years. The fish have been caught by gillnetters in large quantities in the Columbia river near Rainier, Ore., recently. It is believed the cold spell and the low stage of water in the streams has held up the migration.

[Centralia Daily Chronicle (Centralia, WA), Tuesday, March 5, 1929, p. 8, col. 5]

SMELT SHIPPED

KELSO, March 5.—Shipments of Columbia river smelt from Kelso have averaged 150 boxes a day during the past week, according to express company representatives. The fish are taken by gill-netters operating in the Columbia river, the run not having entered either the Cowlitz or Lewis river to data this year. Ordinarily the run enters one of the streams late in January or early in February and it has never been known to be as late as it has been this year.

[Centralia Daily Chronicle (Centralia, WA), Saturday, March 8, 1930, p. 4, col. 1]

Smelt Are Running—Stories of "smelt catches" are running rampant about town this week. The silvery fish entered the Cowlitz several days ago and are now reported to be working their way upstream between Ostrander and Castle Rock. A net on the end of a long pole, a little deftness in its use and one's smelt order is soon filled.

[Chehalis Bee Nugget (Chehalis, WA), Friday, March 21, 1930, p. 5, col. 2]

Smelt at Toledo.

For the past week the Cowlitz river bank has been crowded with people who are busy dipping smelt from the river.

[Centralia Daily Chronicle (Centralia, WA), Wednesday, December 31, 1930, p. 8, col. 3]

SMELT ARE RUNNING

Kelso, Dec. 31.—A few Columbia river smelt, are being dipped from the Cowlitz river each night, but the run of fish this winter is lighter than the usual small mid-winter run and the fish will be gone within a few days. The main run of smelt does not come into the Cowlitz until late in February ordinarily. Smelt are now selling at about 15 cents a pound.

[Centralia Daily Chronicle (Centralia, WA), Thursday, January 29, 1931, p. 4, col. 4]

SMELT RUN BEGINS

LONGVIEW, Jan. 29.—(AP)—The smelt run is on! Innumerable thousands of the little fish are wriggling their way up the Cowlitz river today after meandering for several weeks in the Columbia below here. Several score boxes were packed from last night's dipping by eager commercial fishermen and heavy shipments to outside points have begun. The fish sell locally at four pounds for 25 cents.

[Centralia Daily Chronicle (Centralia, WA), Saturday, February 21, 1931, p. 5, col. 3]

SMELT STILL RUN

KELSO, FEB. 21—Heavy rains the past few days, which brought the Cowlitz river up several feet, have not interfered with the run of smelt that came into the river early this month, and heavy catches of fish were made the past two days. A new run of fish came into the Cowlitz this week. The demand for the fish is holding firm and heavy shipments are going out by rail, truck and boat daily.

[Centralia Daily Chronicle (Centralia, WA), Thursday, March 12, 1931, p. 2, col. 2]

SMELT STILL RUN

KELSO, Mar. 12.—Another heavy run of smelt came in the Cowlitz river Sunday. They are of fine quality and fishermen are catching great quantities of them. The markets are holding up well with year [sic] and heavy shipments continue by rail, mail and truck. Distribution of smelt by truck has been developing on a large scale, and trucks now carry the smelt to points as far distant as Idaho and northern California.

[Centralia Daily Chronicle (Centralia, WA), Tuesday, December 22, 1931, p. 3, col. 5]

FIRST SMELT OF SEASON SHOW UP

KELSO, Dec. 22—(AP)—Mother Nature presented Cowlitz county a Christmas present today when the first smelt of the season appeared in the Cowlitz river. Johnny Wannassay, veteran Indian smelt fisherman, dipped the first catch. It ran about 200 pounds. For several years Wannassay has beaten other fishermen to this honor.

This first run [of] smelt is small. In fishing parlance it is called the scout run and precedes a major or larger run. The smelt come into the Cowlitz in large schools between December and May. When smelt fishing is at its height approximately 200 men find employment in dipping, packing and processing the fish, which are shipped to all parts of the world in one form or another.

[Centralia Daily Chronicle (Centralia, WA), Wednesday, January 6, 1932 p. 8, col. 6]

QUALITY OF SMELT UNUSUALLY GOOD

PORTLAND, Jan. 6.—(AP)—"The smelt are running." This was the call today from many Columbia river and Cowlitz river points as hordes of the small fish piled up stream in silvery waves. Reports from the two streams said the run is one of the earliest large invasions on record, and it was taken by many to presage an early spring.

