December 21, 1993

Director

Executive Director

Request of the Department of the Santa Cruz County Fish and Game Advisory Commission to List the Coho Salmon (Oncorhynchus kisutch) South of San Francisco Bay as a Threatened Species.

Attached is the petition the Commission received from the Santa Cruz County Fish and Game Advisory Commission on December 16, 1993. Pursuant to Section 2073 of the Fish and Game Code, the Commission is referring the petition to the Department for its evaluation. As required by Section 2073.5 of the Fish and Game Code, please provide the Department's recommendations to the Commission within 90 days from receip of this memo.

Thank you for your assistance in this matter.

COPY

Robert R. Treanor

Attachment

cc: Deputy Director Petrovich
Natural Heritage Division
Region 3
Fish and Game - Monterey

A PETITION TO THE STATE OF CALIFORNIA FISH AND GAME COMMISSION

For action pursuant to Section 670.1, Title 14, California Code of Regulations (CCR), and sections 2072 and 2073 of the Fish and Game Code, relating to listing and delisting endangered and threatened species of plants and animals.

I. SPECIES BEING PETITIONED:

Common Name: Coho salmon

Scientific Name: Oncorhynchus kisutch

II. RECOMMENDED ACTION (check the appropriate categories):

XXX List ______ Change Status

______ as Endangered from: ______

XXX as Threatened to: ______

III. AUTHOR OF PETITION:

Name: Dave Hope

Address: 701 Ocean Street, Room 406-B

Santa Cruz, CA 95060

Telephone Number: (408) 454-3096

I hereby certify that, to the best of my knowledge, all statements made in this petition are true and complete.

Signature: Dave Hope

Date: December 13, 1993

EXECUTIVE SUMMARY

SUMMARY OF COASTAL SOUTH OF SAN FRANCISCO BAY COHO SALMON POPULATIONS

The Santa Cruz County Fish and Game Advisory Commission is formally petitioning the California Fish and Game Commission to list the coho salmon populations south of San Francisco Bay (central coast coho salmon) as a threatened species, pursuant to the California Code of Regulations. These populations of coho salmon have declined at an alarming rate. In the last 30 years 11 of the 13 streams known to have coho salmon in this region have completely lost their runs of these locally adapted stocks, leaving only two streams with self sustaining runs of salmon, Scott and Waddell Creeks. The coho using these streams are genetically, behaviorally, and physically distinct stocks of coho salmon that are adapted to and self sustaining in their last two remaining natal streams.

The petition is warranted because these last two refuges of central coast coho are in jeopardy of going extinct if action is not taken immediately. All efforts possible have been taken by the County of Santa Cruz to stem the losses, but we believe and the data shows that the loss of the central coast coho salmon will occur soon without the special protections afforded by State Threatened Species designation.

This listing is requested after considerable review of this issue by staff and Commissioners. The review showed that although few studies have been conducted in the last 50 years, recent evidence exists that streams to the north and south of Waddell and Scott Creeks appear to have completely lost their runs of coho salmon. Waddell and Scott Creeks have lost over 90% of their average documented runs of 50 years ago and declines of from 95% to 98% are evidenced from estimates of the historical runs in the 1800's.

When reviewing the following description of factors which threaten the continued existence of central coast coho, it should be noted that many of these factors combine to produce cumulative effects. For instance, natural predation, which is normally not critical to the survival of a population, has assumed increased significance due to depressed numbers and other pressures on the population. Some of the present threats to the coho salmon come from disease, stream dewatering, lagoon degradation/constrictions, habitat degradation in the lower stream sections, over-exploitation, and poaching.

Lack of summer water due to overuse of drought-limited flow, coupled with a generalized degradation of stream habitat due to excessive bedload accumulations, has contributed to the serious decline in quality coho habitat. Habitat conditions have been degraded due to land use practices that have caused sedimentation and a loss of deep pools. Large woody debris that provides valuable cover and helps create deep pools has been removed and due to the lack of old growth component is not as abundant as needed. Side channel habitats are currently rare, and when the streams are dewatered, no habitat remains for any aquatic life in the lower stream section and lagoon areas, critical habitats for juvenile coho salmon during the summer months.

An additional threat to the coho salmon comes from disease. Studies being conducted on Bacterial Kidney Disease (BKD) show that this disease is rampant in the local coho salmon populations. All coho salmon tested in the Scott and Waddell Creeks tested positive for BKD. The data to date show that this disease is a serious problem for coho salmon (Dr. W. Cox, California Department of Fish and Game).

In 1991, a census of salmon returning to the San Lorenzo River by the Monterey Bay Salmon and Trout Project (MBSTP) staff showed that a part of the winter migration of coho salmon may also have been lost to marine mammals. (Monterey Bay Salmon and Trout Project, personal communication.) The recent population increase in sea mammals locally coupled with the effects of the drought has caused losses in returning adult and in general depleted spawning runs. The drought reduced flows have not opened sand bars at the mouth of the rivers and streams until February or March in some years. This allows schooled fish to become prey to sea mammals and blocks migration of the returning adults.

Instream competition for "wild" coho can come from hold over hatchery steelhead and coho smolts, illegally stocked rainbow trout and to a lesser extent "wild" steelhead in Scott Creek (Weldon Jones, personal communication; Shapovalov and Taft, 1954). Steelhead and coho salmon normally exist side-by-side without serious losses if stream conditions provide adequate cover, deep pools and glides. Degraded habitat has caused increased competition which has reduced the stream's carrying capacity for coho salmon. Predation and competition is also intensified because of the disproportionate size difference between hatchery steelhead and coho and "wild" coho. This artificial situation adds an additional predator to the system an in an area already lacking in pools and cover needed for escape.

To reduce predation and competition, habitat conditions should be improved. If not corrected these conditions could lead to a total loss of coho over the next 10 to 20 years. To survive predation coho need cover and other preferred habitats readily available, deep pools which provide cover and also provide refuge from warm surface waters. Lack of habitat and cover created by artificial dewatering has increased predation by other natural enemies such as raccoons, garter snakes, egrets, kingfishers and herons. If we expect to save the remaining coho populations in this region, there is a critical need to improve these vital coho habitats by increasing summer flows, improving and stabilizing spawning habitat and creating better pool and rearing conditions to reduce the effects predation and critically warm water temperatures.

Hatchery practices and water usages must also be adapted to reduce artificial competition in this critical habitat for central coast coho. Introduction of hatchery smolts has lead to increased predation on Scott Creek. These losses are considered to play a role in the decline of these coho salmon populations, the significance has increased due to the limited number of juvenile coho supported by these streams.

