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Angler Response to Success in the California Salmon Sportfishery: Evidence and Management Implications

ELIZABETH J. ANDREWS

Department of Ecology
University of California, Davis
Davis, CA

JAMES E. WILEN

Department of Agricultural Economics
University of California, Davis
Davis, CA 95616

Abstract *This paper examines effort responsiveness to success in the California salmon partyboat sport fishery. The management process in this important fishery involves setting target harvest levels for both commercial and sportfishing groups and then using closed seasons, restricted gear, and possession limits to dampen effective effort. An important component of the management process involves forecasting sportfishing effort and its effect on catch in order to advance-plan management actions. For want of better information, simple proportionality rules-of-thumb are used currently and this paper examines the plausibility of these. Some simple models forecasting aggregate angler participation and aggregate partyboat catch on a weekly basis are estimated across several different ports. Our findings suggest that anglers are responsive to recent success in several ports (elasticities up to +.5) and that angler participation affects catch with an elasticity exceeding unity. These results indicate that the simple rules of thumb currently in use could be in substantial error.*

Introduction

The passage of the Fisheries Conservation and Management Act (FCMA) in 1976 gave fisheries managers both increased authority and a new set of explicit objectives with which to manage United State coastal fisheries. Despite the good intentions embodied in the act, however, it is probably fair to say that the process of fisheries management has become considerably more difficult since 1976. Part of this is due to the growing complexities of modern fisheries, but a significant part of the problem has to do with the procedural requirements of the act itself.

One of the more far-reaching aspects of the FCMA has been the shift away from relatively well-defined goals directed at fish (e.g., maximum sustainable yield or MSY) toward less precise goals aimed at user groups (e.g., "optimize social yield"). This shift in emphasis has created new difficulties for management staffs who have had to translate broadly-specified social goals into specific actions (such as season/area closures, gear changes, etc.) at the field level. Today it is no longer sufficient (simply!) to determine and achieve a goal like MSY; now managers must predict the economic and social consequences of various options and select the mix of policies that "optimizes" net social benefits.

In addition to changes in the basic objectives of management, there have also been important changes in the procedures for making actual management decisions. Fifteen years ago fisheries biologists could use accumulated experience and the "feel" of a situation and make instant, and on-line, decisions in the field. In contrast, now the act requires that management plans (procedures and decision rules) be developed in advance, subjected to public debate, and then adhered to as legal mandate. These procedural changes obviously have reduced some of the flexibility of management and, more importantly, have forced fisheries managers to rely on models and forecasts to a greater degree.

The combination of changes in objectives and procedures requiring advanced planning has had a dramatic effect on fisheries management institutions. In the pre-FCMA era, management staffs had enough to accomplish in carrying out the biologically-oriented tasks of sampling, monitoring, and forecasting fish populations. Since the passage of the FCMA in 1976, these same staffs have increasingly found themselves faced with the need to forecast *fishermen* behavior in addition to fish dynamics. Given that most management staffs are primarily biologists, it is not surprising that these new modelling demands have been tackled with mixed success. More often than not, managers have had to guess responsiveness of fishermen to regulatory changes and/or build in enough in-season flexibility in management plans to monitor fishermen and then adjust regulations in-season where necessary.

These observations are not intended as criticism of fisheries management staffs. Indeed, given the vagueness of the law and the nature of the procedural changes required, fisheries managers have done remarkable jobs adapting. It is apparent, however, that more input from economists and other social scientists would be useful in improving management. The basic changes engendered by the act create new needs for a body of applied research in an area that has been virtually untouched to date by fisheries economists; namely, the study of (modelling and forecasting) behavior of fishermen under various scenarios. Managers are continually faced with critical but as yet unanswered questions such as: how much will effort intensity increase if the season is shortened? How much will a decrease in sportfishing bag limits change participation rates and values per day? How will gear regulation changes affect the intensity, timing, and spatial location of effort and catch? These and other similar questions dealing with the behavior of the fishing sector are precisely the types of questions the social sciences (particularly economics) are well suited to addressing.

