DEPARTMENT OF COMMERCE
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NATIONAL MARINE FISHERIES SERVICE

PETITION TO LIST EULACHON

THALEICHTHYS PACIFICUS

AS THREATENED OR ENDANGERED

UNDER THE ENDANGERED SPECIES ACT

TO: SECRETARY OF COMMERCE, UNITED STATES DEPARTMENT OF COMMERCE, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, NATIONAL MARINE FISHERIES SERVICE

From: Sam Wright (petitioner), PMB 126, 2103 Harrison NW, Ste. 2, Olympia, WA., 98502-2607 (Phone: (360) 943-4424)

Subject: Petition the Secretary of Commerce to list as threatened or endangered the population, stock or evolutionarily significant unit of eulachon (also known as the Columbia River smelt or candlefish) that is found in the Columbia River system and its tributaries and to designate critical habitats. Note: for the purposes of this petition "population, stock or evolutionarily significant unit" is defined as an important, existing (but severely depressed) indigenous fish resource which is currently at-risk (threatened or endangered) and has no reasonable expectation of being able to recover over time by itself and/or from the surplus production of an adjacent or nearby population of the same species.

BASIS FOR THE PETITION

Petitioner files this petition under the Endangered Species Act (the "ESA"), 16 U. S. C. section 1531-1543 (1982) (ESA), its implementing regulations, 50 C. F. R. part 424, and the Administrative Procedure Act, 5 U. S. C. section 553 (c). The National Marine Fisheries Service ("NMFS") has jurisdiction over this petition under 16 U. S. C. section 1533 (a) and the August 26, 1974, Memorandum of Understanding Between the U. S. Fish and Wildlife Service and National Marine Fisheries Service Regarding Jurisdictional Responsibilities and Listing Procedures Under the Endangered Species Act of 1973.

The petitioner is a scientist and Certified Fisheries Professional (CRP, American Fisheries Society). The conservation, ecological, recreational, research and commercial interests of the citizens of the United States (including the petitioner) will be adversely affected if the requested petition is not granted.

The eulachon was identifed as a species of concern in a July 1998 publication by the American Fisheries Society (Musick 1998). This draft AFS List of Marine Fish Stocks at Risk in North America also identified "Limited vulnerable habitat" as the primary reason for concern (Musick 1998, p. 30).

Petitioner participated in the recreational dip net fishery for eulachon for over two decades, often taking a 20 pound limit (about 200 smelt) in one hour or less from the banks of the Cowlitz River. Newspaper accounts on average smelt catches made during the abbreviated 1999 recreational fishing season ranged from none to a high of two smelt per hour.

The resource in question is managed jointly in the Columbia River mainstem by the Washington Department of Fisheries (WDFW) and the Oregon Department of Fish and Wildlife (ODFW). Each agency manages their respective tributary fisheries. WDFW has already closed year 2000 recreational fishing in Washington Columbia River tributaries through April 30, 2000. It is anticipated that ODFW will support continued commercial fishing in the Columbia River mainstem during 2000. There seems to be a general feeling that a fishery must be allowed to operate since it is the only acceptable way to prove to fishermen that the runs are indeed poor (or to detect an unexpectedly good return). However, it is well known to current managers that both the timing and shape of the run entry pattern varies widely from year to year and cannot be predicted in advance of any supposed "peak". One additional factor is the tremendous demand for eulachon as a bait for sturgeon fishing. Average price per pound data for eulachon landed in Washington were provided to petitioner for the years 1970 thru 1998 as well as prices paid for test fishing catches sold in 1999 (personal communication, Greg Bargmann, WDFW, Olympia). Prices were consistently below thirteen cents per pound (range of 6.0 to 12.3 cents) from 1970 through 1993. As the resource (and hence resultant catches) declined, average prices increased to 27.7 cents per pound in 1994, dipped to 14.1 cents in 1995, and then leaped to $1.56, $1.58, and $2.64 per pound in 1996, 1997, and 1998, respectively. The price paid for test fishing catches in 1999 was $4.02 per pound. It is obvious that the limited catch is now being used exclusively for sturgeon bait and this has been advanced by some as a primary reason for continuing the eulachon fishery in spite of the condition of the resource.

THE PRIMARY BASIS FOR PROPOSED LISTING: AN UNPRECEDENTED SEVEN YEAR DECLINE IN RESOURCE ABUNDANCE FROM 1993 THROUGH 1999

Eulachon annually ascend the Columbia River to spawn in the lower mainstem and tributaries. Typically, the fish enter the Columbia during early to mid-January, followed by tributary entry during mid to late January. Water temperatures in both the mainstem and tributaries are critical in determining the timing and shape of the population's entry pattern. This makes it impossible to assess the population biomass by most of the standard techniques used effectively for other fish resources. Eulachon annually ascend the Cowlitz River, and inconsistently enter the Grays, Elochoman, Lewis, Kalama, and Sandy rivers.

The only long-term measure of stock adundance is commercial catch landings. Commercial landings from 1938-1989 averaged 2.1 million pounds annually. There are no quantitative estimates for recreational catch, total stock biomass or spawning biomass. The commercial catch statistics for 1938 through 1998 are provided in the attached report entitled "Joint Staff Report Concerning Stock Status and Commercial Seasons for Smelt for 1998-99". The estimated 1999 catch was provided by personal communication, Greg Bargmann, WDFW, Olympia. The critical numbers (years and catches in thousands of pounds) are as follows:

1993	513.9
1994	43.4
1995	440.0
1996	9.1
1997	58.6
1998	12.0
1999	5.0

In 1993, eulachon strayed to many Washington coastal streams and bays due to cold Columbia River water temperature. The 1993 catch was the second lowest in 55 years of record from 1938 through 1992 and only slightly exceeded the lowest catch. That was the 498.0 thousand pounds taken in 1984 or four years after the volcanic eruption of Mt. St. Helens. Returns in 1984 could also have been impacted by the record large El Nino event of 1982-1983. The eulachon return primarily as three- and four-year-old fish (see enclosed Figure). All of the other six recent years had catches below anything experienced in the 55 years from 1938 through 1992. After the 1984 low, the next two lowest years were 841.8 and 947.5 thousand pounds in 1964 and 1968, respectively. Worse yet, the eulachon run for the year 2000 will have to come from the low abundances observed in 1996 and 1997, the 2001 run will have to come from the low abundances observed in 1997 and 1998, and the 2002 run will have to come from the low abundances observed in 1998 and 1999. Finally, the four-year-old fish returning in 2003 will have to come from the low abundance observed in 1999.

