SMOLT PRODUCTION FROM, PRAIRIE CREEK HATCHERY JUVENILE COHO REARED IN AN ARCATA WASTEWATER-SEAWATER POND, OCTOBER 1992-MAY 1993

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by George H. Allen
Professor Emeritus Fisheries, Humboldt State University, and
Fisheries-Aquaculture Consultant, HSU Fisheries Department and
City of Arcata Wastewater Utilization Program

BACKGROUND

In 1992 declining state, county, and municipal tax revenues in California, resulted in governmental agencies having to allocate reduced budgets between many competing social needs. Difficult choices were particularly noticeable at local levels (county, municipal, and special districts). In Humboldt County public-funded anadromous fish culture programs were not given high priority when compared to other public services. A county-operated hatchery located near Redwood National Park, Orick, California was an example. Although private citizens solicited combinations of state, county, and private funding sources to continue hatchery operations, these efforts were not successful and the hatchery had to close in late October 1992. When it was determined that hatchery operations were to be discontinued, planning for the disposition of the existing stocks of salmon and steelhead had to be undertaken by the primary responsible state agency for anadromous fisheries (California Department of Fish and Game). On learning of the possibility that the county hatchery might close, I made initial contact with the CDFG through Mr. Ken Gallagher, Hatchery Superintendent, Mad River Hatchery, who informed me that a special task force had been formed within the Department to formulate plans for the disposition of existing hatchery stocks, and that any suggestions for potential use of the stocks would be welcomed. Consequently, I drafted a proposal as forwarded to Mr. Dave McLeod, CFG,

Eureka, California, on September 4, 1992, outlining the availability of pond space for possible production of smolts from available Prairie Creek chinook, steelhead, and coho juveniles. Ponds identified for such smolt production were part of the Arcata wastewater-seawater salmonid culture system (AWWAP) located at the City of Arcata sewage treatment system on Arcata Bay (north arm of Humboldt Bay) (Figure 1). The ponds were being operated by the Fisheries Department, College of Natural Resources and Science, Humboldt State University, as part of a cooperative agreement on Wastewater Utilization with the City of Arcata. During the past two years, salmonid culture under Arcata funding has been limited to trout production for release to Arcata urban lakes and streams. Thus one pond (YP_1 - Yearling Pond No. 1 - 1/3 surface acre) (Figure 1), containing only a small number of coastal cutthroat juveniles, was available for rearing Prairie Creek coho. Although additional alternatives were proposed to use smolts to be produced in imprinting and homing experiments, any such experiments, however, had to be based on the need for returning the majority of the smolts to the Prairie Creek drainage (letter of March 3, 1993, John Hayes, Senior Biologist, CFG, Redding, Calif.). Under the proposed rearing program transportation of juvenile to and from Prairie Creek was provided by CFG fish hauling equipment located at Mad River. Mad River hatchery also supplied fish feeds as needed and was authorized to provide funding for minor emergency supplies and equipment as needed.

An initially estimated 34,000 coho juveniles, plus a few admixed steelhead that could not be segregated under existing transportation deadlines and available personnel, were planted into YP_1, Arcata, on October 28-29, 1992. Smolts produced at Arcata were returned to Prairie Creek and Redwood Creek drainages beginning March 18, with the last of nine lots released on May 7, 1993. Reported here is a summary of pond operations, number of smolts marked and released, and the total coho produced from the project. Also included in this report is a summary of the final disposition of all non-smolt coho juveniles resulting from the program, as well as the recovery of other species of fish reared in YP_1 with the Prairie Creek coho.