In this paper we present the results of a relatively straightforward example of the type of research which needs addressing under new FCMA procedures. The basic behavioral linkages examined are those between relative abundance, sportfishing participation, and aggregate harvest in the California salmon sportfishing. Current management procedures utilize ad hoc assumptions about these relationships; we seek to assess how well these rules of thumb perform under various conditions. In the next section we discuss the fishery and its main characteristics as well as management procedures currently used. The following section presents modelling strategies and results and a final section summarizes the implications for management.

The California Salmon Sportsfishery

The Pacific salmon sportfishery of California operates almost exclusively within 20 miles off the northern and central coast (Fig. 1). The nature of the fishery is governed by the life cycle of salmon. Adult salmon spawn in freshwater river systems along the coast, after which they die. The juveniles spend a few months in freshwater and then migrate to the ocean where they spend one to three years (depending on the species). These adult salmon then return to the same river in which they were spawned to repeat the cycle.

In the California fishery there are two species caught by the recreational and commercial fisheries. Chinook salmon (O. Tshawytscha) spawn in the Sacramento/San Joaquin river systems in the late summer and fall and are intercepted en route along the north central coast and San Francisco Bay Area. Catch in the northern ports is predominantly the smaller Coho salmon (O. Kitsutch) which spawn in the Klamath River and other coastal rivers in midsummer.

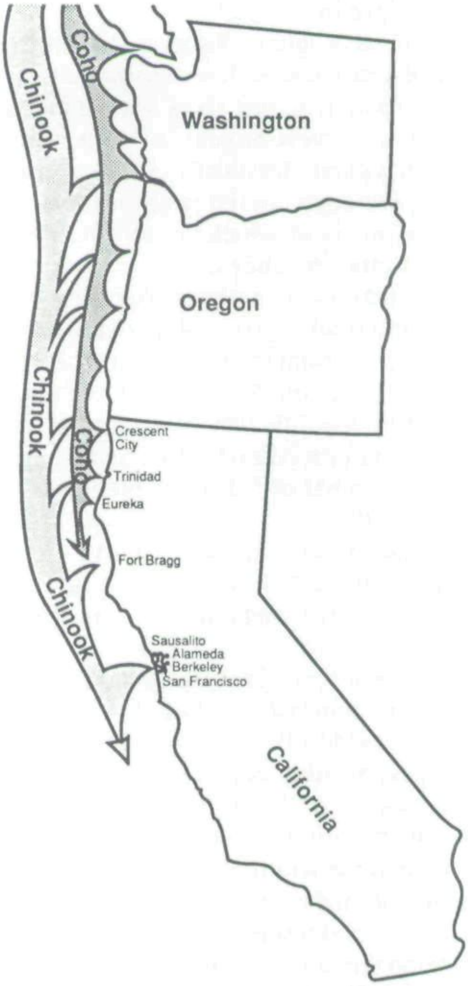

Figure 1. Salmon Runs and Sportfishing Ports

In parallel with events in other fisheries nationwide, the management of California's salmon fisheries has become increasingly complicated over the past decade. The fishery is inherently difficult to manage since it is desirable to allow sufficient "escapement" from the fishery to spawn each year. Ideally managers would like to regulate so that each of the several hundred spawning streams receives enough escapement to fill its spawning grounds. In practice this is impossible because the mixed commercial/sports fishery is operating over fish from many substocks simultaneously.

Although salmon arrive at spawning streams with remarkable temporal regularity each year, the general abundance level can vary widely due to factors affecting survival of each cohort in the ocean, and so forth. Fisheries managers set escapement targets and the surplus over these is allocated each season to the fishery. The FCMA procedures have forced managers to explicitly allocate surpluses between sports and commercial fishermen and currently a sliding scale (proportions dependent on total abundance) is used as an allocation guideline. Season lengths and other instruments are then manipulated to achieve the specific targeted allocations to each group.