A number of subsequent sections will present issues and information which are considered to be pertinent to the listing proposal.

DEFINITION OF AN AT-RISK FISH STOCK

In principle, "stock" is a biological term which refers to a population of fish which is reproductively isolated, or partially isolated, from other such populations of the same species. In terms of basic resource conservation responsibilities or "viewing the resource as your client" (WDFW 1997), an "at-risk stock" should be defined as a population that has no realistic expectation of being able to recover by itself and/or from the surplus production of another population of the same species. Eulachon in the Columbia River system clearly meet this definition.

The greatest danger with a small stock size occurs when predation, parasites and/or disease (i.e., any natural mortality cause) lead to a situation where the highest percent mortality occurs at low abundances of juveniles and/or adults. Peterman (1977) stated that populations with two or more "domains of stability" must be managed accordingly. In these cases, two or more different mortality processes combine in a series to create a stock-recruitment curve with more stable points than the single one exhibited by the standard Ricker model. In one case, an unfished population would be stable at point A, and could be continuously exploited without permanent harm as long as it never dropped down to point B. Below this point, the population would move toward extinction, even if harvesting was completely stopped. In a second case, a critical spawner abundance would also exist, but a population falling below point B would not go toward extinction but toward a lower stable equilibrium (point C), which would be very unproductive for harvesting. Elimination of all harvest would still not permit the population to return to the higher abundance near the upper stable point.

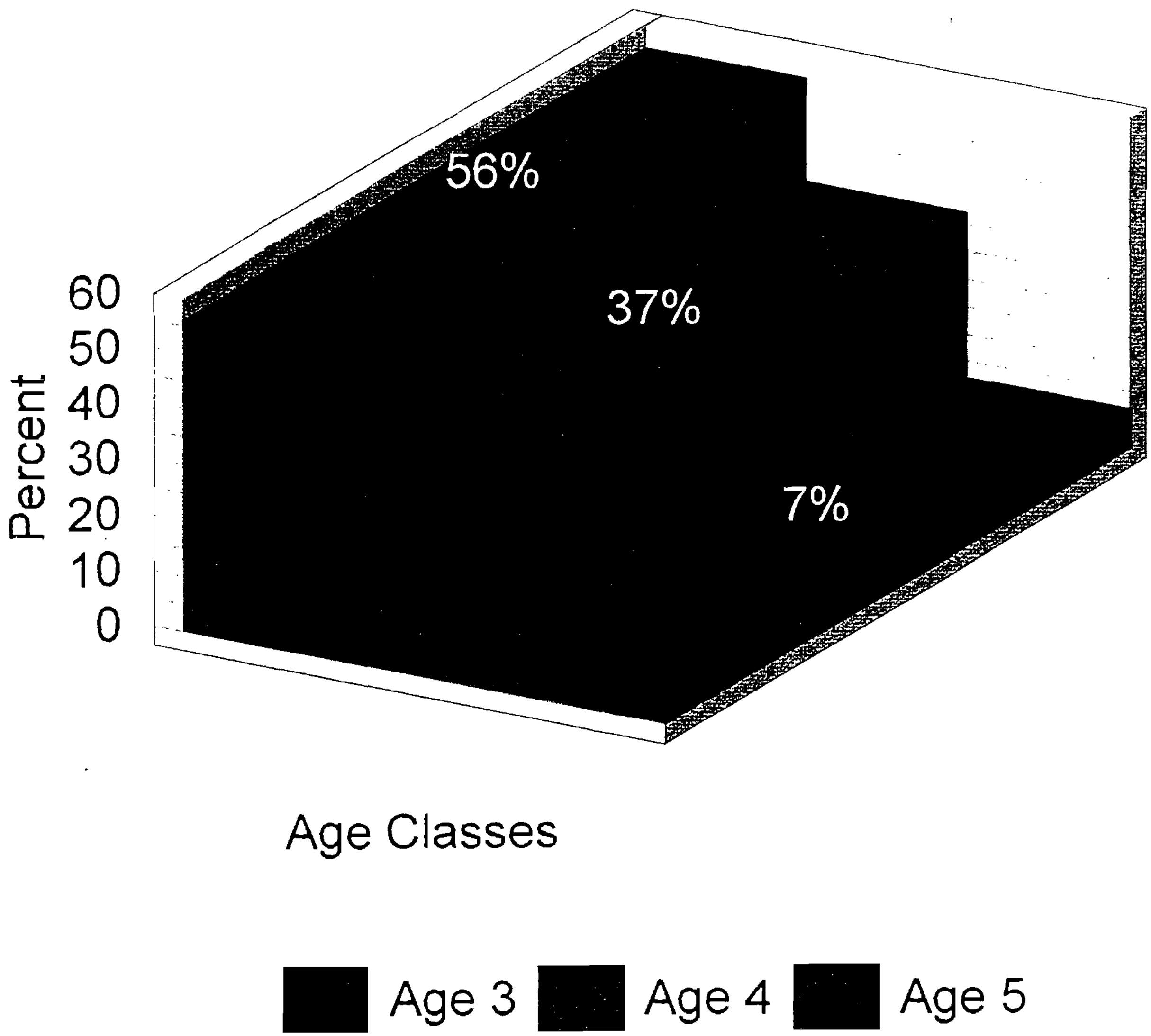
Even in the absence of the situation described above, ecologists often identity the concept of a "critical threshold" or a population level below which reproduction and survival are impaired, limiting the ability of a population to sustain itself.