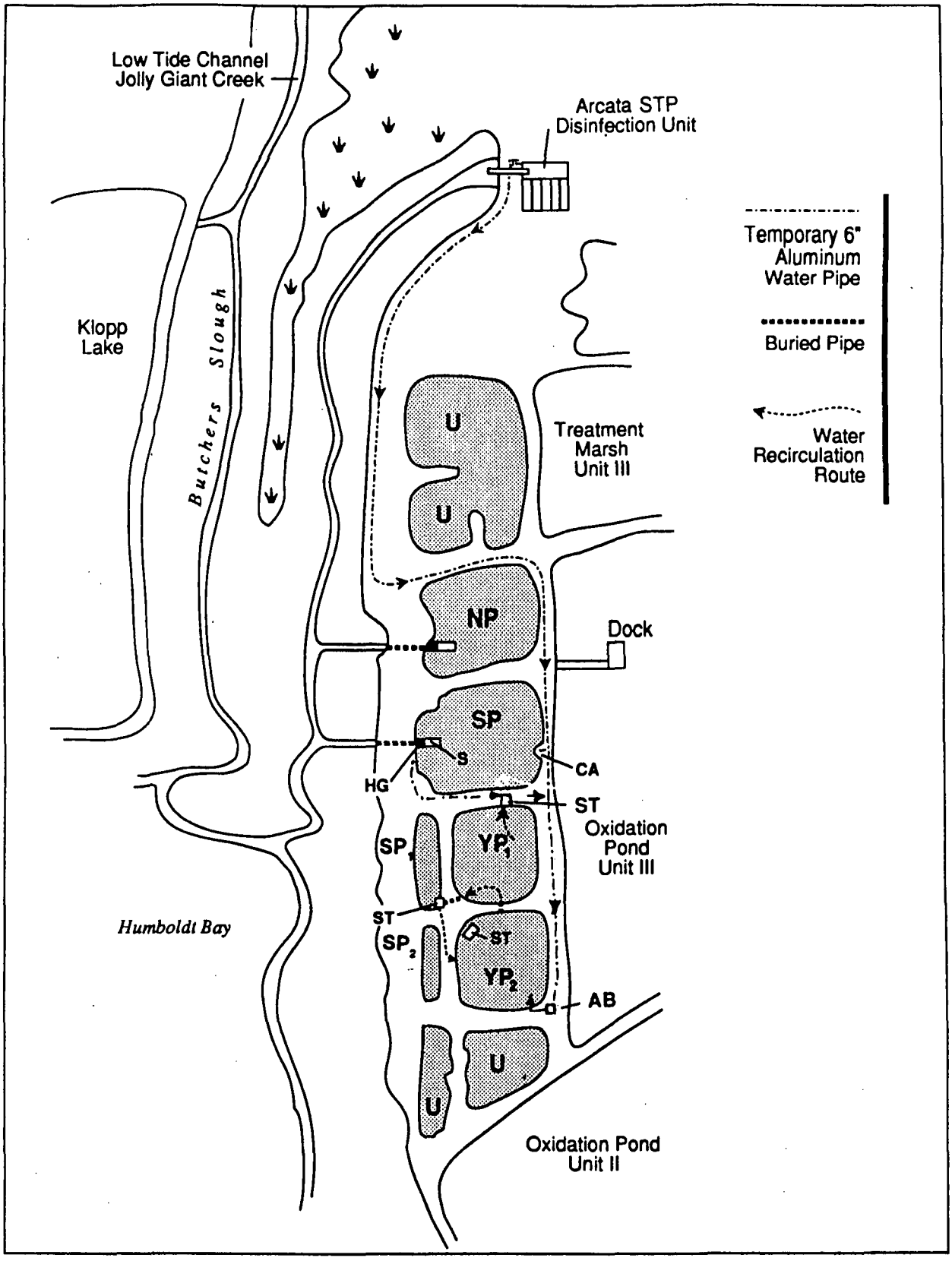

Figure 1. Arcata wastewater-seawater aquaculture ponds. (SP - South Pond; YP_1 - Yearling [Winter] Pond No. 1; YP_2 - Yearling [Winter] Pond No. 2; SP_1 - Summer Pond No. 1; SP_2 - Summer Pond No. 2; ST - Smolt Trap).

OPERATIONS

YP_1 was the first of two "production units" developed at the Arcata project following successful pilot-project studies (Del Sarto 1980; Miyamoto 1979). The pond (YP_1) has been described in detail by Leonhardt (1984) who reported on the first demonstration-level rearing experiments conducted in the pond. Through 1989, all Arcata ponds were employing a static mixture of wastewater and seawater as a culture medium. In 1990 tertiary level effluent from "enhancement marshes", constructed as part of a 1986 upgraded wastewater treatment system, was piped to the aquaculture ponds (Allen and Hull 1991). Beginning in 1992, a constant flow of marsh effluent, disinfected oxidation pond water and seawater was supplied to the two production units operated in series (Allen et al. 1992) (Figure 1). Effluent from YP_1 and YP_2 rearing ponds now discharge to a former pilot-project pond (South Pond), where effluents are tidally flushed to Humboldt Bay (Figure 1). South Pond now functions as the "home-stream" for smolts released at Arcata. Adult salmon returning to this homestream are caught in a trap fitted into the pond headgate during adult migration periods. Initial marked adult coho returned to South Pond in fall 1991 (Allen 1993).