The regulation of California's salmon fisheries has been particularly contentious over the past several years due to low overall salmon returns. Under low abundance conditions the sport fisheries have been allocated larger relative allocations but lower aggregate harvest targets. An important issue has been how to reduce sportfishing catch without drastically cutting consequent economic benefits. Angler expenditures and other tourist revenues are often of critical importance to coastal economies, many of which are already depressed by reductions in commercial fishing and timber revenues.

Reductions in season length (starting later, finishing earlier, midseason closures), reductions in daily and weekly possession limits, and changes in permitted gear have all been candidate instruments for reducing the impact of sportfishing on total harvest. In planning for various levels of reduced abundance, management staffs have been hampered by the difficulty of accurately predicting sportfishing participation rates. The current procedure for forecasting upcoming fishing angler trips involves "dividing the number of fish available for harvest by the (previous year's) catch rate" (PFMC 1986:19). This calculation, if it represents anything, might yield the number of angler trips *needed* to harvest the target but it tells us nothing about how many anglers *will* show up. What is really needed is a behavioral model which includes, among other things, how abundance (via success) affects participation.

In the research reported below we analyze patterns of angler participation in the California charter-boat salmon fishery. For this study, we chose to analyze data from the most recent period (1976–78) in which there were no in-season closures, regulatory changes, or other constraints on fishing. In California, commercial passenger fishing vessels (CPFVs) operate out of a variety of ports on a fee basis, either to groups or to individuals on a daily per-person basis. Boat captains are required to complete and file trip records at the end of each fishing trip, recording the number of anglers, areas fished, number and species landed for each species caught, etc. The initial data set covered three consecutive years and contained 15,540 salmon trip records orginating from 17 fishing ports in Central and Northern California. We limited our analysis to data from those eight ports where more than 50% of the total CPFV trips taken were salmon trips.

These data account for about 95% of the total salmon trips taken.[1] Data were aggregated by port and into one week units for anlaysis.

Modelling and Estimation

In order to model the important interactions between effort, catch, and success in this fishery, we chose to estimate both a catch or (harvest) function and an effort response equation. The catch equation can be viewed as a physical production function in that aggregate catch in a given port in a given week is hypothesized to be a function of aggregate angler effort and an abundance index. The effort equation we estimated is essentially a behavioral response relationship which links up the number of anglers participating in fishing with a measure of success.[2]

The Harvest Production Function

Our harvest production function forms were selected to be both simple and to incorporate a priori understanding of the salmon resource. Our principle data series is a time-series/cross section consisting of eight ports for which we have three contiguous years of weekly data. Our hypothesized relationship between the relevant variables was simply that total harvest levels, H_{it}, in a particular port, i, in a particular week, t, ought to be positively related to both numbers of anglers fishing, E_{it}, and an index, N_{it}, of stock abundance. As in many similar studies of this sort we have no independent measure of salmon abundance. Fortunately salmon follow an obliging life-cycle pattern in that they return to their streams of origin with almost clockwork regularity season after season. We thus hypothesized an abundance index, $g_i(t)$, for each location where t is Julian calendar time.

Our a priori hypothesis was that $g_i(t)$ ought to be different for different ports but follow a predictable qualitative pattern (repeatable over the years) as we move from north to south on the coast. In the northernmost ports (Crescent City and Trinidad), the main salmon runs consist of Coho salmon which return in the spring only. In the southernmost ports in our sample (San Francisco Bay Area), the principle runs are of Chinook salmon which return in two "waves"; one in spring and one in fall. Two middle ports in our sample mix these two stocks.

The specific estimating form chosen for the harvest production functions is:

$$H_{it} = A_i E^{\alpha^{i}}_{it} \, \mathrm{EXP}[g_i(t)] \exp[U_{it}] \qquad U_{it} \sim N(0, \sigma^2) \tag{1}$$

which yields, after logarithmic transformation

$$\ln H_{it} = \alpha_i \ln E_{it} + \ln A_i + g_i(t) + U_{it} \tag{2}$$

with

$$g_i(t) = a_i + b_i \, D76_i + c_i \, D77_i + d_i t + e_i t^2 + f_i t^3 \tag{3}$$

where $e_i = f_i = 0 \quad d_i < 0$ for Crescent City, Trinidad
$f_i = 0 \quad d_i < 0 \; e_i > 0$ Eureka, Fort Bragg
$d_i, f_i > 0 \quad e_i < 0$ San Francisco, Bay Area.