Unfortunately, all of these potential threats are commonly identified after-the-fact when populations have already collapsed and scientists can only debate the causative agents.

In the absence of any quantitative data on spawners and recruits, the eulachon resource managers (WDFW and ODWF) have no knowledge of basis population dynamics, particularily the shape of the spawner-recruit relationship. The catches allowed during the recent

1998 Smelt Age Compostion

Columbia River



unprecedented resource decline may well have ensured that the resource will not recover in the foreseeable future. A responsible resource manager would have stopped fishery exploitation when faced of such uncertainty.

THE UNIQUE CASE OF FORAGE FISH

Many marine and estuarine ecosystems share an important aspect in the structure of their biological communities. These contain a large number of species, collectively called "plankton", at low trophic levels. They also contain a substantial number of species such as large fish, seabirds and mammals at high trophic levels. However, in many of these ecosystems there is a critical intermediate trophic level which is occupied by only a few species of small pelagic fishes (Bakun 1996 cited in Bargmann 1998). This community structure, with many species at the bottom of the food web as well as at the top, but with only a few species at mid-level, has been called a "wasp-waist ecosystem" (Rice 1995 cited in Bargmann 1998). Eulachon from the Columbia River system can be considered a dominant species at the wasp-waist. However, a recurring theme in Bakum (1996 cited in Bargmann 1998) is the decadal-scale shifts in abundance that may occur in wasp-waist species; often, but not always, due to replacement by other forage fishes. Eulachon from the Columbia River system fit the "but not always" portion of this generalization (at least with respect to forage fish spawning in the Columbia River system). One fish species in the Columbia River system, the introduced American shad, is not usually classified as a "forage fish" but has enjoyed an unprecedented increase in abundance during the same time frame when eulachon populations were moving in the opposite direction (ODFW and WDFW 1998).

Table 72 of the above report (p. 212-213) shows the "Minimum Numbers (in Thousands) of Shad Entering the Columbia River, 1938-97." Annual runs never exceeded a million fish from 1938 through 1977, while all runs since have exceeded one million shad. Ten recent runs exceeded two million, with three plus million runs in 1989 and 1992 and a four plus million run in 1990. Similar cause-and-effect relationships involving opposite trends in abundance can be implied between eulachon and a number of marine bird and marine mammal populations. (For example, in the late 1980s when the run size was much larger that at present, the annual consumption of eulachon in the Columbia River by harbor seals was estimated to be 335 tons. Source: personal communication, Greg Bargmann, WDFW, Olympia).

DEFINING OVERFISHING

In many forums, "overfishing" has been defined as fishing rates which cause the spawning biomass to decline below a level which achieves the largest level of maximum sustainable yield. These levels have been suggested as F20%, F30%, and F40%, which represent fishing mortality rates to achieve respective preservation of 20%, 30%, and 40%, respectively, of the unfished spawning stock biomass. These are increasingly more conservative population thresholds and overfishing levels. This is intended to prevent low spawning stock biomass and related variability in recruitment. Many fishery management organizations have adopted F30% or more conservative guidelines, including the Pacific Fishery Management Council and the North Pacific Fishery Management

Council. Available quantitative data (long-term catch records) demonstrate that eulachon in the Columbia River system are currently far below any of the population size standards cited above.

However, there continues to be controversy over the actual existence of relationships between spawners and their resultant recruits, especially for forage fishes. Some maintain that there are no relationships and that all significant observed variabilities can be attributed to environmental factors. However, Myers and Barrowman (1996) analyzed 364 spawner-recruit times series (including a number for forage fishes) to determine whether recruitment was related to spawner abundance. They posed three questions: 1) Does the highest recruitment occur when spawner abundance is high? 2) Does the lowest recruitment occur when spawner abundance is low? and 3) Is the mean recruitment higher if spawner abundance is above rather than below the median? They found that, when there was a sufficient range in spawner abundance, the answer to all three questions was almost always "yes". Myers and Barrowman (1996) concluded that spawner abundance cannot be ignored in the management of fish populations and that overfishing appears to be a common problem.

COMMERCIAL CATCH STATISTICS

The available catch statistics in over a century of commercial exploitation for Columbia River eulachon were often influenced by a limited market demand for the product. This created a fishery history in which the largest runs actually had the lowest exploitation rates and the spawning escapements from small runs were lower than catch statistics implied. This also means that the annual run sizes were often much larger and varied much more from year to year than the catches indicated. Annual catch statistics for 1895 through 1949 were compiled by Craig and Hacker (1940) and it appeared that the market dictated catch even in the earlier years of the fishery. For example, the Fortieth and Forty-First Annual Reports of the Department of Fisheries and Game (Washington combined agency), published in 1932, made the following statement (p. 13): "the amount the commercial smelt fisherman can take generally depends upon the orders the dealers have for fresh smelt to be shipped".

The catch statistics in Craig and Hacker (1940) do not show any catches in three single years (1901, 1924, and 1935) and in a complete ten year block of time from 1913 through 1922. Some subsequent reviewers have interpreted this to mean that eulachon were absent from the Columbia River for an entire decade in the early 1900s, and that the current decline should not be a cause for concern. However, the 1953 Washington Department of Fisheries (WDF) Columbia River Progress Report describes how Kelso (The Kelsonian) and Longview (Longview Daily News) newspaper reports were examined to check for the past occurence of eulachon in the Cowlitz River. For the 1913-1922 period, eulachon runs definitely occurred in the Columbia River system in 1914, 1915, 1917, 1918, 1919, and 1920. No newspapers were on-file to check on for 1913, 1921, or 1922. There was no mention of eulachon in 1916 papers.