Dealers here report the quality of the fish this year is unusually good. The present showing is regarded as rather spectacular and wholly unexpected. Many unemployed persons are working with dip nets on the two rivers. Fancy smelt are selling in Portland markets as low as three pounds for 25 cents.

[Centralia Daily Chronicle (Centralia, WA), Monday, February 1, 1932 p. 2, col. 8]

MAY PLANT SMELT

KELSO, Feb. 1—Another attempt will probably be made this year by the state fisheries department to transplant Columbia river smelt to streams flowing into Puget Sound. Attempts have been made in the past and a large number of smelt were planted in the Nisqually river several years ago. Floyd [sic] Royal of the state biological department is making a study of the matter here, and it is probable that smelt spawn will be hatched in the state hatchery on the Kalama river and the young smelt planted in both the Snohomish and Skagit rivers if the attempt to hatch them proves successful. The smelt are believed to have a four-year-cycle, returning to their native stream after four years, to spawn.

[Centralia Daily Chronicle (Centralia, WA), Monday, April 4, 1932 p. 4, col. 7]

SMELT RUN ENDS

KELSO, April 4.—(AP)—The annual smelt run in the Cowlitz river appears to be over and from other points comes word that catches in the Lewis river and in the Sandy river near Portland are also practically nil. Shipments from Kelso last Friday, when catches made before the closed period beginning Friday morning were sent to market, were very light and yesterday several fishing boats that went as far upstream as the regulations permit, found no smelt worth dipping in the Cowlitz river.

[Centralia Daily Chronicle (Centralia, WA), Wednesday, January 4, 1933 p. 6, col. 5]

SMELT RUNNING

LONGVIEW, Jan. 4—(AP)—The annual winter run of smelt, forerunner of a spring run to come a month or two later, is hovering in the mouth of the Cowlitz river this week. The run has been proceeding slowly up the Columbia river for the past several weeks. Gillnetters in the Columbia are making most of the catches while a few commercial fishermen with dip nets are operating in the Cowlitz.

[Centralia Daily Chronicle (Centralia, WA), Monday, April 7, 1933 p. 3, col. 2]

Fish Notes—Smelt fishing in the Cowlitz river ended several days ago, but the seagulls remained to do their own fishing. Now, according to fishermen returning from the river, each day sees fewer gulls hovering over the water. This is taken as a sure indication that the smelt run is just about over.

[Centralia Daily Chronicle (Centralia, WA), Wednesday, February 28, 1934 p. 6, col. 2]

Smelt Season—Smelt are in the Cowlitz river but in "straggly" quantities, according to fishermen who have been after them with nets. Welfare people here received smelt yesterday that were collected at Castle Rock by fish inspectors, who took them from persons having in their possession more than the legal limit of 20 pounds. The Cowlitz is closed from 8 a. m. Friday to 8 p. m. Saturday to both individual and commercial fishermen.

[Centralia Daily Chronicle (Centralia, WA), Friday, February 1, 1935, p. 8, col. 2]

SHIPPING SMELT

KELSO, Feb. 1.—The largest shipments of Columbia River smelt of the year have been made from here the past few days. Approximately 400 boxes, or more than ten tons of the fish have been shipped daily by express to the more distant points and by truck to Portland and Puget Sound.

The heaviest shippers are the Columbia River Smelt company and the Central Smelt company. The latter is an organization of gill-net operators.

[Centralia Daily Chronicle (Centralia, WA), Thursday, December 5, 1935, p. 14, col. 3]

SMELT RUNNING

LONGVIEW, Dec. 5.—(AP)—The first smelt run of the 1935-36 season was reported off Clatskanie, in the lower Columbia river, today. A small shipment was made from that point to Portland markets yesterday, and two boxes were shipped from Kelso.

Smelt takes so far are males, indicating them to be the advance, or scout run. The female schools are due later.

California

[Daily Evening Bulletin (San Francisco, CA), Friday, December 5, 1879, p. 1, col. 1]

Candle Fish of the Klamath.—A very odd fish is found in large numbers in the Klamath, near its mouth. They are called candle fish. When grown, they are only six or eight inches long. They are very full of oil, which seems to be distributed all through their bodies. Dry them thoroughly and light either end and they will burn with as bright a light as a candle, and for about as long a time. Hence their name. They can be caught abundantly with seines. In their dry state they are quite pleasant to eat, the oil in them not having an odor or disagreeable flavor.

