Benefits from Present and Future Salmon and Steelhead Production in California

A Report to the California Advisory Committee on Salmon and Steelhead

Meyer Resources, Inc.

April, 1988

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I. Executive Summary

It is estimated that realization of the goal of doubling salmon stocks in California would result in an additional 1 million chinook salmon and over 100,000 coho salmon in state waters. The Sacramento/San Joaquin system and the Klamath/Trinity system would provide the major portion of these improvements, with the Eel River also being a potential major producer. A doubling of steelhead in the state would see catch increase to approximately 130,000 fish, with the three above-named systems the major contributors. These estimates are based on available data, which is fairly good for the Sacramento/San Joaquin, variable for the Klamath/Trinity, and substantially incomplete elsewhere. The Eel in particular, given its significant potential, has suffered from a paucity of research in recent years.

This analysis, while developing California-wide estimates of benefit, will also feature three smaller rivers, the Navarro, the Carmel and the Ventura, to illustrate some of the economic benefits that can accrue from restoration of these smaller systems. Steelhead populations on the Carmel and Ventura Rivers are at risk, but no data on "existence values" for those systems is currently available. Consequently, the economic values presented here may significantly underestimate total benefits associated with those systems by area residents.

Finally, discussion with fishery experts confirms that the doubling target discussed here can be achieved, through a variety of actions to restore habitat and stocks and decrease instream mortality. These measures are further discussed in companion work by the California Salmon and Steelhead Advisory Committee.

It is estimated that a doubling of California's stock of salmon and steelhead would increase business revenues by approximately $75 million per year and create more than 8,000 new jobs. Annual net income to businesses is estimated at $30 million. Net economic benefits to Californians, from both business and non-marketed benefits are estimated to approximate $150 million per year.

Over future years, total potential net benefits to businesses resulting from a doubling of salmon and steelhead stocks are estimated to exceed $1 billion. Total future market and non-market benefits associated with doubling salmon and steelhead production are estimated to exceed $6 billion. If such a doubling of stocks were obtained, resulting benefits would justify an investment program in excess of $2 billion. These estimates are outlined in Tables 1 and 2, and are based on a 15 year investment program. They are sensitized in the body of this report.

It is not expected that investment of the full magnitude of monies identified here will be needed to double salmon and steelhead stocks. Rather, these estimates set the feasible upper limits of such an investment program, and identify the major benefits that such a doubling of stocks would bring to the people of California. Further, in many instances, more effective fishery protection, rather than straight dollar investment, will achieve the desired fishery restoration result--thus increasing net beneficial returns to California from salmon and steelhead still further.

Table 1

Estimated Benefits of Doubling California's Salmon and Steelhead

River System	Net Annual Benefits		Total Investment Value [1]	
	Business Benefits	Market and Non-Market Benefits	Business Benefits	Market and Non-Market Benefits
	$ millions			
Sacramento/ San Joaquin	19.7	101.4	886	4,561
Klamath/Trinity	6.8	23.5	306	1,057
Eel	3.0	16.1	135	727
Navarro	0.1	1.0	6	47
Carmel	0.05	1.1	2	50
Ventura	0.025	0.6	1	25
Other California Rivers	0.35	3.4	16	156
Total California	30.0	147.1	1,352	6,623

[1] Based on a 15 year program and a 1 percent rate of discount.

Table 2

Maximum Feasible Investment to Double Salmon and Steelhead Stocks in California

River System	Maximum Level of Viable Investment	
	Count Business Benefits Only	Count Both Market and Non-Marketed Benefits [1]
	$ millions	
Sacramento/ San Joaquin	750	1,000+
Klamath/Trinity	250	1,000
Eel	100	500
Navarro	5	50
Carmel	2.5	50
Ventura	1	25

[1] Based on a 15 year program and a 1 percent discount rate.

II. Present Production and Future Potentials of Salmon and Steelhead in California Streams

1. Overview

Estimation of present production and future potentials for salmon and steelhead in California streams is a difficult task. Production estimates are fairly good with respect to the Sacramento/San Joaquin system, are variable on the Klamath/Trinity system and become less complete or almost non-existent for other watersheds. Ocean catch is reported by port of landing, and does not necessarily reflect stream or state of origin. Estimates of potential capability to increase production are even more sparse. It is nevertheless possible to develop a general estimate of present production for California's chinook salmon, coho salmon and steelhead trout that provides a reliable basis for policy action, to establish feasible goals for increased production of salmon and steelhead resources in the state and to estimate the potential market and non-market economic benefits that may result from such restorative activity.

2. Present Production of Salmon and Steelhead in California

Our procedure for estimating present salmon and steelhead production in California was to first develop data for 6 producing watersheds indicated by the Salmon and Steelhead Advisory Committee (hereafter, the Committee). Basic data sources and procedures for each watershed are detailed in the following text. Estimates of contemporary production for chinook salmon, coho salmon and steelhead from California rivers are presented in Tables 3, 4 and 5.

Table 3

Estimated Contemporary Production of Chinook Salmon in California

River System	Escapement	Commercial Catch	Sport Catch	Indian Catch	Total Stock
	'000 of fish				
Sacramento/ San Joaquin	225	356	110	--	691
Klamath/ Trinity	60	156	15	15	246
Eel	22	46	5	--	73
Other rivers	9	32	2	--	43
Total for California	316	590	132	15	1,053

Table 4

Estimated Contemporary Production of Coho Salmon in California

River System	Escapement	Commercial Catch	Sport Catch	Total Stock
	'000 of fish			
Klamath/Trinity	12	20	11	43
Eel	4	7	3	14
Navarro	2	3	2	7
Other rivers	13	32	2	47
Total for California	31	62	18	111

Table 5

Estimated Contemporary Production of Steelhead in California

River System	Estimated Sport Catch -'000 fish	Estimated Stock Size
Sacramento/San Joaquin	14	35
Klamath/Trinity	22	88
Eel	22	88
Navarro	1	4
Carmel	<1	<4
Ventura	<1	<4
Other rivers	5	20
Total for California	65	243

We can observe that California streams presently produce, on average, some 1.1 million salmon, and that one million of these are chinook. The Sacramento/San Joaquin system produces about 2/3 of all chinook--mostly fall chinook, while the Klamath/Trinity system produces about 25 percent. Together, these two systems produce about 93 percent of California's king salmon.

The Klamath/Trinity system also produces an estimated 39 percent of the state's 100,000+ coho. Together, the two systems produce approximately 87 percent of all California's chinook and coho salmon.

We estimate that about 65,000 steelhead are caught in California each year, although as with salmon, this estimate is based on often uncertain data. The Klamath/Trinity, the Eel and the Sacramento/San Joaquin systems are estimated to produce most of this total.

3. Doubling Salmon and Steelhead Production in California

This report estimates the beneficial impact of doubling California's production of salmon and steelhead--essentially attaining producing levels of over 2 million salmon and 130,000 steelhead over a period of 10 to 20 years. Actions necessary to achieve these objectives are identified, basin by basin, in other work commissioned by the Committee, and are beyond the scope of this economic report. The dominant role that California's large producing systems, the Sacramento/San Joaquin and the Klamath/Trinity, and to a lesser extent, the Eel, would need to play if these objectives are to be achieved is nonetheless evident. Fisheries experts advise that such objectives are achievable. In the Sacramento/San Joaquin system improvements would need to emphasize decreased in-river salmon and steelhead mortality due to inadequate flow, temperature problems, agricultural pumping and blocking of migrating passage. In the Klamath/Trinity, it is believed that adequate flow and improved forest management practices would be particularly important features of a restorative program. On the Eel, improved forest management and streambed rehabilitation may require greatest emphasis. In the smaller systems, a wide variety of restorative actions were considered promising. Again, these restorative action needs are identified in other Committee work, river basin by river basin.

Finally, in our discussion with CF&G experts, we determined that for some river basins, a goal of approximately doubling existing stocks or catches would neither capitalize on all of the production opportunities available, nor, in some instances,

mitigate for past damages. In this analysis, we will apply the economic methodology previously developed for the Committee (Meyer Resources, 1987b) to the targeted increase in total stocks.

Referencing Tables 3 through 5, we allocate our production targets as follows, on an all-California basis (Tables 6 through 8).

Table 6

Present Production and Future Targeted Goals for Chinook Salmon in California

River Basin	Present Stock size	Future Stock Size	Improvement by the Year 2000
	'000 of salmon		
Sacramento/ San Joaquin	691	1,382	691
Klamath/Trinity	246	492	246
Eel	73	146	73
Other California rivers	30	60	30
California Total	1,040	2,080	1,040

Table 7

Present Production and Future Targeted Goals for Coho Salmon in California

River Basin	Present Stock Size	Future Stock Size	Improvement by the Year 2000
	'000 of salmon		
Klamath/Trinity	43	86	43
Eel	14	28	14
Navarro	7	14	7
Other California rivers	47	94	47
California Total	111	222	111

Table 8

Present Production and Future Targeted Goals for Steelhead in California

River Basin	Present Sport Catch[1]	Future Sport Catch[1]	Improvement by the Year 2000
	'000 of salmon		
Sacramento/ San Joaquin	14	28	14
Klamath/ Trinity	22	44	22
Eel	22	44	22
Navarro	1	2	1
Carmel	<1	2	2
Ventura	<1	1	1
Other California rivers	5	10	5
California Total	65+	131	67

[1] In all systems except the Sacramento/San Joaquin we assume a 25 percent catch fraction of in-river run.

4. Benefits Not Included in This Analysis

The gains identified in this policy paper for a doubling of salmon and steelhead stocks in California do not represent a complete listing of benefits. The following further all-California benefits are not included, due to a present lack of data. Experience suggests that these benefits may exceed those analyzed in this report (eg. Meyer, 1987).

i) Existence and Bequest Values for Salmon and Steelhead

Where salmon and steelhead stocks are at risk, prior work by Meyer (1987) in the Sacramento/San Joaquin system identifies that California's citizens associate major importance with the continued existence of stocks, and with passing them on in good health to future generations. In fact, in empirical work to date, these values, when expressed in monetary terms, dwarf the user benefits that have been identified here. The reader is directed to discussion of gains in the Sacramento/San Joaquin system (in our next major section) for treatment of these results. We suspect that similar values apply in other California watersheds where salmon and steelhead stocks are at risk--but no empirical data is presently available.

ii) Values Associated with Commercial Fishing as a Lifestyle in California

Significant values are also likely to be associated with the commercial fishery lifestyle in California, both for present and potential future fishermen. Where stocks of salmon and steelhead are risked, these values become relevant. Conceptual constructs exist to assess such values, but no substantive empirical effort has taken place to date in California.

iii) Benefits to Indian Peoples

Indian peoples obtain important material, cultural and religious values from salmon and steelhead in California. Considerable work has been done in the Pacific Northwest to

incorporate these benefits more fully in technical analysis. To date, however, work in California has been extremely limited, and no usable information base is available.

iv) Benefits Associated with Salmon and Steelhead Stocks by General Recreators

It has been identified by several authors that general recreational benefits are associated with visiting streams where salmon and steelhead spawn, artificial propagation facilities or areas where salmon and steelhead can be generally observed. Benefit estimates have been developed for such activities, but no comprehensive and reliable estimate of associated activity levels is available. We are consequently unable to estimate associated gains from doubling of salmon and steelhead stocks in this all-California section.