Market limitations controlled catches until 1942 when the WDF Annual Bulletin for 1942 noted (p.15) that "Production control as a means of price stabilization lowered the production of Columbia River smelt during the 1942 season. Actually an exceptional run appeared in the Cowlitz River and well over 2,000,000 pounds could have been produced if fishing intensity had been normal." However, three years later, the WDF Annual Bulletin for 1945 stated (p. 45) that "The magnitude of the fishing intensity, which has been steadily on the increase since the start of the war, is directly correlated with the unprecedented market provided by the demand for the armed forces. Again all of the spawning which occurred in the Cowlitz River was within the limits of the dip-net commercial fishery." The record catch in over a century of commercial fishing occurred in 1945 - 5719.3 thousand pounds. Immediately after the war, the WDF Annual Bulletin for 1946 expressed concern over the extreme intensity of the wartime fishery and the possibility that it may have dangerously reduced available stocks of this important species. It also noted that, for the first time in three years, eulachon were able to progress above the commercial fishery and spawn unmolested in the Cowlitz River (due to a new commercial fishing restrictive boundary). Some impact of the heavy fishing during 1943-1945 may have been manifested in a small 1947 run since the WDF Annual Report for 1947 reports (p. 117) that "Commonly, market conditions regulate the commercial catch of smelt when the run is at peak. However, in 1947 insufficient numbers of fish were landed to take care of orders on hand at fish receiving stations." The concern quickly disappeared since the WDF Annual Report for 1948 stated (p. 37) that "One spawning ground survey made by rubber boat during the peak of the run on the Cowlitz River revealed that spawning smelt were so thick in places that they were crowding each other clear to the banks of the river."

By the 1950s, things had returned to "normal" in the eulachon fishery. The 1952 WDF Columbia River Progress Report reported (p. 2) that "The smelt throughout the season were sufficiently abundant to far more than satisfy the demands of the market. Throughout the season the fishery was operated on a quota basis which was directly determined by the market." This was followed by the 1953 WDF Columbia River Progress Report which stated (p. 7) that "a smelt association operated, as it has for at least two previous seasons. The association is composed of nearly all fishermen who catch smelt commercially (except in the Sandy River). Its purpose is to pro-rate the take of fish among fishermen so that only those smelt will be caught which the market demands. This practice reduces waste and keeps the price to the fishermen at a favorable level." The report concludes that catch statistics do not reflect true abundance of fish. It then goes on the relate (p. 7-8) that "During much of the season, most of the fishermen were able to catch their pro-rate of 200 to 300 pounds in less than 30 minutes fishing time."

The unpredictable nature of the run was often evident in a number of consecutive years. For example, the 1955 WDF Columbia River Progress Report stated (p. 5) that "The smelt fishermen's association . . . did not function in the Columbia gill-net fishery. Their office-receiving station did provide an outlet for the fish taken, but at no time acted as a governing agent in respect to assigning fishing members maximum daily poundages." However, a large, late run entered the Cowlitz River in the latter part of March and the buyers attempted to restrict the fishermen's poundage. Market saturation soon occurred and prices dropped rapidly to 1.5 cents per pound. At that point, most fishermen quit even though large quantities of fish were still available. The next year, things seemingly returned to normal since the 1956 WDF Columbia River Progress Report noted (p.4) that

"Four or five weeks after the season began, smelt were abundant enough to require imposition of a quota on the fishermen to maintain a good price." The next year followed yet a different track since the 1957 WDF Columbia River Progress Report stated that the run was was extremely late but (p. 1) "gill net fishermen reported an abundance of fish in the upriver drifts and had little difficulty filling their quotas."

RECREATIONAL FISHERY

The recreational fishery has received very little attention in terms of attempting to quantify the catches which were taken. The WDF Annual Bulletin for 1940 stated (p. 16) that "Although no figures are available on the amount of fish taken by the public, it is conservatively believed that it is between 30 per cent and 50 per cent of the commercial production." This was followed by a statement in the WDF Annual Report for 1948 (p. 37) that "No estimate of the sport take of smelt is possible to obtain at present, but there is no question that it reaches many hundreds of thousands of pounds. The WDF Annual Report for 1957 indicated that the recreational fishery had been accounting for as much as one million pounds each year. The only quantified estimate which could be located appeared in the 1953 WDF Columbia River Progress Report. It was stated that Oregon biologists determined that 1,500,000 pounds of eulachon were taken in the Sandy River during the 1953 season by 60,000 sportsmen. In recent years, current resource managers have stated that the recreational take is probably roughly equivalent to the commercial landings.

COMMERCIAL FISHERY CATCH PER UNIT EFFORT DATA

Resource managers often attempt to quantify changes in fish population abundance by standardizing observed catches to some uniform measure of fishing effort. The 1956 WDF Columbia River Progress Report states (p. 5) that "In 1954, a catch per-unit effort study was initiated to collect data relative to the total pounds caught by participating fishermen, hours fished, and the number of drifts made. These data should be a year to year measure of the relative abundance of smelt." The study was initiated since managers were already well aware of the way that market limitations thoroughly obscured any relationship between total catch and total population abundance (biomass). By 1958, five years of data had been collected from the same four eulachon fishermen. The 1958 WDF Columbia River Progress Report reported that the annual numbers of gill net drifts by these fishermen in 1954 through 1958 totaled 148, 128, 193, 103, and 111, respectively. Average pounds of eulachon caught per drift during the same five years were 203, 237, 283, 263, and 216, respectively. However, the study was discontinued after the 1958 season. It was felt that the data were of only limited value due to differences in timing and density of each year's eulachon run as it entered the Columbia River. A run might be large but widely dispersed or small but compact. Catch per gill net drift data could not easily distinguish between these two possible situations (Note: no weekly data were provided in the WDF Columbia River Progress Reports).