[San Jose Mercury Herald (San Jose, CA), Saturday, February 15, 1919 page 5, column 4]

Candle Fish Run Opens in the North

Eureka. Cal., Feb. 14—The yearly run of candle fish has begun in the Klamath river and fishermen state that it exceeds in volume anything heretofore recorded. It is said that if any means could be found of canning this fish a new product of high food value could find its way to the market. The candle fish is particularly rich in valuable oils.

[Humboldt Standard (Eureka, CA), Thursday, February 21, 1952, page 9, column 7-8]

AROUND OUR TOWN
by SCOOP BEAN

SCATTERED NOTES – Candle Fish are running in the Klamath River –they are caught at night with dip nets—the fish are said to have received their present name from early white settlers who sometimes inserted a wick in the smoked fish for a source of candle light.

[Humboldt Standard (Eureka, CA), Friday, April 1, 1955, page 10, column 3-5]

How're They Biting?
By
Chet Schwarzkopf

FROM JACK MORRIS, maestro at Blue Creek Lodge, on the Klamath, … JACK SAYS FURTHER—"I guess you know we also have a big run of candlefish each spring that affords the people here lots of fun as well as good eating."

[Humboldt Standard (Eureka, CA), Wednesday, April, 10, 1963, p. 10, col. 3]

Heavy Candlefish Run in Klamath

KLAMATH—Meat market sales showed a sharp decline around Klamath over the weekend and Monday. Almost everyone was eating crisp-fried candlefish. Awaited by the old-timers, as a heavy run of candlefish seems to herald a good salmon and steelhead fishing season to come, word spread fast, when the "run" started, a little late this year. Most popular "dipping" area was near the public boat ramp in the Klamath Glen area, perhaps due to easy accessibility.

Owners of the large nets needed to dip for these small fish reported a "turn-over" practically every hour, as each one borrowing it returned the net within a very short time. A few dips netted each one their limit in pounds, and more than enough to feed their families.

[Humboldt Standard (Eureka, CA), Monday, April, 15, 1963, p. 13]

Thousands of Candlefish In Heavy Redwood Creek Run

Photo caption 1:
Joe January of Sacramento dips up a net-load of candlefish at the mouth of Redwood Creek near Orick. Thousands of the silvery fish, called Columbia River smelt in most waters, are running in the creek and the Klamath River, heading upstream to spawn. According to local Fish and Game authorities, this is the first time candlefish have run up Redwood Creek in large numbers. Normally the fish are found only in the Klamath River and a few other northern rivers.

Photo caption 2:
Commercial fishermen net candlefish in the ocean at the mouth of Redwood Creek. Left to right are Fred Shipman, Stanley Dombek and Lawrence Lazio. Commercial catches must be made in salt water.

Photo caption 3:
A herd of sea lions enjoys a feast of candlefish as the silvery smelt run by the thousands at Redwood Creek. Fish derive their local name from the fact Indians dried them and used them for candles.

Photo caption 4:
Silvery candlefish measure five to six inches in length, with a few up to nine inches. Thousands of the small smelt are running up Redwood Creek and the Klamath River to spawn.

Photo caption 5:
Lawrence Lazio of Eureka demonstrates the density of the current candlefish runs by catching them with his hands. Many people lacking nets did just that and caught enough fish for a large fish fry.

Photo caption 6:
Fred Shipman, left, and Stanley Dombeck deliver a large commercial catch of candlefish to a local fish company. The smelt will be sent to the Bay Area and Los Angeles.

[Humboldt Standard (Eureka, CA), Tuesday, April, 16, 1963, p. 7]

Candlefish Running In Mad River

Photo captions:

Local fishermen use nets for an unusual run of silvery candlefish in the Mad River. In top photo, two unidentified men watch as Bill Damgaard, left, and Bob Hoffman, both of McKinleyville, wade into the water to net the fish. Mrs. Sarah Gillman, below, of McKinleyville, empties her net laden with candlefish into a bucket. Heavy runs of the fish, also known as Columbia River smelt, also are reported in Redwood Creek and the Klamath River.

[Humboldt Standard (Eureka, CA), Tuesday, April, 23, 1963, p. 20]

Surf Netters Catch Candlefish Near Redwood Creek

Photo caption:

Countless candlefish are still running at Redwood Creek, this time in the Pacific surf. Scores of fishermen took advantage of Sunday's spring weather to enjoy the sport and prepare for a fish fry. The silvery fish, commonly called Columbia River smelt derived their local name from the fact Indians used them as candles. The fish normally run only in the Klamath River and other Northern streams but recently heavy runs have been reported in Redwood Creek and Mad River and now in the surf.