We have thus assumed that abundance in the two northernmost ports (spring Coho mainly) can be indexed by a linear equation whereas in the southernmost ports a cubic equation with spring and fall peaks is suitable. The two middle ports (Eureka and Fort Bragg) were hypothesized to experience a mixed pattern approximated by a quadratic with midsummer trough. Dummy variables D76 and D77 were also included to shift the origin of the abundance index to reflect different absolute levels of salmon returns (1977 was supposed to have been a low Coho abundance year, for example).[3]

The results for these models are presented in Table 1 below.[4] There are several points worthy of noting in the results. First of all, the simple forms postulated explain a substantial proportion of the variation in observed harvest levels (80–90%). Aggregate numbers of anglers are particularly important as a determinant of aggregate harvest and the elasticity of harvest with respect to anglers is surprisingly high (over unity). The size of this elasticity warrants further investigation; increasing marginal product may be due to searching and information sharing behavior which is more efficient with more numbers, or it may suggest that "good" anglers turn up in large numbers when catch rates are high, and so forth. Also interesting is the fact that the harvest/angler elasticity is higher in the fisheries close to urban areas (e.g., San Francisco, Sausalito, Emeryville, Berkeley) than in the northern rural areas. This is opposite of our initial hypothesis which was based on the belief that sports fishermen in rural areas would be higher skilled and more efficient than their (perhaps tourist-based) urban counterparts.[5] Lastly our indices of abundance work fairly well and give some credence to our hypothesis about repeatable patterns which differ by location. The linear pattern proposed for northern parts is not rejected and the drop in Coho abundance during 1977 is picked up in the between-year dummy variables. The mixed-pattern middle ports results are not as conclusive although the signs are as hypothesized. The Bay Area ports show considerable consistency and appropriate signs. The implied peaks for San Francisco and Sausalito occur on the 36th and 38th weeks of the year, respectively, which is precisely consistent with the late September, early October fall run peaks.

The Effort Response Function

The effort response function was modelled using a simple form reflecting a measure of expected success, S^*_{it}, and an exogenous time trend. Our hypotheses for effort reflected the belief that salmon fishermen respond to good fishing within the season by turning out in larger numbers. The information flow in this fishery is particularly good in comparison with other sport fisheries. Major newspapers and radio programs summarize activities by reporting average fish per angler day and telephone hotlines report percentages of anglers limiting out in various ports on a daily basis. We thus expected that recent (and in fact nearly on-line) information is available, accurate, and used by fishermen in their decision about when and where to fish.

The predictive equation used to model effort response is

$$E_{it} = B_i (S^*_{it})^{\beta_i} \, \mathrm{EXP}[m_i t + n_i t^2] \, \mathrm{EXP}[\epsilon_{it}] \quad \epsilon_{it} \sim N(0, \eta^2) \tag{4}$$

Table 1

Aggregate Harvest Function: Estimated Coefficients by Port (t-statistics, in parentheses)