However, the 1954-1958 data do provide a useful past benchmark for a comparison with similar recent data collected during a period of much lower resource abundance. For the 1998 run, a total of 34 gill net drifts were monitored from the the last week of 1997 through the first seven weeks of 1998 (personal communication, Greg Bargmann, WDFW, Olympia). A total of 913.8 pounds of eulachon were caught or 26.9 pounds per drift. This is about one-tenth of the values from the 1954-1958 period. In addition, 740.0 of the 913.8 pounds were taken during a single week, the fourth of 1998. This is what the 1950s managers would have called a "small but compact" eulachon run. The catch per drift data for 1998 were also influenced by weekly closed periods which allowed the eulachon population to build-up between fishing periods (this build-up could not occur in 1954-1958 since the fishery was open on a continuous basis).

THE RELATIONSHIP BETWEEN RUN TIMING AND WATER TEMPERATURE

The WDF 63rd Annual Report (published in 1954) stated (p. 40) that "Recent studies indicate a correlation between the upstream and tributary migration of smelt with water temperature. Smelt fail to migrate upstream as far as the Cowlitz River until Columbia River temperatures have warmed to approximately 40 degrees F. at Bonneville. In 1953, during a mild winter when water temperatures remained above 40 degrees F. throughout, smelt were present in the Cowlitz River when the commercial season opened on January 3. In other years this appearance has been delayed until as late as March or has not occurred at all." The WDF 64th Annual Report (published in 1954) adds (p. 28) that "It was also found that runs into a tributary stopped when the water temperature exceeded approximately 44 degrees."

WARM WATER EVENTS IN THE OCEAN

As previously stated, the low eulachon abundance in 1984 might be at least partially explained by the record El Nino event of 1982-1983. In addition, there is a common perception that the current decline in eulachon abundance can be totally explained by warm ocean water conditions in the 1990's. However, the true "record", as measured by responses of fish populations, probably occurred in the late 1950's. A number of northern range extensions were recorded by twenty or more tropical and temperate species during this period. The WDF 1958 Fisheries Statistical Report, in first discussing albacore (p. 224), noted that "a substantial quantity of this species was landed by the halibut fleet which encountered schools of albacore in the Gulf of Alaska." This was followed by "Among other rare warmer water fish landed in 1958 were nearly 5,000 pounds of white sea bass taken by trollers and later by coastal gill net boats in river estuaries. No less than seven barracuda, a pompano, a yellowfin tuna, a tropical green sea turtle and what may have been a bluefin tuna . . . were taken by commercial gear in Washington waters." (Note: a table in the same report also shows commercial landings of white sea bass in 1957.)

More recently, Hay et al. (1997) compiled catches of eulachon captured incidentally in annual shrimp trawl surveys conducted off the coast of southern British Columbia and used spatial analysis to estimate eulachon densities. From this, they derived an offshore index of abundance for nearly all years from 1973 to 1996. This was then compared with eulachon catch data from the Columbia and Fraser rivers. Hay et al. (1997) found that the offshore index was significantly correlated with Columbia River catches but not with those from the Fraser River. (Note: this was the logical expectation given the much larger size of the Columbia River resource.) They also found that the offshore eulachon index varied positively with water temperature (sea surface measurements from Amphitrite Point on the west coast of Vancouver Island) but that Fraser River catch varied negatively with temperature. There was no apparent relationship between Columbia River catches and temperature but there was positive covariance between the offshore index and Columbia River catches. Hay et al. (1997) also found that the 1983 offshore index decline preceded a sharp Columbia River catch decline by one year and that the 1993 offshore index decline preceded a 1994 decline in both the Columbia and Fraser rivers. One alternative theory offered by Hay et al. (1997) was that warm water conditions caused a more northerly distribution of eulachon in the ocean. (Note: recent offshore index numbers for eulachon, including 1999, continue to be low. Source: personal communication, D. E. Hay, Fisheries and Oceans Canada, Nanaimo.) To the south of the Columbia River, Moyle (1994) reported that there has been a gradual decline in the California eulachon population during the last 15 years.

CRITICAL SPAWNING HABITAT

McHugh (1940) reported on efforts to discover the spawning grounds of eulachon in the Fraser River, stating (p. 18) that "Owing to the muddy nature of the river water direct observation of spawning was not possible. The search for eggs was therefore carried out by dredging the bottom with a heavy iron frame to which was attached a bag of sacking. . . . In all cases they were found attached to particles of course sand, and since the bottom deposits become increasingly finer in a downstream direction, the size of the sand grains may determine the limits of spawning." McHugh (1940) further reported (p. 19) that "The egg becomes attached to sand grains in the river bottom in a rather peculiar manner . . . The mature egg as it leaves the female has a double outer membrane. The outer layer is easily broken, separates from the inner covering, and becomes turned inside out. Since the two membranes remain attached over a small area . . . a short stalk or peduncle is formed. The free edges of the broken membrane are extremely adhesive and readily become attached to the particles of sand."

Smith and Saalfeld (1955, p. 23-24) reported thar "Spawning occurs primarily over a bed of pea-sized gravel where water flows at moderate velocities. To a lesser extent, eggs have been found on semi-sandy areas and frequently small sticks and bits of debris form an anchorage for them." Smith and Saalfeld (1955) also reported on studies conducted at the Kalama River Hatchery in 1949 which demonstrated that eulachon prefer coarse sand and pea-sized gravel for spawning. In these experiments, live eulachon were placed in hatchery troughs with sand, fine gravel, large rocks, brush, sticks and boughs.

JUVENILE MONITORING

In studies of juvenile eulachon in the Fraser River, McHugh (1940) reported (p. 19) that "Young fish were captured by towing with a fine meshed cone-shaped net. Tows were taken from Mission to the mouth of the Fraser and in all cases the fish secured were in a very early stage of development. Since the newly-hatched fish are relatively feeble swimmers, they are apparently carried to the sea in a short space of time after emerging from the egg. If entirely at the mercy of the river current the newly-hatched larvae would drift from Mission to the sea in less than 24 hours." More extensive recent assessments of eulachon in the Fraser River (egg and larval surveys) were reported by Hay et al. (1997).

