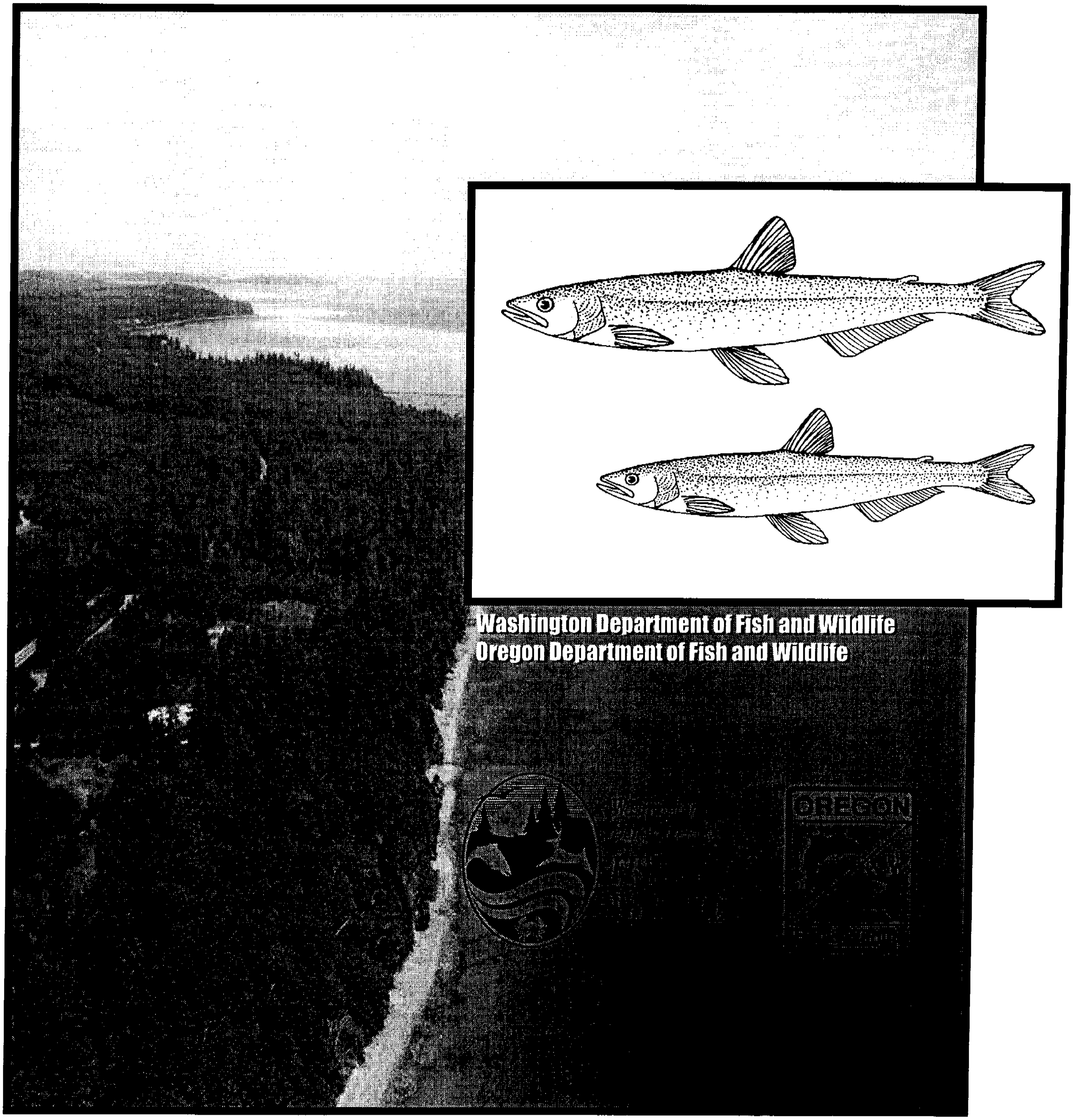
STATE OF WASHINGTON November 2001

Washington and Oregon Eulachon Management Plan



Washington Department of Fish and Wildlife
Oregon Department of Fish and Wildlife

WASHINGTON AND OREGON EULACHON MANAGEMENT PLAN

WASHINGTON DEPARTMENT OF FISH AND WILDLIFE
OREGON DEPARTMENT OF FISH AND WILDLIFE

Washington Department of FISH and WILDLIFE

OREGON Fish & Wildlife

OCTOBER 2001

TABLE OF CONTENTS

LIST OF TABLES

APPENDIX TABLES

LIST OF FIGURES

INTRODUCTION

PURPOSE OF DOCUMENT

Eulachon, or Columbia River smelt, (*Thaleichthys pacificus*) are a small, schooling, anadromous fish that inhabit the Northeast Pacific. The main run in Washington and Oregon returns to the Columbia River and its tributaries. The eulachon resource has been in recent decline and is the subject of increasing management and research activity. In particular, the decline prompted the fishery management agencies, the Washington Department of Fish and Wildlife (WDFW) and the Oregon Department of Fish and Wildlife (ODFW) to reassess their management framework for eulachon, as management had historically not been responsive to interannual changes in abundance or distribution. The purpose of this document is to provide abundance-based guidance for the eulachon management and research activities conducted by the WDFW and ODFW.

IMPORTANCE OF EULACHON

Eulachon are important ecologically, providing a food source for a wide variety of organisms such as birds, marine mammals, and fish in both marine and freshwater ecosystems. Spent spawners and unfertilized eggs probably have an important nutrient input role, similar to salmon (Cederholm et al 2000), in the freshwater ecosystem. Humans have exploited eulachon for centuries. At the time of the Lewis and Clark expedition there was a thriving Native American subsistence fishery in the lower Columbia River (Craig and Hacker 1940). Commercial fisheries for eulachon have occurred without interruption since the late 1800's. A thriving recreational fishery exists, especially in the Cowlitz River and other lower Columbia tributaries.

BIOLOGY OF EULACHON

Eulachon are the largest member of the smelt family, *Osmeridae*, and the only member of its genus. They are a small fish, averaging about 200 mm in length (Scott and Crossman 1973) and a maximum length of about 300 mm (McAllister 1963). The eulachon is an anadromous species; the adults spawn in freshwater and the larvae drift to sea where the fish live until returning to freshwater to spawn.

DISTRIBUTION

Eulachon are found from the Klamath River in California north to Bristol Bay, Alaska and the Pribilof Islands (Scott and Crossman 1973). Major runs occur in the Klamath River (California), Columbia River (Washington and Oregon), and Fraser and Nass rivers (British Columbia) (Figure 1). Spawning also occurs in many other coastal rivers from California to Alaska. In the Columbia, major spawning runs occur in the mainstem lower Columbia and Cowlitz rivers with periodic runs appearing in the Grays, Skamokawa, Elochoman, Kalama, Lewis, and Sandy rivers (Figure 2). Prior to the construction of Bonneville Dam, there was some evidence of occasional migration upstream as far as Hood River (Smith and Saalfeld 1955). Washington rivers outside the Columbia Basin where eulachon have been known to spawn include the Bear, Naselle, Nemah, Wynoochee, Quinault, Queets, and Nooksack rivers.

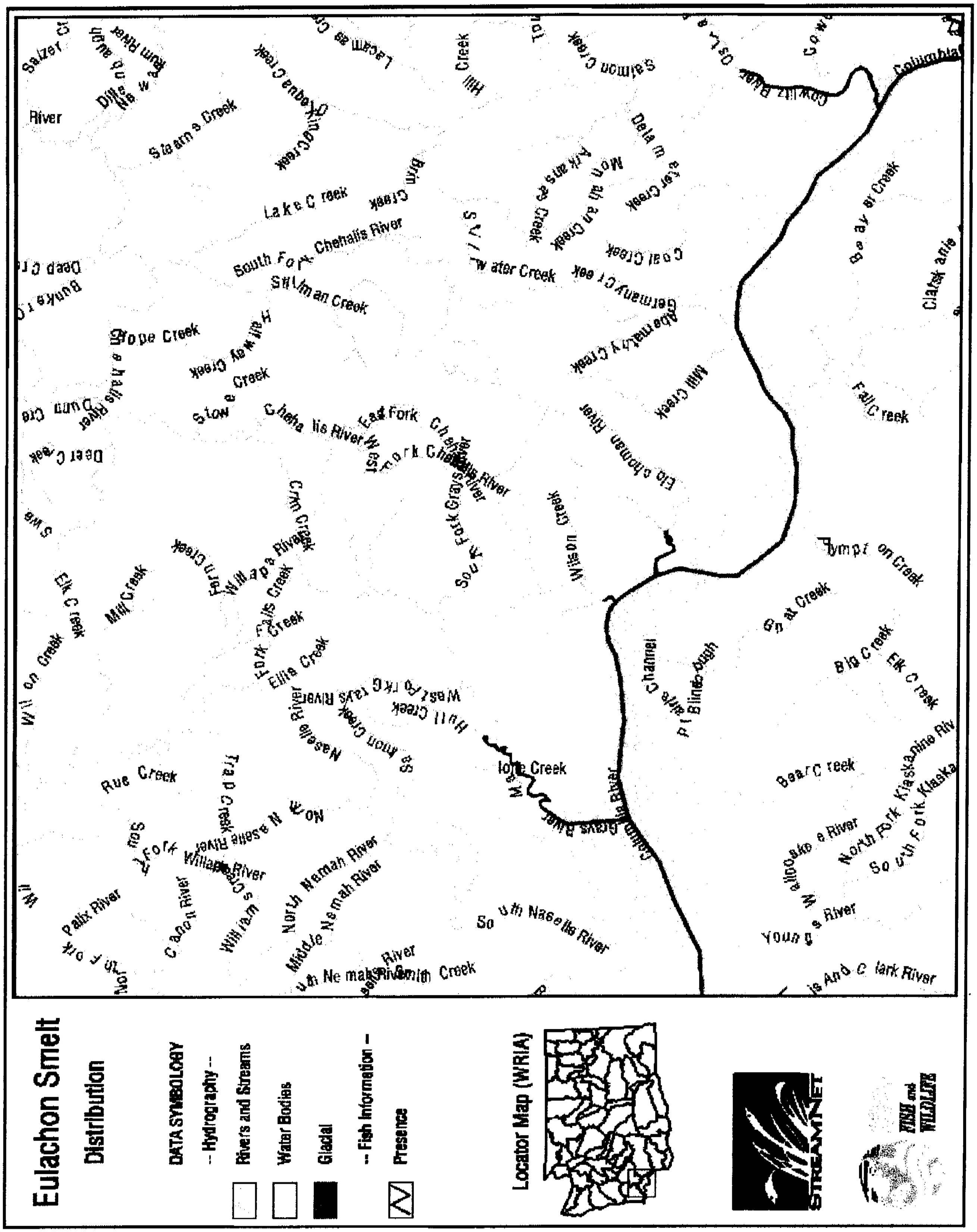


Figure 1. Distribution of smelt in the Lower Columbia River (River Mile 0-68).