5. A Summary Review of Benefits

It can be observed from Table 1 that a doubling of salmon and steelhead stocks in California would yield net economic benefits to California businesses that would exceed 1.3 billion dollars. Total market and non-market benefits from doubling salmon and steelhead stocks would exceed $6 billion. Altering our assumptions will move these estimates upward or downward, and a range of sensitivity is provided in our following detailed estimates by river system.

The actual hands-on program that would be required to facilitate this doubling of stocks has not been specified as part of the present analysis. As noted, the Committee has identified key restorative targets in other portions of its

advisory work. Final restorative plans and initiatives would also require detailed consideration by the California Department of Fish and Game. What this report does, is identify the benefit potentials associated with such actions.

III. Benefits from Expanding Salmon and Steelhead Production in Selected Watersheds

1. The Sacramento/San Joaquin Drainage

i) Chinook Salmon

The Sacramento/San Joaquin drainage produces approximate 68 percent of California's chinook salmon. Historically, spring, fall, late fall and winter adult chinook salmon returned at variant seasons and ages to provide a diversified production capability to the system. Over time, this natural production has declined markedly--and has been replaced to some degree by hatchery production of fall chinook. In this process, overall runs of spring, late fall and winter chinooks have declined sharply, and virtually all usable production is now focussed on fall run chinook, most often returning at 3 years of age. Table 9 presents data on total stock, escapement and catch for the Sacramento/San Joaquin system, based on recent calculations by the California Department of Fish and Game. Five year moving averages tend to dampen fluctuations in chinook salmon returns observed year to year, and are considered more reliable for assessing trend. Focussing on these averages, it can be observed that total stock levels in the 1952-1956 period have not been achieved in subsequent years, with the latest 5-year period (1982-86) lower by some 19 percent. However, stock sizes have fluctuated throughout

Table 9

Historic Estimates of Production and Catch of Chinook Salmon for the Sacramento/San Joaquin System

Year	Spawning Escapement[1]	Commercial Catch	Sport Catch Ocean	Sport Catch River[2]	Total Catch	Total Stock	Harvest Ratio	Five Year Averages Total Stock '000	Five Year Averages Harvest Ratio
	thousands of fish								
1952	298	341	44	37	422	720	.59	--	--
53	478	334	50	60	444	922	.48	--	--
54	390	499	61	49	609	999	.61	849	.63
55	320	439	66	40	545	865	.63	781	.66
56	133	529	58	17	604	737	.82	702	.68
57	93	254	23	12	289	382	.76	665	.66
58	224	248	27	28	303	527	.57	650	.64
59	378	362	28	47	437	815	.54	654	.62
1960	377	344	19	47	410	787	.52	687	.60
61	203	465	22	25	512	715	.72	726	.62
62	202	282	83	25	390	592	.66	711	.65
63	235	401	56	29	486	721	.67	683	.69
64	251	391	69	31	491	742	.66	641	.69
65	157	428	41	20	489	646	.76	595	.68
66	157	279	49	20	348	505	.69	569	.69
67	145	150	50	18	218	363	.60	571	.69
68	168	289	112	21	422	590	.72	576	.66
69	258	355	104	32	491	749	.66	601	.64
1970	250	294	96	31	421	671	.63	648	.67
71	253	220	129	32	381	634	.60	721	.68
72	146	297	137	18	452	598	.76	713	.68
73	254	534	135	32	701	955	.73	705	.68
74	241	331	107	30	468	709	.66	701	.69
75	207	326	70	26	422	629	.67	717	.68
76	213	321	54	27	402	615	.65	638	.68
77	198	367	85	25	477	675	.71	627	.70
78	154	337	51	19	407	561	.73	627	.70
79	179	384	68	22	474	653	.73	640	.71
1980	188	384	35	24	443	631	.70	689	.73
81	207	400	49	26	475	682	.70	666	.71
82	208	573	112	26	711	919	.77	637	.68
83	150	233	41	19	243	443	.66	658	.66
84	221	199	60	28	287	508	.56	691	.66
85	286	317	100	36	453	739	.61	--	--
86	260	457	94	33	584	844	.69	--	--

[1] All chinook slamon over 24 inches total length. The 1952-70 total chinook escapement data as reported by Fry and Petrovich (1970) were adjusted to account for 20% escapement of jacks (1971-82).

[2] Estimated at 11.1 percent of in-river run size, based on 1970-1972 average data.

Source: These calculations were conducted by the California Department of Fish and Game. Data for ocean commercial and sport troll catch was extracted from USFWS Exhibit 31 to the Bay/Delta Hearings, Appendices 32 and 33, 1987.

the years, and we obtained a best fit regression coefficient (R^2) of only .10 in considering total stock averages. The best fit equation is:

(1) $y = 1{,}272.397 - 142.8492 (\ln x)$,

where,

y = predicted 5 year average total stocks;

n = the year in which the average is centered.

This regression equation indicates that stocks of chinook salmon in the Sacramento/San Joaquin system have declined, but its predictive power is weak. We consequently also performed regressions on peak stock sizes that have been achieved in the system since 1952, and similarly, on minimum stock sizes. Our best fit equation for minimum stock sizes achieved an R^2 of only 0.0481. This is considered too low to reach any conclusion concerning progressive change in minimum stock sizes for Sacramento/San Joaquin fall chinook during periods of low return. However, the data from Table 9 indicate that during years of strong returns, total Sacramento/San Joaquin fall chinook runs are not reaching the peak levels of prior years. The regression coefficient (R^2) associated with this conclusion is a robust .7852. The associated regression equation follows. The variables x and y are as defined in Equation (1).

(2) $y = 4{,}074.232\ x^{0.4046}$

Finally, a regression of the 5-year moving average of harvest ratios for Sacramento/San Joaquin chinook salmon was completed. This analysis indicated that harvest ratios have increased over the 1952-86 period. However, the predictive power (R^2) associated with this finding is a moderate .3112--chiefly, it appears, as a result of an apparent decline in harvest ratio levels experienced in the 1977-82 period. Consequently, while these data provide modest support for the contention that hatchery-based production has enabled increased percentage harvest of total stocks, this conclusion would seem to require several more years of data before its statistical validity can be fully verified.

Predictive values associated with Equation (1), and to a lesser degree, Equation (2), are considered worthy of presentation, however--and are provided in Table 10.

Table 10

Predicted Peak Stock Levels and Harvest Rates for Sacramento/San Joaquin Chinook Salmon (1954-1988)

Year	Peak Stock Level --'000 salmon---	Harvest Ratio
1954	811	.64
1960	777	.65
1970	730	.67
1980	692	.69
1988	666	.70
R^2	0.7852	0.3112

Source: Equations (1) and (2).

What can be concluded from these data? Examination of the 1952-86 record provides some indication of decline in stocks of Sacramento/San Joaquin chinook salmon, although the predictive power of these indications is relatively weak. It is much clearer that peak runs are not reaching previous high levels, that chinook stocks other than the fall run have declined significantly and that the age class structure of returning fall chinook has narrowed to primarily 3 year old fish. Hatchery production has moved to partially offset natural declines, and has apparently enabled a somewhat higher ratio of harvest to total stock. Overall, variability in chinook salmon returns render reading of trends in total stock size and catch difficult. Evidence of decreased chinook salmon resiliency as illustrated by decreasing peak run size, and increased risk as seasonal and age class diversity of stocks decline while pressures potentially adverse to salmon increase in-river, is clearer. It is our consequent conclusion that protection of existing chinook salmon stocks of the Sacramento/San Joaquin system and progressive action to double production from the system will need to focus on reducing in-river mortality, in combination with optimizing production from existing artificial facilities. Further, these latter efforts should give particular attention to issues of seasonal and age class diversity of stocks.

Present and projected future levels of chinook salmon utilized in this analysis are based on average data from the 1982-86 period. Those data are presented in Table 11.

Table 11

Estimated Present and Potential Future Production of Chinook Salmon from the Sacramento/San Joaquin System

	Spawning Escapement	Commercial Catch	Sport Catch	Total Stock
	---'000 of chinook salmon---			
Present Production	225	356	110	691
Future Production	450	712	220	1,382

ii) Steelhead

Rowell (1980) estimates sport catches of steelhead in the Sacramento River system approximated 30,000 fish in the late 1960's. Natural stocks have declined sharply, however, and today's steelhead stocks are almost entirely supported by hatchery production at Battle Creek (Coleman), Feather River and Lower American River (Nimbus). California Department of Fish and Game (F. Meyer, 1987) reports that catch of American River steelhead has been averaging 4,500 fish annually, while annual Feather River catches approximate 6,000 steelhead. U.S. Fish and Wildlife Service (1984) estimate average annual Coleman Hatchery production at about 3,700 steelhead. Adding these data, and rounding, we obtain a present sport catch estimate of about 14,000 steelhead. Efforts to double this catch would have to continue to rely on hatchery-based production together with requisite instream flows and associated survival conditions.

iii) Benefits Associated With Doubling Production of Salmon and Steelhead from the Sacramento/San Joaquin System

Estimation of benefits associated with doubling salmon and steelhead in selected watersheds follows the methodology previously developed for the Salmon and Steelhead Advisory Committee (Meyer Resources, 1987b). Estimated production of salmon and steelhead is obtained from immediately preceding sections and is displayed in Table 12. Chinook salmon are estimated to weigh 10.3 pounds on average (Meyer Resources, 1985).

Table 12

Estimated Production and Future Potential of Salmon and Steelhead from the Sacramento/San Joaquin System

	Present Production			Future Production		
	Commercial Catch		Sport	Commercial Catch		Sport
Species	Pieces '000	Pounds '000 lbs	Catch '000	Pieces '000	Pounds '000 lbs	Catch '000
Fall Chinook	356	3,667	110	712	7,334	220
Steelhead	--	--	14	--	--	28

Under instructions from the Committee, we will schedule recommended increases in salmon and steelhead production to achieve doubling by the years 2000 (Scenario A), 2005 (Scenario B) and 2010 (Scenario C) respectively. Assuming first returns in 1991, these scheduling scenarios produce the following estimates of increased production (Table 13).