Coho smolts are removed from AWWAP ponds by (1) trapping downstream migrant (DSM) smolts (North Trap and SW Trap; Figure 1), (2) by seining, and finally (3) by pond draining to remove remaining juveniles after cessation of smolt trapping. DSM has generally decreased in the ponds with the appearance of daily minimum temperatures of 17 C or above. This usually has occurred in late April or the first week in May. However, pond draining is mainly controlled by the availability of student personnel to assist in processing smolts.

In spring 1993 to assist with removal, counting, and fin-marking of smolts, a 1-unit course in Smolt Biology was offered on a voluntary basis by AWWAP aquaculture project consultant (G.H.Allen) and assisted by Dr. T. Kerstetter, biology department, HSU. Students in the class were essential to

the daily monitoring of the DSM traps. Two additional classes in fisheries and aquaculture assisted with seining and/or fin-marking smolts during peak recovery periods.

On October 28-29, 1992, 1,200 pounds of juvenile salmonids were transported and released into YP_1. Coho averaged 26 per pound. Along with coho juveniles, a small number of steelhead trout were mixed in with the allottment. In addition to Prairie Creek salmonids YP_1 also contained the survivors of 1,700 coastal cutthroat trout fry released into the pond in May 1992, in an experiment to test trout survival under high water temperature regimes that occur in unshaded ponds during hot-weather periods in late spring and early fall. Also in the pond were white sturgeon routinely retained in ponds as "cleaner fish".

Coho at the density planted into YP_1 in October 1992 have successfully produced normal-sized out-migrant smolts with no or only minimal supplemental feeding (Del Sarto 1980). Thus the Prairie Creek coho were only fed minimally (0.5% body weight per day). Feeding was discontinued in April except for a 5-day period when medicated feed (Romet) was fed at peak migration as a therapeutic measure.

RESULTS

From a revised estimate of approximately 31,200 coho released into the pond, over 27,000 juveniles (87 percent) were removed by personnel (Table 1). Of these, 22,000 (71 percent) were smolts. Of the 3,342 juveniles listed as parr removed by pond draining (Table 1), about 75 percent (2,540) were actually presmolt or smolting juveniles (see Discussion and Table 3). Thus nearly 80 percent of the Prairie Creek coho reared in the cooperative study attained presmolt or smolt condition. About 14,600 smolts were transported by Mad River hatchery personnel to Prairie Creek and Redwood Creek drainage between March 18 and May 7, 1993 (Table 2). Of these, 56 percent were fin-marked (RM, RP). About 6,000 smolts were released into South Pond, all of which were fin-marked left or right ventral (LV, RV). Of smolts released,

Table 1. Total live parr and smolts recovered from 31,200[1] coho juveniles from Prairie Creek released October 27-28, 1992, into YP_1, Arcata wastewater-seawater salmonid culture system[1] (hand counted).

	Number Recovered		
Method of Recovery	Parr	Smolt	Total Recovered
Trapping (DSM's)			
North Trap		8,805	
South Trap		3,586	12,391
Seining	1,727	6,613	8,340
Pond Draining	3,342[3]	3,078[2]	6,420
Total	5,069	22,082	27,151

[1]Number reported by Mad River hatchery (34,000) corrected for total pounds delivered (1,300 estimated versus 1,200), and for inclusion of steelhead trout.

[2]Includes some small (less than 11 cm) presmolts that were not separated during hand-counting.

[3]About 2,500 were in transition to presmolt and smolt stages (See Table 3).

Table 2. Number, fin-mark, and location of release of smolts recovered (hand counted) from Prairie Creek juveniles reared in YP_1 from 27-28 October 1992 to May 7, 1993, Arcata wastewater-seawater salmonid culture system.