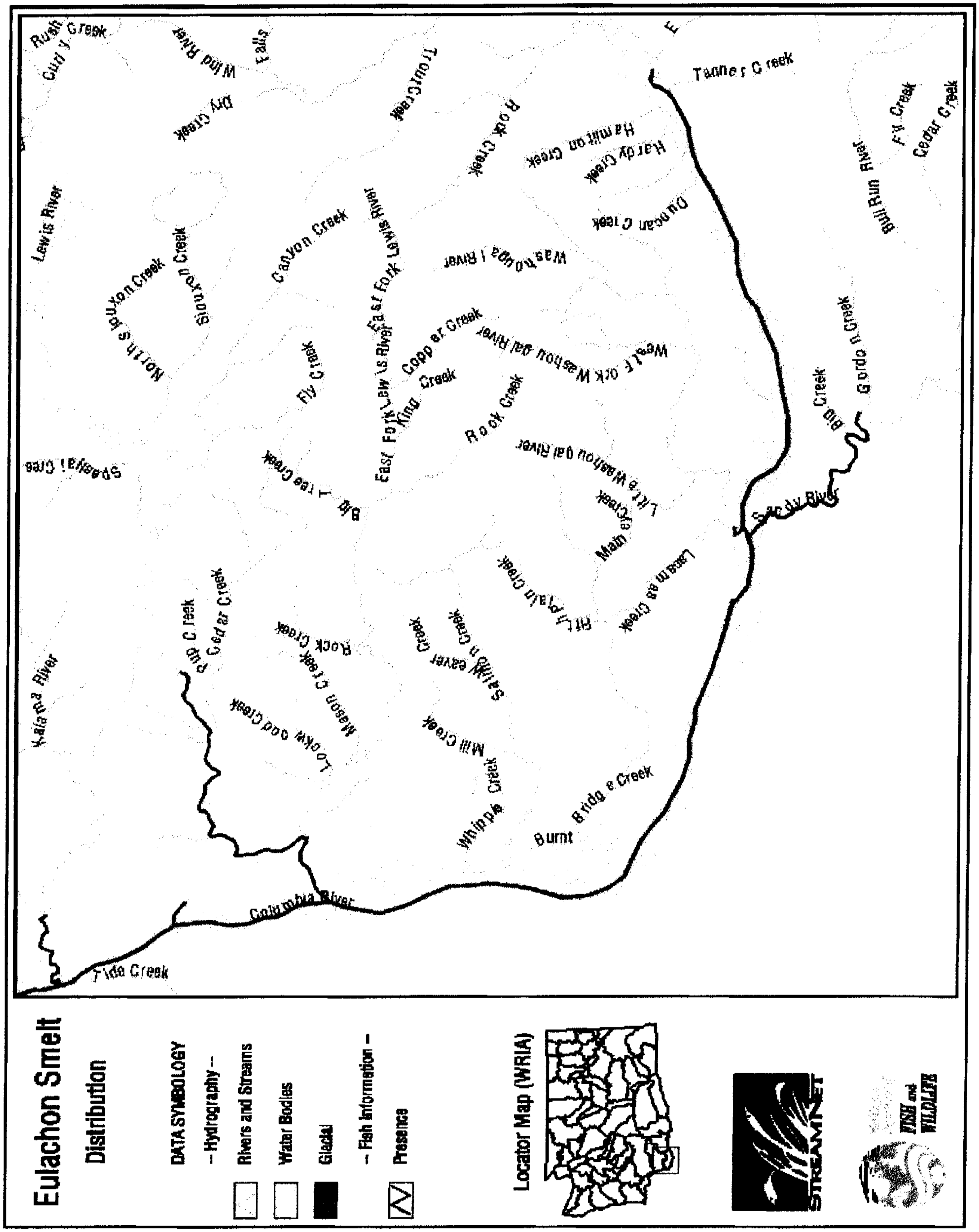


Figure 2. Distribution of smelt in the Lower Columbia River (River Mile 68-145)

Reproductive Biology

Spawning occurs in the lower sections of rivers at temperatures ranging from 4 to 10°C. Water temperatures colder than 4°C slow or stop migration. Adult spawning eulachon typically enter the Columbia River system from December to May with peak entry and spawning during February and March. The timing and location of spawning may differ from year to year depending on the age structure of returning adults and environmental conditions such as water temperature. Eulachon broadcast spawn and prefer coarse, sandy substrates. Approximately 7,000 to 31,000 eggs are laid, depending on the size of the female. Most, but not all adults die shortly after spawning.

Eggs

Eulachon eggs are spherical and approximately 1 mm in diameter. Mature eggs have double membranes. Upon fertilization the outer membrane peels back to form an adhesive peduncle (Hart and McHugh 1944). The eggs adhere to river substrates, typically in areas of pea-sized gravel and coarse sand. Incubation is temperature dependent with longer incubation periods during cold water. Hatching generally occurs within 3 to 4 weeks.

Larvae

Larvae are 4-8 mm in length at hatching. The larvae are rapidly flushed out to sea, often within days of hatching. Larvae first subsist on their yolk sacs during downstream dispersal. Soon after their yolk sacs are depleted they initiate exogenous feeding on pelagic plankton. Eulachon larvae are found in the scattering layer of near-shore marine areas when they reach the sea (Morrow 1980).

Juveniles

Eulachon rear in near-shore marine areas at moderate or shallow depths (Barraclough 1964). Young eulachon have been caught at sea as small as 23 mm and within eight months they can attain lengths of 46-51 mm (Barraclough 1964). They are a major forage base for many North Pacific marine mammals, birds, and fish species. Their value to marine ecosystems is due to their large biomass and high energy fat content which can be as high as 15% of their body weight. As they grow at sea they tend to migrate to greater depths and have been found as deep as 625 m (Allen and Smith 1988).

Adults

Adult eulachon range in size from 14 to 30 cm and usually spawn at 3 to 5 years of age. Although adults as old as 9 years of age have been observed in the Columbia River, the majority of the adults return as 3-year-olds. Spawning runs are dominated by males early in the run and are therefore more prevalent in sport and commercial catches. Although adults can repeatedly spawn, most die after spawning.

Food and Feeding

Eulachon are planktivorous. Larvae and juveniles consume phytoplankton, copepods, copepod eggs, mysids, ostracods, worm larvae, and eulachon larvae. Juveniles and adults consume euphausiids, copepods, and other planktonic organisms. Eulachon only feed while at sea; adults do not feed during their spawning migration (McHugh 1939, Hart and McHugh 1944).

PREDATION AND SCAVENGERS

A large variety of animals feed on eulachon including dogfish shark, salmon, sturgeon, halibut, whales, porpoises, seal lions, seals, and various marine birds. Presence and distribution of various fauna of the Northeast Pacific are correlated to the presence and distribution of eulachon (Clemens et al. 1936, Emmett et al. 1991, Jeffries 1984, Rexstad and Pikitch 1986).

Impressive numbers of predators and scavengers accompany large runs of smelt from the time they first enter the Columbia through completion of spawning. The vast majority are avian, including eight species of gulls, Bald Eagles, mergansers and cormorants. Numbers of Harbor Seals and California Sea Lions also accompany the runs and eulachon form an important part of Harbor Seal diet during the winter (Beach, et al 1985). During the mid-1980s, peak counts of Bald Eagles in conjunction with eulachon upstream migration and spawning were as high as 50 in areas of the lower mainstem Columbia, along the Cowlitz and along the Lewis (WDFW and U.S. Army Corps of Engineers, unpublished data). Gull counts in the mid-1980s along the lower Cowlitz River during the peak of eulachon abundance exceeded 10,000 birds of eight species: Glaucous, Glaucous-winged, Western, Herring, Thayer's, California, Ring-billed and Mew (Bill Tweit, WDFW, unpublished field notes).

FISHERY MANAGEMENT

THE REGULATORY ENVIRONMENT

Eulachon, in common with other fish in the Columbia River system, inhabit a complex regulatory environment. The lower Columbia River marks the border between the states of Washington and Oregon. Management actions for Columbia River fish and fisheries in the trans-boundary mainstem reaches of the lower basin are decided jointly by both states, generally by reaching consensus.

COLUMBIA RIVER COMPACT

Under the Congressionally approved Columbia River Compact, Washington and Oregon jointly regulate commercial fishing on the Columbia River. The Compact states can open a commercial fishery only with the "mutual consent and approbation of both states." The Compact does not, however, restrict the right of either state to adopt regulations that are more conservative than those of the other, though such regulations can be enforced only in the adopting state's waters. The Washington and Oregon Fish and Wildlife Commissions, through their delegated authority, represent the states of Washington and Oregon on the Columbia River Compact. The Commissions have delegated to their respective directors (or designees) the authority to make permanent rules for eulachon fishing.

JOINT STATE SPORT FISHERY MANAGEMENT

A similar consensus management policy is in place for the states of Washington and Oregon to make sport fishing decisions in the trans-boundary mainstem reaches of the lower Columbia River. This, however, is rarely an issue in eulachon sport management since very little sport effort occurs in the mainstem Columbia River.

INDIVIDUAL STATE JURISDICTIONS

Recreational and commercial fisheries in the tributaries are managed by the individual states. In recent years, each state has managed the tributary fisheries consistent with the mainstem fisheries, in order to meet conservation needs.

STATE AND FEDERAL ENDANGERED SPECIES ACTS

The eulachon population decline of the 1990s prompted a petition in 1999 to the National Marine Fisheries Service (NMFS) for listing under the federal Endangered Species Act (ESA). In November of 1999 the NMFS determined that the petition did not present substantial scientific evidence to warrant listing of this species; however, the NMFS urged "state and tribal co-managers to redouble efforts focusing on eulachon management and research. In particular, the agency will underscore the need to evaluate whether the current harvest strategies are adequately protective of the species and to move apace with additional, more accurate eulachon abundance and life history surveys" (64 FR 66601-03, November 29, 1999).

Eulachon are listed as a Candidate species by WDFW. The Candidate list includes 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 (WDFW Policy M-6001). Based on that listing, as well as their status as a Food Fish, WDFW includes Eulachon in their listing of Priority Habitats and Species (PHS); Priority Species are defined as "fish and wildlife species requiring protective measures and/or management guidelines to ensure their perpetuation."

Columbia River Mainstem and Tributary Fisheries

Columbia River Mainstem Fisheries

Eulachon are caught in target commercial and sport fisheries in the lower Columbia River downstream from Bonneville Dam. They are valued as human consumptive fare and as prized bait for sturgeon sport fisheries.