Central coast coho have been faced with limited spawning and rearing habitat for most of the years since the original clear-cut logging. The resulting reduction in reproduction has caused populations to be depressed for a long period of time. The ability of these depressed populations to recover from floods or drought events has been severely limited by the generally low population levels.

Available habitat on Waddell Creek, for instance, is not adequate to produce the 4,000 to 8,000 juvenile coho needed to produce spawning runs of 200 to 400 adults that can sustain the populations through further stochastic events

(Waples and Teel, 1990). Dr. Jerry Smith has conducted studies that show there are presently coho habitats that are not occupied. An underutilization of the preferred habitat by local cohos does not indicate that there is an overabundance of coho habitat. This situation does appear to suggest that coho do not exist in numbers adequate to fill the existing habitat or to sustain natural production over a long period of time.

Salmon have clearly evolved in and are accustom to a system that has occasional huge upheavals and they are adapted for survival in this environment. It must be made clear that it is the addition of numerous chronic negative effects that ultimately weakens the species and causes long term reduction in populations that finally leads to extinction (Dave Hope personal observation).

The ocean commercial and sport take of salmon on the central coast is established from estimates of runs from Oregon, northern California and Sacramento River coho and chinook salmon populations. Because the local coho salmon share ocean migration routes with these salmon populations, they can be incidentally harvested at rates beyond their capacity to sustain minimal escapement goals. With every return adult being critical, any losses can be considered excessive and adjustments in ocean harvest must be enacted to protect these stocks. In steam fishing can also be very detrimental, in reviewing 1990 through 1993 returns on Scott Creek (Monterey Bay Salmon and Trout Project (MBSTP), if 2 females were caught instream, 15 to 100% of the returning spawners would be lost. The existing allocations for Ocean commercial and sport fishing, combined with stream sport fishing, are problematic for the dwindling central coast coho spawning runs.

EVOLUTIONARILY SIGNIFICANT UNIT

South of San Francisco Bay or central coast coho salmon originated from specific watersheds and return to those streams to spawn, creating reproductive isolation of groups, or stocks, of salmon (Ricker, 1972). Because the central coast coho are separated by 50 miles from any other northern California coho stream (a long-standing condition), they may be considered a genetically isolated stock of Pacific salmon (Waples, 1991). The populations of central coast coho should be considered a distinct population segment of Pacific coast salmon, because these fish are reproductively isolated from north of San Francisco Bay coho salmon. The coho remaining in the central coast region of California as exhibited in Scott and Waddell creeks, are genetically , behaviorally and physically distinct stocks of coho salmon that are adapted to and self sustaining in their last two remaining natal streams.

Researchers have found that salmon populations can maintain genetic isolation even if one individual per year from an outside population enters and spawns with a given stock of salmon (Wright, 1978). This threshold is referred to as the maximum allowable gene flow rate. Studies on Scott and Waddell Creeks have shown that 15% to 26% of cohos respectively, may stray to streams up to 5 miles away (Shapovalov and Taft, 1954). This study also shows that a mere 1% of coho strayed to the San Lorenzo River, 13.5 miles away. In the case of central coast coho salmon, considering the limited straying rate of 15 miles the likely hood of fish straying 50 miles south from Marin County or 50 miles north from San Mateo County is so remote that justification for isolation is strong. Therefore the isolation of central coast salmon is both behaviorally and -

geographically founded and the declaration as a stock of pacific salmon is justified.

Given the great distance between Marin and San Mateo County it is unlikely that the maximum allowable gene flow rate has been exceeded until hatchery stocks were introduced in the early 1900's.

The first hatchery plantings did move coho in from outside stocks, the first plants were conducted in 1913. Because this may have brought in other stock genes, we must then consider what possible effects hatchery plantings may have had on central coast coho genetics. Table 1 is an excerpt from data compiled on hatchery fish plants into the central coast of California (this report is considered to be the most comprehensive research into hatchery plants ever compiled and is complete and up to date) (Streig, 1991).

TABLE 1

COHO SALMON

Coho Salmon Hatchery Plants and Returns

Fingerling Plants July-September	Fingerling Plants SCOTT	Fingerling Plants WADDELL	Source of Fish	Year	Adult Returns SCOTT	Adult Returns WADDELL
1909	None	None		1908-09	1,295*	N/A
1910	None	None		1909-10		
1911	None	None		1910-11	N/A	
1912	None	None		1911-12		
1913	25,000	15,000	Sisson	1912-13	N/A	
1914	None	None		1913-14		
1915	25,000	18,000	Sisson	1914-15		
to						
1928	None	None		1927-28		
1929	25,000	22,700	Unknown	1928-29	333*	N/A
1930	36,700	30,000	Unknown	1929-30	150*	N/A
1931				1930-31	N/A	409**
1932	15,000	None	Unknown	1931-32	N/A	748**
1933	18,592	16,005	Prairie Cr	1932-33	N/A	131**
1934	15,020	None	Unknown	1933-34	138*	395**
1935	10,000	None	Unknown	1934-35		111**
1936	5,248	None	Unknown	1935-36	72*	130**
1937	81,275	None	Unknown	1936-37	513**	279**
1938	77,060	None	Unknown	1937-38	681*	279**
1939	53,518	None	Unknown	1938-39	374*	324**
to						
1965	None	None	None	1964-65		
1966	None	10,000	Darrah Spr	1965-66		
1967	10,000	None	Darrah Spr	1966-67		
1968	# unknown	None	Noyo	1967-68		
1969	None	None	None	1968-69		
1970	None	# unknown	Noyo	1969-70		
1971	None	# unknown	Trinity	1970-71		
1972	None	None				
to						
1992	None	None				

*Estimates taken from Scotts Creek egg taking station. Egg production was divided by 2,700 (average female egg production) times 1.5. This formula assumes all females were trapped that year and a 60 to 40 male to female spawning run (Shapovalov and Taft, 1954; Streig, 1991).