Place of Release	Date Released		Fin-Mark	Number	No/Lb	Total Lbs
South Pond, Arcata	14 Mar - 20 Apr		RV	3,993	17	235
	25 Apr - 9 May		LV	1,836	17	108
	14 Mar - 9 May		UM	126+	20	6
			RP	9		
	Total			5,964+		349
McDonald Creek (Redwood Creek)	25 Mar		RM	800	23	32
Prairie Creek (Wolf Creek bridge)	18 Mar		RP	1,039	14	74
Prairie Creek (Davidson Creek bridge)	14 Apr - May 5	(4/14)	RP	1,000	17	40
		(4/20)	RP	2,150	14.6	147
		(4/26)	RP	1,089	20	90
			UM	697		
		(4/30)	RP	574	19.3	103
			UM	1,418		
		(5/03)	RP	610	21.4	74
			UM	978		
		(5/05)	RP	838	18.9	56
			UM	225		
		(5/07)	RP	110	27.5	116
			UM	3,075		
	Total			14,603[1]		732
Grant Total Smolts Planted				20,567+		1081
Yearling Pond No. 1 (Arcata)	10 May			5,069[2]	47	108

[1] RM: 800; RP:7,410; UM: 6,393.

[2] Uncorrected for mortalities during holding in tanks (see Table 3).

Table 3. Summary of smolts produced but not available for release, Prairie Creek coho rearing program, October 1992-1993, AWWAP.

Category	Description	Number	Remarks
Parr for 2-year-old smolt production	Stunts, parr, and small presmolts hand sorted at pond draining.	5,069	40% parr; 36% presmolt; 24% smolt.[1]
Precocious 2-year female (jill) production study	Larger smolts from traps and seining retained in SP_2.	270	Hand counts
Losses to toxicity in holding tanks	City tap water left running into recirculating system for 24-hour period.	~243	Hand counts
Marking and handling mortalities	Training sessions, with students clipping 2,000 RP smolts in single laboratory period.	~140	Hand counts

[1]Determined from 204 juveniles sampled from 274 fish being retained in holding tank.

71 percent were returned to Prairie Creek or Redwood Creek drainage, while 29 percent were released to South Pond. Virtually the same total poundage of coho (1200 pounds) was recovered as originally planted (Table 2).

DISCUSSION

RV-marked coho released to South Pond were taken from the early portion of the DSM (Table 2), with a smaller number marked LV mark released on or after April 26. The latter was an emergency release. Mortalities began occurring in the indoor recirculating holding tanks on a day when a large number of recently migrated smolts were being fin-marked RP by students for Prairie Creek release. Smolts marking was changed to the LV-clip and smolts released to South Pond during a short period when an experiment was undertaken to test whether water quality and/or student handling and fin-marking were causing holding tank losses. Subsequently, most mortalities in holding tanks showed hemorraghing at the base of the pectoral fin. Losses during this period in holding tanks were attributed to too-deep fin incisions and handling stress. About 400 smolts were lost in the holding tank from chlorine toxicity, or from marking and handling stress (Table 3).

Not all smolts recovered from YP_1 were fin-marked and planted A small complement (270) of the larger, faster-growing smolts were retained for a master of science thesis project (Table 3). The study objective is to describe ovarian development in two-year-old precocious female salmon. This study was stimulated by the production of 12 jills from force-feeding of accelerated smolts segregated from 0+ smolts being placed into YP_1 on December 1991. The population in YP_1 was sampled from July 1992 through February 1993. Cursory and unsophisticated observations of ovaries in females sampled suggested the posibility of abnormal ovarian development in some of these precocious female coho. The 270 faster-growing smolts sequestered from the Prairie Creek stock in spring 1993 are being reared in SP_2, and are to be heavily fed to in an attempt to again produce mature 2-year-old coho females. Review of the literature has produced virtually no papers describing ovarian

development in first-year in the ocean coho salmon, although such observations are employed in assigning status of maturity in coho sampled in research and commercial fisheries. Also documenting the rate of occurrence of mature 2-year-old coho females in wild or hatchery runs has been difficult. At the time of this report, we have located data on such fish occurring in a coastal Oregon drainage (Reimers, Paul, 1993; Oregon Department of Fish and Game. Personal Communication).

In reporting past results of Arcata coho rearing experiments I have made an effort to explain reasons for rearing losses. Allocations of unaccounted for coho in the Prairie Creek rearing program to various causes are tabulated in Table 4.