Columbia River Commercial Fishery

The commercial eulachon fishery is primarily conducted using 2-inch bobber gill nets, although diver gill nets and otter trawl are also used. Dip net gear is legal, but rarely used. Washington rules (WAC 220-33-040) and Oregon rules (OAR 635-042-0130) limit commercial eulachon gear to 2-inch stretch-measure gill net and dip nets with frames no larger than 36 inches in diameter. Currently trawl vessels greater than 32 ft. are prohibited upstream from Tongue Point. Washington commercial fishers are required to have a Columbia River smelt license to fish commercially for eulachon in the Columbia (RCW 77.65.200 (1) (g)). Oregon does not require a separate smelt license for fishers harvesting smelt for human consumption; fishers must have a commercial fishing license and a commercial fishing boat license. Fishers harvesting for bait sales, and not for human consumption, may purchase a bait fishing license only, in lieu of the commercial fishing and boat licenses.

During the winter and spring fresh eulachon are the bait of choice for Columbia River sport sturgeon anglers and the Columbia River commercial fishery supplies eulachon for this market, especially early in the season when the eulachon have not yet entered the Cowlitz River. Columbia River caught eulachon appear on the fresh food market also. The Columbia River fishery typically drops off dramatically after eulachon enter the Cowlitz River and other lower Columbia tributaries since markets then fill with fish landed in tributary commercial fisheries. Annual commercial landings from the Columbia River have averaged about 376,000 pounds; a maximum catch of almost 1.4 million pounds was attained in 1951 (Appendix Table 1, Figure 3). Low market availability, due to poor eulachon returns in 1994-1999 and conservative fishery management since 1995, brought the ex-vessel price in the Columbia River commercial fishery to as high as $7.00/lb.

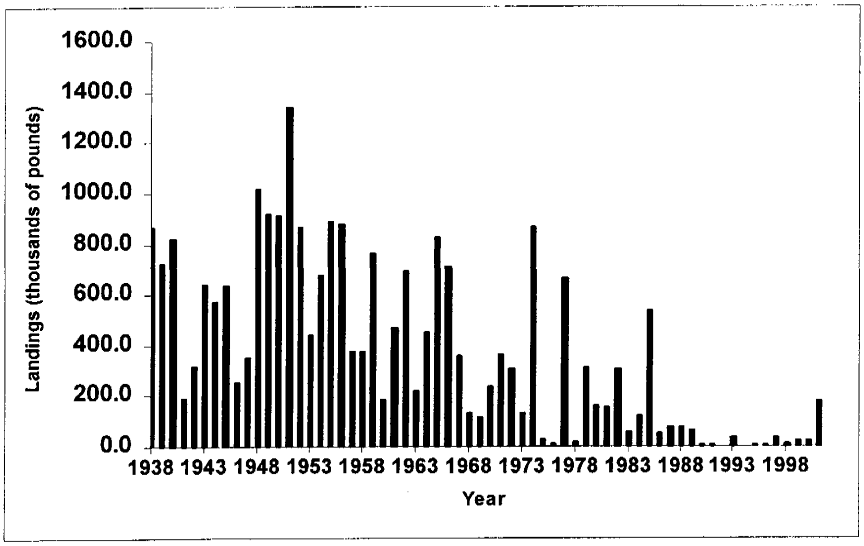


Figure 3. Eulachon landings in Columbia River mainstem commercial fisheries, 1938-2001.

Prior to 1995, the Columbia River commercial eulachon fishery was open seven days a week from December 1 through March 31 (Appendix Table 2). Poor spawning returns from 1994-1999 compelled a more conservative management philosophy. During 1995 and 1996 the commercial fishery was restricted to fewer fishing days per week but did extend through the end of March. In 1997 and 1998 the fishery was further reduced to a test fishery, which ended in mid-February. Relational catch rate data was used from these test fisheries to index run size relative to past years and enable in-season management. A two-three boat test fishery was attempted after the full-fleet test fishery closed in 1999, but it proved to be inadequate for stock status or fishery management needs.

Columbia River Sport Fishery

Neither Oregon nor Washington requires an angling license for sport harvest of eulachon. Eulachon are rarely caught by sport dippers in the mainstem Columbia River, notwithstanding that it is open to sport fishers using dip net and jig gear. Oregon smelt fishers may take smelt with dip net only with no restrictions on the bag frame. In Washington, legal dip net gear is defined by WAC 220-16-028, and is not to exceed 36" across the bag frame. Jig gear is allowable in Washington only, and is defined as hooks not exceeding 3/8" gap width with a limit of up to three treble hooks or nine single hooks. The daily bag limit in Washington waters was reduced from 20 pounds per person to 10 pounds per person on May 1, 1998, while in Oregon the daily bag limit remains at the first 25 pounds dipped per person, no sorting allowed. Oregon regulations require that each dipper must have their own container and it is unlawful to have more than one daily limit in possession while in the dipping areas. Washington closed the mainstem Columbia to sport dipping in 1999 due to low returns. Washington reopened the sport eulachon fishery on the mainstem Columbia by emergency action on February 24, 2001 with the realization of the second consecutive year of improved spawning runs. The fishery in both states is now open 7 days per week and 24 hours per day. Harvest is negligible since the vast majority of sport effort occurs in Columbia River tributaries.

COLUMBIA RIVER TRIBUTARY FISHERIES

COLUMBIA RIVER TRIBUTARY COMMERCIAL FISHERIES

Commercial eulachon tributary fisheries have been conducted primarily in the Cowlitz River but other Columbia River tributaries have contributed as well (Appendix Table 1, Figure 4). Annual harvest in the tributaries during 1938-2001 has averaged over 1.5 million pounds but landings have exceeded 50 thousand pounds only once since 1994. Maximum landings of almost 5 million pounds annually occurred during World War II when demand was highest. The Cowlitz River fishery has accounted for almost three quarters of the average annual tributary commercial catch during 1938-2001. Only dip net gear is used to harvest eulachon in tributary fisheries. Commercial fisheries in Washington tributaries were closed in 1999 and 2000 due to low run sizes.

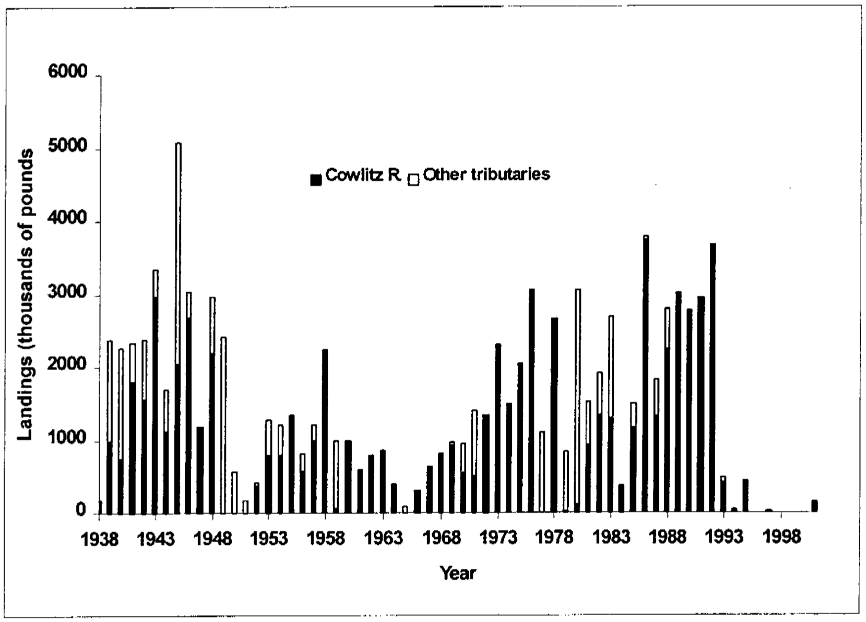


Figure 4. Eulachon landings in commercial Columbia River tributary fisheries, 1938-2000.

There are unique marketing opportunities for commercial eulachon fishers in the tributaries. Since eulachon are only harvested by dip net gear in tributaries by statute, the product is generally less damaged than eulachon landed in the mainstem Columbia river gill net fisheries. Eulachon harvested in gill net gear are often shaken out of the net resulting in head loss and other body damage. This is avoided when using dip net gear. Some specialty commercial markets that supply eulachon for human consumption covet eulachon landed in tributary fisheries and offer a higher price. The U.S. Navy maintains a marine mammal research facility where captive cetaceans are fed a diet rich in fatty forage fish such as eulachon. They desire the eulachon landed in Columbia River tributary commercial fisheries since there is little body damage and there is usually good availability early in the season (Dan Shinder- personal communication).

Columbia River Tributary Sport Fisheries

Sport fisheries for eulachon are primarily conducted in the tributaries using dip net gear. Most of the harvest occurs in the Cowlitz River, although eulachon have been caught in other tributaries including the Grays, Elochoman, Kalama, and Lewis rivers in Washington and the Sandy River in Oregon. While accurate sport catch records for eulachon have not been kept, it is believed that the magnitude of harvest in sport tributary fisheries is generally similar to that of the commercial tributary fisheries, except in recent years when commercial fisheries have been closed (Appendix Table 1, Figure 4).

Washington tributary sport eulachon fisheries were restricted beginning in 1997 in response to poor spawning returns to lower Columbia River tributaries (Appendix Table 2). On May 1, 1998, the daily limit in Washington for sport eulachon dippers changed from 20 pounds per person per day to 10 pounds per person per day. On May 1, 1999 this daily limit was adopted by permanent regulation. Oregon allows 25 pounds per person per day. Only the Cowlitz River and Oregon tributaries were open for sport harvest in 2000 and 2001. The Cowlitz River sport fishery was monitored in 2000 to assess that run. There was no run in the Sandy River in 2000. Smelt returned to the Sandy in 2001, the first significant run since 1988.

When the Cowlitz run is not depressed, the sport fishery attracts much effort. In 2000, during a return that was apparently stronger than any since 1992, there were many traffic problems in popular and congested dipping areas. These problems appeared to decrease in 2001, possibly due to increased enforcement presence and to advance preparations with local governments.

Tribal Subsistence Fisheries

Yakama Tribal Fishery

Native Americans have fished for eulachon in tributaries of the lower Columbia river for centuries. At present, members of the Yakama Nation (YN), which includes members who trace their ancestry to the Cowlitz Band of Native Americans, routinely fish for eulachon for subsistence purposes using dipnet gear in the lower Cowlitz. In addition, tribal fisheries program staff annually harvest eulachon from the Cowlitz for distribution to tribal elders and those unable to fish for themselves. Program staff generally coordinates with WDFW to avoid non-tribal sport and commercial fisheries and to reduce confusion among enforcement staff. The annual catch of eulachon by Yakama tribal members is relatively small.