Table 13

Gains to Fishery Sectors from a Doubling of
Salmon and Steelhead Stocks in the Sacramento/San Joaquin System

Year	Commercial Chinook Salmon			Chinook Sport Catch			Steelhead Sport Catch		
	Scenario A	Scenario B	Scenario C	Scenario A	Scenario B	Scenario C	Scenario A	Scenario B	Scenario C
	'000 pounds			'000 fish					
1991	367	244	183	11	7	6	1	1	1
92	733	489	367	22	15	11	3	2	1
93	1,100	734	550	33	22	16	4	3	2
94	1,467	978	734	44	29	22	6	4	3
1995	1,834	1,222	917	55	36	28	7	4	4
96	2,200	1,467	1,100	66	44	33	8	5	4
97	2,567	1,712	1,284	77	51	38	10	6	5
98	2,934	1,956	1,467	88	58	44	11	7	6
99	3,300	2,200	1,651	99	66	50	13	8	6
2000	3,667	2,445	1,834	110	73	55	14	9	7
01	--	2,690	2,017	--	80	60	--	10	8
02	--	2,934	2,201	--	88	66	--	11	8
03	--	3,178	2,384	--	95	72	--	12	9
04	--	3,423	2,568	--	102	77	--	13	10
2005	--	3,667	2,751	--	110	82	--	14	10
06	--	--	2,934	--	--	88	--	--	11
07	--	--	3,118	--	--	94	--	--	12
08	--	--	3,301	--	--	99	--	--	13
09	--	--	3,485	--	--	104	--	--	13
2010	--	--	3,667	--	--	110	--	--	14

Finally, and again following Meyer Resources (1987b), these future benefits will be discounted to present dollar terms, using three differing perspectives concerning the relative weight that should be given to benefits or costs incurred by present citizens, relative to future generations. The first calculation will simulate the perspective that present economic gains and losses should be given greater weight in decision-making than future gains and losses--and will employ discount factors of 1 and 3 percent. The second calculation will simulate the perspective that present and future gains or losses should be given equal weight in decision-making--and will use a 0 discount factor. The third calculation will simulate the perspective that the future should be given greater weight than the present in decision-making--and apply a discount factor of -1 percent.

Values per commercial pound and per sport fish for the Sacrament/San Joaquin system are taken from Meyer Resources (1987b). Net business revenues associated with chinook sport fishing are weighted to reflect a 75 percent-25 percent division between ocean and in-river sport catch, 1982-86 (from Table 9). Non-market sport fishing values have been reworked to reflect further analyses of results reported in Meyer (1987) and Thompson and Huppert (1987)--two surveys of non-market values in the Sacramento/San Joaquin system. This further analysis is reported in other work for the Committee (Meyer Resources, 1988). The Thompson and Huppert results suggest compensatory non-market estimates that range from $350

per sport caught salmon or striped bass to $1,700, depending on assumptions used (Thompson, 1987). Results reported by Meyer Resources (1987) fall within the high end of this range. For this analysis, noting that indications of declining chinook stock size in the Sacramento/San Joaquin system are associated with relatively low R^2 values, we will apply an average of the lower and average range of compensatory estimate from Thompson and Huppert, and use $675 per sport caught chinook salmon in our analysis. We will continue to use the recommended value of $530 per sport caught steelhead presented in Meyer Resources (1987b). Existence, bequest and option values are not included in this analysis of restorative opportunity. Unit values are summarized in Table 14.

Table 14

Unit Values Associated with Sacramento/San Joaquin Salmon and Steelhead

Type of Value	Commercial Chinook Salmon $/lb.	Sport Chinook Salmon $/fish	Sport Steelhead $/fish
Commercial fishing	2.29	--	--
Commercial fish processing	1.19	--	--
Commercial fish retailing	1.08	--	--
Total commercial fishery value	4.56	--	--
Net revenues to businesses servicing sport fishermen	--	21.84	39.94
Sport fisheries non-market value	--	675	530

Integrating data from Tables 13 and 14, we obtain the following total benefit estimates for a doubling of chinook salmon and steelhead stocks of the Sacramento/San Joaquin system (Tables 15 through 17). Readers are reminded that non-market values are presented for sport fishing but not for commercial fishing. Therefore, the results reported here cannot be used to reallocate salmon between these two fishing sectors.

Table 15

Estimated Economic Benefits from a Doubling of Salmon and Steelhead Stocks from the Sacramento/San Joaquin System over Ten Years

Year	Benefits to Commercial Businesses			Non-Market Benefits	Total Benefits
	Commercial Fishing	Sport Fishing	Total		
	---$'000---				
1991	1,674	280	1,954	7,955	9,909
92	3,342	560	3,902	16,440	20,342
93	5,016	880	5,896	24,395	30,291
94	6,690	1,201	7,891	32,880	40,771
1995	8,363	1,481	9,844	40,835	50,679
96	10,032	1,761	11,793	48,790	60,583
97	11,706	2,081	13,787	57,275	71,062
98	13,379	2,361	15,740	65,230	80,970
99	15,048	2,681	17,729	73,715	91,444
2000 and beyond	16,722	2,962	19,684	81,670	101,354

Table 16

Estimated Economic Benefits from a Doubling of Salmon and Steelhead Stocks from the Sacramento/San Joaquin System over Fifteen Years

Year	Benefits to Commercial Businesses			Non-Market Benefits	Total Benefits
	Commercial Fishing	Sport Fishing	Total		
	$'000				
1991	1,113	193	1,306	5,255	6,561
92	2,230	407	2,637	11,185	13,822
93	3,347	600	3,947	16,440	20,387
94	4,460	793	5,253	21,695	26,948
1995	5,572	946	6,518	26,420	32,938
96	6,690	1,161	7,851	32,350	40,201
97	7,807	1,353	9,160	37,605	46,765
98	8,919	1,546	10,465	42,860	53,325
99	10,032	1,761	11,793	48,790	60,583
2000	11,149	1,954	13,103	54,045	67,148
01	12,266	2,147	14,413	59,300	73,713
02	13,379	2,361	15,740	65,230	80,970
03	14,492	2,554	17,046	70,485	87,531
04	15,609	2,747	18,356	75,740	94,096
2005 and beyond	16,722	2,962	19,684	81,670	101,354

Table 17

Estimated Economic Benefits from a Doubling of Salmon and Steelhead Stocks from the Sacramento/San Joaquin System over Twenty Years

Year	Benefits to Commercial Businesses			Non-Market Benefits	Total Benefits
	Commercial Fishing	Sport Fishing	Total		
	$'000				
1991	834	171	1,005	4,580	5,585
92	1,674	280	1,954	7,955	9,909
93	2,508	429	2,937	11,860	14,797
94	3,347	600	3,947	16,440	20,387
1995	4,182	771	4,953	21,020	25,973
96	5,016	880	5,896	24,395	30,291
97	5,855	1,030	6,885	28,300	35,185
98	6,690	1,201	7,891	32,880	40,771
99	7,529	1,332	8,861	36,930	45,791
2000	8,363	1,481	9,844	40,835	50,679
01	9,198	1,630	10,828	44,740	55,568
02	10,037	1,761	11,798	48,740	60,538
03	10,871	1,932	12,803	53,370	66,173
04	11,710	2,081	13,791	57,275	71,066
2005	12,545	2,190	14,735	60,650	75,385
06	13,379	2,361	15,740	65,230	80,970
07	14,218	2,532	16,750	69,810	86,560
08	15,053	2,681	17,734	73,715	91,449
09	15,892	2,791	18,683	77,090	95,773
2010 and beyond	16,722	2,962	19,684	81,670	101,354

The year by year benefits identified in Tables 15 through 17 are extended forward over a 75 year time period using the discounting perspectives already discussed. Total benefits associated with doubling of salmon and steelhead stocks from the Sacramento/San Joaquin system can then be presented in present day terms. These calculations are presented in Table 18. Benefits for all scenarios are assumed to commence in Year 4 of the calculation (ie. in the fourth year after the restoration program begins).

Table 18

Estimated Total Benefits from Doubling Salmon and Steelhead Stocks of the Sacramento/San Joaquin System--Expressed in Present Day Terms

Benefit Scenario	Giving More Weight to the Present: 3% Discount Rate	Giving More Weight to the Present: 1% Discount Rate	Weighing the Present and Future Equally: 0% Discount Rate	Giving More Weight to the Future: -1% Discount Rate
	millions of dollars			
A. Doubling Over 10 Years				
- Benefits to Commercial Businesses	476	931	1,388	1,828
- Non-Market Benefits	1,975	3,863	5,758	7,389
- Total Benefits	2,451	4,794	7,146	9,217
B. Doubling Over 15 Years				
- Benefits to Commercial Businesses	439	886	1,338	1,751
- Non-Market Benefits	1,821	3,675	5,549	7,262
- Total Benefits	2,260	4,561	6,887	9,013
C. Doubling Over 20 Years				
- Benefits to Commercial Businesses	423	844	1,289	1,695
- Non-Market Benefits	1,754	3,500	5,349	6,906
- Total Benefits	2,177	4,344	6,638	8,601

Program actions to obtain these benefits require final specification by fishery scientists. These experts consider the goals identified here as attainable. In this final section on the Sacramento/San Joaquin watershed, we associate ratios of benefit to cost for alternative levels of investment in fisheries to obtain a doubling of stocks. We apply these alternative investment levels over periods of ten, fifteen and twenty years respectively. Resulting estimates are provided in Tables 19 through 21.

Table 19

Estimated Ratio of Benefits to Program Costs from Doubling Salmon and Steelhead Production in the Sacramento/San Joaquin System in Ten Years

Full Program Investment	Annual Investment	Giving More Weight to the Present		Weighing the Present and Future Equally	Giving More Weight to the Future
		3% Discount Rate	1% Discount Rate	0% Discount Rate	-1% Discount Rate
-----$ million---------		----------ratio of benefits to costs----------			
A. Counting Benefits to Businesses Only					
100	10	5.6	9.8	13.9	17.2
250	25	2.2	3.9	5.6	7.0
500	50	1.1	2.0	2.8	3.5
750	75	0.7	1.3	1.8	2.3
1,000	100	0.6	0.9	1.4	1.7
B. Counting Both Market and Non-Market Values					
100	10	28.8	50.5	71.5	87.0
250	25	11.5	20.2	28.6	35.0
500	50	5.7	10.1	14.3	17.5
750	75	3.8	6.8	9.5	11.7
1,000	100	2.9	5.1	7.1	8.7

Table 20

Estimated Ratio of Benefits to Program Costs from Doubling Salmon and Steelhead Production in the Sacramento/San Joaquin System in Fifteen Years

Full Program Investment	Annual Investment	Giving More Weight to the Present		Weighing the Present and Future Equally	Giving More Weight to the Future
		3% Discount Rate	1% Discount Rate	0% Discount Rate	-1% Discount Rate
-----$ million---------		----------ratio of benefits to costs----------			
A. Counting Benefits to Businesses Only					
100	6.67	5.5	9.6	13.4	16.2
250	16.67	2.2	3.8	5.4	6.5
500	33.33	1.1	1.9	2.7	3.2
750	50.00	0.7	1.3	1.8	2.2
1,000	66.67	0.6	0.9	1,3	1.6
B. Counting Both Market and Non-Market Values					
100	6.67	28.2	49.6	68.9	83.5
250	16.67	11.4	19.7	27.5	33.2
500	33.33	5.7	9.9	13.8	16.6
750	50.00	3.8	6.6	9,2	11.1
1,000	66.67	2.8	4.9	6.9	8.3

