OREGON'S DUNGENESS CRAB FISHERY:

an economic analysis of productivity and profitability

David S. Liao
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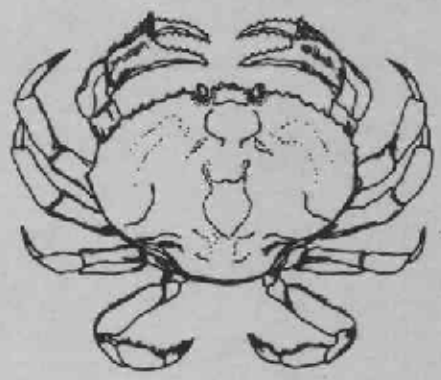

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related publication

OREGON'S COMMERCIAL FISHERMEN: CHARACTERISTICS, PROFITS AND INCOMES IN 1972, by David S. Liao and Joe B. Stevens. Publication no. T-75-003. 19 pp.

Results of a survey of 214 commercial fishermen. Details the social and economic characteristics of fishermen, the costs and returns from commercial fishing and fishermen's incomes from fishery and nonfishery employment. Among the findings: only about 10 per cent of Oregon's commercial fishermen (exclusive of gillnetters) make most of their income from fishing. On the other hand, the largest single group of Oregon commercial fishermen--those who troll exclusively for salmon at a part-time basis--lost an average of $100 per fisherman in 1972.

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introduction

The Pacific Marine Fisheries Commission and the National Marine Fisheries Service are attempting to develop a State-Federal Dungeness Crab Management Program for Oregon, California, and Washington. The primary purpose of the program is to manage the Dungeness crab fisheries on a basis consistent with sound biological principles, to enhance the net benefits from the resource, and to promote an orderly fishery. An Oregon State University research project concerning resource productivity, profitability of crab enterprises, and the potential impact of a moratorium on entry into the Oregon Dungeness crab fishery was conducted to provide economic information as an input to future policy decisions. This report presents some initial results of the study, based on data for the 1972 fishing season from a stratified random sample of 37 crab fishermen.

This report contains four sections. The first deals with landings and effort in the Oregon Dungeness crab fishery. The second deals with characteristics of crabbing enterprises--including costs, returns, and enterprise profitability. The third section includes estimates of production functions and resource productivities; the final section is a summary.

LANDINGS AND EFFORT (TABLES 1 AND FIGURE 1)

Dungeness crabs are harvested with circular wire-mesh pots; about 90 percent of the harvestable crab are harvested annually. The total number of pots fished has increased rapidly in the past two decades. The number of crab boats has also increased steadily over the years. There were about 208 resident boats in the 1972 season--twice the number that had crabbed three years prior to that year.

Total crab landings have varied from a high of 15.0 million pounds in 1971 to a low of 3.6 million pounds in the 1964 season. The cyclical movement in Oregon Dungeness crab landings from 1952 through 1972 is shown in Figure 1. Average landings per pot in the 1972 season was 123 pounds, a record low in the fishery.