[Humboldt Standard (Eureka, CA), Friday, April, 9, 1965, p. 13, col. 1]

Sideline Slants by Don Terbush
Candlefish Run Top Weekend Prospect

The annual spawning run of candlefish is on in the Klamath River and the oily rascals are said to be numerous. Big runs are usually followed by large runs of salmon, according to veteran anglers along the river.

Don't forget—a valid fishing license is required.

[The Times-Standard (Eureka, CA), Thursday, March 14, 1968, p. 19, col. 1]

Anglin' Around by Ray Peart

CANDLEFISH AT KLAMATH — It has started. The small fish called Candlefish or Eulachon are making their spawning run up the Klamath and should be found in Redwood Creek and Mad River soon.

Eulachon normally die after spawning, but Marine Resources biologists tell me they have recovered a few spawned-out fish in the ocean while conducting shrimp sampling cruises.

The Eulachon (Thaleichhys [sic] pacificus) was first recorded from British Columbia waters in 1866 by A. Gunther on the basis of four specimens eight to nine inches in length, collected near Vancouver Island by C. B. Wood, surgeon on HMS Plumper, and presented to the British Museum. The fish is common along the whole coast of British Columbia, and enters large rivers during March, April and May to spawn. It matures at two to three years of age and usually dies after spawning. The average female spawns 25,000 eggs which hatch in two to three weeks. The young are then carried by the current to the sea where they mature.

In the old days, Eulachon were used extensively by Indians for food and production of oil for cooking. Previous to the advent of manufactured candles and other lighting devices, these fish were dried, fitted with wicks and used as candles, hence the frequently used name, candlefish.

Most people now smoke the fish, and some of the oil is worked out this way. They are very rich. Others pickle them. A gourmet treat is the roe from females mixed with salami and eggs, made into patties and fried.

Last year there was a huge run of candlefish in Redwood Creek. For eight days, these small dry-feeling fish swam up past Orick in a continuous school from bank to bank. That was around the first week in April.

It's fun to net these fish. Take the family for a day at the beach. The limit is 25 pounds and you do need a license. Check the 1968 Sport Fishing Regulations for new rules concerning netting candlefish in Redwood Creek and Mad River.

[The Times-Standard (Eureka, CA), Wednesday, April 16, 1969, p. 21, col. 5]

Candlefish Run Again in Klamath

KLAMATH—Large catches of candlefish have been taken from the Klamath River this past week, and were still running heavily Sunday evening.

Quite a number of fish are brought up each dip of the large nets used. The heavy run is late this year, as usually the month of March is the time of the most of the run. A number of the local people smoke large quantities of the fish, as well as those who enjoy them just fried very crisp.

Candlefish are similar to the Columbia River smelt. A heavy concentration of sea gulls and large groups of sea lions accompany the run. Several days last week, the sand spit at the mouth of the river, was covered with the sea lions, as they sunned themselves, after dining on the fish, no doubt.

APPENDIX C: SELECTED ACCOUNTS OF EULACHON IN EARLY PERIODICALS

Pacific Fisherman, March, 1905, Vol. 3(3): 19.

Big Catch of Smelt.

C. R. Gatchet, a Portland fish dealer, reports that 150 tons of smelt were taken from the Cowlitz river between February 1 and 7. All were caught between Kelso and the mouth of the river. Mr. Gatchet kept a close account of the output. Allowing five smelt to the pound, the catch represents 1,500,000 fish. At the market price of five cents a pound they are worth $15,000.

Pacific Fisherman, April, 1905, Vol. 3(4): 11.

Kelso Smelt Industry.

Kelso, in Cowlitz county, Washington, with 1,200 population, is the center of the smelt industry. No other point visited by the myriad schools of fish can rival it. The season lasts several months, that just closed having commenced November 19, and ended March 15. During this period Kelso records show that 400 tons of smelt were sent from there to the world. This tonnage represents 16,000 boxes of smelt, each box weighing 50 pounds.

The fact that you can dip smelt from the Cowlitz river with a pitch fork, drive a wagon into the stream and load the bed in a short time, or annually ship to the hungry world 400 tons of this diminutive fish is a matter of pride at Kelso, for this community takes first honors in the smelt industry.