Table 21

Estimated Ratio of Benefits to Program Costs from Doubling Salmon and Steelhead Production in the Sacramento/San Joaquin System in Twenty Years

Full Program Investment	Annual Investment	Giving More Weight to the Present		Weighing the Present and Future Equally	Giving More Weight to the Future
		3% Discount Rate	1% Discount Rate	0% Discount Rate	-1% Discount Rate
-----$ million---------		----------ratio of benefits to costs----------			
A. Counting Benefits to Businesses Only					
100	5	5.7	9.4	12.9	15.3
250	12.5	2.3	3.7	5.2	6.1
500	25	1.1	1.9	2.6	3.0
750	37.5	0.7	1.2	1.7	2.0
1,000	50	0.6	0.9	1.3	1.5
B. Counting Both Market and Non-Market Values					
100	5	29.4	48.3	66.4	77.5
250	12.5	11.7	19.2	26.6	30.9
500	25	5.8	9.6	13.3	15.5
750	37.5	3.9	6.4	8.8	10.3
1,000	50	2.9	4.8	6.6	7.7

As noted, the amount of investment required to double salmon and steelhead stocks in the Sacramento/San Joaquin system is unknown. Considering benefits to businesses only, the preceding data suggest that under even the most stringent assumptions, an investment of up to $500 million, spread over 10, 15 or 20 years would yield net positive benefits. Under assumptions that place less emphasis on present benefits and costs, relative to the future, higher levels of investment would be justified. If both market and non-market benefits of the Sacramento/San Joaquin system's salmon and steelhead are

considered, a total investment exceeding $1 billion over the same time period would still yield substantial positive net benefits.

2. The Klamath/Trinity Drainage

i) Chinook Salmon

Data for the Klamath/Trinity system are less complete than for the Sacramento/San Joaquin, but are reasonably adequate for chinook salmon. The Pacific Fishery Management Council (PFMC), in their review of 1986 fisheries (PFMC, 1987) provide data on in-river disposition of adult fall chinook. CH2M Hill (1985) report that ocean run size may equal twice in-river run size, and estimate that 92.5 percent of ocean catch has historically been taken by the commercial fishery. The California Department of Fish and Game estimates that a commercial share of 95 percent of ocean catch may be more appropriate for Klamath/Trinity fall chinook (Boydstun, 1988). Utilizing this latter figure, and the data from PFMC, we are able to estimate recent returns of adult fall chinook to the Klamath/Trinity system (Table 22).

Table 22

Estimated Adult Returns of Fall Chinook to the Klamath/Trinity System

Year	Spawning Escapement	In-river Sport Catch	Indian Net Catch	In-river Run Size	Ocean Catch Commercial	Ocean Catch Sport
			'000 of salmon			
1978	72	2	18	91	173	9
1979	34	2	14	50	95	5
1980	28	4	12	44	84	4
1981	38	6	33	77	146	8
1982	42	8	14	65	124	6
1983	46	4	8	58	110	6
1984	23	2	18	43	82	4
1985	44	4	12	59	112	6
1986	144	17	25	186	353	19
Average 1982-86	60	7	15	82	156	8

Source: PFMC
: California Department of Fish and Game

The present situation on the Klamath/Trinity is very dynamic. Recent returns of fall chinook have been greatly improved over those of the previous decade, in significant part, it is believed, due to improved instream flow and ocean survival conditions. However, experienced fishery analysts would not base future projections on only one or two years of data--and we have maintained a five year averaging convention for our analysis. Further, a major breakthrough between fishery user

groups has seen a new allocation agreement that is eventually targeted to return 60 percent of adults to ocean fisheries and 40 percent to river catch and escapement (Boydstun, 1988). This agreement is subject to ongoing negotiation. For this analysis, we will retain the 2:1 ocean to in-river distribution of chinook salmon for our baseline analysis, but will shift to a ratio of 1.5 ocean to 1 river adult salmon for our analysis of stock doubling. Future in-river allocation between escapement, sport catch and Indian catch will then be estimated using average proportions from the 1982-86 period.

While the greater portion of returning escapement of fall chinook is of hatchery origin, spawning in the Klamath/Trinity system primarily occurs in the natural river itself. It follows that existing hatchery capability should be fully utilized, and that doubling of stocks will be facilitated by continued improvement in instream flows, restoration of natural spawning capability and control and reduction of stream degradation caused by logging practices, gravel removal and similar potentially deleterious activities. Our final estimates of present and potential future production of chinook salmon in the Klamath/Trinity system are provided in Table 23.

Table 23

Estimated Present and Potential Future Production of Chinook Salmon from the Klamath/Trinity System

	Spawning Escapement	In-river Catch		Ocean Catch		Total Stock
		Sport	Indian	Commercial	Sport	
	'000's of chinook salmon					
Present Production	60	7	15	156	8	246
Future Production	144	17	36	280	15	492

ii) Coho

Very little data is available on the magnitude of coho stocks from the Klamath/Trinity system. CH2M Hill (1985) estimated spawning escapement of coho between 12,000 and 15,000 fish. Biosystems Analysis (1986) estimated ocean catch at 2.56 times escapement with a 65 percent commercial fishery share--primarily from southern Oregon data. We will use the more conservative 12,000 spawning figure, and the other estimates cited to project present production of coho from the Klamath/Trinity system, together with potential future production levels should a doubling occur (Table 24).

Table 24

Estimated Present and Potential Future Production of Coho Salmon from the Klamath/Trinity System

	Spawning Escapement	Commercial Catch	Sport Catch	Total Stock
	'000's of coho salmon			
Present Production	12	20	11	43
Future Production	24	40	22	86

iii) Steelhead

Data on steelhead populations for the Klamath/Trinity system is also poor. CH2M Hill (1985) reports that catch estimates for 1980 and 1981 ranged between 12,000 and 33,000 steelhead, down from estimates of the early 1960's. We will choose a median present catch estimate of 22,000 steelhead for our base case analysis. On this basis, estimated present and potential future catch is presented in Table 25.

Table 25

Estimated Present and Potential Future Catch of Steelhead from the Klamath/Trinity System

Production Period	Estimate of Catch 000's of steelhead
Present Catch	22
Future Catch	44

iv) Benefits Associated with Doubling Production of Salmon and Steelhead from the Klamath/Trinity System

Benefit estimates associated with doubling salmon and steelhead stocks in the Klamath/Trinity system follows Meyer Resources (1987b). Estimates of present and future production from the system are summarized in Table 26. Following Maahs (1988) adult chinook salmon caught in the commercial fishery are estimated to weigh 8.8 pounds. Coho are assumed to weigh 7 pounds (CH2M Hill, 1985). As adequate data is not presently available to estimate the full value of salmon and steelhead catch to Indian peoples, analysis of that segment of the fishery is not carried forward in subsequent tables.

Table 26

Estimated Production and Future Potential of Salmon and Steelhead from the Klamath/Trinity System

Species	Present Production			Future Production		
	Commercial Catch		Sport	Commercial Catch		Sport
	Pieces '000	Pounds '000 lbs	Catch '000	Pieces '000	Pounds '000 lbs	Catch '000
Fall Chinook	156	1,373	15	280	2,464	32
Coho	20	140	11	40	280	22
Steelhead	--	--	22	--	--	44

Again, scenarios are constructed to double stocks by the years 2000 (Scenario A), 2005 (Scenario B) and 2010 (Scenario C). Initiating increases in 1991, expected production gains are displayed for chinook salmon in Table 27, and for coho and steelhead in Table 28.

Table 27

Gains to Fishing Sectors from a Doubling of Chinook Salmon Stocks in the Klamath/Trinity System

Year	Commercial Chinook Salmon			Chinook Sport Catch		
	Scenario A	Scenario B	Scenario C	Scenario A	Scenario B	Scenario C
	'000 pounds			'000 fish		
1991	109	73	55	2	1	1
92	218	145	109	3	2	2
93	327	218	164	5	3	3
94	436	291	218	7	4	3
1995	545	364	273	8	6	4
96	654	436	327	10	7	5
97	763	509	382	12	8	6
98	872	582	436	14	9	7
99	981	654	491	15	10	8
2000	1,091	727	546	17	11	8
01	--	800	600	--	12	9
02	--	872	655	--	13	10
03	--	945	709	--	14	11
04	--	1,018	764	--	15	12
2005	--	1,091	818	--	17	13
06	--	--	873	--	--	14
07	--	--	927	--	--	14
08	--	--	982	--	--	15
09	--	--	1,036	--	--	16
2010	--	--	1,091	--	--	17

Table 28

Gains to Fishing Sectors from a Doubling of
Coho Salmon and Steelhead Stocks in the Klamath/Trinity System

Year	Commercial Coho Salmon			Coho Sport Catch			Steelhead Sport Catch		
	Scenario A	Scenario B	Scenario C	Scenario A	Scenario B	Scenario C	Scenario A	Scenario B	Scenario C
	'000 pounds			'000 fish					
1991	14	9	7	1	1	1	2	1	1
92	28	19	14	2	1	1	4	3	2
93	42	28	21	3	2	2	7	4	3
94	56	37	28	4	3	2	9	6	4
1995	70	46	35	6	4	3	11	8	6
96	84	56	42	7	4	3	13	9	7
97	98	65	49	8	5	4	15	10	8
98	112	74	56	9	6	4	18	12	9
99	126	84	63	10	6	5	20	14	10
2000	140	93	70	11	7	6	22	15	11
01	--	102	77	--	8	6	--	16	12
02	--	112	84	--	8	7	--	18	13
03	--	121	91	--	9	7	--	20	14
04	--	130	98	--	10	8	--	21	16
2005	--	140	105	--	11	8	--	22	17
06	--	--	112	--	--	9	--	--	18
07	--	--	119	--	--	9	--	--	19
08	--	--	126	--	--	10	--	--	20
09	--	--	133	--	--	10	--	--	21
2010	--	--	140	--	--	11	--	--	22

As in the prior river basin, future benefits will be discounted to present dollar terms under a range of weighing perspectives regarding the future. Values per commercial pound are as estimated for the Sacramento/San Joaquin system. Sport values per fish are as recommended in Meyer Resources (1987b). For both chinook and coho, ocean and in-river sport values are averaged to reflect an approximate 50-50 sport catch spilt (eg. Table 23). Unit values are summarized in Table 29.

Table 29

Unit Values Associated with Klamath/Trinity Salmon and Steelhead

Type of Value	Chinook Salmon		Coho Salmon		Steelhead
	$/lb	$/fish	$/lb	$/fish	$/fish
Total commercial value	4.56	--	2.78	--	--
Net revenues to businesses servicing sport fishermen	--	31.20	--	31.20	24.96
Sport fisheries non-market value	--	179	--	179	530

Integrating data from Tables 27, 28 and 29, we obtain the following total benefit estimates for doubling of salmon and steelhead stocks of the Klamath/Trinity system (Tables 30 through 32).