Marine Fisheries

Eulachon are commonly caught as bycatch in marine trawl shrimp fisheries. The interception of eulachon is known to exist in Washington and Oregon shrimp trawl fisheries, but the harvest and mortality rates due to handling are currently unknown. Hay et al. (1999) estimated that as much as 27% of the biomass caught in select shrimp trawl fisheries in British Columbia consisted of eulachon. The Department of Fisheries and Oceans (DFO) in British Columbia has set area-specific action level quotas for bycatch such as eulachon in marine trawl shrimp fisheries. In 2000 the shrimp fishery in Queen Charlotte Sound was curtailed early due to exceeding the eulachon bycatch action level (D. Hay, DFO, personal communication).

Faster tows by shrimp trawls resulted in a greater bycatch of eulachon (D. Hay, DFO, personal communication). The ODFW has investigated the use of eulachon excluder devices in shrimp trawl fisheries to reduce bycatch. These excluders are a larger mesh in the trawl net that allow non-target species to escape capture. Excluders are typically employed to reduce the handle of other fish species, such as small rockfish and hake, but they do provide some benefit to eulachon also. At best excluders could be expected to reduce handle of eulachon by 40-60%. Limited studies indicate that 5-inch excluders reduced the handle of baitfish in general by 0-83%. Excluder use is expected to increase in 2001 to reduce the handle of small rockfish (B. Hannah, ODFW, personal communication).

POPULATION STRUCTURE AND GENETIC RELATIONSHIPS

Eulachon are found throughout the northeast Pacific. The genetic relationships among populations of eulachon are not clearly known. Mitochondrial DNA (mtDNA) evidence suggests that populations of eulachon are derived from a postglacial dispersal from a single Wisconsinian glacial refuge (McLean et al. 1999). While many private mtDNA haplotypes were found, suggesting possible regional population structure, over 97% of the total variation was found within populations. These data suggest that eulachon might be considered as one meta-population. McLean et al. (1999) conclude that there is a lack of definitive evidence that distinct populations of eulachon exist.

The fidelity of spawning fish to a geographic area is often an indicator of stock structure and a mechanism for genetic differentiation. The question of spawning fidelity among eulachons is also not clear. It is interesting to note that in 1993, when the eulachon run into the Columbia River was delayed (presumably due to cold water conditions), they were noted in large abundance in the Quinault and Wynoochee rivers, outside the Columbia Basin. The interannual variation in the presence of eulachon in various river systems (including lower Columbia river tributaries) may be evidence of a lack of fidelity to single spawning areas. Likewise, mtDNA evidence (McLean et al. 1999) and elemental analysis of eulachon otoliths (Carolsfeld and Hay 1998) support the contention that eulachons lack fidelity to spawning rivers. However, Hay et al. (1999) argue that the disparate spawning times in different rivers throughout the range of eulachons is consistent with the species showing fidelity to natal rivers.

FACTORS AFFECTING ABUNDANCE AND SURVIVAL

ENVIRONMENTAL FACTORS

MARINE ENVIRONMENT

Many researchers have surmised that the abundance of forage fishes like eulachon are strongly determined by oceanographic processes during their first year at sea. The coastal Northeast Pacific is a complex ecosystem subject to high winds, upwelling, currents, and the influences of large rivers and estuaries; factors that tend to create an unstable physical environment. There are several hypotheses on how such factors tend to influence abundance, recruitment, and survival of forage fishes, most of them concerning how these factors affect larval feeding and survival (Cushing 1973, Harden-Jones 1968, Lasker 1978, Rothschild and Osborn 1988, Sinclair and Illes 1989). McLean et al. (1999) suggest that their genetic results support the member-vagrant hypothesis (Sinclair 1988, Sinclair and Illes 1989) rather than isolation of populations by distance. The member-vagrant hypothesis states that mean abundance differences between populations of the same species are defined by the size of the physical oceanographic features that restrict dispersal of eggs and early stage larvae. These physical processes, which affect abundance and distribution of both eulachon larvae and the plankton they feed on, include upwelling, currents, temperature, etc. The extreme effect of El Niño climatic episodes on these physical processes has undoubtedly caused major periodic declines in abundance, recruitment, and survival of eulachon, especially in the southern portions of their range (Hay 1999). The relatively strong returns to the lower Columbia River in 2000 and 2001 were likely due to a return of favorable marine conditions after the disappearance of the severe El Niño climatic patterns that were present through much of the 1990s.

FRESHWATER ENVIRONMENT

The health of the freshwater ecosystems where eulachon spawn may also influence productivity. Eulachon have been shown to be sensitive to pollution in freshwater. With their high lipid content, eulachon may rapidly bioaccumulate hydrophobic contaminants during their spawning runs (Rogers et al. 1990). Others have questioned this logic since neither larvae nor adult eulachon spend much time in freshwater and are not feeding while in freshwater at either life stage. Whether contaminants can cause reproductive dysfunction or whether risks of bioaccumulation extend only to eulachon predators is unknown. Logging, disruption of normative river flows, entrainment by dredges, pulp mill effluents, and other anthropogenic disturbances to freshwater habitats can also impact eulachons (Smith and Saalfeld 1955, Rogers et al. 1990, Mikkelson et al. 1996).

Variable river conditions do affect eulachon spawning. Water temperature has a direct influence on spawning with adults only entering freshwater when temperatures are between 4.4°C and 10.0°C. Whether temperature anomalies in any given year in production streams have any affect on survival and recruitment is unknown. The dynamics of river flows and how they influence eulachon larval dispersal and survival are also not well understood. However, if eulachon numbers are limited by a member-vagrant dynamic, then hydrologic conditions within spawning areas and during larval dispersal may be a key suite of parameters for focus of further research.

Critical physical habitat for spawning eulachon has not been well characterized. While a 6°C water temperature range and a proclivity for coarse, sandy substrates seem to generally describe eulachon spawning habitat, there is little understanding of how flow variation, subtle substrate features, and other habitat variables influence spawning and egg/larval survival. Lou Reebs[1] (pers. comm.) hypothesizes that changes in sediment bed load in the Toutle and lower Cowlitz rivers due to the U.S. Army Corps of Engineers Sediment Retention Structure (SRS) on the North Fork Toutle River are responsible for poor spawning returns to the Cowlitz River during 1994-1999. The Reebs theory maintains that the amount of "non-seasonal" suspended fines in the bed load have increased since construction of the SRS. The relatively strong returns to the Cowlitz River in 2000 and 2001, as evidenced by excellent sport dipping and increased larval densities should be analyzed relative to estimates of the quantity, quality, and timing of sediment bed load in the Toutle River system downstream from the SRS. Investigating such effects, as well as the influence of the May 1980 Mt. St. Helens eruption on eulachon spawning in the Cowlitz River, may provide some insight on how sediment and substrate features contribute to eulachon productivity.

---

[1] Mr. Reebs is a retired engineer living on the Cowlitz River who has studied the history and operation of the USACE Sediment Retention Structure on the North Fork Toutle.

Exploitation

Exploitation has also been theorized to limit recruitment, survival, and abundance of forage fishes. Beverton (1990) explored the relative contribution of exploitation and environmental change in the fate of select forage fish populations. He analyzed data for many of the classic collapses of small pelagic forage fish populations (e.g., California sardine, Peruvian anchovetta, various North Atlantic and North Sea herring stocks) to analytically distinguish the role of exploitation in causing population collapse. In all cases, excessive exploitation played a role in the collapse, but tended not to be the ultimate vector for the decline. Stocks that rebounded quickly after collapse showed a density-dependent increase in reproductive rate that ameliorated the effect of excessive fishing mortality. In cases where stock collapse and disappearance persisted, exploitation continued at a high rate due to the shoaling behavior of immature fish, and the ease of modern trawlers to locate and catch these depleted, yet aggregated fish. In most cases, with one notable exception, Icelandic spring-spawning herring (Saville 1980), stocks recovered after collapse with no apparent loss of genetic fitness or productivity. Mechanisms, such as a density-dependent increase of reproductive rate, tend to make pelagic forage fishes very resilient. Excessive exploitation compromised future target fisheries and often contributed to stock declines, but did not cause long-term reduction of stock fitness. It is, however, unknown if eulachon populations are capable of such density dependent responses, although their apparent rebound in 2000 and 2001 provide an indication that they are capable.

In all of the above cases continued high exploitation of both immature and adult forage fish, made possible by their shoaling behavior and ease of detection and capture, was largely responsible for stock collapse (Beverton 1990). In the case of eulachon, fisheries target the mature, adult stock in freshwater, where they exhibit shoaling behavior and are readily detected by fishers. The only known harvest of immature eulachon occurs incidentally in Northeast Pacific marine trawl fisheries targeting shrimp. Without the combined high exploitation of immature and mature eulachon, fishing mortality is a less likely cause of stock declines. Risk of overexploitation should continue to be averted by changes in shrimp trawl gear and fishing methods and an abundance-based management framework for harvest of adults in freshwater. The biological resiliency of eulachon tends to decrease the risk of long-term consequences of overexploitation, if the overexploitation is corrected relatively quickly. In order to insure that overexploitation risk is minimized at low abundance levels, where the risks of overexploitation are the greatest, managers should be exercise the greatest caution when abundances appear to be low or declining rapidly.

Assessing Stock Size

Columbia River eulachon runs have never been well evaluated. The best long-term data on Columbia River eulachon returns are commercial landings in mainstem and tributary fisheries (Table 1, Figures 1 and 2). However, commercial landings are a poor index of run size since market forces dictate the magnitude of harvest. Above average run sizes are probably larger than commercial landings would indicate because market demand drops once the supply reaches saturation, which results in a huge decline in price and fishing effort. Likewise, the low catches in the last few years are misleading since conservative management strategies have significantly dampened effort and catch. Other methods need to be developed to assess eulachon returns to avoid management mistakes.

FISHERY-DEPENDENT ASSESSMENT

In recent years Washington and Oregon fishery managers have closed the open-access commercial and sport fisheries, which were the status quo for the last century. A full fleet commercial test fishery was instituted for one day per week in 1999-2001 to assess run size in the mainstem Columbia River. Similarly, two-day per week sport fisheries were adopted for the Cowlitz River in 1999 and 2000 and one day per week in 2001 to assess the eulachon abundance. Both fisheries were monitored to gain a better understanding of the abundance, distribution, and run timing of eulachon runs.