**Shapovalov and Taft, 1954, FB #98, Table 10-11

N/A - Not available

Table 1 indicates that during 14 of the last 79 years on Scott Creek and 8 of the last 79 years on Waddell Creek, hatchery plants from an outside source occurred. On Waddell Creek there were five fingerling plants between 1913 and 1933, three plants between 1966 and 1971 and no hatchery plants in the last 22 years. What is of greatest significance is that no hatchery plants have been made on Waddell Creek in the last 22 years and only three plants (that were all trapped upon return) in the last 60 years. Scott Creek has had only two plants from outside sources in the last 54 years. THE STOCKS OF COHO IN SCOTT AND WADDELL CREEKS HAVE BEEN SELF SUSTAINING FOR MORE THAN TWO DECADES AND HAVE WITH ONLY MINOR INFLUENCE HAVE BEEN SELF SUSTAINING FOR AT LEAST FIFTY TO SIXTY YEARS.

The effect these hatchery plants had on genetic makeup of local coho populations should be viewed by using extensive genetic testing to determine their exact makeup. But in light of the limits of the existing science, several factors should be considered as reasons for limited genetic mixing with hatchery plants. With sporadic fingerling plants, it is unknown whether these hatchery coho survive to return and mix with the wild coho at rates high enough to influence the genetic makeup. This is due to the reduced survival of coho transplants from foreign streams (R. Reisenbichler, 1988).

There are reasons to believe that many planted fingerlings don't survive, due to a lack of predator avoidance skills possessed at the time when they are placed in the stream. In addition, feeding behavior is not well established in hatchery fingerlings due to their time spent as hand-fed young. In Pacific salmon, adaptation to local environments creates unique characteristics that increase fitness within a stock (E. Mayr, 1971). The non-native hatchery coho used within Santa Cruz County were derived from stream habitats that are dissimilar from local streams. Generally poor spawning conditions, high sediment loads and late winter storms create special conditions that require local adaptations which few other anadromous fish possess. These conditions are coupled with generally warmer waters, resulting in an overall success rate of transplanted hatchery stocks which approaches zero.

There has been much local discussion on behavioral differences between salmon from other locations. Observational evidence indicates coho plants from outside sources (northern California, Oregon, Washington), do not fare well in local streams (MBSTP). The difference in timing of return runs is especially evident in hatchery fish from other locations (D. Streig, personal communication). The return spawning runs of hatchery fish have been documented as early as August and generally from September through November (MBSTP Staff). The success of early run coho in accessing spawning grounds during the early fall period is poor, at best, due to the closure of the river mouths by sand bars (Shapovalov and Taft, 1954; Smith, 1990). Survival of eggs in these early run coho spawning redds is also poor due to the disturbance of the extremely mobile bedload and high sediment input from storms that occur from December to as late as March and April (Smith, personal communication).

Spawning success for early run hatchery fish under these circumstances is very poor. In reviewing the literature on hatchery return runs, their success at sea is poor, as documented by the lower percentage return rates (Chilcote, Leider, Lock; 1986). In the case of coho, hatchery reared smolts have not shown the same tenacity for producing adult returns as have naturally produced fish (McMahon, 1983). All of these factors reduce the total number of hatchery plants which have returned to mix with the "wild" stocks, as evidenced by Table 2.

TABLE 2

WADDELL CREEK DATA

Plant* Year	Plants	Year	Downstream Migrants	Returning Adults	Age Class 1/1	Age Class 1/2	
1930	30,000*	1930-31					
1931		1931-32		748	137*	611	
1932		1932-33		131	22	109*	246*
1933	16,005**	1933-34	3,430**	395	85	310	
1934		1934-35	3,573	111	4**	107	
1935		1935-36	4,911	130	34	96**	100**
1936		1936-37	1,067	279	24	255	
1937		1937-38	1,926	279	64	217	
1938		1938-39	852	324	71	253	
1939		1939-40	1,740	317	No data	No data	
1940		1940-41	152	288	No data	No data	
1941		1941-42	711	260	No data	No data	

Data taken from Shapovalov and Taft, 1954, Table 10-11

"Wild" Downstream Migrants	Adult Returns	%
3,573	284	4.9
4,911	241	4.9
1,067	417	39.0

Hatchery Plants or Plants + D.S. Migrants		Adult Returns	%
*P	30,000	246	.82
**P+D.S.	19,435	100	.51

This table shows that very few fish returned to spawn in the years following hatchery plants. The return of 1/1 males and all 1/2 males and females show that the 1930 plant of 30,000 fingerlings combined with the "wild" coho produced 137 1/1 males and 109 1/2 males and females. The 1933 plant of 16,005 fingerlings combined with 3,430 wild juvenile to produce 4 1/1 male and 96 1/2 male and females. The data indicates a low rate of return for these years, suggesting that the influence on genetic makeup by hatchery plants may be less than would be assumed by merely reviewing the number of fish originally planted.

Average return runs of coho salmon subtracting years of influence by plant was 4.9%, 4.9% and 39% (Table 2) during the Shapovalov and Taft study. Average returns for years including planting were 0.82% and 0.51%.

These figures do not take into account other factors that may influence the coho salmon return, but they do show that hatchery plants were probably not successful in returning great numbers of adults to affect the native populations.

It has been reported that as soon as the hatchery plants on many local streams were stopped, the coho salmon population crashed, some to extinction (Streig, personal communication). The San Lorenzo River is an example of this phenomenon. The extensive planting of fish from northern California streams and elsewhere appear to have helped to drive out native populations and created hatchery runs that were not able to sustain themselves after the hatchery program ceased (MBSTP).

Since hatchery plants from outside sources were discontinued 22 years ago, the remaining coho salmon runs on Scott and Waddell Creeks appear to be remnants of those "native" coho that could survive both the negative effects of hatchery plantings including some minor genetic mixing from sporadic fingerling plants. The poor survival rate of hatchery plants in general compared to the 5%-30% survival rate of native coho reported by Shapovalov and Taft (Table 2) also supports the assertion. The rate of gene influence by hatchery fish should not be considered adequate to remove important genetic differences between central coast coho salmon and north of San Francisco coho salmon. The fact that these stocks of coho are self sustaining even in the face of a BKD epidemic and abusive land practices gives credence to their adapting to the local conditions. (Silver-King Oceanic farms operated a commercial salmon ranching facility near Waddell Creek from 1967 through 1972. This facility trapped all returning fish, but some strays were noted by the Monterey Bay Salmon and Trout Project staff. The number of strays was not documented.)

"The existence of stocks, as defined by Ricker (1972), is no longer in doubt. The subdivision of a species into local populations which posses genetic differences that are adaptive is the fundamental basis of the stock concept, and it is this concept that must be incorporated into management if fishery reserves are to be restored and maintained" (MacLean and Evans, 1981). "We recognize that many instances will arise where there is doubt about the existence of a stock and insufficient evidence to remove the doubt. In those cases, we believe the prudent manager will recognize the stock in question until such time that enough evidence is collected to show otherwise. Since the loss of a stock is an irreversible loss, its existence should be given the benefit of any doubt" (Nehlsen, Williams and Lichatowich, 1991).