Table 30

Estimated Economic Benefits from a Doubling of Salmon and Steelhead Stocks from the Klamath/Trinity System over Ten Years

Year	Benefits to Commercial Businesses			Non-Market Benefits	Total Benefits
	Commercial Fishing	Sport Fishing	Total		
	$'000				
1991	536	112	648	1,597	2,245
92	1,072	256	1,328	3,015	4,343
93	1,608	424	2,032	5,142	7,174
94	2,144	568	2,712	6,739	9,451
1995	2,680	711	3,391	8,336	11,727
96	3,216	855	4,071	9,933	14,004
97	3,752	998	4,750	11,530	16,280
98	4,288	1,167	5,455	13,657	19,112
99	4,824	1,279	6,103	15,075	21,178
2000 and beyond	5,364	1,423	6,787	16,672	23,459

Table 31

Estimated Economic Benefits from a Doubling of Salmon and Steelhead Stocks from the Klamath/Trinity System over Fifteen Years

Year	Benefits to Commercial Businesses			Non-Market Benefits	Total Benefits
	Commercial Fishing	Sport Fishing	Total		
	$'000				
1991	358	87	445	888	1,333
92	714	168	882	2,127	3,009
93	1,072	256	1,328	3,015	4,343
94	1,430	368	1,798	4,433	6,231
1995	1,788	512	2,300	6,030	8,330
96	2,144	568	2,712	6,739	9,451
97	2,502	655	3,157	7,627	10,784
98	2,860	768	3,628	9,045	12,673
99	3,216	849	4,065	10,284	14,349
2000	3,574	936	4,510	11,172	15,682
01	3,932	1,023	4,955	12,060	17,015
02	4,288	1,104	5,392	13,299	18,691
03	4,646	1,217	5,863	14,717	20,580
04	5,003	1,304	6,307	15,605	21,912
2005 and beyond	5,364	1,423	6,787	16,672	23,459

Table 32

Estimated Economic Benefits from a Doubling of Salmon and Steelhead Stocks from the Klamath/Trinity System over Twenty Years

Year	Benefits to Commercial Businesses			Non-Market Benefits	Total Benefits
	Commercial Fishing	Sport Fishing	Total		
	$'000				
1991	270	87	357	888	1,245
92	536	144	680	1,597	2,277
93	806	231	1,037	2,485	3,522
94	1,072	256	1,328	3,015	4,343
1995	1,342	368	1,710	4,433	6,143
96	1,608	424	2,032	5,142	7,174
97	1,878	512	2,390	6,030	8,420
98	2,144	568	2,712	6,739	9,451
99	2,414	655	3,069	7,627	10,696
2000	2,684	711	3,395	8,336	11,731
01	2,950	768	3,718	9,045	12,763
02	3,220	855	4,075	9,933	14,008
03	3,486	911	4,397	10,642	15,039
04	3,756	1,023	4,779	12,060	16,839
2005	4,022	1,080	5,102	12,769	17,871
06	4,292	1,167	5,459	13,657	19,116
07	4,558	1,192	5,750	14,187	19,937
08	4,828	1,279	6,107	15,075	21,182
09	5,094	1,335	6,429	15,784	22,213
2010 and beyond	5,364	1,423	6,787	16,672	23,459

As noted, these estimates do not include substantial benefits generated for Indian peoples. In 1987, for example, a commercial Indian net fishery at the mouth of the Klamath River returned substantial subsistence and cultural benefits and almost $1 million in income to Indian fishermen.

Annual benefits identified in Tables 30 through 32 are extended forward over a 75 year time period. Then, using alternative discounting perspectives, total benefits are displayed in Table 33 in present day terms. Benefits for all scenarios are assumed to begin in Year 4 of the analysis.

Table 33
Estimated Total Benefits from Doubling Salmon and Steelhead Stocks of the Klamath/Trinity System - Expressed in Present Day Terms

Benefit Scenario	Giving More Weight to the Present		Weighing the Present and Future Equally	Giving More Weight to the Future
	3% Discount Rate	1% Discount Rate	0% Discount Rate	-1% Discount Rate
	millions of dollars			
A. Doubling Over 10 Years				
- Benefits to Commercial Businesses	164	321	478	679
- Non-Market Benefits	403	789	1,175	1,503
- Total Benefits	567	1,110	1,653	2,182
B. Doubling Over 15 Years				
- Benefits to Commercial Businesses	151	306	461	604
- Non-Market Benefits	373	751	1,134	1,484
- Total Benefits	524	1,057	1,595	2,088
C. Doubling Over 20 Years				
- Benefits to Commercial Businesses	140	288	445	584
- Non-Market Benefits	345	715	1,093	1,437
- Total Benefits	485	1,003	1,538	2,021

In Tables 34, 35 and 36 ratios of benefits to costs are associated with alternative investment programs to attain the benefits described in Table 33 for the Klamath/Trinity watershed. As in prior analysis, calculations are made for ten, fifteen and twenty year investment periods.

Table 34

Estimated Ratio of Benefits to Program Costs from Doubling Salmon and Steelhead Production in the Klamath/Trinity System in Ten Years

Full Program Investment	Annual Investment	Giving More Weight to the Present: 3% Discount Rate	Giving More Weight to the Present: 1% Discount Rate	Weighing the Present and Future Equally: 0% Discount Rate	Giving More Weight to the Future: -1% Discount Rate
-----$ million---------		----------ratio of benefits to costs----------			
A. Counting Benefits to Businesses Only					
75	7.5	2.6	4.5	6.4	8.7
100	10	1.9	3.4	4.8	6.4
200	20	0.9	1.7	2.4	3.2
250	25	0.8	1.4	1.9	2.6
500	50	0.4	0.7	0.9	1.3
B. Counting Both Market and Non-Market Values					
75	7.5	8.9	15.6	22.0	28.0
100	10	6.7	11.7	16.5	20.6
200	20	3.3	5.9	8.3	10.4
250	25	2.7	4.7	6.6	8.3
500	50	1.3	2.3	3.3	4.1
750	75	0.9	1.6	2.2	2.8
1,000	100	0.7	1.2	1.6	2.1

Table 35

Estimated Ratio of Benefits to Program Costs from Doubling Salmon and Steelhead Production in the Klamath/Trinity System in Fifteen Years

Full Program Investment	Annual Investment	Giving More Weight to the Present		Weighing the Present and Future Equally	Giving More Weight to the Future
		3% Discount Rate	1% Discount Rate	0% Discount Rate	-1% Discount Rate
-----$ million---------		----------ratio of benefits to costs----------			
A. Counting Benefits to Businesses Only					
75	5	2.5	4.4	6.1	7.6
100	6.67	1.9	3.3	4.6	5.6
200	13.33	0.9	1.7	2.3	2.8
250	16.67	0.8	1.3	1.8	2.2
500	33.33	0.4	0.7	0.9	1.1
B. Counting Both Market and Non-Market Values					
75	5	8.7	15.3	21.3	26.1
100	6.67	6.6	11.5	16.0	19.3
200	13.33	3.3	5.7	8.0	9.8
250	16.67	2.6	4.6	6.4	7.7
500	33.33	1.3	2.3	3.2	3.9
750	50.00	0.9	1.5	2.1	2.6
1,000	66.67	0.7	1.1	1.6	1.9

Table 36

Estimated Ratio of Benefits to Program Costs from Doubling Salmon and Steelhead Production in the Klamath/Trinity System in Twenty Years

Full Program Investment	Annual Investment	Giving More Weight to the Present		Weighing the Present and Future Equally	Giving More Weight to the Future
		3% Discount Rate	1% Discount Rate	0% Discount Rate	-1% Discount Rate
-----$ million---------		----------ratio of benefits to costs----------			
A. Counting Benefits to Businesses Only					
75	3.75	2.5	4.2	5.9	7.0
100	5	1.9	3.2	4.4	5.3
200	10	0.9	1.6	2.2	2.7
250	12.5	0.8	1.3	1.8	2.1
500	25	0.4	0.6	0.9	1.0
B. Counting Both Market and Non-Market Values					
75	3.75	8.7	14.8	20.5	24.3
100	5	6.6	11.1	15.4	18.2
200	10	3.3	5.6	7.7	9.2
250	12.5	2.6	4.4	6.2	7.3
500	25	1.3	2.2	3.1	3.6
750	37.5	0.9	1.5	2.1	2.4
1,000	50	0.7	1.1	1.5	1.8

In the Klamath/Trinity system, consideration of business benefit only associated with a doubling of salmon and steelhead stocks would predict positive economic returns for an investment program of up to $200 million. If non-market benefits are also considered, a total investment program between $500 million and $750 million could be justified.

3. The Eel River Drainage

i) Chinook Salmon

Data on salmon and steelhead in the Eel River drainage is extremely limited. Our primary sources of data are chinook and coho escapement estimates by Wahle and Pearson (1987), and a catch-based estimate of total production of chinook salmon from California rivers excluding the Sacramento/San Joaquin and the Klamath/Trinity by Maahs (1988). All authors point out that the data necessary to obtain such estimates is significantly deficient. Our procedure here is as follows. First, we utilize the escapement estimates contained in Wahle and Pearson (1987), the ocean catch to in-river run size, the ocean commercial-sport allocation rate and the ocean in-river sport catch equivalence previously applied to Klamath/Trinity stocks, to estimate escapement, catch and total production on the Eel River. We then compare this total production estimate to that provided by Maahs (1988). We observed that the Maahs (1988) estimate exceeds that from Wahle and Pearson (1987) by 55 percent. Finally, we increased our escapement-based estimate derived from Wahle and Pearson (1987) by 27.5 percent, to represent an average of the two alternative estimates. Results are presented in Table 37. Production estimates if chinook stocks in the Eel drainage were doubled are also incorporated in the table. Fishery experts indicate that action to effect such doubling of stocks should initially focus on proper inventory assessment of existing stocks and habitat in the Eel system, instream flow and associated

improvements to lessen adverse impacts from upstream dams and protection and rehabilitation of instream habitat.

Table 37

Estimated Adult Returns of Fall Chinook Salmon to the Eel River System

Level of Production	Escapement	Commercial Catch	Sport Catch	Total Stock
	'000 of chinook salmon			
Present production	22	46	5	73
Future production	44	92	10	146

The future production estimates provided here still fall below the 55,000 escapement estimated in the mid-1960's (State of California, 1965).

ii) Coho

Data concerning coho production from the Eel system is similarly sparse. We will base our analysis here on estimates of escapement by Wahle and Pearson (1987). Estimates of commercial and sport catch were again based on Klamath/Trinity data, and assume ocean catch at 2.56 times escapement and a commercial fishery take of 65 percent of that total. Resulting current and potential doubling estimates are provided in Table 38. Again, these estimates fall below the 14,000 escapement estimated for the mid-1960's (State of California, 1965).