Fishery catch rates, including weekly trends in CPUE and sex ratio, were tracked to determine run strength. These data were analyzed relative to past years' runs as an index of run size (Table 1). The magnitude and trends of weekly catch rates and the distribution of catch in the fishery were used to make in-season management decisions. For instance, in 2000, weekly CPUE data were compared to 1988-1993 and 1994-1999 data. These were considered baseline periods for recent-year strong and poor returns, respectively (the 1988-1993 average weekly CPUE was 844 pounds/delivery while the 1994-1999 average weekly CPUE was 157 pounds/delivery, Table 1). Weekly sex ratio data can provide an indication of run timing since female return timing is skewed later than that of males.

Table 1. Columbia River commercial eulachon CPUE (pounds per delivery) by year and statistical week, 1988-2001.

Week	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	0	0	0	0	0	0	0	150	50	0	0	0	151	0
2	0	0	409	0	0	0	53	59	46	22	0	25	38	0
3	125	0	445	86	0	0	0	8	41	79	40	21	207	0
4	702	101	1650	113	0	0	0	48	151	94	223	123	52	0
5	78	0	0	0	0	18	0	550	124	168	94	146	418	6
6	214	0	0	107	232	0	0	157	0	216	30	183	91	950
7	0	0	0	685	290	224	0	265	445	672	17	297	312	1694
8	0	0	0	0	0	0	0	31	49	214	0	110	241	2048
9	0	0	0	0	80	2136	0	255	150	0	0	0	37	3637
10	0	419	0	940	36	2300	35	98	20	0	0	0	0	2369
11	0	1724	0	1250	0	0	109	35	11	0	0	0	0	0
12	0	110	0	0	0	990	38	21	9	0	0	0	0	0
13	0	1549	0	0	0	1450	0	21	14	0	0	0	0	0
14	0	2234	0	0	0	0	0	15	0	0	0	0	0	0
Totals	535	1396	709	389	192	1841	59	180	95	304	134	172	211	n/a

Otoliths have also been collected throughout recent-year runs to the lower Columbia River and its tributaries. Otoliths collected during 1992-1998 have been examined and preliminary readings indicate that Columbia River eulachon returns were comprised of 26-66% age 3 fish with age 3 fish comprising over 50% of the run in 4 of the 7 years (Table 2). Age 4 fish comprised 28-49% of the run while age 5 fish comprised 5-25% of the run. Similar results were reported for samples from 1946-1948 (Smith and Saalfeld 1955). Otolith collection and examination is expected to continue for the purpose of determining annual age compositions. Development of run reconstruction and cohort tables may prove useful for both monitoring and forecasting the status of the Columbia River eulachon run.

Table 2. Age composition of Columbia River eulachon, 1987-2000.[1]

	Age Composition			Average Length (mm) by Age		
Year	**3**	**4**	**5**	**3**	**4**	**5**
1987	n/a	n/a	n/a	n/a	n/a	n/a
1988	n/a	n/a	n/a	n/a	n/a	n/a
1989	n/a	n/a	n/a	n/a	n/a	n/a
1990	n/a	n/a	n/a	n/a	n/a	n/a
1991	n/a	n/a	n/a	n/a	n/a	n/a
1992	26%	49%	25%	169.4	189.3	190.8
1993	39%	39%	22%	164.4	159.4	149.0
1994	66%	28%	6%	178.7	177.4	164.8
1995	41%	46%	13%	171.3	181.0	197.5
1996	56%	39%	5%	168.5	179.4	170.2
1997	60%	33%	7%	165.4	170.5	162.8
1998	56%	37%	7%	173.5	181.5	175.9
1999	n/a	n/a	n/a	n/a	n/a	n/a
2000	n/a	n/a	n/a	n/a	n/a	n/a

1 Otolith samples taken in all years but, as of the time of this writing, only 1992-1998 samples have been processed and read.

How well does fishery-dependent assessment work? The experiences of several recent seasons have provided some answers. A limited assessment fishery of 2-3 boats was inadequate to gauge run size in the lower Columbia river, especially when abundance was low and distribution was patchy. The variability in daily catch rates, even in years of higher abundance, indicates that more effort is needed to obtain useful information. While the one day per week full fleet test fishery may not capture the variability of daily returns every week, it does achieve a good distribution of effort by area and should capture some of the temporal variability of returns if conducted well into the spawning season. The risk of overexploiting a low return is minimized if the fishery is limited (managers estimated that the 1999 and 2000 test fisheries did not exceed a 5% harvest rate based on the proportion of time opened). However, there are two major problems with using CPUE to estimate eulachon run strength. First, during periods of high abundance, nets may become saturated with fish and CPUE not reflect true abundance. Also during high abundance, markets may not be able to process and sell the available catch and so, fishers deliberately reduce their catch rate. The second problem occurs during periods of low abundance. Because of their shoaling nature, catchability may remain artificially high even when overall abundance has declined substantially.

Monitoring eulachon fisheries is the only in-season assessment tool available. Unlike most of the major salmonid runs, where estimates of stock size provide the basis for development of reliable forecasts, there is no developed forecasting or assessment model that can provide useful information. It is recommended that monitoring of all eulachon fisheries be incorporated as a management and assessment objective. Such a monitoring program will provide a real-time index of eulachon spawning returns, can be designed conservatively if run size is low, and can be used to evaluate other assessment models currently in development (see next section).

Monitoring bycatch in marine trawl shrimp fisheries may also be a useful assessment tool. Assessing eulachon biomass in shrimp handled in the ocean shrimp fishery could be used as a relative index of run size. Anecdotal information exists that suggests that there may be some correlation between eulachon bycatch in shrimp fisheries off the Washington and Oregon coasts and Columbia River eulachon returns during the following year. Eulachon handle in ocean fisheries was relatively high until the mid-1990's. Beginning in about 1993-1995 eulachon handle in ocean fisheries dropped significantly and remained low through 1999, coincident with the crash in the Columbia River. Interestingly, eulachon handle was up in 2000 (B. Hannah, ODFW, personal communication) coincident with improved ocean conditions, which may have correlated with the increased return to the Columbia River in 2001. Onboard monitoring of this fishery could serve a dual purpose of measuring potential impacts of shrimp trawl interceptions and developing an assessment and forecasting tool for eulachon.

FISHERY-INDEPENDENT ASSESSMENT

In 1994 the WDFW initiated eulachon larval sampling in the Cowlitz River (some sampling was performed in 1986) and other lower Columbia tributaries. The objective was to determine the presence/absence of spawning in these tributaries during a year of low abundance. In 1995 eulachon larval sampling was also initiated in the mainstem Columbia River downstream from the mouth of the Cowlitz River. In 1997 a transect across the lower Columbia River from navigation marker number 35 at Price Island and across the downstream end of Clifton Channel was established as an index to be sampled systematically every year. The long-term objective is to develop a relational index of eulachon production in the lower Columbia Basin that can be used to assess interannual variation in spawning and recruitment.

In March 2000 a two-year research study with the U.S. Army Corps of Engineers was initiated to investigate potential impacts associated with deepening the navigation channel from the mouth of the Columbia River upstream to the Willamette River (Howell and Uusitalo, In press). A central focus of this study was to determine the horizontal, vertical, and temporal distribution of eulachon larvae in the mainstem Columbia River. Sampling was conducted from Price Island to the mouth of the Lewis River (river miles 34-87).

Larvae and eggs were collected with plankton net gear consisting of a non-closeable, tapered nylon sock (335 cm in length and 300 μm mesh size) attached to a stainless steel circular frame of 61cm diameter. A General Oceanics mechanical flow meter was attached to the frame to measure water flow. A 7.9 cm, two piece, sample collection cup was attached at the base of the net. Spherical lead weights (2.54 kg, 9.07 kg or both) were attached to the frame base. Plankton nets were deployed from vessels anchored in the current and fished for one-minute intervals at each location. Prior to 1999, estimates of larval/egg density in each sample were made in the field. In 1999 some samples were preserved in dilute ethyl alcohol and larval counts were performed in the laboratory with the aim of evaluating the efficacy of field counts. Results showed that larval abundance was consistently underestimated in the field. However regression analysis established a significant relationship and field estimates from previous years sampling were amended accordingly. In 2000 and 2001 all samples were preserved in diluted ethyl alcohol and counted in the laboratory. Summaries of larval sampling are provided in Tables 3 and 4.

Larval sampling results correlated well with the commercial fishery catch rate data for the years 1995-2001 (Tables 3 and 4). Spawning returns in 1994-1999 were considered poor with a dramatic improvement observed in 2000 and 2001. This is consistent with the abatement of the severe El Niño ocean conditions prevalent in the 1990s. Relatively high densities of larvae were observed in the lower Columbia mainstem and tributaries (especially in the Cowlitz and Grays rivers) in 2000 and 2001 (Tables 3 and 4). However, larval sampling has not been adequately evaluated as an assessment tool. Until the performance of this abundance index has been evaluated through a broad range of run sizes and relative to an independent index of abundance, such as fishery monitoring, then its efficacy as an assessment tool remains uncertain.

Table 3. Summary of annual eulachon larval sampling in the lower Columbia River, 1995-2001.

Reach	Sampling Data	1995	1996	1997	1998	1999	2000	2001
Price Is./Clifton Channel Index[1]	Mean larval density (larval/m^3)	n/a	n/a	3.9	0.9	0.7	1.3	87.3
30-39	Mean larval density (larval/m^3)	0.2	n/a	n/a	n/a	n/a	4.0	92.9
40-49	Mean larval density (larval/m^3)	n/a	n/a	n/a	n/a	n/a	7.0	116.0
50-59	Mean larval density (larval/m^3)	0.5	2.7	0.7	0.3	n/a	16.4	90.2
60-69	Mean larval density (larval/m^3)	0.3	1.6	0.7	0.9	0.8	9.9	125.2
70-79	Mean larval density (larval/m^3)	n/a	n/a	n/a	n/a	n/a	0.3	n/a
80-89	Mean larval density (larval/m^3)	n/a	n/a	n/a	n/a	n/a	0.4	n/a

[1] Price Island/Clifton Channel index established in 1997. Catch data for this index in 1997-2001 also included in River Mile 30-39 data.

Table 4. Summary of annual lower Columbia tributary eulachon larval sampling. With the exception of the Cowlitz and Grays, comparisons of interannual abundance are tentative as sampling has not been systematic from year to year.