A eulachon larval sampling project was initiated in the Cowlitz River in 1994 and in the Columbia River mainstem in 1995. The program was developed to determine where the fish were spawning and to determine relative spawning success of a given year's run when compared to other years. The available results through 1998 are provided in the attached report entitled "Joint Staff Report Concerning Stock Status and Commercial Seasons for Smelt for 1998-1999.

PART TWO: ADDITIONAL INFORMATION

UTILIZATION OF EULACHON BEFORE 1900

Prior uses were summarized by Hay et al. (1997, p. 512) as follows: "In the last century, eulachon was much better known, mainly because of its importance among the coastal Aboriginal cultures . . . In particular, it was an extremely important source of food, and a vital cultural and economic commodity among coastal communities. The remarkable characteristic about eulachons was its high lipid content, so high that it is possible to ignite the tail of dried specimens and have the carcass burn like a candle. Oil, or "grease" derived from the eulachon was so important as a trading commodity in Aboriginal society that extensive transport trails throughout the coast were known as "grease trails." The rendering of the fish to grease took on enormous significance and the technology developed variations among different societies. Therefore, for centuries, and perhaps millennia, the variations in the distribution and abundance of eulachons have been under intense observation and scrutiny among people living in coastal communities." Thus, eulachon have supported fisheries in the Columbia River for centuries. Lewis and Clark, in their journey in 1806, purchased eulachon from the Indians and proclaimed it to be of the highest quality.

HISTORICAL DISTRIBUTION OF EULACHON

The construction of Bonneville Dam in the late 1930s blocked the normal access of eulachon to any mainstem or tributary spawning sites upstream. The fish ladders at Bonneville Dam were not designed to accommodate eulachon and there is no evidence that they attempted to make any serious use these facilities. Smith and Saalfeld (1955) reported that prior use by eulachon extended at least as far upstream as Hood River, Oregon, and that, only in 1945, were eulachon present in sufficient numbers to continue through the ship locks at Bonneville Dam to the area above. A possible presence in the Klickitat River was also reported for this same year (1945) and it is likely that this tributary was part of the historical distribution.

The 1953 WDF Columbia River Progress Report stated (p. 6) that "a tremendous population arrived late in the season at Bonneville Dam." For the next season, the WDF 63rd Annual Report (published in 1954) related (p. 40) that "Only a small fishery fished stocks which in late April migrated in tremendous numbers as far upstream as Bonneville Dam."

HISTORICAL CHANGES IN THE COLUMBIA RIVER ESTUARY

The Columbia River system is best known for its extensive development in terms of mainstem and tributary hydroelectric dams. These structures have selectively cut-off the natural supply of certain sediments such as the coarse sand and pea-sized gravel preferred by eulachon for spawning. However, large changes in morphology of the estuary have also been caused by navigational improvements (jetties, dredged channels, and pile dikes) and by diking and filling much of the wetland area. In the past, dredging and other development activities often occurred during the eulachon spawning period.

The overall effects of human intervention in the physical processes of the estuary were documented by Sherwood et al. (1990) who found decreases in freshwater inflow, tidal prism (about 15% less), and mixing. Increases occurred in flushing time and fine sediment deposition, and net accumulation of sediment. Perhaps the most import change to fish populations was an estimated 82% reduction in emergent plant production from wetland habitats and a 15% reduction in benthic macroalgae production. While these losses were partially offset by an increase in the supply of riverine detritus derived from freshwater phytoplankton primary production, there was a definite shift in the amount and make-up of material available at the base of the food web. Large volumes of sediment have been eroded from the entrance region and deposited on the continental shelf and in the balance of the estuary, contributing to the formation of new land.

Mahnken et al. (1981) described how reservoir flow controls have changed conditions in the Columbia River system. Since completion of Canadian storage reservoirs in the early 1970s, turbidity is reduced in the spring and nutrients formerly carried to sea are now "trapped" in reservoirs. Instead of the spring freshet, less water is released during the spring and more in the fall and winter when power demand is highest. The reduced spring flows have altered the physical/chemical characteristics of the esturary and near-shore ocean areas. Less water in the river plume, as it enters the ocean, leads to less entrained deeper ocean water and, therefore, less local upwelling. Observed time changes on the transition from a northward to a southward near-shore ocean current may also be important.

The evolution of successful diadromy (use of both freshwater and marine habitats by a species) always involves a major "cost" for migration. It must be more than offset by a combination of "benefits" from the two habitats that exceeds those available from continuous use of only one habitat during the life history of a species. (Gross 1987). The main expenditure of energy is the osmoregulatory cost associated with crossing the sea-freshwater boundary. The most important marine area benefit is probably a higher relative availability of food since seas are often more productive than freshwaters in the temperate zone. The main Columbia River benefit is that the number of predators is probably less on egg and larval stages. Hay et al. (1997) stated that egg and larval stage losses must be less than for a marine area spawner such as Pacific herring. This species can have egg predation rates exceeding 50% during the incubation period (Haegele 1993 cited in Hay et al. 1997). In addition, predation rates on pelagic herring larvae in marine areas can be very high, up to 10% per day (Arai and Hay 1991 cited in Hay et al. 1997). However, for the anadromous eulachon, ecosystem changes described above may have cancelled out net benefits. Clearly, the current Columbia River estuary is not the same one that the species evolved to use.

Dawley et al. (1986) found a decline in food consumption of yearling chinook salmon during the peak outmigration and believed it was related to interspecific interaction and slow recovery of food resources available. Significant dietary overlaps were indicated between the other salmonids. Stomach content weights from subyearling and yearling chinook were less than similar sized fish examined at other Pacific Coast estuarine and riverine locations. Results of proximate analysis of stomach contents indicated that the food eaten was not of sufficient quality to compensate for low consumption rates.