Furunculosis, BKD and vibriosis, are a normal fauna of estuarine and open-ocean seawaters, and sporatic losses to furunculosis and vibriosis have occurred in Arcata ponds. In the 1991-92 smolt rearing program warm weather during April produced confirmed losses from furunculosis in smolts (Allen 1993). The actual percent mortalities directly assignable to the disease was difficult to estimate. A unique eye-cloudiness was a particularly easily recognizable indicator of the disease, especially when observations of smolts was made in bright sunlight during fin-clipping conducted outdoors. Only very sporatic recoveries of coho with hemorraghing at fin bases or with ulcerations away from fin-bases, and no smolts with cloudy eyes, were recorded in the 1992-93 Prairie Creek coho rearing program. Fin-base hemorraghing was mainly noted in mortalities recovered from bioassay studies on fish retained in holding facilities in the indoor freshwater recirculating tanks as discussed earlier. Mortality due to disease certainly was not more, and probably less, than associated with experimental results during the previous three years of rearing (1990-1992) in which over 85 percent survival was recorded in all years.

Some losses in pond-reared coho could have occurred from predation by piscivorous fish in the pond (Table 5). Such predation could have been expected from the 127 Prairie Creek steelhead trout averaging over 20 cm in

Table 4. Summary of juvenile coho produced in YP_1, October 1992-May 1993 but not counted, and of assignment of losses to various causes, Prairie Creek coho reared in YP_1, October 1992-May 1993.

Category	Description	Number	Remarks
Operation Losses	Unmarked smolts lost to South Pond from unseated North Trap (1 day)	<100	Estimated
	Smolts surcharging temporary screens on SW trap during augmented flow studies (3 days)	50	Estimated
	Juveniles killed during seining; jumping from holding tanks	50	Estimated
Natural Pond Mortalities	Predation by resident kingfisher, eared-grebe, and 5 "guard" geese	Slight	No estimate
	Egrets, cormorants, Great Blue herons, and kingfishers have all gained temporary access to ponds	~ 50	Counts from regurgitated juveniles
	Juveniles consumed by steelhead, cutthroat and sturgeon	Unknown	Not assessed
	Direct pond mortalities (disease or other causes)	~100	Estimated from hand counts not yet tabulated
	Stunts recovered in DSM traps	~300	Estimated from hand counts not yet tabulated

Table 5. Summary of non-coho species recovered from YP_1 during rearing of Prairie Creek coho juveniles in YP_1, October 1992-May 1993, Arcata seawater-wastewater salmonid aquaculture system (hand counted).

Common Name	Scientific Name	Number
Cutthroat trout	*Oncorhynchus clarki*	433[1]
Steelhead trout	*Oncorhynchus mykiss*	127[2]
White sturgeon	*Acipenser transmontanus*	9[3]
Topsmelt	*Atherinops affinis*	47+
Stickleback	*Gasterosteus aculeatus*	250+
Herring	*Clupea pallasi*	125+
Staghorn sculpin	*Leptocottus armatus*	4+
Arrow goby	*Clevlandia ios*	1+
Shrimp	*Crangon* sp.	250+

+ Recoveries during pond draining. Not all specimens retained or counted.

[1] 25 percent survival of fry planted spring 1992.

[2] Most steelhead smolts were >20 cm. (13 percent recovered in DSM traps).

[3] 100 percent survival.

fork length recovered from YP_1, and especially in larger steelhead which attained 26 cm. Of the 433 coastal cutthroat trout recovered from YP_1 in spring 1993, most fish were about 13 cm, but some trout reached over 20 cm and also could have been expected to eat coho juveniles. In 1991-92 many large-sized cottids of two species were recovered from YP_1. In 1992-93, however, only a few small cottids were recovered so little predation on coho occurred from cottids. Some losses to predation by the nine "cleaner sturgeon" (mean fork length 80 cm; and mean weight 9 lbs) could have occurred. Predation on coho juveniles from all three species (steelhead, cutthroat, sturgeon) was actually observed. We noted surface feeding by sturgeon. Smolts were recovered from mouths of both steelhead and cutthroat trout during taken during seining. Such incidents, however, may have been artifacts associated with opportunistic feeding on crowded coho. Although a potential level of coho juvenile consumption by sturgeon and trout might be estimated from energetic-feeding rate parameters assumed available in the literature, I did not attempt such a study for this report.