SPECIES DESCRIPTION AND BIOLOGY

COHO SALMON - Oncorhynchus kisutch

Coho salmon are widely distributed in streams along the California coast and are important to sport and commercial fisheries. Their life history is well known because one of the southernmost populations was the subject of the classic life history study by Shapovalov and Taft, 1954. They have adapted to the unpredictable conditions present in most California coastal streams. Coho salmon, nevertheless, have demanding habitat requirements and are most abundant in least disturbed, heavily forested watersheds. They move upstream in response to an increase in stream flows caused by fall storms, especially in small streams when water temperatures are 39-57 degrees F. Spawning sites are typically at the head of riffles or tail of pools where there ideally are beds of loose, silt-free, course gravel and where cover exists nearby for the adults. Optimal temperatures for development of the embryos in the gravel is 43-50 degrees F. Juveniles prefer deep (greater than 3 feet), well shaded pools with plenty of overhead cover. Juveniles prefer water temperatures of 50-59 degrees F and demand high oxygen and food (invertebrates) levels. High turbidity is detrimental to emergence, feeding and growth of young coho.

Description: These are fairly large salmon, with spawning adults typically attaining 22 to 28 inches in length and weighing 6.5-13.2 pounds. They have 9-12 dorsal fin rays, 12-17 anal fin rays, 13-16 pectoral fin rays, and 9-11 pelvic fin rays. Lateral line scales number from 121-148 and the scales are pored. There are 11-15 branchiostegal rays on either side of the jaw. Gill rakers are rough and widely spaced, with 12-16 on the lower half of the first arch.

Spawning adults are dark and drab. The head and back are dark green, the sides are a dull maroon to brown, and the belly is gray to black. Females are paler than males. Spawning males are characterized by a bright red lateral stripe, hooked jaw, and a slightly humped back. Both sexes have small black spots on the back, dorsal fin, and upper lobe of the caudal fin. The gums of the lower jaw are gray, except the upper area at the base of the teeth which is generally whitish (Fry, 1973). Parr have 8-12 narrow parr marks centered along the lateral line. The marks are narrow and widely spaced. The adipose fin is finely speckled, imparting to it a gray color, but the other fins lack spots and are tinted orange.

Taxonomic Relationships

Coho salmon are one of five species of Pacific salmon (Oncorhynchus) found in California. They do not appear to have the genetically distinct, temporally segregated runs that characterize the more abundant chinook salmon and steelhead trout. However, the strong homing abilities of coho salmon make it likely that each coastal stream has a distinctive strain of coho adapted to local environmental conditions. For the purposes of this section, the coho populations are divided into big-river coho salmon and short-run coho salmon. Big-river cohos are those that migrate up large river systems 65-130 miles or more to spawn in the river tributaries. They typically start entering the streams in September or October, somewhat earlier than short-run coho. In the Klamath River and some other systems, much of the production of the big-river fish takes place in hatcheries.

Short-run coho salmon occupy the smaller coastal streams and the tributaries of the lower reaches of the big rivers and rarely migrate more than 65 miles upstream. These populations in any one stream system are typically small and highly dependent on natural reproduction. Overall, coho populations in California are the southernmost for the species and have adapted to the extreme conditions (for salmon) of many coastal streams. From Mendocino County south, the conditions in California are even more extreme. The physical, climatic, and hydrologic factors make coho salmon survival in the far southern end of the range even more rigorous.

Life History

The life history of the coho salmon in California has been well documented by Shapovalov and Taft (1954) and Hassler (1987). Most coho salmon return to their parent streams to spawn after spending two years in the ocean (up to three years in Alaska). Jack males may, however, return after one growing season in the ocean (at age 2 years), but most fish in California return after two growing seasons in the ocean (age 3 years). In California, spawning migrations begin after heavy late fall or winter rains breach the sand bars at the mouths of coastal streams, allowing the fish to move into the streams. However, migration typically occurs when stream flows are either rising or falling, not necessarily when streams are in full flood.

In the Klamath River, the coho will run between September and late-December, with peak runs occurring during October and November. Spawning itself occurs mainly in November and December (U.S. Fish and Wildlife Service, 1979). In Waddell Creek, peak spawning is between January 15 and February 15 and spawning migrations often do not begin until late November or December (Shapovalov and Taft, 1954). In Oregon streams spawning can occur as late as March, if drought conditions delay rains or runoff (Sandercock, 1991). This condition also exists on Scott and Waddell Creeks in California (Smith, 1991).

Coho salmon migrate and spawn mainly in small coastal streams that flow directly into the ocean or in the tributaries of large rivers. Females choose the spawning sites (redds), usually near the head of a riffle (at the tail of a pool) at, or slightly upstream of the hydraulic control, where the water changes from a smooth to a turbulent flow and there is a medium to small gravel substrate (1/2"-4.4"). The flow characteristics at the location of the redd usually ensure good aeration, and the circulation facilitates fry emergence from the gravel. Each female builds a series of redds, moving upstream as she does so, and deposits a few hundred eggs in each. Thus, spawning may take about a week to complete and a female can lay between 1,400 to 7,000 eggs. There is a positive correlation between fecundity and size of females. Both males and females die soon after spawning. In Scott and Waddell Creeks, the average egg production is 2,700 showing the smaller average size of central coast coho salmon.

Eggs hatch after 8-12 weeks of incubation, the time being inversely related to water temperature. Hatchlings remain in the gravel until their yolk sacs have been absorbed 4-10 weeks after hatching. Upon emerging, they seek out shallow water, usually along the stream margins. Initially they form schools, but as they grow bigger the schools break up and the juveniles (parr) set up individual territories. The larger parr tend to occupy the heads of pools; the smaller parr are found further down the pools (Chapman and Bjornn, 1969). As the fish continue to grow, they move into deeper water and expand their territories until, by July and August, they are in deep pools. Territory size in coho is inversely related to the amount of food available.

Growth rate slows at this stage, possibly due to lack of food or because the fish stop or reduce feeding as a result of warmer temperatures. Some evidence suggests that when coho are in warmer waters, their metabolic rate increases and a larger percentage of energy derived from food is used to fuel normal metabolic processes, to the detriment of growth. Lethal temperatures appear to be around 65-68 degrees F.