EULACHON TAGGING STUDIES

The WDF 63rd Annual Report (published in 1954) reported (p. 40) that "Tagging studies, initiated for the first time in 1953 by the Oregon and Washington research staffs, indicated that the upstream migration of fish was relatively rapid. Some smelt migrated over 30 miles in less than 48 hours. Of the 20,000 fish tagged about 100 were recovered by the commercial and sport fisheries. The low tag recovery indicates that the total abundance of fish was far in excess of that taken by the fishery."

EULACHON TRANSPLANTING EFFORTS

Two references were located that described 1959 transplants, both within the Columbia River system and to at least one river in Puget Sound. The WDF Annual Report for 1959 stated (p. 68) that "Because of the erratic behavior of these tiny fish and the difficulty of predicting whether or not a tributary run will appear, a cooperative program with the Oregon Fish Commission resulted in transplanting smelt from the Lewis River to other likely tributaries in both Washington and Oregon." The 1959 WDF Columbia River Progress Report stated (p. 9) that "A smelt transplant was initiated in 1959 from the Lewis River to the Puyallup River . . . Approximately 4,500 fish were transplanted with an estimated egg potential of 40 million."

POSSIBLE IMPACTS FROM WATER POLLUTION

Water pollution, especially from pulp mills, has been suspected of having adverse impacts on eulachon populations since at least the early 1950's. The WDF 62nd Annual Report (published in 1953) reported (p. 54) that "In 1951 shipments of artificially fertilized smelt eggs were taken to the Deception Pass Marine Laboratory. Results indicate that the liquors were harmful to young smelt. In studies with adults, "The smelt were placed in a partitioned trough which held pure river water on one side and river water mixed with certain dilutions of effluent on the other. The number of fish emerging from either side of the trough were carefully enumerated. Under these circumstances smelt showed an aversion to the effluents in dilutions approximating one part to 800."

More recently, Rogers et al. (1990) studied eulachon in the Fraser River estuary as a possible water pollution indicator organism during 1986 and again in 1988. Water and tissue samples contained chlorophenols from wood preservation operations and chloroguaiacols from pulp bleaching. Whole fish also contained DDE and DDD, while PCBs were present in some fish gonads in 1986, but not in 1988. With the exception of whole body concentrations of 2,3,4,6-tetrachlorophenol (TeCP), concentrations of pentachlorophenol (PCP), 3,4,5-trichloroguaiacol (3,4,5-TCG), tetrachloroguaiacol (TeCG), DDE and DDD in whole bodies, livers and gonads revealed an increasing trend with distance of the eulachon capture site upstream from the Fraser River mouth. Rogers et al. (1990) suggested that the high lipid content of eulachons makes them a good potential integrator of low-level contaminants. Their tissues serve as a "sink" for lipophilic materials encountered during the spawning migration. Since they do not feed in fresh water, the uptake of toxic chemicals must occur directly from the environment.

PRESENCE OF EULACHON IN WASHINGTON COASTAL AREAS

One of the common explanations for the recent drastic declines of eulachon in both the

Columbia and Fraser river systems is that they simply strayed to other areas. For example, Hay et al. (1997, p. 528) noted that "In 1994 . . . there was a novel eulachon spawning event in the Chehalis River system (in the Wynoochee tributary) where eulachons spawned for the first time . . . Unpublished correspondence within DFO also reveals that eulachon have spawned once, in 1955, in the Somass River, draining into Alberni Inlet on the west coast of Vancouver Island." As noted previously, eulachon strayed to a number of Washington coastal areas in 1993 due to the cold water temperature in the Columbia River system. Eulachon entered the Queets River in 1998. Conversations with tribal members indicated that a eulachon run in the Queets is not unusual, occurring every 4 years or so (personal communication, Greg Bargmann, WDFW, Olympia).

The WDF Commercial Fishing Statistics for 1952 reported (p. 5) that "Surprise catch of the year was the 93,387 pounds of eulachon smelt produced by the Quinault River. The only previous records of smelt in the Quinault were in 1940 and 1936." Eulachon landings were also reported from the Quinault for 1958. The 1936 and 1940 runs were only four years apart and could have represented a successful combination of spawners and recruits. The other years were too far apart to offer this possibility. Eulachon have also entered the Quillayute River system on a sporadic basis but the presence of a regular Tribal fishery for surf smelt prevents any accurate determination of specific entry events.

BYCATCH OF EULACHONS IN SHRIMP TRAWLS

Hay et al. (1998) examined the 1997 bycatch in British Columbia shrimp trawls since there are relatively few eulachon populations and many have declined sharply in recent years. The highest bycatch was from otter trawlers in the central coast where the ratio of eulachon to shrimp was 0.210. An estimated 90 tonnes of eulachons were taken in this area. Eulachon bycatch was also high in otter trawls off the west coast of Vancouver Island, where an estimated 52 tonnes were taken. In general, eulachon bycatch estimates were lower in other areas and negligible in the Strait of Georgia. Bean trawls had lower eulachon catches, although they took an estimated 22 tonnes off the west coast of Vancouver Island. Overall, the eulachon bycatch in the Canadian shrimp fishery was estimated to be over 160 tonnes (Hay et al. 1998). While this might not be a cause for concern in "normal" times, it occurred in 1997 or just before the poor return to the Columbia River in 1998. Hay et al. (1997) had already established a positive relationship between their offshore eulachon "index" and subsequent eulachon catches in the Columbia River. While the average historical Columbia River run size was undoubtedly much greater than southern British Columbia eulachon populations, it may not have dominated the 160 plus tonne shrimp fishery bycatch made in 1997.