Port	ln A	ln E	Week	$Week^2$	$Week^3$	$Year_{76}$	$Year_{77}$	RHO	R^2	R^2adj.	N
Crescent City	0.51	1.14	−0.047			0.15	0.26		0.88	0.87	37
	(0.73)	(14.32)	(−2.41)			(0.71)	(−0.12)				
Trinidad	3.00	1.12	−0.10			−0.39	−1.95	0.86	0.90	0.88	36
	(1.95)	(10.92)	(−2.05)			(0.43)	(−3.26)	(10.16)			
Eureka	6.73	1.24	−0.44	0.0058		−0.21	−0.67	0.43	0.85	0.83	55
	(1.63)	(7.09)	(−1.45)	(1.16)		(−0.67)	(−2.22)	(3.58)			
Fort Bragg	0.20	1.28	−0.18	0.0035		0.79	−0.036		0.86	0.85	52
	(0.061)	(10.90)	(−0.68)	(0.77)		(2.81)	(−0.13)				
San Francisco	−3.97	1.38	0.24	−0.0098	0.00012	0.13	0.13	0.43	0.83	0.82	115
	(−4.44)	(14.68)	(2.46)	(−2.60)	(2.65)	(0.85)	(0.86)	(5.18)			
Sausalito	−4.57	1.50	0.22	−0.0097	0.00012	0.073	−0.14	0.43	0.80	0.79	115
	(−4.55)	(12.60)	(2.27)	(−2.41)	(2.42)	(0.49)	(−0.98)	(5.13)			
Emeryville	−2.54	1.23	0.16	−0.0063	0.000070	0.37	0.049	0.43	0.79	0.77	115
	(−2.60)	(12.70)	(1.34)	(−1.32)	(1.20)	(2.03)	(0.28)	(5.15)			
Berkeley	−1.39	1.07	0.084	−0.0026	0.000020	0.25	0.12	0.52	0.81	0.79	115
	(−1.40)	(14.70)	(0.69)	(−0.53)	(0.33)	(1.21)	(0.61)	(6.46)			

We used the mean catch per angler day in the previous week as our expectations variable, S^*_{it}. This variable differs by port and over the season and, as indicated above, is a widely available measure of fishermen success.[6] The time trend we hypothesized was quadratic in Julian time. Some earlier work on angler participation in California and recent work on Alaska sportfishing (Jones and Stokes 1987) found evidence of a midsummer peak in participation, *independent* of success and possibly reflecting the fact that people prefer to take vacation when weather is good, children are out of school, and so forth. A test of this hypothesis would thus be $m_i > 0$, $n < 0$ and the peak given by $(m_i/2n_i)$ approximately equal across ports. Our final estimation equation was

$$\ln E_{it} = \beta_i \ln (S^*_{it}) + \ln B_i + m_i t + n_i t^2 + p_i d76_i + q_i d77_i + \epsilon_{it} \qquad (5)$$

The results are given in Table 2 below.

These results also suggest some interesting aspects of angler participation. First of all, within-season success has some impact on numbers of anglers showing up to participate in partyboat angling. The elasticity of angler participation with respect to success is significant in several ports although small in magnitude. Response is generally higher in the urban ports, a finding which seems to suggest that the urban areas are more than just tourist-based. It seems, in fact, that the urban areas within the Bay Area are better characterized as a pool of active potential salmon fishermen who respond readily to within-season patterns in success. Of interest also is the consistency across ports of the exogenous time trend in effort. The quadratic fits well overall with consistent signs and low-variance estimates. In addition, as Table 3 below shows, the predicted seasonal peaks in effort are all very close (about the first week in July). Note also that these effort peaks are not simply echoing abundance peaks and in fact are basically out of phase; effort peaks occur just about when run sizes are at their lowest levels in nearly all ports. All of this points to fairly conclusive evidence of a predictable seasonal pattern of angler participation—basically increasing, peaking and then decreasing from July forward, modified by within-season responses to high catches that range up to 1% increases in participation for every 2% increase in success.

Conclusions and Implications for Management

The above analysis, simplified as it is, suggests several conclusions that are important with respect to recreation angling. First, the impact in this fishery of anglers on catch is surprisingly high; proportional increases in anglers generate more than proportional increases in catch, other things being equal. While these estimates ought to be taken with some caution in view of our imperfect abundance measures, they are consistent with findings of other salmon angling studies conducted in British Columbia (Peterman, R. M. and G. J. Steer 1981). The possibility of elasticities greater than unity suggests several topics worthy of future investigation. For example, is the nonproportionality associated with numbers of anglers per se, or numbers of vessels (i.e., mass contact effects of more lines in the water or more vessels "searching" wider areas)? Is it due to differences in skills so that higher numbers of anglers are associated with higher average skills, and so forth?