A major loss to smolt production came from the known phenomenon of "stunting" by coho salmon when reared in brackish or saltwater environments for rearing. A variable percentage of coho when placed in such saline waters are unable to feed and slowly die of starvation. Slow-growing stunted parr were in Paririe Creek juveniles delivered to the Arcata ponds. One dip-net sample of parr was taken from each of the three loads of juvenile coho delivered and retained in a holding tank. A bimodal population was found in 162 re-sampled for length measurement. About 18.5 percent of the parr were less than 89 mm (mode 65 mm), with most juveniles ranging from 9 to 14 cm (60 percent 10-12 cm). Mortalities among these smaller fish was first noted associated with hauling stress. These mortalities were virtually all from the largest load of coho planted (500 pound load). Mortalities averaged 80 mm (range 46-110 mm). Further losses in stunted parr were recorded in DSM traps where as moribund juveniles drifted passively into the traps. About

16 percent of the original juveniles released into YP_1 never reached the normally assumed minimal size for smolting (roughly 10.5 cm).

By the time of pond draining, YP_1 contained many slow-growing parr just approaching the minimum smolting length (10-11 cm). Under normal conditions, an extra 2-3 weeks of growth would have produced smolting in these fish and presumably an associated DSM behavior. Additionally, many juveniles 10.5-12 cm in size were in the "pre-smolt" stage of livery and presumably would have emigrated if the pond had not been drained. Stunts, normal parr and presmolts of small size were hand-sorted from the larger presmolts and smolts recovered on pond draining on May 7, 1993. Larger presmolts and smolts were loaded directly into the planting truck. All smaller coho segregated were retained in available holding tanks. YP_1 was refilled and on May 10 smaller coho were returned to the pond for an additional year's rearing (Table 2,3). Stress from handling and holding was appearing in stunts in holding tanks prior to the time of release to YP_1. One tank had held juveniles up to 7 days. Since these tanks were not fitted with filters for water quality maintenance, an expected loss of stunts and other stressed juveniles occurred following planting (total count 1,234 from May 2-18). This was 4 percent of the original number of coho released into YP_1. Surviving juveniles began feeding in YP_1 soon after planting and were given a 5-day medicated feed (Romet) treatment.

There were some incidental losses of coho smolts during pond operations that can be counted as pond production (Table 4). Experiments were conducted to induce smolt migrations through "augmented" flows. Tripling the volume of flow through North Trap was possible through storing 3-4" of inflowing water. When released the stored water tripled the normal pond outflow. On the morning the May 1 when releasing stored water from YP_1 we found the North trap screen to be seated improperly. This allowed smolts to escape into South Pond over a previous 12-hour period. Seining in the South Pond sump to survey for unmarked coho produced only a single unmarked fish. Based on previous monitoring of smolt out-migration from South Pond by seining, the estimated

loss into South Pond was less than 100 unmarked smolts. During all three days of the augmented flow studies, a few smolts surcharged temporary screening at the SW trap. These smolts were either killed when sucked into the pump operating the trap, or gained entrance into SP_2 where they were observed amongst the 2+ adult coho being reared in brood stock studies.

Parr that subsequently failed to grow in the saltwater pond (stunts) and that survived to pond draining would have been ineffective if returned to Prairie Creek. Thus, roughly 5,000 stunted parr, small normal parr and presmolts, were sequestered and returned to YP_1 for additional rearing as noted. Some additional smolts can be expected from this group as two-year-olds. When the two-pond system began normal operations in early June, smolts began appearing again in the DSM traps (water temperatures 18.0-19.5^{0}C) and a few were still migrating by late June in water temperatures of 21-23^{0}C. Production of 1+ coho smolts will be monitored during spring 1994.

A summary of non-target species of fish and invertebrates recovered from YP_1 on pond draining is given in Table 5. The number and biomass of non-target species was low, probably due to competition from and predation upon by the larger salmonid population.

ASSESSMENT AND FUTURE PLANS

My original 4 September 1992 proposal for producing smolts from juvenile salmon and steelhead made available by Prairie Creek hatchery closure outlined a range in historical parameters recorded for previous coho rearing in the Arcata wastewater-seawater ponds. Prairie Creek juveniles attained the overall survival percentage recorded in the past three years (over 85 percent). About 44 percent of smolts from YP_1 in spring 1993 were trapped (volunteer migration). This equalled or exceeded percent removals by DSM trapping recorded during the past three years. Of the smolts released, 71 percent were returned to Prairie Creek or Redwood Creek drainage. The authorized split of 90:10 would have almost been attained (80:20) except for the emergency release of 1850 LV-marked smolts during late April to South Pond

and would have been fully implemented if the 2,500 presmolts if pond draining could have been held longer in the pond.