Between December and February, winter rains result in increased stream flows and by March, following peak flows, fish again feed heavily on insects and crustaceans and grow rapidly. Toward the end of March and the beginning of April they begin to migrate downstream and into the ocean. Out-migration in small California streams typically peaks from mid-April to mid-May, if -

conditions are favorable. Migratory behavior is related to rising or falling water levels, size of fish, day length, water temperature, food densities and dissolved oxygen levels. At this point, the outmigrants are about one year old and 10-13 centimeters in length. The fish migrate in small schools of about 10-50 individuals. Parr marks are still prominent in the early migrants, but the later migrants are silvery, having transformed into smolts.

After entering the ocean, the immature salmon initially remain in near-shore waters close to the parent stream. They gradually move northward, staying over the continental shelf. Coho salmon can range widely in the north Pacific, but the movements of California fish are poorly known (although fin clipped fish from the Scott Creek hatchery have been caught in Morro Bay to the south and Half Moon Bay to the north, MBSTP). Most coho caught off California in ocean fisheries were reared in coastal Oregon streams (natural and hatcheries). In 1990, for instance, 112,600 coho were caught in commercial and recreational ocean fisheries, a number which greatly exceeds the present production capability of California populations alone (A. Baracco, California Department of Fish and Game, personal communication).

Oceanic coho tend to school together. Although it is not known if the schools are mixed, consisting of fish from a number of different streams, fish from different regions are found in the same general areas. Adult coho salmon are primarily piscivores, but shrimp, crabs, and other pelagic invertebrates can be important foods in some areas.

HABITAT REQUIREMENTS

Coho salmon move upstream in response to an increase in stream flow caused by fall storms, especially in small streams when water temperatures are 39-57 degrees F. Spawning sites are typically at the head of riffles or tail of pools where there are beds of loose, silt-free, course gravel and cover exists nearby for adults. Unlike other salmon species, coho salmon redds can be situated in substrates composed of up to 10% fines (Emmett, et al, 1991) , but in general, spawning success and fry survival are favored by very clean gravels consisting of less than 5% fines (California Department of Fish and Game, 1991). Dr. Jerry Smith and Don Alley, a consulting fisheries biologist, have observed coho spawning in areas where fines composed up to 70% of the substrate. These redds were reportedly successful in producing young. Spawning depths are 4-21 inches, with water velocities of 6.5-26.2 feet per second (Hassler, 1987). Optimal temperatures for development of the embryos in the gravel is 43-50 degrees F, although eggs and alevins can be found in 40-70 degrees F water. Dissolved oxygen levels should be above 8 mg/l for juveniles (Emmett, et al, 1991).

J. SMITH

Juveniles prefer deep (greater than 3 feet), well shaded pools with plenty of overhead cover; highest densities are typically associated with logs and other woody debris in the pools or runs. Juveniles require that water temperatures not exceed 71-77 degrees F for extended periods of time and that oxygen and food (invertebrates) levels remain high. Preferred temperatures are 50-59 degrees F (Hassler, 1987); preferred water velocities for juveniles are .25-1.5 feet per second, depending on habitat. High turbidity is detrimental to emergence, feeding and growth of young coho (Emmett, et al, 1991). Young and adult coho salmon are found over a wide range of substrates, from silt to bedrock.

HISTORIC AND CURRENT DISTRIBUTION

California

In California, principal populations are located in the Klamath, Trinity, Mad, Noyo, and Eel rivers, with other populations in smaller coastal streams south to Scott and Waddell Creeks. In the Eel River system, they formerly ascended 390 kilometer (246 miles) of stream in 69 tributaries (Mills, 1983) of the South Fork Eel, the lower main stem Eel River, and the Van Duzen River (Brown, 1987). Annual runs in the Eel River system in earlier years have been estimated at over 40,000 fish (U.S. Heritage Conservation and Recreation Service, 1980); current runs are probably less than 1,000 fish (Brown and Moyle, 1991). Brown and Moyle (1991) found historical records of occurrence of coho in 582 California streams, ranging from the Smith River near the Oregon border to the Big Sur River on the Central Coast. More recent surveys available for 42% of these streams indicate that 46% have lost their populations (Brown and Moyle, 1991).

Generally, the further south a stream is located, the more likely it is to have lost its coho population (Brown and Moyle, 1991). Coho salmon are rare in the Sacramento River even though several attempts have been made to establish runs (Hallock and Fry, 1967). It is likely that runs occurred at one time at least in tributaries to San Francisco Bay, if not in more interior streams. Coho salmon of hatchery origin also have been stocked in reservoirs such as Lake Berryessa with considerable success. The coho do not reproduce in reservoir tributaries, however, and thus must be restocked annually to support angling.

Santa Cruz/San Mateo/Monterey Counties

Coho salmon were widely distributed on the central coast of California until the 1960's. Surveys in the 1970s showed 4 streams in San Mateo County, 6 streams in Santa Cruz County and 2 streams in Monterey County had documented runs of coho salmon. These streams were San Gregorio, Pescadero, Butano, Gazos, Waddell, Scott, San Vicente, Soquel, Aptos, and Soquel Creeks and San Lorenzo, Carmel and Big Sur Creeks (Hassler, Sullivan, Stern 1991). On the central coast the 13 streams with historic runs of coho in the 1800's were reduced to 12 in the 1970's, and probably 4 in the early 1980's and finally 2 in the mid to late 1980's (Dave Hope, personal observation).

The loss of coho salmon has progressed generally from the south end of the region to the north, although since the mid 1980's, there have been no documented sightings or electrofishing data showing evidence of coho salmon in San Mateo County streams to the north of Scott and Waddell Creeks.

Pescadero Creek, a tributary to the Pajaro River, had strong runs of coho salmon in the 1920's and 1930's, but lost it's coho salmon runs by 1968 (Dave Streig, personal communication); Corralitos Creek, a major tributary in the Pajaro Valley above Watsonville also lost its coho population at that time (Lollock, Vestel, 1968). In Aptos Creek, coho salmon were last observed in the winter of 1973 (Dave Streig, personal communication). In Soquel Creek, the last coho runs were in 1968 and only stray coho from the San Lorenzo River have been observed since 1968 (Matt McCaslin, MBSTP, personal communication). The San Lorenzo River lost its coho salmon runs in 1977-78 soon after the drought and stocking of hatchery fish was terminated (Matt McCaslin, MBSTP, personal communication). The last stream in Santa Cruz County to lose it's coho salmon runs was San Vicente Creek in the winter of 1981-82 (Dr. J. Smith, personal communication). Recent unpublished surveys in 1991 show no coho in San Vicente Creek (Dr. J. Smith, personal communication).