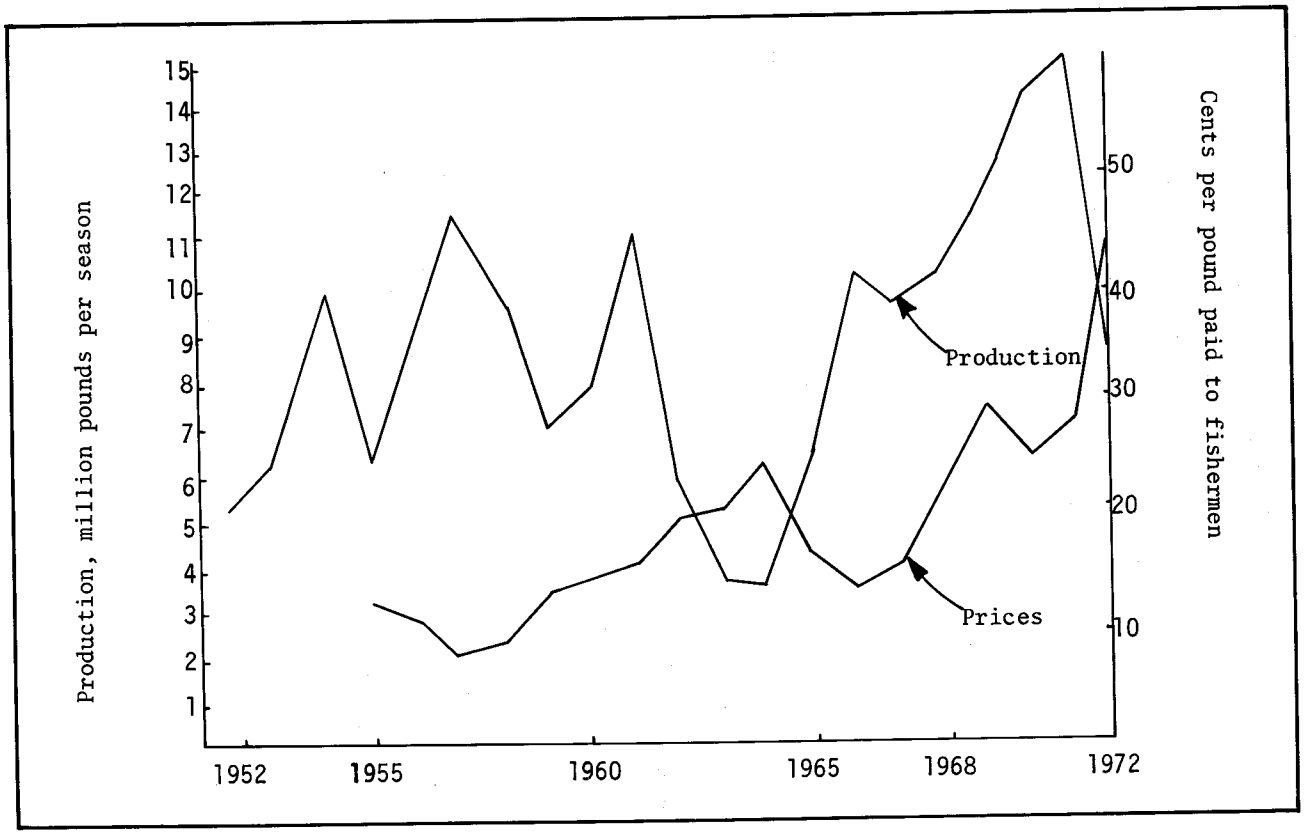
Table 1. Fishing effort, total catch, and catch per pot by resident Oregon crab boats, 1952 to 1972 crab seasons. 1/

Season	Number of boats	Number of pots fished	Pounds landed	Pounds per pot
1952	83	15,709	5,407,675	344
1953	71	13,507	6,413,275	475
1954	83	16,117	10,131,125	626
1955	91	19,634	6,413,275	327
1956	92	18,923	8,910,600	471
1957	94	19,206	11,737,800	611
1958	73	21,307	10,103,000	474
1959	81	32,824	7,125,528	326
1960	97	20,623	8,296,125	402
1961	118	24,443	11,359,000	465
1962	134	28,399	5,813,125	205
1963	118	24,618	3,620,975	147
1964	95	23,000	3,586,335	156
1965	106	22,085	6,418,611	291
1966	101	25,016	10,476,476	419
1967	103	27,116	9,580,968	353
1968	102	28,550	10,214,695	358
1969	105	29,221	11,965,246	409
1970	143	33,491	14,062,793	420
1971	178	49,580	15,002,764	303
1972	208	54,939	6,780,071	123

1/ Seasons were generally from December of previous year through August of year shown (e.g., December, 1971 - August, 1972 was 1972 season).

Source: Fish Commission of Oregon, compiled by Dale Snow.

Fig. 1. Oregon Dungeness crab prices and production by season.



CHARACTERISTICS OF CRABBING ENTERPRISES

Characteristics of the Skippers and Vessels (Tables 2 and 3)

Three types of resident fishermen landed Dungeness crab in 1972. These were (1) specialized crab fishermen who landed little, if any, of other species, (2) those who fished for salmon and/or tuna in addition to crab, and (3) drag fishermen who fished for shrimp and/or bottomfish in addition to crab. Although the numbers in each type are not known precisely, it is estimated that about 50 percent of the total crab fishermen were in the salmon-tuna/crab category. The average characteristics of the three groups are shown in Table 2.

The three types of skippers were much alike, although specialized crabbers tended to be somewhat older and had fewer years of formal education. Almost without exception, all three types lived in coastal port areas.