The cooperative project succesfully returned near 15,000 quality smolts to Prairie Creek. Two-thirds of these smolts returned to Prairie Creek were from downstream migrants. Del Sarto (1980) showed that such smolts rapidly continue their migration when immediately released into a freshwater stream. With the wet spring in 1993, smolts delivered to Prairie and Redwood creek drainages should have migrated rapidly to the ocean. The influence of early ocean survival as determined by near-shore water temperatures, and other oceanographic-related parameters, can only be addressed after monitoring returning marked adults. Traps at South Pond and on Jolly Giant Creek will be operated for capture of LV and RV-marked adults and such marks can also be monitored by HFAC trap on Freshwater Creek. Agencies administering salmon resources of the Prairie Creek and Redwood Creek drainages hopefully will monitor these drainages for marked adults returning in 1993 and 1994 migration seasons.

The cooperative rearing program was particularly successful in assisting the educational mission of the fisheries department at Humboldt State University. Students from three separate classes assisted in collecting, counting, and fin-marking smolts. In addition, the Prairie Creek smolts produced in spring 1993 will be contributing directly to two Master of Science theses projects. Out-migrants from YP_1 in spring 1994 will be studied by students in Wastewater Aquaculture. I foresee possible efforts at automatic counting of these smolts (Ouellette 1987) with direct migration to South Pond to avoid stress and losses from marking, handling, and transportation.

The estuarine location of the Arcata aquaculture system on a stream without any native run of coho provides a site where perceived conflicts between "native" and cultured stocks are not an issue. Thus the Arcata site has distinct advantages should any efforts to further enhance Humboldt Bay runs for recreational fisheries by artificual culture be considered. The relatively low operating and maintenance costs of the Arcata facility needs to

be documented at even higher levels of smolt production than employed in 1993 program in order to properly compare overall performance with traditional salmonid culture systems.

I consider the program of opportunity for rearing coho assigned to Arcata from Prairie Creek by the Department of Fish and Game to have been highly successful. Hopefully the Arcata wastewater-seawater rearing system as now being operated by the Fisheries Department can continue to serve the state and local needs in research and education, and in development of Humboldt Bay and adjacent ocean salmon fisheries as originally conceived in 1963.

ACKNOWLEDGEMENTS

With the overall reduced levels of coho stocks in north coastal streams over the past decade, it was extremely fortuitous that the Arcata system could be allocated coho juveniles to a density level approaching those in early pilot project work. The acceptance of the proposal to rear coho stocks available at Prairie Creek in the Arcata system represents a significant and high level of cooperation between the City of Arcata, the Fisheries Department at Humboldt State University, and the Caliofrnia Department of Fish and Game, which I would like to acknowledge and commend.

The program could not have been conducted with the skeleton crew available at the Arcata ponds (Mark Osburn, Graduate Student in Wastewater Utilization and Christine Jackson, Graduate Student in Fisheries - both one-fourth time positions). Consequently, the availability of students for seining and marking smolts by fisheries department of classes was critical to meeting project objectives. To those participating students and their professors (Dr. Roger Barnhart, Dr. Gary Hendrickson), I am most grateful. Students enrolling in the Smolt Biology class knew they were being recruited for a "hands on" experience and they subsequently provided the bulk of assistance with daily operations that provided the majority of marked smolts returned to Prairie Creek. Special help was provided by Dr. Joe Meyers, Wastewater Utilization Program Coordinator, Mr. Ken Gallagher, Mad River

Hatchery superintendent, and Mr. Vincent Franklin, Arcata sewage treatment plant operator and former fish technician on the project, who was responsible for setting up and operating city pumps for pond drainings. Mr. David Couch, Arcata sewage treaatment plant operator, and also a former fish technician, assisted in emergencies throughout the project. Mad River hatchery personnel were particularly cooperative with fish transport to Prairie Creek, often on very short notice. To the many other individuals on the list of over 50 faculty, students, and other personnel who participated in the program whom I cannot name individually, my sincere thanks. The continued cooperation and support of the California Cooperative Fishery Research Unit was very important to the success of the rearing project. Seines and marking equipment were particularly helpful. Delores Neher, Unit Secretary, typed all drafts and final report. And, finally to my wife who must have thought she was married to a smolt.

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