Table 2

Aggregate Effort Response Equation: Estimates of Coefficients by Port (t-statistics, in parentheses)

Port	ln B	ln S*	Week	Week^2	Year$_{76}$	Year$_{77}$	RHO	R^2	R^{2}adj.	N
Crescent City	−29.24	0.11	2.32	−0.040	−0.58	−0.81	0.36	0.77	0.73	37
	(−6.06)	(0.52)	(6.72)	(−6.82)	(−1.69)	(−2.23)	(2.33)			
Trinidad	−35.20	0.22	2.71	−0.048	0.32	−0.52		0.58	0.51	36
	(−3.94)	(1.08)	(4.46)	(−4.65)	(1.02)	(−1.60)				
Eureka	−17.37	0.25	1.32	−0.021	0.62	0.52	0.42	0.82	0.80	55
	(−8.11)	(4.26)	(9.41)	(−9.43)	(3.06)	(2.47)	(3.43)			
Fort Bragg	−18.45	0.11	1.56	−0.027	1.45	−0.61	0.79	0.76	0.73	52
	(−3.27)	(1.81)	(3.90)	(−3.97)	(1.70)	(−0.90)	(9.24)			
San Francisco	2.77	0.50	0.13	−0.0024	−0.16	−0.21	0.25	0.59	0.58	115
	(7.46)	(6.22)	(6.14)	(−6.25)	(−1.53)	(−2.05)	(2.72)			
Sausalito	3.25	0.35	0.12	−0.0021	0.095	0.093	0.33	0.61	0.60	115
	(9.99)	(4.91)	(6.02)	(−5.79)	(0.97)	(0.96)	(3.70)			
Emeryville	2.14	0.41	0.13	−0.0022	−0.23	0.047	0.27	0.50	0.48	115
	(5.23)	(5.13)	(4.78)	(−4.57)	(−1.70)	(0.36)	(3.75)			
Berkeley	1.95	0.12	0.21	−0.0036	0.068	0.093		0.41	0.38	115
	(5.26)	(1.75)	(8.18)	(−8.05)	(0.55)	(0.76)				

Table 3
Predicted Seasonal Peak ($\hat{a}/2\hat{b}$)

Crescent City	29.0
Trinidad	30.1
Eureka	31.4
Fort Bragg	28.9
San Francisco	27.1
Sausalito	28.6
Emeryville	29.5
Berkeley	29.2

The results from the effort response equations are also potentially important. First of all, there is fairly conclusive evidence of an exogenously-driven trend in angler participation rates. It doesn't seem to matter, in fact, what port is being considered or what abundance levels are; angler participation peaks in early July at about exactly the same week in all ports. This is a possible explanation for some odd results reported in some travel-cost studies in which success affected valuation with the wrong sign. If researchers sample over a season without controlling for the fact that the population of potential anglers peak in midsummer (exogenously), then it is possible to get spurious correlations suggesting high willingness to pay exactly when abundance is lowest.

Perhaps more important is the evidence that (in some ports at least) angler participation does react to success. This has important implications for current management practices which (implicitly and explicitly) assume nonresponsive behavior and proportional catch elasticities. To see this, note that we model the system

$$
\begin{aligned}
C_t &= AE_t^{\alpha}N_t \\
E_t &= B(S_t^*)^{\beta}g(t)
\end{aligned}
\tag{6}
$$