The boat operated by the average drag fishermen was about 56 feet long and valued at $68,560. The market value of the boats operated by the other types of crabbers averaged between $22,000 and $35,000. Draggers employed more crewmen and more crab pots than did specialized crab or salmon-tuna/crab fishermen.

The average drag fishermen spent about 49 days crabbing and 115 days in other fisheries. The average number of fishing days for specialized crab fishermen was about 82. Salmon-tuna/crab fishermen averaged 98 days in crabbing, and 74 days in fishing salmon and/or tuna.

The specialized crab fishermen who were interviewed had slightly higher landings (60,538 pounds) than the others. The average landings for drag fishermen were 45,300 pounds, while salmon-tuna/crab fishermen averaged 53,889 pounds (Table 3).

Table 2. Average characteristics of Oregon commercial crab enterprises for the 1972 season.

ITEM	Type of fishermen		
	Crab	Salmon-tuna/crab	Drag
Estimated number of Oregon resident skippers:	35 to 60	90 to 155	40 to 85
Number in sample	8	19	10
Characteristics of boat:			
Length (feet)	38	44	56
Horsepower	163	177	257
Age (years)	21	30	19
Number of crab pots	206	233	377
Market value of boat ($)	22,438	35,079	68,560
Fishing effort:			
Number of fishing days:			
- crab fishery	82	98	49
- noncrab fishery	--	74	115
Number of men on the boat:			
- crab fishermen	2.3	2.4	3.7
- noncrab fishermen	---	2.0	3.6
Characteristics of skipper:			
Age	51	44	46
Years of commercial fishing experience	23	19	22
Years of formal education	9	12	12

Table 3. Distribution of landings in the 1972 season, by type of crabber.

Type of fishermen	Percent of fishermen in sample	Percent of landings in sample	Crab landings per enterprise (pounds) 1/	
			Average	95% confidence limits
Crab	22%	25%	60,538	4,500-116,500
Salmon-tuna/crab	51%	52%	53,889	32,500- 75,500
Drag	27%	23%	45,300	22,000- 68,500
Total	100%	100%	---	-----

1/ Our estimates of aggregate 1972 landings by the three types of crabbers would appear to exceed the Fish Commission's estimate of total landings in 1972 (Table 1). This could be due to: (a) admittedly imperfect knowledge of the number of crabbers in each type, and/or (b) those crabbers who were interviewed may have been more efficient than average, even though the sample was randomly drawn.

COST AND RETURNS

The gross return to a fishing enterprise is the sum of money received from sale of fish or crab landed during the year. Production costs are broken down into two categories: variable and fixed. Variable costs comprise all cost items which are incurred only when the boat is actually used for fishing. Fixed costs include cost items which do not vary with fishing effort (insurance, depreciation, moorage, etc.). Total costs are the sum of fixed and variable costs. Costs which could not easily be allocated to a particular enterprise (e.g., insurance) were allocated in proportion to the days fished in each enterprise. The net return to a fishing enterprise, then, is equal to gross returns less total costs of production.

Costs and Returns: Crab Enterprises (Table 4)

On the average, specialized crabbers had higher gross returns from crabbing ($25,656) than did the other types of fishermen. The total cost of production for specialized crabbers averaged $16,960; thus, their average net returns (gross returns less total cost) were $8,696. Not all specialized crab enterprises were profitable; fifty percent of the skippers in this group had negative net returns.

The average gross returns of salmon-tuna/crab fishermen were $22,838, while their total costs were $11,158; thus, their average net returns were $11,680. In spite of having lower gross returns than specialized crabbers, this group had both higher net returns and fewer

Table 4. Costs, returns and efficiency of crab enterprises in 1972.

Financial and efficiency indicators	Average, by type of fishermen: Crab	Salmon-tuna/crab	Drag	All Groups
Number of fishermen in sample	8	19	10	37
Costs and returns ($)				
Gross returns a/	25,656	22,838	19,198	22,464
Variable costs b/	14,423	9,387	11,023	10,918
Fixed costs c/	2,537	1,771	2,670	2,180
Net returns d/	8,696	11,680	5,505	9,366
Returns to labor and management e/	6,685	10,076	3,835	7,656
Returns to investment f/	-1,566	2,546	-2,175	381
Efficiency ratios g/ ($)				
Gross return per dollar of total cost	1.80	3.00	1.60	3.20
Gross return per man	15,246	8,463	5,691	9,180
Gross return per day fished	312	299	445	341
Total cost per day fished	217	139	317	204
Net return per day fished	95	160	128	137
Percent of enterprises with positive net returns	50	84	60	70