Table 38

Estimated Adult Returns of Coho Salmon to the Eel River System

Level of Production	Escapement	Commercial Catch	Sport Catch	Total Stock
	'000 of coho salmon			
Present production	4	7	3	14
Future production	8	14	6	28

iii) Steelhead

State of California (1965) estimated 82,000 steelhead spawners in the Eel system. Data on steelhead populations from the Eel River system are not available today on a system-wide basis. This represents a major deficiency in modeling the economic potential of the system. Discussion with persons knowledgeable concerning the river suggests that there are at least as many steelhead as salmon produced by the system. We consequently assigned a steelhead run size equivalent to that for chinook and coho salmon combined, for purposes of this analysis. Finally, we assumed a catch rate of 25 percent of that run size (Taylor, 1987). On this basis, estimates of present and potential future returns under a stock doubling scenario are presented in Table 39.

Table 39

Estimated Adult Returns of Steelhead to the Eel River System

Level of Production	Total Run Size	Estimated Sport Catch
	'000's of steelhead	
Present production	87	22
Future production	174	44

iv) Benefits Associated with Doubling Production of Salmon and Steelhead from the Eel River System

Benefit estimates associated with doubling salmon and steelhead stocks in the Eel River drainage follow Meyer Resources (1987b). Estimates of present and future production from the system are summarized in Table 40. Following, Maahs (1988), chinook salmon caught in the commercial fishery are assumed to weigh 9.8 pounds. Coho follow our Klamath/Trinity estimate of 7 pounds (CH2M Hill, 1985).

Table 40

Estimated Production and Future Potential of Salmon and Steelhead from the Eel River System

Species	Present Production			Future Production		
	Commercial Catch		Sport Catch	Commercial Catch		Sport Catch
	Pieces '000	Pounds '000 lbs	'000	Pieces '000	Pounds '000 lbs	'000
Fall Chinook	46	451	5	92	902	10
Coho	7	49	3	14	98	6
Steelhead	--	--	22	--	--	44

Scenarios are again constructed to double stocks by the years 2000 (Scenario A), 2005 (Scenario B) and 2010 (Scenario C). Initiating increases in 1991, expected production gains for chinook salmon are displayed in Table 41. Gains for coho and steelhead are displayed in Table 42.

Table 41

Gains to Fishery Sectors from a Doubling of Chinook Salmon Stocks in the Eel River System

Year	Commercial Chinook Salmon			Chinook Sport Catch		
	Scenario A	Scenario B	Scenario C	Scenario A	Scenario B	Scenario C
	'000 pounds			'000 fish		
1991	45	30	23	0.5	0.3	0.2
92	90	60	45	1.0	0.6	0.5
93	135	90	68	1.5	1.0	0.8
94	180	120	90	2.0	1.3	1.0
1995	226	150	113	2.5	1.6	1.2
96	271	181	135	3.0	2.0	1.5
97	316	211	158	3.5	2.3	1.8
98	361	241	180	4.0	2.6	2.0
99	406	271	203	4.5	3.0	2.2
2000	451	301	226	5.0	3.3	2.5
01	--	331	248	--	3.6	2.8
02	--	361	271	--	4.0	3.0
03	--	391	293	--	4.3	3.2
04	--	421	316	--	4.6	3.5
2005	--	451	338	--	5.0	3.8
06	--	--	361	--	--	4.0
07	--	--	383	--	--	4.2
08	--	--	406	--	--	4.5
09	--	--	428	--	--	4.8
2010	--	--	451	--	--	5.0

Table 42

Gains to Fishery Sectors from a Doubling of
Coho Salmon and Steelhead Stocks in the Eel River System

Year	Commercial Coho Salmon			Coho Sport Catch			Steelhead Sport Catch		
	Scenario A	Scenario B	Scenario C	Scenario A	Scenario B	Scenario C	Scenario A	Scenario B	Scenario C
	'000 pounds			'000 fish					
1991	5	3	2	0.3	0.2	0.2	2	2	1
92	10	7	5	0.6	0.4	0.3	4	3	2
93	15	10	7	0.9	0.6	0.4	7	4	3
94	20	13	10	1.2	0.8	0.6	9	6	4
1995	24	16	12	1.5	1.0	0.8	11	8	6
96	29	20	15	1.8	1.2	0.9	13	9	7
97	34	23	17	2.1	1.4	1.2	15	10	8
98	39	26	20	2.4	1.6	1.3	18	12	9
99	44	30	22	2.7	1.8	1.4	20	14	10
2000	49	33	24	3.0	2.0	1.5	22	15	11
01	--	36	27	--	2.2	1.6	--	16	12
02	--	40	29	--	2.4	1.8	--	18	13
03	--	42	32	--	2.6	2.0	--	20	14
04	--	46	34	--	2.8	2.1	--	21	16
2005	--	49	37	--	3.0	2.2	--	22	17
06	--	--	39	--	--	2.4	--	--	18
07	--	--	42	--	--	2.6	--	--	19
08	--	--	44	--	--	2.7	--	--	20
09	--	--	47	--	--	2.8	--	--	21
2010	--	--	49	--	--	3.0	--	--	22

As for other watersheds, projected future benefits were discounted to present dollar terms using differing relative weighing for the present and the future. Values for commercial and sport catch were taken from Meyer Resources (1987b), and are the same as those presented for the Klamath/Trinity system in Table 29. Integrating data from Table 29 with that from Tables 41 and 42, we obtain the following total benefit estimates from doubling of salmon and steelhead stocks of the Eel River system (Tables 43 through 45).

Table 43

Estimated Economic Benefits from a Doubling of Salmon and Steelhead Stocks from the Eel River System over Ten Years

Year	Benefits to Commercial Businesses			Non-Market Benefits	Total Benefits
	Commercial Fishing	Sport Fishing	Total		
	$'000				
1991	219	75	294	1,203	1,497
92	438	150	588	2,406	2,994
93	657	250	907	4,140	5,047
94	876	324	1,200	5,343	6,543
1995	1,097	399	1,496	6,546	8,042
96	1,316	474	1,790	7,749	9,539
97	1,535	549	2,084	8,952	11,036
98	1,755	649	2,404	10,686	13,090
99	1,974	724	2,698	11,889	14,587
2000 and beyond	2,193	799	2,992	13,092	16,084

Table 44

Estimated Economic Benefits from a Doubling of Salmon and Steelhead Stocks from the Eel River System over Fifteen Years

Year	Benefits to Commercial Businesses			Non-Market Benefits	Total Benefits
	Commercial Fishing	Sport Fishing	Total		
	$'000				
1991	145	66	211	1,149	1,360
92	293	106	399	1,769	2,168
93	438	150	588	2,406	2,994
94	583	215	798	3,556	4,354
1995	728	281	1,009	4,705	5,714
96	881	324	1,205	5,343	6,548
97	1,026	365	1,391	5,962	7,353
98	1,171	431	1,602	7,112	8,714
99	1,319	499	1,818	8,279	10,097
2000	1,464	540	2,004	8,899	10,903
01	1,609	580	2,189	9,518	11,707
02	1,757	649	2,406	10,686	13,092
03	1,900	714	2,614	11,835	14,449
04	2,048	755	2,803	12,546	15,349
2005 and beyond	2,193	799	2,992	13,092	16,084

Table 45

Estimated Economic Benefits from a Doubling of Salmon and Steelhead Stocks from the Eel River System over Twenty Years

Year	Benefits to Commercial Businesses			Non-Market Benefits	Total Benefits
	Commercial Fishing	Sport Fishing	Total		
	----------$'000----------				
1991	110	37	147	602	749
92	219	75	294	1,203	1,497
93	330	112	442	1,805	2,247
94	438	150	588	2,406	2,994
1995	549	212	761	3,538	4,299
96	657	250	907	4,140	5,047
97	768	293	1,061	4,777	5,838
98	876	328	1,204	5,361	6,565
99	987	362	1,349	5,944	7,293
2000	1,097	399	1,496	6,546	8,042
01	1,206	437	1,643	7,148	8,791
02	1,316	474	1,790	7,749	9,539
03	1,425	512	1,937	8,351	10,288
04	1,535	549	2,084	8,952	11,036
2005	1,644	587	2,231	9,554	11,785
06	1,755	649	2,404	10,686	13,090
07	1,863	686	2,549	11,287	13,836
08	1,974	724	2,698	11,889	14,587
09	2,082	761	2,843	12,490	15,333
2010 and beyond	2,193	799	2,992	13,092	16,084

The annual benefits identified in Tables 43 through 45 are extended forward over 75 years using the alternative discounting procedures discussed previously. On this basis, total benefits associated with doubling salmon and steelhead stocks from the Eel River system are presented in Table 46. Benefits in all scenarios commence in Year 4 of the calculations.

Table 46
Estimated Total Benefits from Doubling Salmon and Steelhead Stocks of the Eel River System - Expressed in Present Day Terms

Benefit Scenario	Giving More Weight to the Present: 3% Discount Rate	Giving More Weight to the Present: 1% Discount Rate	Weighing the Present and Future Equally: 0% Discount Rate	Giving More Weight to the Future: -1% Discount Rate
	millions of dollars			
A. Doubling Over 10 Years				
- Benefits to Commercial Businesses	73	141	211	271
- Non-Market Benefits	317	619	923	1,206
- Total Benefits	390	760	1,134	1,477
B. Doubling Over 15 Years				
- Benefits to Commercial Businesses	67	135	204	266
- Non-Market Benefits	294	592	892	1,172
- Total Benefits	361	727	1,096	1,438
C. Doubling Over 20 Years				
- Benefits to Commercial Businesses	62	128	196	258
- Non-Market Benefits	270	561	858	1,132
- Total Benefits	332	689	1,054	1,390

Finally, we can again integrate the benefit results from Table 46 with alternative levels of investment spread over ten, fifteen and twenty years, to identify potential ratios of benefits to costs in the Eel River system associated with each benefit-investment combination. These data are presented in Tables 47 through 49.