Year	Sampling Data	Grays	Elochoman	Skamokawa	Cowlitz	Kalama	Lewis	Sandy
1986	Mean larval density (larval/m^3)	n/a	n/a	n/a	8.1	n/a	n/a	n/a
1994	Mean larval density (larval/m^3)	n/a	n/a	n/a	0.7	n/a	n/a	n/a
1995	Mean larval density (larval/m^3)	n/a	n/a	n/a	19.2	32.4	n/a	n/a
1996	Mean larval density (larval/m^3)	n/a	n/a	n/a	1.2	0.2	n/a	n/a
1997	Mean larval density (larval/m^3)	n/a	n/a	n/a	0.7	0.3	0	n/a
1998	Mean larval density (larval/m^3)	2.8	22.1	n/a	0.5	0.3	0	0.1
1999	Mean larval density (larval/m^3)	1.2	2.5	2.3	0.5	0.4	0	0.1
2000	Mean larval density (larval/m^3)	26.6	3.5	n/a	54.9	0.1	0.2	0.1
2001	Mean larval density (larval/m^3)	139.5	n/a	n/a	450.7	5.5	17.6	n/a

RECOMMENDATIONS

This section provides the recommendations to guide fishery management and research efforts for eulachon in Washington and Oregon. Considering the great uncertainty associated with the effect of exploitation and environmental factors on eulachon persistence and productivity, this management plan and the recommendations contained herein should be construed as a flexible, "living" document subject to change as our collective knowledge grows and our assumptions change. Similarly, to the extent that these management recommendations are guided by the precautionary principle due to the relative lack of stock assessment data as well as the uncertainty surrounding factors influencing their annual abundance, as additional data are accumulated and uncertainties resolved, the management recommendations will change to take advantage of increased knowledge and certainty.

POLICY RECOMMENDATIONS FOR EULACHON CONSERVATION AND FISHERY MANAGEMENT

The following policies guide the management of Washington and Oregon eulachon fisheries:

CONSERVATION POLICY

- Maintain healthy populations of eulachon while assuring the integrity of the ecosystem and habitat upon which they depend.
- Management actions will consider the role of eulachon in both the marine and freshwater ecosystems and the need to maintain sufficient populations of eulachon for proper ecosystem functioning.
- A precautionary approach to resource management shall be utilized.
- Consider the best scientific information available and strive to improve the information base for eulachon.

FISHERY MANAGEMENT RECOMMENDATIONS

- Maintain commercial and recreational fishing opportunity in the lower Columbia River to include opportunities in both the mainstem and tributaries for both fleets.

These policies and management recommendations were adopted on December 8, 2000 by the Washington Fish and Wildlife Commission (WFWC) and are expected to be considered for adoption in the near future by the Oregon Fish and Wildlife Commission. These policies are considered wise-use management precepts that are consistent with the need to maintain an ecosystems approach to resource decisions. The ecological importance of eulachon is underscored in much of the body of research in the Northeast Pacific ecosystem and should be the fundamental consideration when making fishery management decisions affecting the health of this resource.

Fishery Management Recommendations

The Joint Staff of the WDFW and ODFW provide consensus recommendations for the following eulachon fishery management options for the lower Columbia basin; however they await policy and Commission level consensus. Elements of this plan (the policy statements listed above) were adopted by the WFWC on December 8, 2000 and by the Columbia River Compact on December 18, 2000. Additionally, the WFWC delegated decision making for the remainder of the plan to the Columbia River Compact. ODFW is expected to follow a similar procedure for adoption of this plan.

Mainstem Columbia River and Tributary Fisheries

The Joint Staff of the WDFW and the ODFW recommend three levels of fishing for lower Columbia River mainstem and tributary sport and commercial eulachon fisheries. Levels of fishing would be tied to eulachon abundance. As abundance increases, fishing opportunity and potential harvest are ramped up. Risk of overexploitation should be considered when determining fishing levels and impacts. Each level of fishing will be discussed relative to the factors we believe should also be considered when determining the appropriate fishing level for a given year. We recommend conducting eulachon fisheries in the December through March time period. December opportunity should be allowed 24 hours a day and seven days per week in mainstem Columbia commercial and sport fisheries. This would allow fishers to prospect for eulachon, giving fishery managers the ability to learn of the first arrival of eulachon. Eulachon abundance is always low in December, therefore there is little risk of overexploitation during that month.

Prior to opening tributary recreational fisheries, the WDFW will work with local governments and private citizens to address public safety and security concerns in these areas.

Given the uncertainty in determinants of eulachon productivity, the pre-season management framework should be conservative, taking into account information on the abundance and distribution of successful spawners in the brood year and information on recent trends in marine productivity. Consideration for in-season management changes would be initially predicated on the productivity indices discussed below. Further evidence of improved abundance from in-season assessments would be necessary for liberalized fishing opportunity. We recommend development of a simple and adaptive model that differentially weighs the importance of various productivity indices and stock-recruitment relationships and attempts to forecast gross levels of eulachon abundance and productivity.

Productivity Indices

There is currently no reliable forecasting technique for eulachon or a clear understanding of the dynamics that affect their abundance. A holistic approach to estimating productivity should consider indices that provide some indication of freshwater production and marine survival as well as potential stock-recruitment relationships that might occur with Columbia River eulachon. It should acknowledge the uncertainty about the role of exploitation versus environmental factors affecting eulachon, and the risk factors that uncertainty creates. Development of reliable forecasting techniques will decrease uncertainty about resource status, and therefore should provide increased opportunity for fisheries.

The large body of evidence for marine survival and physical processes in the Northeast Pacific being ultimately responsible for variations in eulachon recruitment compels us to recommend consideration of potential ocean productivity indices when deciding between fishing levels. Various indices exist (Southern Oscillation Index, Upwelling Index, sea surface temperature profiles) that may be useful for predicting eulachon survival and recruitment. Management actions should probably be tempered by gross variation in ocean regimes (i.e., El Niño v. La Niña regimes).

Evidence of favorable marine survival of other anadromous species may be a useful positive productivity index for eulachon. For instance, regional adult salmonid returns, especially of broods that spend three years in the ocean, may be a useful indicator. We should also explore the use of abundance indices for other local forage fish populations (e.g.,. sardine, herring, and northern anchovy CPUE) if there is timely availability of relevant data.

Anecdotal information suggests that handle of eulachon in marine shrimp fisheries may be correlated to subsequent eulachon returns to the Columbia River. This information needs to be more fully examined to determine if a relationship does exist because this relationship could provide fishery managers with a general abundance expectation for the upcoming year. Improved monitoring of the marine shrimp fishery could provide data that would be valuable in clarifying the extent of this relationship, if it exists.

Stock-recruitment parameters such as relative abundance of parent returns and relative density of lower Columbia eulachon larvae should also be considered. Although stock-recruitment relationships are theoretically less important than physical oceanographic processes in determining recruitment, strong parent returns and higher larval densities in freshwater are good indicators that year class strength is at least positive prior to ocean entry.

Level One Fisheries

Level one fisheries should be adopted when there is either great uncertainty in run strength or indications of a poor return. Level one fisheries would be the most conservative, similar to those adopted during 1997-2000, and should be scheduled to effect a harvest rate of 10% or less. Data obtained from these fisheries should give us a better index of run strength and productivity. The purpose of level one fisheries would be to gain some insight on spawning returns to the lower Columbia River and its tributaries. The intent would be to capture some of the variability of eulachon returns and further develop a fishery database while minimizing the risk of overexploiting the return. The Joint Staff recommends one 12-24 hour fishing period per week for the mainstem Columbia River commercial fishery. Sport and commercial dipnet fisheries consisting of one 12-24 hour fishing period per week would be used to monitor returns to the Cowlitz River. The daily bag limit for Washington tributaries should be 10 pounds per person at these low levels of abundance. The Joint Staff recommends these fisheries be adopted for the January through March time frame with fisheries closed during the remainder of the year, except December as described below, as per permanent rules. These fisheries would be used to gain some real time insight of run size strength. Days and hours to be fished should be developed with the respective participants. The commercial fishery can be shaped to maximize marketing opportunities and the sport fishery could, for instance, be conducted during a weekend day to maximize opportunity. Fishery monitoring data would be one factor used to make in-season decisions about increase of the fisheries to level two or three. December opportunity should be allowed 24 hours a day and seven days per week in mainstem Columbia commercial and sport fisheries, as previously noted.

Level Two Fisheries

When fishery data indicates a promising abundance in the spawning return and productivity indices are favorable, yet it is still uncertain whether the run is moderate or strong, then fishing time would be increased to collect additional data concerning relative eulachon abundance. The trigger to extend the fishery from level one to two should be carefully deliberated. The Joint Staff does not currently have a specific recommendation for a level two trigger. We believe evidence of increased run strength beyond what was observed solely in level one fisheries (e.g., the presence of significant concentrations of birds and marine mammals attending the run) should be considered as well when ramping up fisheries.

The Joint Staff recommends a two or three day commercial fishery in the mainstem Columbia River. The sport and commercial dip net fisheries in the Cowlitz River should be similarly increased to two or three days. Managers could also consider whether to expand sport and commercial fisheries to lower Columbia tributaries other than the Cowlitz River. The Joint Staff recommends these fisheries be adopted for the January through March time frame with fisheries closed during the remainder of the year, except December in the mainstem, as per permanent rules. Fishery monitoring data would be one factor used to decide if it would be appropriate to increase fisheries to level three or decrease fisheries to level one.

Level Three Fisheries

Level three fisheries are the most liberal that the Joint Staff would recommend. The decision to adopt this level of fishing opportunity would be based on very positive indicators of strong abundance and productivity and therefore a very low level of risk of overexploitation. The Joint Staff recommends that level three fisheries be conducted four days per week in the Columbia River with additional commercial opportunity of up to four days per week in all lower Columbia tributaries. Sport fishing should be open in all tributaries for four to seven days per week. The Joint Staff recommends these fisheries be adopted for the January through March time frame with fisheries closed during the remainder of the year, except December in the mainstem when fisheries are open with no daily closures, as per permanent rules. Increasing the daily bag limit for Washington sport dippers from ten pounds per person per day is appropriate at this level of fishing. This increase could range from 15 to 25 pounds, the latter value would be consistent with Oregon regulations. Fishery monitoring data would be one factor used to decide if it would be appropriate to decrease fisheries to level two or one.

Fishery Management Strategy

Initially, fishing seasons will be adopted in accordance with eulachon stock status as described by various abundance and productivity indices. Indices would consist of: 1) parental abundance as indexed by sport and commercial fisheries data, 2) juvenile brood production as indexed by larval sampling data, and 3) ocean productivity as indexed by environmental measures (i.e. Upwelling Index) and abundance of other species (e.g., Columbia River salmonids, other baitfish species, eulachon handle in ocean shrimp fishery). Based on these indices, the expected eulachon abundance would be categorized as strong, moderate, poor, or uncertain and adopted fishing seasons would be consistent with the expected abundance (i.e. level one fisheries would be adopted if expected abundance is categorized as being poor or uncertain). Any adopted fishery may be modified inseason based on data collected from ongoing sport or commercial fisheries.