a/ Average *ex vessel* crab price in 1972 was slightly over 42¢ per pound.
b/ Costs that vary with fishing effort (fuel, boat repair, gear repair, crewshare, etc.)
c/ Costs that do not vary with fishing effort (insurance, license fees, depreciation, etc.)
d/ Gross returns less total costs.
e/ Net returns less opportunity costs of investment (9 percent of investment)
f/ Net returns less opportunity costs of skipper's labor and management
g/ As an example of how these ratios were calculated, suppose that one fisherman's ratio of "gross return per day fished" was $324 per day. If a second fisherman's ratio was $300 per day, the average of the two would be $312 per day. (The ratios in the Table cannot be derived from Tables 2 and 4 because of the mathematical nature of the ratios.)

members with negative net returns.

The drag fishermen had lower gross and net returns than either the specialized crabbers or the salmon-tuna/crab fishermen. Their gross return per day fished ($445), however, was higher than for the other groups, reflecting their larger crew size and greater number of crab pots.

Costs and Returns: Noncrab Enterprises (Table 5)

On the average, drag fishermen had considerably higher gross and net returns ($63,855 and $29,722) from noncrab fishing than did salmon-tuna/crab fishermen ($13,969 and $4,096). Drag fishermen had $63,855 in gross returns from 115 days of noncrab fishing, compared to $19,198 in gross returns from 49 days of crabbing.

Crabbing was clearly the more profitable enterprise for salmon-tuna/crab fishermen, while the noncrab enterprise was clearly more profitable for draggers. This holds true either in comparing net returns *or* net returns per day fished.

Table 5. Costs, returns and efficiency of non-crab enterprises in 1972

Financial and efficiency indicators	Average, by type of fishermen: Salmon-tuna/crab	Drag	Both Groups
Number of fishermen in sample	19	10	29
Costs and returns ($)			
Gross returns a/	13,969	63,855	31,170
Variable costs b/	8,111	28,732	15,222
Fixed costs c/	1,762	5,401	3,017
Net returns d/	4,096	29,722	12,932
Returns to labor and management e/	2,591	25,232	10,398
Returns to investment f/	-1,492	4,180	464
Efficiency ratios g/ ($)			
Gross return per dollar of total cost	1.80	2.40	2.00
Gross return per man	7,141	17,641	10,761
Gross return per day fished	189	556	316
Total cost per day fished	146	301	200
Net returns per day fished	43	255	116
Percent of enterprises with positive net returns	74	90	79

a/ Average *ex vessel* prices for 1972: coho salmon, 50¢/lb.; chinook salmon, 57¢/lb.; tuna, 31¢/lb.; shrimp, 14¢/lb; bottomfish, 9.5¢/lb.
b/ Costs that vary with fishing effort (fuel, boat repair, gear repair, crewshare, etc.)
c/ Costs that do not vary with fishing effort (insurance, license fees, depreciation, etc.)
d/ Gross returns less total costs.
e/ Net returns less opportunity cost of investment (9 percent of investment).
f/ Net returns less opportunity costs of skipper's labor and management (40 percent of gross returns)
g/ As an example of how these ratios were calculated, suppose that one fisherman's ratio of "gross return per day fished" was $324 per day. If a second fisherman's ratio was $300 per day, the average of the two would be $312 per day. (The ratios in the Table cannot be derived from Tables 2 and 4 because of the mathematical nature of the ratios.)

Factors Affecting Profitability (Tables 6 and 7)

An attempt was made to identify some physical, economic, and sociological factors that might be associated with profitability of fishing enterprises. "Profit" refers to net returns or gross returns less total costs.

No correlations between profit from crabbing and physical characteristics of the boat were significant. Gross returns and gross returns per day fished were the only variables significantly correlated with profits from crabbing. For noncrab production, on the other hand, profit was also significantly correlated with boat size, engine horsepower, crew size, and number of fishing days. This indicates that the profitability of noncrab enterprises depends to a considerable extent on the physical characteristics of the boat and on fishing effort.

Positive and significant coefficients for gross returns and gross returns per day fished were observed for noncrab enterprises as well as for crab enterprises. The relationships between profit and the sociological variables were nonsignificant in both types of enterprises.