Table 47

Estimated Ratio of Benefits to Program Costs from Doubling Salmon and Steelhead Production in the Eel River System in Ten Years

Full Program Investment	Annual Investment	Giving More Weight to the Present: 3% Discount Rate	Giving More Weight to the Present: 1% Discount Rate	Weighing the Present and Future Equally: 0% Discount Rate	Giving More Weight to the Future: -1% Discount Rate
-----$ million---------		----------ratio of benefits to costs----------			
A. Counting Benefits to Businesses Only					
50	5	1.7	3.0	4.2	5.2
75	7.5	1.1	2.0	2.8	3.5
100	10	0.9	1.5	2.1	2.6
200	20	0.4	0.7	1.1	1.3
B. Counting Both Market and Non-Market Values					
50	5	9.1	16.2	22.7	28.4
75	7.5	6.1	10.7	15.1	18.9
100	10	4.6	8.0	11.3	13.9
200	20	2.3	4.0	5.7	7.1
250	25	1.8	3.2	4.5	5.6
500	50	0.9	1.6	2.3	2.8

Table 48

Estimated Ratio of Benefits to Program Costs from Doubling Salmon and Steelhead Production in the Eel River System in Fifteen Years

Full Program Investment	Annual Investment	Giving More Weight to the Present: 3% Discount Rate	Giving More Weight to the Present: 1% Discount Rate	Weighing the Present and Future Equally: 0% Discount Rate	Giving More Weight to the Future: -1% Discount Rate
$ million		ratio of benefits to costs			
A. Counting Benefits to Businesses Only					
50	3.33	1.7	2.9	4.1	4.9
75	5	1.1	2.0	2.7	3.3
100	6.67	0.8	1.5	2.0	2.5
200	13.33	0.4	0.7	1.0	1.2
B. Counting Both Market and Non-Market Values					
50	3.33	9.0	15.8	21.9	26.6
75	5	6.0	10.5	14.6	18.0
100	6.67	4.5	7.9	11.0	13.3
200	13.33	2.3	3.9	5.5	6.7
250	16.67	1.8	3.1	4.4	5.3
500	33.33	0.9	1.6	2.2	2.7

Table 49

Estimated Ratio of Benefits to Program Costs from Doubling Salmon and Steelhead Production in the Eel River System in Twenty Years

Full Program Investment	Annual Investment	Giving More Weight to the Present		Weighing the Present and Future Equally	Giving More Weight to the Future
		3% Discount Rate	1% Discount Rate	0% Discount Rate	-1% Discount Rate
$ million		ratio of benefits to costs			
A. Counting Benefits to Businesses Only					
50	2.5	1.7	2.8	3.9	4.7
75	3.75	1.1	1.9	2.6	3.1
100	5	0.8	1.4	2.0	2.3
200	10	0.4	0.7	1.0	1.2
B. Counting Both Market and Non-Market Values					
50	2.5	9.0	15.3	21.1	25.3
75	3.75	5.9	10.1	14.1	16.7
100	5	4.5	7.7	10.5	12.5
200	10	2.2	3.8	5.3	6.3
250	12.5	1.8	3.0	4.2	5.0
500	25	0.9	1.5	2.1	2.5

Examination of Tables 47 through 49 suggest that an investment of up to $100 million dollars could be justified to double Eel River salmon and steelhead production, if only returns to businesses are considered. If non-market values are added to the calculation, investment of up to $500 million to double stocks could be justified.

4. The Navarro River

The Navarro River reaches t
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Table 50 provides estimates of
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Tabl

Estimated Production and Fut
Steelhead from t

Species	Present Production		
	Commercial Catch		Sport
	pieces '000	pounds '000 lbs	Catch '000
Coho	3	21	2
Steelhead	--	--	1

Tabl

Estimated Gains from Doubling
from the Na

Species	Benefits to Businesse		
	Commercial	Sport	
Coho	58	62	
Steelhead	--	25	
Both Species	58	87	

As for other rivers, scenar
stocks between 1991 and t
(Scenario B) and 2010 (Scen
annual benefits extended forw
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Table 52

Estimated Total Benefits from Doubling Salmon and Steelhead Stocks of the Navarro River - Expressed in Present Day Terms

Benefit Scenario	Giving More Weight to the Present: 3% Discount Rate	Giving More Weight to the Present: 1% Discount Rate	Weighing the Present and Future Equally: 0% Discount Rate	Giving More Weight to the Future: -1% Discount Rate
	millions of dollars			
A. Doubling Over 10 Years				
- Benefits to Commercial Businesses	3.5	6.9	10.2	13.3
- Non-Market Benefits	21.5	42.0	62.6	81.5
- Total Benefits	25.0	48.9	72.8	94.8
B. Doubling Over 15 Years				
- Benefits to Commercial Businesses	3.2	6.5	9.9	12.9
- Non-Market Benefits	19.8	40.0	60.4	79.0
- Total Benefits	23.0	46.5	70.3	91.9
C. Doubling Over 20 Years				
- Benefits to Commercial Businesses	3.0	6.2	9.5	12.5
- Non-Market Benefits	18.3	38.1	58.2	76.5
- Total Benefits	21.3	44.3	67.7	89.0

As in previous sections of this report, we can compare the values identified in Table 52 with alternative investment strategies stretched over ten, fifteen and twenty years, respectively, to identify boundary investment conditions for doubling of salmon and steelhead stocks from the Navarro River. This is done in Tables 53 through 55.

Table 53

Estimated Ratio of Benefits to Program Costs from Doubling Salmon and Steelhead Production in the Navarro River System in Ten Years

Full Program Investment	Annual Investment	Giving More Weight to the Present: 3% Discount Rate	Giving More Weight to the Present: 1% Discount Rate	Weighing the Present and Future Equally: 0% Discount Rate	Giving More Weight to the Future: -1% Discount Rate
$ million		ratio of benefits to costs			
A. Counting Benefits to Businesses Only					
2.5	.25	1.7	2.9	4.1	5.1
5	.5	0.8	1.5	2.0	2.6
10	1	0.4	0.7	1.0	1.3
B. Counting Both Market and Non-Market Values					
2.5	.25	11.9	20.4	29.1	36.5
5	.5	5.8	10.4	14.6	18.2
10	1	2.9	5.1	7.3	9.1
25	2.5	1.2	2.0	2.9	3.6
50	5	0.6	1.0	1.5	1.8

Table 54

Estimated Ratio of Benefits to Program Costs from Doubling Salmon and Steelhead Production in the Navarro River System in Fifteen Years

Full Program Investment	Annual Investment	Giving More Weight to the Present		Weighing the Present and Future Equally	Giving More Weight to the Future
		3% Discount Rate	1% Discount Rate	0% Discount Rate	-1% Discount Rate
$ million		ratio of benefits to costs			
A. Counting Benefits to Businesses Only					
2.5	.167	1.6	2.8	4.0	4.8
5	.33	0.8	1.4	2.0	2.4
10	.67	0.4	0.7	1.0	1.2
B. Counting Both Market and Non-Market Values					
2.5	.167	11.5	20.2	28.1	34.0
5	.33	5.8	10.1	14.1	17.0
10	.67	2.9	5.0	7.0	8.5
25	1.67	1.2	2.0	2.8	3.4
50	3.33	0.6	1.0	1.4	1.7

Table 55

Estimated Ratio of Benefits to Program Costs from Doubling Salmon and Steelhead Production in the Navarro River System in Twenty Years

Full Program Investment	Annual Investment	Giving More Weight to the Present: 3% Discount Rate	Giving More Weight to the Present: 1% Discount Rate	Weighing the Present and Future Equally: 0% Discount Rate	Giving More Weight to the Future: -1% Discount Rate
-----$ million---------		----------ratio of benefits to costs----------			
A. Counting Benefits to Businesses Only					
2.5	.125	1.6	2.7	3.8	4.5
5	.25	0.8	1.4	1.9	2.3
10	.5	0.4	0.7	1.0	1.1
B. Counting Both Market and Non-Market Values					
2.5	.125	11.2	19.3	27.1	32.4
5	.25	5.8	9.8	13.5	16.2
10	.5	2.9	4.9	6.8	8.1
25	1.25	1.1	2.0	2.7	3.2
50	2.5	0.6	1.0	1.4	1.6

Considering business benefits only, these data suggest that doubling of salmon and steelhead stocks for the Navarro River could conservatively justify investment of between $2.5 million and $5 million. If both market and non-market benefits are considered, investment to 5 times that level could be considered.

5. The Carmel River

The Carmel River has differing characteristics than those drainages previously analyzed in our report. This river produces only steelhead as a game fish--and its economic importance is chiefly characterized by both market and non-market benefits associated with sport fishing. However, the Carmel is accessible

to local central coast residents and to the populous greater San Francisco area. In such circumstances, work in the San Francisco area by Meyer (1987) suggests that "existence" of viable fish runs is valued highly by residents. Thus, the economic values presented here undoubtedly underestimate the total benefits associated with maintaining viable steelhead runs in the Carmel River by a considerable amount.

Sport fishing is presently available in the Carmel only intermittently due to interrelated problems of inadequate habitat, poor instream flow conditions and inadequate fish passage. Sport catch is estimated to be less than 1,000 fish (Dettman, 1986). The California Department of Fish and Game reports that steelhead production in the Carmel drainage could be substantially rehabilitated, however--potentially reaching a population of 7,700 adult fish (Snider, 1983). These improvements would result from increased instream flows in the river, and unhampered passage for steelhead at Los Padres Dam. Previous discussion in this report indicates that catch rates for steelhead can range between .25 and .40 of total stock, suggesting a potential sport catch between 1,925 steelhead and 3,080 steelhead in the river. Our analysis here will be based on a 2,000 steelhead sport catch improvement.

Unit values utilized for steelhead in this report are the same as for other California streams--and have been previously displayed in Table 29. Existence and bequest values have not been developed for steelhead runs in the Carmel River--and this may be a significant omission. Economic values associated with

increasing sport catch in the Carmel River by 2,000 steelhead are presented in Table 56.

Table 56

Estimated Gains from Increasing Sport Catch in the Carmel River by 2,000 Steelhead

Component of Value	Estimated Annual Benefit $'000
Benefits to Businesses	50
Non-Market Value	1,060
Total value	1,110

As with other drainage, we construct restorative scenarios over ten, fifteen and twenty years of improvement, respectively, and under alternative valuing perspectives concerning the future. Resulting estimates of total benefit from a 2,000 steelhead increase in sport catch from the Carmel River are presented in Table 57.

Table 57

Estimated Total Benefits from a 2,000 Steelhead Improvement in Sport Catch from the Carmel River - Expressed in Present Day Terms

Benefit Scenario	Giving More Weight to the Present: 3% Discount Rate	Giving More Weight to the Present: 1% Discount Rate	Weighing the Present and Future Equally: 0% Discount Rate	Giving More Weight to the Future: -1% Discount Rate
	millions of dollars			
A. Doubling Over 10 Years				
- Benefits to Commercial Businesses	1.2	2.4	3.5	4.6
- Non-Market Benefits	25.6	50.1	74.7	97.3
- Total Benefits	26.8	52.5	78.2	101.9
B. Doubling Over 15 Years				
- Benefits to Commercial Businesses	1.1	2.3	3.4	4.4
- Non-Market Benefits	23.7	47.7	72.1	93.0
- Total Benefits	24.8	50.0	75.5	97.4
C. Doubling Over 20 Years				
- Benefits to Commercial Businesses	1.0	2.1	3.3	4.3
- Non-Market Benefits	21.9	45.4	69.4	90.7
- Total Benefits	22.9	47.5	72.7	95.0

Again, we relate the values displayed in Table 57 to alternative investment strategies over ten, fifteen and twenty years, respectively, to identify the range of feasible investment options available on the Carmel River. Results are presented in Tables 58 through 60.