Coho salmon runs in San Mateo County appear to have been lost in the early 1980's, and no confirmed sightings of coho have been made in San Mateo County since 1986, although only scattered data has been collected recent studies in 1992-93 found no coho salmon in Gazos Creek (Keith Anderson, Jennifer Nelson California Department of Fish and Game, personal communication). In San Mateo County, streams listed with coho in the 1970's were Pescadero Creek, Gazos Creek, Butano Creek and San Gregorio Creek (Cherr and Griffin, 1979). With coho salmon runs extinct in Monterey County and if runs have indeed been lost in San Mateo County, Scott and Waddell Creeks are the only streams south of San Francisco Bay which still have documented runs of wild coho salmon.

HISTORIC AND CURRENT ABUNDANCE

California

Historical figures of state-wide coho salmon abundance are estimates made by fisheries managers, presumably based on limited catch data, hatchery records and personal observations of runs in various streams. Estimates for the number of coho spawning in the state in the 1940's range from 100,000-200,000 (Gerstung, California Department of Fish and Game, personal communication) to close to 1 million (California Advisory Committee on Salmon and Steelhead Trout, 1988). According to some researchers (Brown and Moyle, 1991), coho population numbers held at about 100,000 in the 1960's and dropped to an average of 33,500 during the 1980's (Brown and Moyle, 1991). The reliability of these estimates is uncertain, and they must be viewed only as "order-of magnitude" approximations. Brown and Moyle (1991) estimated that the total number of adult coho salmon entering California streams in 1988-90 averaged about 31,000 fish per year. However, hatchery fish made up 57% of this total, and many main stem populations contain at least some fish of recent hatchery ancestry. The hatchery stocks, without exception, have in their ancestry fish from other river systems and often from outside California (Brown and Moyle, 1991). This may explain the overall lack of genetic differentiation of coho salmon from different California streams that have been extensively planted (Bartley, 1991).

Brown and Moyle (1991) considered 5,000-7,000 fish to be a realistic assessment of the total number of naturally spawned adults returning to California streams each year since 1987, although this number includes some stocks that contain fish of recent hatchery derivation. Presently, there may be less than 5,000 wild coho salmon spawning in California each year, and many of these fish are in populations composed of less than 100 individuals. These small populations likely fall below the minimum population size required to preserve the genetic diversity of the stock and provide a buffer from natural environmental disasters. Based on stock population assessments, it appears that coho populations are in decline and there is every reason to believe that California's coho populations will continue to decline based on existing information. Higgins (1992) divides California's coho populations in to 18 "stocks"; 10 of these are considered to be "at high risk of extinction." Coho salmon abundance in Oregon is also low (Nehlsen, 1991), and the species is classified there as "sensitive-critical" (Weeks, 1992).

Santa Cruz/San Mateo/Monterey Counties

Estimates of populations were derived from average returns per 1,000 feet of stream, as reported by Shapovalov and Taft. (Waddell Creek was calculated to have 28,000 feet of coho habitat with an average return of 281 coho.) Average length of streams was estimated by calculating areas open to migration with suitable habitat and less than 2.5% gradient. Estimates were made to indicate the scope of decline as requested by the State petition guidelines. No inference is made that this data is compiled by any means other than those stated. All estimates should be considered to be average low-end ranges.

The recent population estimates are based on some instream trapping surveys and diving studies. Although these studies have not been extensive enough to make definite conclusions, no evidence exists to contradict the downward trend and the estimates given. Declines in central coast coho salmon populations in the thirteen streams that historically supported coho salmon range from 90% to 100%. The four southernmost streams in Santa Cruz County and all 3 Monterey County streams have completely lost their coho populations. The two remaining streams, Scott and Waddell Creeks, have sustained losses of approximately 90 to 95%.

Studies conducted by Dr. Jerry Smith in 1992,93 (copies attached) confirm that coho salmon populations are very low, with 19 juvenile coho found in sampling Waddell Creek and 42 juvenile coho found in sampling Scott Creek in 1992. Results for 1993 look more promising with 119 coho juvenile found in Waddell Creek. Recent sampling and field review on Scott Creek shows a good spawn with many juvenile coho present (study unpublished).

No coho salmon runs have been documented or coho found in surveys conducted in San Mateo County since the early 1980's. Although not conclusive, existing evidence would indicate that coho runs have ceased, on Pescadero, San Gregorio, Butano and Gazos Creeks. Conservative estimates of the total spawning run in these four streams using average production rates multiplied by habitat area available during the 1800's, is 1,100 returning adult coho salmon. If present trends continue, it is estimated that extinction of coho on the central coast of California could occur between the years 2000 and 2010.

The San Lorenzo River at this time has a hatchery supported run of coho salmon (from Noyo and Prairie Creek eggs source) conducted by the Monterey Bay Salmon and Trout Project. Natural reproduction from the returning run is extremely limited, however (MBSTP, personal communication).

Listed on Table 3 are the estimated historical and present runs for Santa Cruz and San Mateo counties.

TABLE 3

Historical and Present Coho Spawning Runs on Various Santa Cruz /San Mateo/Monterey County Streams

Source			Year	Present	
E	Big Sur River	200	1800's	0	S
E	Carmel River	400	1800's	0	S
E	Salinas River	600	1800's	0	S
E	Pajaro River	1,000	1800's	0	S
E	Aptos Creek	100	1800's	0	S
E	Soquel Creek	180	1800's	0	S
E	San Lorenzo River	3,000	1800's	0	S
E	San Vicente Creek	200	1800's	0*	SS
E-D	Scott Creek	1,295	1908	15- 40	D
D	Waddell Creek	748	1932	20- 60	D
E	Gazos Creek	200	1800's	0	SS
E	San Gregorio Creek	200	1800's	0	
E	Pescadero Creek	700	1800's	0	S
		8,823		35-100	

Source

- E - Estimates
- D - Documented
- S - Spot surveyed, no coho salmon found
- SS - Surveys conducted and later repeated showing no coho salmon
- E-D - Estimated from documented egg taking data divided by 2,700 + 60%
- * - No native central coast coho

Table 4 provides an estimate of coho population numbers on Scott and Waddell Creeks, as well as the San Lorenzo River.