GENETIC STUDIES

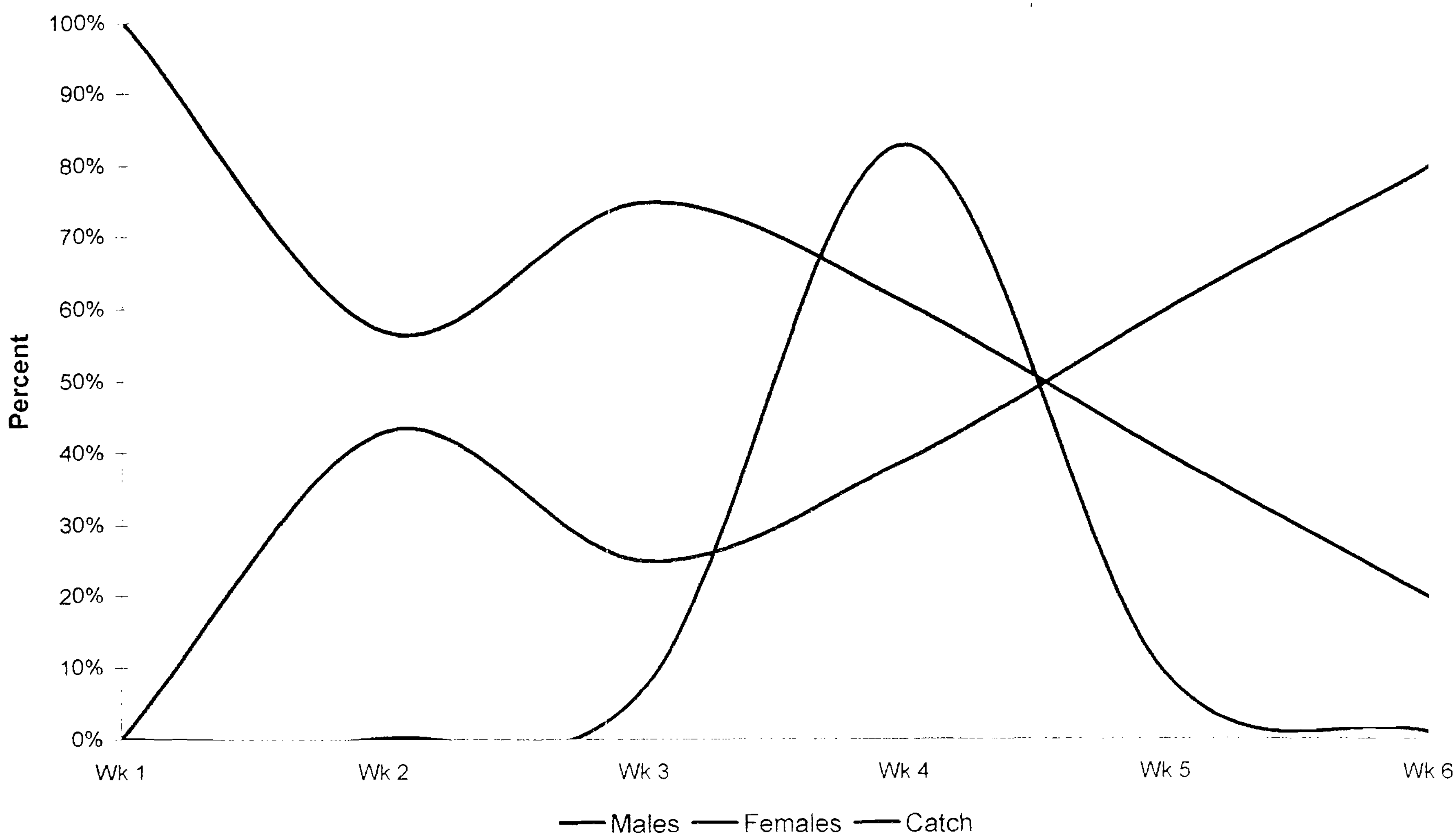
McLean and Taylor (in press) reported on mitochondrial DNA analysis of the population structure of eulachon. Their data were consistent with the hypothesis that eulachon survived the last widespread glaciation of North America in a single "refuge". Many Pacific Coastal fish populations show evidence of two separate refugia. In addition, other anadromous fish (such as salmon) are often comprised of a number of genetically distinct freshwater spawning populations. MtDNA data has generally shown that this is not true for eulachon (which are also anadromous). McLean and Taylor (in press) found that there was a great deal of genetic variation in eulachon and that there was evidence of high gene flow among sampling locations (with two exceptions - while there is a geographic explanation for low gene flow around the Aleutian Peninsula, the heterogeneity in mainstem Columbia and Cowlitz samples requires further study). The authors concluded that the pattern of genetic variation in eulachon is more consistent with marine fish than with anadromous fish. This pattern is consistent with their life history of spending very little time in early freshwater habitats.

SEX RATIOS IN EULACHON POPULATIONS

There is seemingly contradictory evidence in the literature on eulachon sex ratios. One obvious possibility for sampling error comes from the fact that males typically predominate in the early part of the run, females in the latter part (see enclosed Figure). However, Rogers et al. (1990) reported that males predominated over females in Fraser River test catches by an average ratio of 3.4 to 1 in 1986 and 5.9 to 1 in 1988. The authors stated that this agreed with earlier estimates made by Hart and McHugh (1944). However, more recent work by other Canadians (Hay et al. 1997) developed Fraser River eulachon biomass estimates by assuming that the sex ratio was 1 to 1.

In earlier work in the Columbia River, Smith and Saalfeld (1955) cited Royal (1932) as their main basis for concluding that male fish are at least three times as abundant as females throughout the run. They stated (p. 23) that " an over-all ratio of 4.5 males to 1 female was the average for all rivers combined. Royal believed these figures to be the minimum of the proportion of males because the samples were taken near shore (except in the Columbia River gill net catches) where females are reported to be most abundant. Smith and Saalfeld (1955, p. 23) added that "The reason for such an unequal sex ratio throughout the Columbia River smelt population is not understood. One hypothesis is that the type of spawning of smelt may necessitate an excess of males. Surprisingly, in the ocean-caught samples previously mentioned, only one male was found in the sample of 50 fish." These types of observations lead to a number of questions such as whether or not the proportion of male fish changes during a period of low abundance. An understanding of the reason behind this disparity in sex ratios may well lead to the reason for the current population decline.

1998 Columbia River Smelt Sex Ratio and % Catch by Week



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