Catching smelt on the Cowlitz is an interesting process. The fleet of small boats stand out in the stream, one man to each craft, armed with dipnet having a 15-foot handle. The ring at the end of the pole has a spread of 18 inches, while the net behind it is of sufficient capacity to carry many pounds of fish. The schools of fish, which surge up the river, are soon located, when the fishermen commence dipping down stream. Each stroke is richly rewarded, for, after a school is located, there are few water hauls. Lee Galloway, one of the best fishermen of the stream, has last season[‘]s record, catching 96 boxes in one night, each box weighing 50 pounds. This record means that with one of these poles he lifted from the stream 4,800 pounds of fish, or about two and a half tons.

Charles R. Gatchet

Pacific Fisherman, April, 1906, Vol. 4(4): 16.

Smelt Cease Running—The run of smelt on the Cowlitz river has ceased after a very successful season. The season’s catch was the largest ever taken from the Cowlitz river. Over 700 tons were shipped, the amount being double that handled last year.

Pacific Fisherman, April, 1907, Vol. 5(4): 8

Kelso's Important Smelt Fishing Industry

By G. E. Kellogg

There are places, hundreds of them, which are noted for the production of some staple or marketable article, and of all the thus noted towns in Western Washington, Kelso has the distinction of being the best known on account of the smelt industry.

The little fish which tickles the palates of thousands of people each winter are the mainstay of the fishing people of this vicinity and not only put thousands of dollars in their pockets each year, but they add a great deal to the prosperity of Kelso and vicinity.

The smelt are a peculiar fish. Hatched in the headwaters of the Cowlitz or Sandy they return to the open sea in the spring. Returning in the fall and winter they unfailingly enter the Cowlitz, seeking the old spawning grounds beyond the reach of fishermen's nets. They travel in schools, or rather strings, the first run arriving at or near Kelso about the Holidays. The run of fish is most uncertain. Sometimes they last until the middle of March and sometimes they stop short in January.

So far this season there have been upwards of 3,000 boxes shipped from Kelso, a total of 37,350 pounds, going by express in the month of January alone. Carload shipments have been made in years when smelt were plentiful and cheap, but lately the demand has kept up so steadily that the fish are shipped almost as fast as they can be taken from the water.

Smelt have always been so plentiful that they never needed protection by law other than licensing fishermen, and there has never been any thought or fear of their extinction entertained by anyone who knew their habits.

Thus we have an industry which might be called perpetual, as there is no doubt of its continuance for many years to come.

We are enabled to produce the accompanying engravings showing smelt fishing scenes in the vicinity of Kelso by the courtesy of the Kelso Journal.

Pacific Fisherman, April, 1907, Vol. 5(4):

Smelt in the Upper Columbia River—For the first time in many years smelt are running up the Columbia river above Kalama. Large schools have been passing Vancouver, Wash., and fishermen have reaped a rich harvest. The few smelt which have hitherto gone further up the river have been of poor quality, but these have been of the best. Just what turned the smelt aside from their favorite haunts up past Kelso has not yet been determined.

Pacific Fisherman, January, 1910, Vol. 8(1): 19.

Columbia River

… Smelt have arrived in the river for the first time this winter and are being caught in the vicinity of Kathlamet. They are a luxury on the breakfast table as the fishermen are wholesaling them at 25 cents per pound, but at the same time their flesh is so firm and high flavored that they are well worth the price for an epicure.

Pacific Fisherman, March, 1910, Vol. 8(3): 14.

Columbia River

The largest run of smelt for years in the Cowlitz River is now in progress. The river has never been known to contain so many smelt in the memory of the oldest fishermen. This may bode good for the coming fishing season in the Columbia, as I is said that a good run of smelt has always been followed by a good run of salmon. The increased run found the trade unprepared to handle it successfully and this accounts for the breaking of values to 10c and even lower. … Although the smelt, now so generously in the Portland markets, bear the name "Columbia River," the great preponderance of them is taken in the vicinity of Kelso from the Cowlitz River. Kelso this season has shipped out approximately 15,000 boxes. Each box contains 50 pounds and the fish average eight to the pound. The catch, so far, therefore represents approximately 6,000,000 fish.

Pacific Fisherman, April, 1913, Vol. 11(4):

DONATE CARLOAD OF SMELT TO SUFFERERS

The citizens of Kelso, Wash., donated a carload of Columbia river or Cowlitz river smelt, 20,000 pounds in all, to the Ohio flood sufferers. The Kelso fishermen donated 400 boxes of fish, the business men paid for the boxes and labor and an express company and the railroad furnished the transportation free.

Pacific Fisherman, February, 1914, Vol. 12(2): 20.

HEAVY RUN OF SMELTS IN COLUMBIA RIVER VALLEY.