TABLE 4

POPULATION ESTIMATES AND DATA ON SCOTT AND WADDELL CREEKS — AND THE SAN LORENZO RIVER

Waddell Creek	Year		Number of Silver Salmon/Source	
1 year	1931-1932	=	748	1
10 year average	1930-1940	=	247	1
10 year average*	1980-1990	=	20-40	2, 3, 4
1 year **	1991-1992	=	85 total, 8 females	3,4,5
1 year **	1992-1993	=	?20-30 poor trapping results	
Scott Creek				
1 year	1908-1909	=	1,228	6
2 year average	1928-1930	=	241	6
3 year average	1936-1939	=	522	1
10 year average	1930-1940	=	350	1, 2, 3
10 year average***	1980-1990	=	20-30	2, 3, 4
1 year #	1992-1993	=	44 total, 17 females	2, 3
San Lorenzo River				
10 year average	1930-1940	=	1,500-2,000	3, 2
	1977-1978	=	0	2, 3, 4
	1978-1979	=	0	2, 3, 4
5 year average	1980-1985	=	10-20****	2, 3
5 year average	1985-1990	=	100-200****	2, 3
previous year	1990-1991	=	50****	2, 3
1 year	1991-1992	=	40-50***	2, 3
1 year	1992-1993	=	13 poor trapping	2, 3

1. Shapovalov and Taft, Fish Bulletin No. 98
2. Monterey Bay Salmon And Trout Project. Data obtained through diving, trapping and seine results.
3. Santa Cruz County Resource Planning Section
4. California Department Of Fish And Game
5. Dr. Jerry Smith
6. Estimates from egg taking data divided by 2,700 (average egg, production per female) times 3 (2 to 1 male to female ratio).

*Estimates only, gained through interviews, consensus on returns, a Santa Cruz County Resource Section and California Fish and Game Department.
**Marked fish and recapture estimates (Dr. J. Smith).
***Artificially propagated fish from the MBSTP.
****MBSTP propagated fish and some repropagation of return runs. # Many coho were not trapped and spawned naturally not shown as total.

SETTING

Scott and Waddell Creeks- Central California Coast

The settings for central California coastal coho streams are similar to the two remaining watersheds as most originate in the Santa Cruz Mountain Range.Scott and Waddell Creeks are neighboring watersheds that flow into the Pacific Ocean within four miles of one another. These two streams are located on the north coast of Santa Cruz County approximately 15 miles to the north of the City of Santa Cruz. Scott Creek has the larger watershed, 35 square miles, while the Waddell Creek watershed covers 26 square miles.

The headwaters of both creeks begin in the redwood forests of the Santa Cruz mountains at an elevation of approximately 2,500 feet, and terminate in lagoons that are closed by sand bars during the summer months. The watersheds receive the majority of their rainfall between October and April and the headwaters receive a mean average rainfall of between 60 and 70 inches. The coastal areas average between 25 and 35 inches of rainfall per year. Flows range from peak winter flows of 5,000 cubic feet per second to summer flows of less than 1 cubic foot per second during drought periods. Average winter storms can produce 1,000 cubic feet per second flows and summer flows average between of 3 and 5 cubic feet per second.

Scott and Waddell Creeks are typical small coastal streams. Their main stems are 18 and 12 miles long respectively, with 35 to 45 miles of total tributary length. The water courses begin as small headwater streams that traverse many different geologic formations. In granitic or limestone areas the water tumbles or falls rapidly through narrow canyons and ravines, while tributaries in sandstone areas posses sandy substrate and lower gradients. The lower portion of these basins experience dense fog during the spring and summer. The headwaters areas are hot, and support upland coniferous forest and dry chaparral plant communities.

These two streams are very diverse in the types of stream habitats they exhibit. The headwater areas are characterized by both broad meadows with meandering streams and also contain incised bedrock channels with boulder cascades and waterfalls. These channels traverse mixed coniferous forests, forming large deep pools and a turbulent stream that transitions into main stem areas.

Lower headwater areas are Rosgren channel types, A2 and A3 stream types, with the mid sections exhibiting B1, B2, B3, B1-1 and C1 through D4 types and the two lower sections show mostly C1, C1-1, C3, C4, stream types. Waddell Creek is composed of 52% type C, 47% type B and less than 1% type A channel. Scott Creek is composed of 77% type C, 17% type B and 6% type A channel.

The upper main stems of both creeks are characterized by wide stream channels with fewer pools, and possess gravel and cobble substrate with sand deposits in slack water areas. The banks in this area are lined with red alder, big leaf maple, buckeye, tan oak, huckleberry, madrone, and California bay laurel. The lower reaches are low gradient sections with sand and gravel beds. The banks in the mid section are lined with white alder, black cottonwood, willows, redwood and Douglas fir and an occasional California nutmeg. Shallow pools and riffles give way to long pool and glide sections leading to the lagoons. The channels upstream of the lagoons are dominated by alder and willow, while the lagoons themselves are surrounded by grasslands or cultivated crops.

NATURE OF THE THREAT

Central Coast Coho

Human development and it's associated impacts is primarily responsible for the decline of central coast coho salmon populations. Habitat loss, disease, over-exploitation and other human-related influences on the populations of central coast coho salmon have created a critical situation for the continued existence of coho salmon south of San Francisco. Many events over the last 100 years have combined to reduce the coho populations to their dangerously low levels in these streams and in California in general. Habitat, disease, loss combined with the disruption caused by floods and droughts, commercial over-harvest and agricultural diversions appear to constitute the most obvious threats to central coast coho salmon populations at this time.

Watersheds

The favorable habitat conditions present in these watersheds prior to the 1800's have been dealt many serious setbacks. The clear cutting and burning of the entire watershed at the turn of the century resulted in increased runoff, excessive erosion and sedimentation. Increased runoff transported soils into the streams, causing channel erosion in upland areas, deposition of bedload and streambank erosion in the lower mainstems of the streams.

Erosion and sedimentation, when accelerated by human activities, clearly can be seen to have escalating effects. An increase in bedload aggrades stream beds which, in turn, causes increased bank erosion. Bank loss directly affects sediment loads, further increasing aggradation. Bank loss also widens streams, slowing flows and resulting in increased sediment deposition and even more aggradation, especially in lower gradient areas. The resulting widened streams possess shallow, sediment laden stream beds.