Table 58

Estimated Ratio of Benefits to Program Costs from a 2,000 Steelhead Improvement in Sport Catch for the Carmel River Achieved over Ten Years

Full Program Investment	Annual Investment	Giving More Weight to the Present: 3% Discount Rate	Giving More Weight to the Present: 1% Discount Rate	Weighing the Present and Future Equally: 0% Discount Rate	Giving More Weight to the Future: -1% Discount Rate
$ million		ratio of benefits to costs			
A. Counting Benefits to Businesses Only					
1	.1	1.4	2.5	3.5	4.4
2.5	.25	0.6	1.0	1.4	1.8
5	.5	0.3	0.5	0.7	0.9
B. Counting Both Market and Non-Market Values					
1	.1	31.5	55.3	78.2	98.0
2.5	.25	12.8	21.9	31.3	39.2
5	.5	6.2	11.2	15.6	19.6
10	1	3.2	5.5	7.8	9.8
25	2.5	1.3	2.2	3.1	3.9
50	5	0.5	1.1	1.6	2.0
75	7.5	0.4	0.7	1.0	1.3

Table 59

Estimated Ratio of Benefits to Program Costs from a 2,000 Steelhead Improvement in Sport Catch for the Carmel River Achieved over Fifteen Years

Full Program Investment	Annual Investment	Giving More Weight to the Present		Weighing the Present and Future Equally	Giving More Weight to the Future
		3% Discount Rate	1% Discount Rate	0% Discount Rate	-1% Discount Rate
$ million		ratio of benefits to costs			
A. Counting Benefits to Businesses Only					
1	.067	1.4	2.5	3.4	4.1
2.5	.167	0.6	1.0	1.4	1.6
5	.33	0.3	0.5	0.7	0.8
B. Counting Both Market and Non-Market Values					
1	.067	31.0	53.8	75.5	90.2
2.5	.167	12.4	21.7	30.2	36.1
5	.33	6.2	10.9	15.1	18.0
10	.67	3.1	5.4	7.6	9.0
25	1.67	1.2	2.2	3.0	3.6
50	3.33	0.6	1.1	1.5	1.8
75	5	0.4	0.7	1.0	1.2

Table 60

Estimated Ratio of Benefits to Program Costs from a 2,000 Steelhead Improvement in Sport Catch for the Carmel River Achieved over Twenty Years

Full Program Investment	Annual Investment	Giving More Weight to the Present: 3% Discount Rate	Giving More Weight to the Present: 1% Discount Rate	Weighing the Present and Future Equally: 0% Discount Rate	Giving More Weight to the Future: -1% Discount Rate
$ million		ratio of benefits to costs			
A. Counting Benefits to Businesses Only					
1	.05	1.4	2.3	3.3	3.9
2.5	.125	0.5	0.9	1.3	1.6
5	.25	0.3	0.5	0.7	0.8
B. Counting Both Market and Non-Market Values					
1	.05	30.9	52.8	72.7	86.4
2.5	.125	12.1	20.7	29.1	34.6
5	.25	6.2	10.6	14.5	17.3
10	.5	3.1	5.3	7.3	8.6
25	1.25	1.2	2.1	2.9	3.5
50	2.5	0.6	1.1	1.4	1.7
75	3.75	0.4	0.7	1.0	1.1

Results from Tables 58 through 60 suggest that benefits associated with an incremental catch of 2,000 steelhead from the Carmel River would justify direct and indirect investment of up to $2.5 million, if only business benefits are considered, and $25 million or more, if both market and non-market benefits are evaluated.

6. The Ventura River

The Ventura River flows through several expanding residential communities in Ventura County, before reaching the sea at Ventura (San Buenaventura). There are several public parks along the river, and access is fairly easy. It may consequently be typical of streams serving urban and sub-urban south coast communities.

In earlier times, the Ventura River was described as a consistently good southern California stream for steelhead fishing (Fry, 1938). Clanton and Jarvis (1946) estimated a minimum average run size between 2,000 and 2,500 adult steelhead for the Matilija Creek portion of the drainage, and total river run size may have been approximately double that number (Capelli, 1988). Jensen (1974) estimated that it might be possible to sustain a hatchery-based steelhead population of 2,000+ adults, generating a sport catch of 1,800 steelhead.

Today, adult steelhead populations in the Ventura River are smaller, numbering in the hundreds--chiefly due to loss of habitat and to often inadequate instream flows (Sasaki, 1988). Restoration efforts would consequently need to focus first in these areas. Further, continued existence of viable steelhead runs on the Ventura is an important issue. Consequently, as with the Carmel River, the use-based economic values presented here will substantially underestimate total benefits associated with maintenance of a viable steelhead population in the Ventura River by south coast residents.

For our purposes, we will consider the steelhead population estimate by Jensen (1974) as limiting, and evaluate the benefits

associated with an increased sport catch from the Ventura River of 1,000 steelhead. Unit values utilized for steelhead here are the same as for other California streams, and have been previously displayed in Table 29. Existence and bequest values are not provided, as no empirical estimates are available. As for the Carmel River, this may represent a deficiency of the present analysis. Economic values associated with increasing sport catch by 1,000 steelhead are presented in Table 61.

Table 61

Estimated Gains from Increasing Sport Catch in the Ventura River by 1,000 Steelhead

Component of Value	Estimated Annual Benefit $'000
Benefits to Businesses	25
Non-Market Value	530
Total value	555

We again construct this restorative scenario over ten, fifteen and twenty year periods, respectively, and under alternative perspectives concerning weighing of present versus future benefits. Resulting estimates of total benefit from a 1,000 steelhead increase in sport catch from the Ventura River are presented in Table 62.

Table 62

Estimated Total Benefits from a 1,000 Steelhead Improvement in Sport Catch from the Ventura River - Expressed in Present Day Terms

Benefit Scenario	Giving More Weight to the Present: 3% Discount Rate	Giving More Weight to the Present: 1% Discount Rate	Weighing the Present and Future Equally: 0% Discount Rate	Giving More Weight to the Future: -1% Discount Rate
	millions of dollars			
A. Doubling Over 10 Years				
- Benefits to Commercial Businesses	0.60	1.20	1.75	2.30
- Non-Market Benefits	12.80	25.05	37.35	48.65
- Total Benefits	13.40	26.25	39.10	50.95
B. Doubling Over 15 Years				
- Benefits to Commercial Businesses	0.55	1.15	1.70	2.20
- Non-Market Benefits	11.85	23.85	36.05	46.50
- Total Benefits	12.40	25.00	37.75	48.70
C. Doubling Over 20 Years				
- Benefits to Commercial Businesses	0.50	1.05	1.65	2.15
- Non-Market Benefits	10.95	22.70	34.70	45.35
- Total Benefits	11.45	23.75	36.35	47.50

Relating benefits from Table 62 to alternative investment strategies over ten, fifteen and twenty years, respectively, we identify the range of feasible investment options for the Ventura River in Tables 63 through 65.

Table 63

Estimated Ratio of Benefits to Program Costs from a 1,000 Steelhead Improvement in Sport Catch for the Ventura River Achieved over Ten Years

Full Program Investment	Annual Investment	Giving More Weight to the Present: 3% Discount Rate	Giving More Weight to the Present: 1% Discount Rate	Weighing the Present and Future Equally: 0% Discount Rate	Giving More Weight to the Future: -1% Discount Rate
$ million		ratio of benefits to costs			
A. Counting Benefits to Businesses Only					
0.5	.05	1.4	2.6	3.5	4.4
1	.1	0.7	1.2	1.8	2.2
2.5	.25	0.3	0.5	0.7	0.9
B. Counting Both Market and Non-Market Values					
0.5	.05	31.2	55.9	78.2	98.0
1	.1	15.6	27.6	39.1	49.0
2.5	.25	6.4	11.0	15.6	19.6
5	.5	3.1	5.6	7.8	9.8
10	1	1.6	2.8	3.9	4.9
25	2.5	0.6	1.1	1.6	2.0

Table 64

Estimated Ratio of Benefits to Program Costs from a 1,000 Steelhead Improvement in Sport Catch for the Ventura River Achieved over Fifteen Years

Full Program Investment	Annual Investment	Giving More Weight to the Present: 3% Discount Rate	Giving More Weight to the Present: 1% Discount Rate	Weighing the Present and Future Equally: 0% Discount Rate	Giving More Weight to the Future: -1% Discount Rate
$ million		ratio of benefits to costs			
A. Counting Benefits to Businesses Only					
0.5	.033	1.4	2.5	3.4	4.1
1	.067	0.7	1.2	1.7	2.0
2.5	.167	0.3	0.5	0.7	0.8
B. Counting Both Market and Non-Market Values					
0.5	.033	31.0	54.3	75.5	90.2
1	.067	15.5	27.2	37.8	45.1
2.5	.167	6.2	10.8	15.1	18.0
5	.33	3.1	5.4	7.6	9.0
10	.67	1.6	2.7	3.8	4.5
25	1.67	0.6	1.1	1.5	1.8

Table 65

Estimated Ratio of Benefits to Program Costs from a 1,000 Steelhead Improvement in Sport Catch for the Ventura River Achieved over Twenty Years

Full Program Investment	Annual Investment	Giving More Weight to the Present		Weighing the Present and Future Equally	Giving More Weight to the Future
		3% Discount Rate	1% Discount Rate	0% Discount Rate	-1% Discount Rate
-----$ million---------		----------ratio of benefits to costs----------			
A. Counting Benefits to Businesses Only					
0.5	.025	1.4	2.3	3.3	3.9
1	.050	0.7	1.2	1.6	2.0
2.5	.125	0.2	0.4	0.6	0.8
B. Counting Both Market and Non-Market Values					
0.5	0.25	30.9	52.8	72.7	86.4
1	0.05	15.4	26.4	36.4	43.2
2.5	0.125	6.0	10.4	14.6	17.3
5	0.25	3.1	5.3	7.2	8.6
10	0.5	1.6	2.6	3.6	4.3
25	1.25	0.6	1.0	1.4	1.8

The values identified in Tables 63 through 65 suggest that total benefits associated with an improved catch of 1,000 steelhead from the Ventura River would justify investment of up to $25 million. If benefits to business only were considered, an investment of up to $1 million appears justified.

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Appendix A

Calculation of Salmon and Steelhead Production for "Other California Rivers"

To provide a complete estimate of contemporary salmon and steelhead production in California, it was necessary to estimate current production for other rivers not explicitly treated in our analysis. Little information is available to this task. Wahle and Pearson (1987) estimated escapement of chinook and coho to California's rivers. Barngrover (1987) provided estimates for steelhead production from the Mad River. Maahs (1987) provided estimates of production from "other California rivers" inclusive of the Eel. Using these data, catch to escapement ratios for our Eel River analysis and inference from general discussion with California Department of Fish and Game personnel, we estimate the following production for "other rivers" in California (Table A). As noted, these estimates are speculative, and based on very fragmentary information.

Table A

Estimated Production of Salmon and Steelhead from Other California Rivers

Species	Escapement	Commercial Catch	Sport Catch	Total Stock
	'000			
Chinook	9	19	2	30
Coho	13	32	2	47
Steelhead	--	--	5	20