Assume for simplicity that g(t) is constant so that $Bg(t) = K$. Suppose that we wish to project total effort in this fishery over a year associated with a projected abundance level $\overline{N}$. Dropping time subscripts and substituting $S^* = C/E$ from the first equation into the second, we have

$$
\overline{E} = K^{Y/\beta}A^{Y}\overline{N}^{Y} \qquad \text{where } Y = \frac{\beta}{1 + \beta - \alpha\beta} \tag{7}
$$

as the "equilibrium" predicted effort level associated with N. Notice that actual effort will be proportional to abundance only when $\alpha\beta = 1$ so that the coefficient Y becomes unity. In our estimates, α is greater than one, β is less than one and the product is less than one in all cases. Thus, $Y < 1$ from our results and we would predict effort to respond somewhat, but less than proportional, to changes in abundance allocated to sportfishing. This is in contrast to the assumptions embodied in current management practices which estimate the upcoming season's angler trips by "dividing the number of fish available for harvest by the (previous year's) catch rate'' (PFMC 1986:19). This procedure (ignoring the fact that it confuses the causality among these relationships) appears to assume that catch per unit effort is a constant and that we may, therefore, use this constant to estimate this year's participation if we simply divide it into this year's sportfishing allocation.

In practice, management agencies allocate marginal increases in abundance proportionately to targeted groups (sport and commercial fishermen). Suppose, for example, that N represents total abundance available to the sport and commercial fishermen and λ is the share to be allocated to sport fishermen. Then current managers ''estimate'' angler participation with the implicit model

$$E_t = \frac{\lambda N_t}{K} \qquad \text{where } K = \frac{C_{t-1}}{E_{t-1}} = \frac{\lambda N_{t-1}}{E_{t-1}} \tag{8}$$

With K assumed constant, this amounts to a belief that effort is proportional to abundance. (Management documents note that when K is regarded as ''abnormal,'' the ratio appropriate to another year or some average of previous years is used.) As we have discovered, effort will not respond proportionately to abundance and hence current management procedures *overestimate* both the economic gains from abundance increases and the economic losses from abundance decreases.

The next issue is how our model predicts sportfishing *harvest* in comparison with current management practices. It is apparent in examining salmon management plans that to the extent that any model is used to predict catch, a simple proportional model such as $C_t = qN_t$ or $C_t = qE_tN_t$ is typical. As we have shown, this is apt to be off for two reasons: (i) catch may respond nonlinearly to effort; and (ii) abundance (via success) may in turn affect effort. The implications of our behavioral response findings can be determined by substituting in our predicted value of $\overline{E}$ into the production equation to get:

$$\overline{C} = A\overline{E}^{\alpha}\overline{N} = z\overline{N}^{1+\alpha Y} \qquad \text{where } \alpha Y = \frac{\alpha\beta}{1 + \beta - \alpha\beta} \tag{9}$$

Note that $\alpha Y > 0$ so that we predict that catch will increase more than proportionately with abundance increases. This occurs because of a ''direct effect'' of abundance in increasing catch plus an ''indirect effect'' due to the fact that abundance also increases effort by boosting success rates. The bottom line is thus that current practices probably *underestimate* how many salmon will be taken by sport fishermen when abundance increases and also underestimate the decrease associated with abundance decreases. In Table 4 below we show relevant elasticities and the corresponding equilibrium effort and catch response elasticities. As an example, San Francisco's Y value is 0.69 and the corresponding value for $1 + \alpha Y$ is 1.952. These estimates suggest that if abundance was predicted to rise by 10%, the level of effort would rise by 6.9% whereas catch would rise by 19.52%. These are in contrast to current management procedures which would estimate 10% rises in both effort and catch. These are substantial differences; enough, in fact, to result in serious management mistakes if other measures (e.g., on-line monitoring of catch and effort, etc.) are not taken.[7]

In summary, we have some preliminary evidence that behavioral responses

Table 4

	α	β	γ	$1 + \alpha\gamma$
Crescent City	1.14**	0.11	0.13	1.148
Trinidad	1.12**	0.22	0.25	1.280
Eureka	1.29**	0.25**	0.32	1.397
Fort Bragg	1.28**	0.11*	0.14	1.179
San Francisco	1.38**	0.50**	0.69	1.952
Sausalito	1.50**	0.35**	0.53	1.795
Emeryville	1.23**	0.41**	0.50	1.615
Berkeley	1.07**	0.12*	0.13	1.139

* Significant at 90%.
** Significant at 99%.

matter in management. Current procedures are hampered by incomplete understanding of some of the mechanisms examined here. For example, the 1986 salmon management plan sites "many factors affect the number of angler trips which will be taken during a season including catch rates, fishermen's response to success rates, weather conditions, fishermen's response to publicity concerning fishing opportunities, etc. All of these are difficult, if not impossible, to predict" (PFMC 1986:20). Our anlaysis, preliminary and admittedly simplified, nevertheless suggests that it is possible to shed light on some of these unknowns and hopefully improve management decision making for these fisheries.