This cycle of increased erosion and sedimentation tends to be self perpetuating and an extended period of quiescence is required for stream processes to establish a new equilibrium. This accelerated period of erosion and aggradation in the Scott and Waddell Creek watersheds was followed by normal flood events that caused widespread collapse of stream banks. Riparian trees downed during these events then diverted flows into banks and caused still further bank erosion and sedimentation.

Loss of riparian trees removed shading and further warmed the shallow streams. This caused problems, especially in the lower reaches with gradients of less than 2.5% gradient used extensively by coho salmon as preferred habitat (Dr. J. Smith, personal communication). Quality coho habitats include cool waters found in deep pools or side channels, now filled with accumulated sediment. Other habitat elements, large woody debris, rootwads and large trees, were also missing because of lack of recruitment after the clear cutting operations removed all old of the growth timber. This lack of recruitment was followed by aggressive removal of log jams and downed trees beginning in the 1950's. Old growth timber is critical in this type of watershed because these large immovable trees are critical for the creation of scour pools. Trees and rootwads provide cover and form good habitat even in low gradient sections prone to sedimentation.

Following the clear cutting operations, the stage was set for a long slow recovery. Small coastal watersheds in this condition have limited hydraulic power to transport bedload, especially when flows are not concentrated in the mid channel by competent stream banks. Bedload transport in lower gradient areas near the coast has been particularly affected. This region is, again, the preferred habitat of the coho salmon on Scott and Waddell Creeks (Dr. J. Smith, personal communication).

Lagoons

Bedload transport to the ocean has also been hindered in these two watersheds by highway fills across the lagoons. Large fill projects associated with highway bridge crossings inhibit the flushing of bedload and stop the normal range of a stream seeking for weak breaching points. The most pronounced effect on the breaching occurs during low flow periods when sand bar accumulations are sometimes immediately opposite the highway fill and bridge and armored fill is across 95% of the lagoon blocking normal breaching.

The Scott Creek lagoon was modified not only by the Highway 1 bridge and fill, but also by agricultural development (Marston, 1992). The highway and agricultural modifications of the lagoons have greatly reduced the channel cross-section. The USGS Davenport Quad shows construction of a levee prior to 1955. This levee can still be seen today confining Scott Creek to a narrow channel of 50 to 60 feet and blocking off access or causing backwater siltation to the remainder of the lagoon which is 900 feet wide by 500 feet long. Prior to the highway construction the sandbar impounded lagoons breached at altering locations depending on changing site conditions. Breaching occurred at locations of least resistance, often at the southern edge of the sand bar were accumulations of sand are less due to the southeast littoral drift pattern or at areas of wind protection. The existing fill crossings not only reduce lagoon capacity but they limit stream meandering at a critical point of ocean entry.

In the case of Scott Creek it is now forced to flow to the ocean to the north in a less direct path where sand accumulations are greater. This increases the hydraulic force necessary to breach the sand bar. The larger sand deposits require greater lagoon volume to breach, often causing delays in breaching compared to other streams (Marston, 1992). The lagoon alterations have adversely affected all aquatic species, especially coho salmon, as adults have been observed to school at affected river mouths due to lagoon closures (Marston, 1992). Such schooling increases the exposure to predation by marine mammals and may cause lower egg survival. The timing of the spawn is critical to these short run coho, and can easily disrupted by delays in run timing. The higher straying rate between Scott Creek to Waddell Creek (26%) compared to Waddell Creek to Scott Creek (15%) may be explained by the delayed breaching of Scott Creek compared to Waddell Creek. The late breaching often occurs after flows are diminished following a storm. When the sand bars finally breach following the of accumulation of adequate runoff in the lagoons, the instream flows have often declined to levels that restrict upstream migration.

The Scott and Waddell Creek lagoons exhibit both a lack of depth, cover and overall size due to sedimentation (Dave Hope, personal observation). This leaves fish with minimal area for growing and acclimation to salt water before entering the ocean. Additional human impacts to the lagoons and lower sections comes from dewatering. The local coho population numbers are so low that artificial dewatering of the lower portions of the stream in 1987, 1990 and 1991 killed many wild coho salmon, accounting for a serious loss of wild coho stocks from Scott Creek (Dave Hope, personal observation). Similar dewatering episodes on Waddell Creek during the drought period also have had serious effects on the coho populations in that stream.

During periods of heavy rains or floods, these streams have ample water for aquatic life and adjacent agricultural uses. Conversely, periods of drought result in decreased flows and competition between instream and agricultural uses. In the summer of 1987, there was a documented decline in the salmonid population level in the Scott Creek lagoon (Smith, 1987). This population reduction appears to be directly attributable to the degradation of the water quality of the lagoon due to warmer water temperatures caused by a reduction of surface flows entering the lagoon (Marston, 1992). In 1990 and 1991 the entire Scott Creek lagoon and a 1/2 mile reach of stream were dewatered. This dewatering trapped coho in pools, and ultimately led to a loss of all coho and other aquatic life in the lower portions of Scott Creek (Dave Hope, Jack Harrell, personal observations). Dewatering events have occurred on both Scott and Waddell Creeks throughout the historical period of agricultural diversion, contributing to the decline of central coast coho salmon.

Summer inflows to the lagoon often cease due to agricultural pumping from upstream wells which tap the subsurface flow in Scott Creek, resulting in a warmer and shallower lagoon (Marston, 1992). On Waddell Creek, the agricultural surface diversion draws on the demand of the pressure readings in the 6-7 mile pipeline. This line is in disrepair and breaks and leaks occur often. This causes the pump rates to increase to meet the pressure demands. This in turn leads to stream and lagoon dewatering events (Department of Fish and Game). The lack of inflows warms the lagoon, forcing the fish inhabiting the deeper, cooler, well oxygenated portion of the lagoon into warmer and less oxygenated waters. This results in greater mortality, increased predation and/or physiological stress (Dean Marston, 1992).

Over Exploitation

Over exploitation of central coast coho salmon populations has occurred for over 100 years. In the 1800's, returning coho salmon were pitchforked as they swam over the sand bar and harvested by the hundreds in these streams by anglers. In the past, the harvesting occurred instream and in the ocean, while today the largest harvests take place at sea.

Today, the limited escapement of juvenile coho salmon face major natural and unnatural threats when they enter the ocean environment. Many coho are lost at sea due to commercial and sport fisheries, and growing sea mammal predation. Commercial fishing quotas on the central coast are set by the Pacific Fisheries Management Council, using population estimates from larger river systems. These quotas do not take into consideration the overlapping ocean migration routes of salmon from smaller streams (Roger Haas, 1991).