RECREATIONAL FISHERY LICENSES

At present, there are no license requirements in Washington or Oregon for recreational fishing for eulachon, due in part to the historical lack of a management framework, or of active fishery management or stock assessment activities. The management framework recommended in this plan represents a significant change from past management practices; it is predicated upon annual stock assessment and fishery management activities. Consistent with the change from passive to active management, it is recommended that state statutes be amended to require a recreational fishing license for eulachon.

TRIBAL SUBSISTENCE FISHERIES

WDFW and the YN have competing views on whether the YN has federally-secured off-reservation fishing rights on the Cowlitz River or other Washington tributaries. However, in the desire to avoid conflict and litigation and to accommodate our respective interests, we recommend the following for management of tribal subsistence fisheries for eulachon

Annual coordination will continue with the YN regarding tribal subsistence needs for eulachon. Fishery plans will be developed jointly between the WDFW and the YN for fisheries occurring in Washington tributaries of the Columbia River. Details of the plan will be agreed to by both parties and implemented annually through adoption of joint regulations by WDFW and YN.

The annual plans should specify the following:

1. The enrolled members of the Yakama Nation may fish for smelt in Washington tributaries of the Columbia River.

2. Tribal members must have a tribal identification card on their person while fishing.

3. WDFW and the Yakama Nation will consult to determine appropriate levels of subsistence fishing, based on abundance and conservation needs.

4. The daily limit in place for the non-Indian sport fishery will not be in effect for Yakama Nation tribal members.

5. Tribal members may fish any day of the week, whether or not the fishery is open for non-Indian sport/commercial fishers.

6. Smelt taken by Yakama Nation members will be used for subsistence purposes only and may not be sold commercially.

7. The Yakama Nation will establish a call-in system for tribal fishers to register their fishing plans, and the Yakama Nation Fisheries Program staff will notify the WDFW Region 5 Enforcement division of any fishing plans they receive.

Washington and Oregon Marine Trawl Fisheries

It is recommended that Washington and Oregon investigate eulachon bycatch in Washington and Oregon marine trawl fisheries. An observer program should be initiated to determine this bycatch and explore strategies to minimize it. These strategies may include mandating gear specifications that exclude eulachon, adjusting the time and area when and where these fisheries are conducted, and mandating slower tow speeds by shrimp trawlers to minimize eulachon bycatch. Consideration of alternative marine trawl management strategies may be appropriate if eulachon exclusion strategies are unsuccessful.

Assessment Recommendations

The Joint Staff recommends continued implementation and refinement of fishery monitoring and larval sampling activities to assess eulachon abundance and productivity. Fishery management recommendations (levels one and two) are consistent with the need to maintain adequate commercial and recreational fisheries to assess run size of eulachon in the lower Columbia River and its tributaries. These fisheries should be broad enough in scope to capture some of the inherent variability in run timing, but not so liberal as to increase risk of overexploitation in years when abundance is low. Resources need to be committed by the WDFW and the ODFW to continue monitoring fisheries.

Larval sampling has shown promise as a fishery-independent eulachon assessment technique. Continued implementation is recommended to understand interannual variability in freshwater production of eulachon in the lower Columbia River. We may be able to better understand potential stock-recruitment relationships and factors affecting productivity. The USACE-funded study continues the assessment needed in the mainstem Columbia through 2001. However, continued larval sampling in lower Columbia tributaries and in the mainstem Columbia after 2001 should be a monitoring priority.

Abundance forecasting techniques need to be more thoroughly evaluated. Abundance of other Columbia River salmonids or other baitfish species may provide insight on expected smelt abundance. Additionally, further investigation of the possible relationship between eulachon handle in marine shrimp fisheries and subsequent eulachon returns to the Columbia River is necessary. Ocean productivity indices also need to be evaluated for use in forecasting annual eulachon abundance.

Habitat Recommendations

Critical habitats need to be better defined and characterized to protect Washington's eulachon resources. Mapping the mainstem Columbia River and tributary spawning habitats is a necessary first step to protecting these areas. A general knowledge of eulachon spawning sites is inferred from monitoring fisheries and determining the distribution of areas that frequently demonstrate high catch levels. Intensive eulachon egg and larval sampling in the mainstem Columbia River in 2000 and 2001 to investigate potential impacts of deepening the navigation channel should provide a better understanding of lower Columbia spawning areas. The states of Washington and Oregon have also contributed some resources to investigate some of the tributary spawning areas. These efforts need to continue in order to better understand spawning areas and the physical factors that affect spawning and freshwater survival. We also recommend further investigation of the Reebs theory and how sediment bed load may affect eulachon spawning in the lower Cowlitz River.

Fishery managers should consider establishing one or more spawning sanctuaries. Commercial fisheries in the Cowlitz River are limited to areas downstream from Peterson's Eddy (aka Miller's Eddy), which is about 2 miles upstream from Ostrander Creek on the Cowlitz River. Sport fisheries could also be constrained to the lower Cowlitz River downstream from Peterson's Eddy if additional escapement is desired, although it would exacerbate the problems of a crowded fishery in the lower Cowlitz River.

The USACE should consider potential impacts to eulachon when conducting dredging activities in the lower Columbia River downstream from the mouth of the Sandy River. Dredging should not be conducted in winter and early spring to avoid entrainment of eulachon adults or larvae. The USACE-funded study conducted in 2000-2001 by the WDFW and the ODFW provided insight on larval distribution and potential mainstem Columbia spawning areas. Future study objectives should include refining our understanding of the location and physical characteristics of these habitats and determining strategies to minimize dredging impacts to these areas. Further larval sampling should provide a better understanding of larval migration timing and distribution. These results will be used to develop recommendations for conducting channel deepening and/or maintenance dredging activities.

Water quality needs to be improved in the lower Columbia basin. Affects of contaminant bioaccumulation on reproductive physiology, development, and survival are poorly understood but theorized to contribute to declined productivity in some eulachon populations. Dredging, industrial and residential development, mining, farming, and logging activities in the critical eulachon spawning habitats in Washington and Oregon should consider potential impacts to eulachon. Eulachon may be a desirable species to model to gauge ecosystem health since they are sensitive to changes in their habitats and are a keystone species in Northwest ecosystems.

LITERATURE CITED

Allen, M.J., and G.B. Smith. 1988. Atlas and zoogeography of common fishes in the Bering Sea and northeastern Pacific. NOAA Tech. Rep. NMFS 66, 151 p.

Barraclough, W.E. 1964. Contribution to the marine life history of the eulachon *Thaleichthys pacificus*. Journal of the Fisheries Research Board of Canada 21(5): 1333-1337.

Beach, R.J., A.C. Geiger, S.J. Jeffries, S.D. Treacy and B.L. Troutman. 1985. Marine mammals and their interactions with fisheries of the Columbia River and adjacent waters, 1980-1982. Final report to the NOAA National Marine Mammal Laboratory, Seattle, in fulfillment of requirements for NOAA, NMFS Grant No. 80-ADB-0012.

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

Carolsfeld, J., and D.E. Hay. 1998. Fish-forest interactions: eulachon stock structure examined by elemental analysis of otoliths. Report submitted to the B.C. Science Council, February 7, 1998.

Cederholm, C.J., D.H. Johnson, R.E. Bilby, L.G. Dominguez, A.M. Garrett, W.H. Graeber, E.L. Greda, M.D. Kunze, B.G. Marcot, J.E. Palmaisano, R.W. Plotnikoff, W.G. Pearcy, C.A. Simenstad, and P.C. Trotter. 2000. Pacific Salmon and Wildlife – Ecological Contexts, Relationships and Implications for Management. Special Edition Technical Report, prepared for D.H. Johnson and T.A. O'Neil (Manag. Dirs.), Wildlife-Habitat Relationships in Oregon and Washington. Washington Department of Fish and Wildlife, Olympia.

Clemens, W.A., J.L. Hart, and G.V. Wilby. 1936. Analysis of stomach contents of fur seals taken off the west coast of Vancouver Island in April and May, 1935. Can. Dep. Fish. Ottawa. 20 pp.

Craig, J.A., and R.L. Hacker. 1940. The history and development of the fisheries of the Columbia River. U.S. Bureau of Fisheries Bulletin 49(32):132-216.

Cushing, D.H. 1973. The natural regulation of fish populations. Pages 389-412 *in* Sea Fisheries Research, F.R. Harden-Jones (ed.), Elek Science, London.

Emmett, R.L., S.A. Hinton, S.L. Stone, and M.E .Monaco. 1991. Distribution and abundance of fishes and invertebrates in West Coast estuaries, Volume II: species life history summaries. Estuarine Living Marine Resources Program Report No. 8. NOAA/NOS Strategic Environmental Assessments Division, Rockville, Maryland. 329 pp.

Harden-Jones, F.R. 1968. Fish Migration. Edward Arnold Ltd., London, 375 pp.

Hart, J.L., and J. L. McHugh. 1944. The smelts (*Osmeridae*) of British Columbia. Bulletin of the Fisheries Research Board of Canada 64:1-27.

Hay, D.E. 1999. Climate change and the decline of eulachons. Canadian Conference for Fisheries Research, January 1999, Edmonton, Alberta.

Hay, D.E., R. Harbo, J. Boutillier, E. Wylie, L. Convery, and P.B. McCarter. 1999. Assessment of bycatch in the 1997 and 1998 shrimp trawl fisheries in British Columbia, with emphasis on eulachons. Canadian Stock Assessment Secretariat Research Document 99/179, Ottawa. 44 pp.

Howell, M., and N.M. Uusitalo. In press. Eulachon (*Thaleichthys pacificus*) studies related to lower Columbia River channel deepening operations. Report to be submitted to the U.S. Army Corps of Engineers, Portland, Oregon.

Jeffries, S. 1984. Marine mammals of the Columbia River estuary. Washington State Department of Game, Olympia, Washington. 95 pp.

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.

McAllister, D.E. 1963. A revision of the smelt family, *Osmeridae*. National Museum of Canada. 191: 1-53.

McHugh, J.L. 1939. The eulachon. Fisheries Research Board of Canada Pac. Progress Report 40: 17-22.

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*. Molecular Ecology 8: S143-S158.

Mikkelson, P., J. Paasivirta, I.H. Rogers, and M. Ikonomou. 1996. Studies on eulachon tainting problem: analyses of tainting and toxic aromatic pollutants. Pages 327-333 *in* Environmental fate and effects of bleached pulp mill effluents. Servos, Munkittrick, Carey and Van Der Kraak (eds.), Delray Beach, Florida.

Morrow, J.E. 1980. The freshwater fishes of Alaska. University of. British Columbia, Animal Resources Ecology Library, Vancouver, British Columbia. 248pp.

Rexstad, E. A., and E. K. Pikitch. 1986. Stomach contents and food consumption estimates of Pacific hake, *Merluccius productus*. Fish. Bull. 84(4):947-956.