An unusually heavy run of smelts appeared in the Columbia river in January and large catches are now being made in that river and its numerous tributaries, more particularly in the Cowlitz river, where the annual run of this delicious species forms the basis of a considerable commercial industry. This year, in addition to being shipped fresh on ice, large numbers are being dried at the Kelso plant of the Northwestern DeAquating Company, thus making it possible to almost indefinitely extend the market for Cowlitz smelts.

Pacific Fisherman, February, 1915, Vol. 13(2): 29.

SMELT IN THE KALAMA RIVER

Early in February smelt entered the Kalama river in large numbers and the fishermen reaped a harvest for a time. It is a rare thing for the smelt to enter this river in any numbers. In the Cowlitz river, where the smelt usually run in immense numbers, but few have been seen this season. Considerable catches have been made in the Columbia river proper.

Pacific Fisherman, March, 1918, Vol. 16(3): 51.

EULACHON RUN LATE

Great preparations were made this year for handling large shipments of eulachon from the Columbia river, as the fish has become well established in several Eastern markets and interest has been greatly stimulated by the Bureau of Fisheries exploitation work. The run, however, has so far been very disappointing. Up to the first of March the usual run in the Cowlitz river has not appeared, and a fair run that started in the Kalama river was of short duration.

During the second week of March the eulachon appeared in large numbers in the Lewis River, and large catches have been made, with the fish in unusually good condition. The handling of the catch is somewhat more difficult than if the fish had run in the usual direction, but a heavy shipping movement to the East has been started, and it is expected that the shipments in that direction will reach important figures before the run is over. There was a fairly large movement last year, and the fish were well liked wherever they appeared, a large quantity having been placed on the New York market at a time of acute food shortage.

Pacific Fisherman, May, 1920, Vol. 18(5): 48.

OREGON SMELT RUNNING

The annual run of smelt in the Sandy River, an Oregon tributary of the Columbia, started April 24.

Pacific Fisherman, March, 1924, Vol. 23(3): 35.

Shipping Smelt

For several weeks during February, shipments of smelt from Kelso, Wash., amounted to about 2,000 fifty-pound boxes daily, according to W. A. Mabie, manager of the Columbia River Smelt Company. Most of the shipments went to Portland, Ore., for distribution to consuming markets.

Pacific Fisherman, February, 1926, Vol. 24(3): 30.

Columbia River Activities

Up to the last of January, the run of smelt in the Columbia River which usually starts about January 15, had not appeared. About the middle of the month there was a small run, but few went up as high as the Cowlitz River or any of the other small streams which empty into the Columbia, except for about one day Grays River on the Washington side opposite Astoria fishermen secured considerable poundage. The run is still looked for by experienced men.

Pacific Fisherman, March, 1926, Vol. 24(4): p. 44
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Good Oulachan Pack

The Candle Fish company, Kelso, Wash., engaged in dry-salting oulachans, or Cowlitz river smelts, for the Chinese market, report that owing to the unusually good run this year little difficulty is anticipated in filling their contracts. More than 80 tons of salted oulachans were in the company's vats on the Kelso dock Feb. 15. Profiting by this year's experience the company is planning on improvements that will more than double their production next year.

Most of the catches during February were made at Sandy Bend between Kelso and Castle Rock. Fishermen and individual shippers of fresh smelts have been reaping a harvest from their catches, the Columbia River Smelt company shipping on an average of 500 boxes daily.

Pacific Fisherman, Annual Statistical Volume, January, 1930 Vol. 28(2): 189.

The run of Columbia River smelt appeared in the Cowlitz River again in 1929 in volume reported to exceed that of any previous season. The two preceding years had been complete failures and had given rise to the fear that pollution had destroyed the Cowlitz smelt, a supposition adequately disproved by the experience in 1929.

Pacific Fisherman, Annual Statistical Volume, January, 1933, 31(2): 167.

Cowlitz Smelt

At the opening of the year production of fresh fish in the Pacific Northwest centered to a large degree on the Columbia River, where the winter salmon season yielded in a normal way, while the smelt run supplied another item of fresh fish. Before the smelt entered the Cowlitz the fishermen were able to hold the price to them at 2c per lb. or above by the simple expedient of suspending their operations whenever the price went below that figure.

When the smelt run struck the Cowlitz the price dropped off sharply, as has been mentioned. The Washington smelt catch was one of the largest on record, being 1,476,939 lbs., surpassed in the previous seven years only by 1931.