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Notes

1. The ports selected and respective shares of total salmon trips are:

Port	Total CPFV Trips	Total Salmon Trips	% of Tot. CPFV Trips in Port	% of Tot. Salmon Trips in Calif.	Cumulative % Tot. Salmon Trips in Calif.
Sausalito	5409	4926	91.1	31.69	31.69
San Francisco	5526	4670	84.5	30.05	61.74
Berkeley	2715	2040	75.1	13.12	74.86
Emeryville	2565	1405	54.8	9.04	83.90
Fort Bragg	1064	709	66.6	4.56	88.46
Crescent City	561	419	74.2	2.67	91.13
Eureka	292	251	86.0	1.61	92.74
Trinidad	270	248	91.9	1.59	94.33

2. Our approach differs from most of the literature on recreational fishing in that we estimate aggregate relationships directly. Most of the literature, in contrast, estimates

micromodels of choice and then (if necessary) aggregates microlevel results to the population as a whole [cf. recent studies on Pacific Coast sportfishing reported in Rowe et al. (1985), Huppert and Thompson (1984, 1987), and Jones and Stokes (1987)]. Whether one chooses a micro- or macromodelling perspective depends upon the aims of the modelling exercise; our approach has the virtue of simplicity but it masks detail which might be of interest in another context.

3. There are alternative ways to attempt to estimate the impacts of abundance on catch. One preferable approach would be to obtain independent measures of catch rates from (for example) commercial fishermen. We considered but then rejected the possibility after examining corresponding commercial data. Reported data on average commercial catch is reported on a "per delivery" basis (thus depending on hold size, etc.) and often contains unreliable area of catch information. Given that one is forced to work with proxies (as we have done here) there are still alternatives to our process of selecting a priori functional forms ranging from detrending using monthly dummies or more sophisticated time-series methods. We ultimately selected an approach which seemed to offer ease of interpretation, simplicity, and a quick test of a priori beliefs about salmon biology.
4. The results presented here are corrected for first-order autocorrelation with a Cochrane-Orcutt iterative method where D/W tests indicated its presence.
5. It may well be, however, that this hypothesis is still largely correct in that serious rural salmon fishermen may own their own skiffs and that those remaining to go out on charterboats are less skilled spradic fishermen (perhaps summer tourists).
6. Our "week" started on Thursdays in this study in order to avoid splitting three-day weekends when they occurred. Coincidentally, most newspaper reports on angler success the previous week appear in Thursday papers.
7. The variance estimates associated with α are uniformly small for all ports. Variance estimates for β are mixed so that estimated variances for the Y and αY coefficients are unclear by inspection. Using a Taylor series expansion, we calculated standard error estimates for both terms. As the table below shows, Y and αY are significantly different from zero with considerable confidence in the ports of Eureka, San Francisco, Sausalito, and Emeryville and with less confidence in the ports of Fort Bragg and Berkeley. For the two northernmost parts of Crescent City and Trinidad, one cannot make a case against the standard proportional models of harvest and effort response.

	γ	SE_γ	$1 + \alpha\gamma$	$SE_{\alpha\gamma}$
Crescent City	0.125	0.295	1.148	0.384
Trinidad	0.246	0.263	1.280	0.330
Eureka	0.310	0.097	1.397	0.150
Fort Bragg	0.141	0.098	1.179	0.161
San Francisco	0.690	0.159	1.952	0.308
Sausalito	0.525	0.167	1.795	0.372
Emeryville	0.504	0.121	1.615	0.186
Berkeley	0.128	0.080	1.139	0.092

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