Rogers, I.H., I.K. Birtwell, and G.M. Kruzynski. 1990. The pacific eulachon (*Thaleichthys pacificus*) as a pollution indicator organism in the Fraser River estuary, Vancouver, British Columbia. Science of the Total Environment 97/98: 713-727.

Rothschild, B.J. and T.R. Osborn. 1988. Small-scale turbulence and plankton contact rates. J. Plankton Res., 10, 465-474.

Saville, A. (ed.). 1980. The assessment and management of pelagic fish stocks. Rapports et procès verbeaux des Rèunions du Conseil International pour l'Exploration de la Mer 177.

Scott, W.B., and E. J. Crossman. 1973. Freshwater Fishes of Canada. Bulletin 184 Fisheries Research Board of Canada, Ottawa, Canada.

Sinclair, M. 1988. Marine Populations: an essay on population regulation and speciation. University of Washington Press, Seattle, Washington. 252 pp.

Sinclair, M., and T.D. Illes. 1989. Population regulation and speciation in the oceans. J. Cons. int. Explor. Mer, 45, 165-175.

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

Appendix Table 1. Lower Columbia River and tributary commercial eulachon landings in thousands of pounds, 1938-2001.

Year	Columbia	Grays	Cowlitz	Kalama	Lewis	Sandy	Total
1938	866.7	2.1	33.1	76.6	63.1	0.0	1041.6
1939	721.6	35.7	996.4	0.0	1342.7	0.0	3096.4
1940	820.2	53.7	736.8	3.0	1341.3	127.5	3082.5
1941	193.2	.0.	1793.0	0.0	377.0	168.6	2531.8
1942	318.6	51.8	1555.3	0.0	0.0	760.3	2686.0
1943	643.0	3.7	2972.5	0.0	273.2	84.9	3977.3
1944	572.7	10.9	1126.4	44.3	514.2	0.0	2268.5
1945	633.3	59.2	2048.4	32.5	1552.8	1393.1	5719.3
1946	253.2	0.3	2674.0	0.0	0.0	348.5	3276.0
1947	352.3	0.0	1192.6	0.0	0.0	0.0	1544.9
1948	1015.8	0.0	2197.8	0.0	574.6	212.9	3974.1
1949	919.1	0.0	0.8	0.0	1940.9	472.5	333.6
1950	912.7	0.3	0.0	1.0	557.2	0.0	1482.5
1951	1337.6	11.6	0.0	0.0	0.0	179.3	1516.9
1952	867.1	0.0	380.6	17.8	8.1	1.3	1274.9
1953	439.3	0.0	795.4	2.8	0.0	457.9	1711.0
1954	673.9	15.6	792.9	16.2	360.9	40.4	1884.3
1955	887.5	0.0	1349.6	0.0	0.0	0.0	2237.1
1956	877.4	0.0	575.1	32.6	0.0	198.8	1683.9
1957	377.5	0.0	987.8	0.0	0.0	211.5	1579.0
1958	373.3	2.2	2243.1	0.0	0.0	0.0	2616.4
1959	760.0	0.0	62.3	44.1	889.7	0.0	1756.1
1960	185.7	0.0	985.8	0.0	0.0	0.0	1172.2
1961	466.4	0.7	585.9	0.0	0.0	0.0	1052.3
1962	690.3	0.0	783.3	0.0	0.0	0.0	1473.6
1963	222.3	0.0	833.5	0.0	0.0	0.0	1077.1
1964	452.9	21.3	388.9	0.0	0.0	0.0	841.8
1965	828.7	0.0	0.0	0.0	82.0	0.0	910.7
1966	712.2	0.0	316.1	0.0	0.0	0.0	1028.3
1967	357.1	0.0	620.5	0.0	0.0	0.0	1000.8
1968	133.3	23.2	813.0	0.0	0.0	0.0	947.5
1969	113.7	1.2	917.2	0.0	0.0	0.0	1083.7
1970	238.2	52.8	559.7	55.9	325.6	0.0	1183.9
1971	364.5	4.5	509.4	0.0	902.8	0.0	1776.7
1972	304.1	0.0	1339.4	0.0	0.0	0.0	1643.5
1973	132.0	0.0	2302.4	0.0	0.0	0.0	2434.4
1974	868.4	0.0	1474.7	0.0	0.5	12.0	2361.8
1975	28.3	6.2	2049.3	0.0	0.0	0.0	2077.6
1976	9.4	0.0	3055.3	0.0	0.0	10.4	3075.1
1977	662.7	0.0	0.0	326.2	0.0	764.1	1753.0
1978	16.6	0.0	2642.7	0.0	21.0	0.0	2680.3
1979	313.6	0.0	18.2	0.0	233.3	591.6	1156.7
1980	160.1	0.0	116.5	0.7	2651.6	273.8	3211.5
1981	158.2	8.8	932.5	0.0	567.1	14.5	1672.3
1982	304.2	0.0	1343.2	8.2	554.4	0.0	2210.0
1983	58.7	0.0	1307.3	0.0	1364.4	0.0	2730.4

Appendix Table 1. Lower Columbia River and tributary commercial eulachon landings in thousands of pounds, 1938-2001.

Year	Columbia	Grays	Cowlitz	Kalama	Lewis	Sandy	Total
1984	120.4	0.0	377.6	0.0	0.0	0.0	498.0
1985	537.8	0.0	1160.8	0.0	0.0	304.5	2038.0
1986	53.0	34.9	3736.1	0.0	49.7	0.0	3838.8
1987	73.6	0.0	1321.0	0.7	500.4	0.0	1895.7
1988	72.8	0.0	2244.3	0.0	549.6	1.0	2867.7
1989	65.2	0.0	3001.6	0.0	0.0	0.0	3066.8
1990	6.4	0.0	2756.2	0.0	21.6	0.0	2784.2
1991	5.8	0.0	2944.6	0.0	0.0	0.0	2950.4
1992	0.8	0.0	3673.0	0.0	0.0	0.0	3673.8
1993	33.2	0.0	413.9	66.8	0.0	0.0	513.9
1994	0.2	0.0	43.2	0.0	0.0	0.0	43.4
1995	7.7	0.0	431.4	0.9	0.0	0.0	440.0
1996	7.1	0.0	2.0	0.0	0.0	0.0	9.1
1997	37.1	0.0	21.5	0.0	0.0	0.0	58.6
1998	11.8	0.0	0.2	0.0	0.0	0.0	12.0
1999	20.9	0.0	0.0	0.0	0.0	0.0	20.9
2000	25.5	0.0	0.0	0.0	0.0	0.0	25.5
2001	177.4	0.0	149.2	0.0	0.0	0.0	326.6
1938-2001 avg.	372.7	6.4	1104.5	11.4	274.9	103.6	1873.3
1994-2000 avg.	15.8	0.0	71.2	0.1	0.0	0.0	87.1

Appendix Table 2. Columbia River commercial and sport eulachon seasons, 1960-2001.

Year	Area Open	Season	Weekly Period	Total Days Open
		Commercial Seasons		
1960-64	Columbia and tributaries	Jan. 1-Dec. 31	12 pm Sat.-12 am Wed.	183
1965-66	Columbia and tributaries	Jan. 1-Dec. 31	12 pm Sat.-12 am Thurs.	235
1967-77	Columbia and tributaries	Jan. 1-Dec. 31	12 pm Sat.-12 am Wed.	183
1978-84	Columbia and tributaries	Jan. 1-Dec. 31	7 days/week	365
1985	Columbia and tributaries Columbia upstream from Cowlitz/ Wahkiakum county line only	Jan. 1-Dec. 31 Feb. 22-Mar. 31	7 days/week 7 days/week	365 38
1986-94	Columbia and tributaries	Dec. 1-Mar. 31	7 days/week	121
1995	Columbia and tributaries	Dec. 7-Jan. 7 Jan. 7-Mar. 31	7 days/week 8 pm Sat.-8pm Wed.	38 48
1996	Columbia and tributaries	Dec. 1-Feb. 2 Feb. 3-Mar. 31	7 days/week Noon Mon.-6 pm Fri.	64 32
1997	Columbia and tributaries	Dec. 1-Jan. 27 Jan. 30-Feb. 21	7 days/week 6 am Thurs.-6 pm. Fri.	58 8
1998	Columbia and tributaries	Dec. 1-31 Jan. 2-Feb. 13	7 days/week 6 am-6 pm Mon. & Fri.	31 13
1999	Columbia	Dec. 1-Dec. 23 Dec. 30-Feb. 10	7 days/week 7am-7 pm Wed.	23 7
2000	Columbia	Dec. 1-26 Dec. 29-Feb. 16 Feb. 20-22 Feb. 24-25	7 days/week 7 am-7 pm. Wed. 6 pm Sun.-6 pm Tues. Noon Thurs.-Noon Fri.	26 8 2 1
2001	Columbia Cowlitz	Dec. 1-Dec. 31 Jan. 3-Mar. 10 Mar. 11-Mar. 31 Jan. 21-Mar. 11 Mar. 11-Mar. 18 Mar. 19-Mar. 31	7 days/week 3 am-9 pm Wed. 3 am-9 pm Mon. & Wed. 6 pm-6 am Tues./Wed. 6 pm-6 am Sun/Mon & Tues/Wed. 6 pm-6 am Sun/Mon, Mon/Tues & Tues/Wed	31 10 6 10 3 5
		Sport Seasons		
1960-96	Columbia and tributaries	Jan. 1-Dec. 31	7 days/week	365
1997	Columbia and OR tributaries WA tributaries	Jan. 1-Dec. 31 Jan. 1-Feb. 28	7 days/week 7 days/week	365 59
1998	Columbia and OR tributaries WA tributaries	Jan. 1-Dec. 31 Jan. 1-Feb. 2	7 days/week 7 days/week	365 33

Appendix Table 2. Columbia River commercial and sport eulachon seasons, 1960-2001.

Year	Area Open	Season	Weekly Period	Total Days Open
1999	Columbia and OR tributaries WA tributaries	Jan. 1-Dec. 31 Jan. 2-Feb. 13	7 days/week Wed. & Sat.	365 14
2000	Columbia and OR tributaries WA-Cowlitz only	Jan. 1-Dec. 31 Dec. 31-Feb. 26	7 days/week Fri. & Sat.	365 18
2001	Columbia and OR tributaries WA-Cowlitz only WA tributaries (inc. Cowlitz) WA tributaries (inc. Cowlitz)	Jan. 1-Dec. 31 Jan. 6-Mar. 7 Mar. 7-Mar. 18 Mar. 19-Mar. 31	7 days/week 6 am-10 pm Sat. 6 am-10 pm Sat., Sun. & Wed. 6 am-10 pm Sat., Sun, Mon. & Wed.	365 9 6 7