Table 6. Profitability of crab enterprises as related to various physical, economic and sociological factors.

Factors	Average value in crab production: Those skippers with profit 1/	Those skippers with no profit 2/	Correlation with profit 3/
(Sample size)	(26)	(11)	---
Physical factors			
size of boat (feet)	46	47	-0.02
horsepower of engine	191	207	0.08
number of crab pots	268	261	0.08
men on the boat	3	3	0.01
fishing days	83	76	0.07
Economic factors ($)			
gross returns	28,077	9,196	0.81***
gross returns per day fished	388	121	0.64***
variable costs per day fished	137	227	-0.31
total costs per day fished	113	193	-0.29
Sociological factors			
years in commercial fishing	23	17	0.15
years as skipper	18	13	0.08
age of skipper	46	48	-0.13
years of formal education	11.4	11.3	-0.18

1/ Gross returns exceeded total costs.

2/ Total costs exceeded gross returns.

3/ *** significant at 1% probability level.

Table 7. Profitability of noncrab enterprises as related to various physical, economic, and sociological factors.

Factors	Average value in noncrab production: Those skippers with profit 1/	Those skippers with no profit 2/	Correlation with profit 3/
(Sample size)	(23)	(6)	---
Physical factors			
size of boat (feet)	50	43	0.53***
horsepower of engine	220	145	0.74***
men on the boat	3	2	0.56***
fishing days	92	81	0.45**
Economic factors ($)			
gross returns	36,444	10,957	0.93***
gross returns per day fished	396	135	0.84***
variable costs per day fished	168	175	0.34
total costs per day fished	203	203	0.34
Sociological factors			
years in commercial fishing	21	17	-0.20
years as skipper	17	14	-0.22
age of skipper	44	46	-0.22
years of formal education	11.8	12.5	-0.12

1/ Gross returns exceeded total costs.

2/ Total costs exceeded gross returns.

3/ *** Significant at 1% probability level.
** Significant at 5% probability level.

PRODUCTION FUNCTIONS AND RESOURCE PRODUCTIVITIES

Production Function (Table 8)

The above analysis of enterprise profitability is one way of organizing the data, from individual fishermen, on fishing costs and returns. Another way to use the data is to estimate production functions, or the relationship between resources (cost items) and output (gross returns). The production functions estimated below are of the Cobb-Douglas type,

$$Y = \hat{a} X_1^{\hat{b}1} X_2^{\hat{b}2} X_3^{\hat{b}3}$$

where Y refers to the value of landings and X's refer to specified resources. The elasticities of production, $\hat{b}_i$, indicate the percentage by which the value of production would increase with a one percent increase in use of a particular resource.

Two production functions, one for crabbing and one for the noncrab enterprises, were estimated. The values of the elasticities for the two production functions and related statistics are presented in Table 8. All elasticities for crab and noncrab production were less than

one. This indicates that a one percent increase in the use of a particular resource would result in less than a one percent increase in the value of production. For crab interprises, for example, a one percent increase in labor usage would result in an increase of 0.41 percent in the value of crab landings.

The sum of the elasticities exceeds 1.0 in both cases. This indicates a potential for gaining some economies of size, especially in the noncrab enterprises.

Table 8. Production functions and related statistics for Dungeness crab fishermen, Oregon, 1972.

	Crab function	Noncrab function
Value of $\hat{a}$ (log form)	-0.9648	-2.8410
Value of $\hat{b_i}$ (elasticities)		
$\hat{b_1}$: labor	0.4104	0.6574
$\hat{b_2}$: operating capital	0.4658	0.3536
$\hat{b_3}$: boat capital	0.5591	0.9263
Sum of elasticities	1.4353	1.9479
Value of "t" for elasticities		
labor	1.8143*	3.2948***
operating capital	2.4723**	2.4314**
boat capital	3.0068***	4.4657***
R^2	0.52	0.84
Sample size	37	29

*** Significant at 1 percent probability level.
** Significant at 5 percent probability level.
* Significant at 10 percent probability level.

Resources Used and Factor Productivity (Table 9)

Fishermen used more resources in noncrab production than in crab production. Even with greater labor and capital inputs in noncrab production, the "marginal value product" of most resources used for noncrab production was still higher than in crab production. A "marginal value product" is the addition to gross returns which would result from the addition of one unit of a particular resource, if all other resources were held constant at their mean values. The marginal value product of operating capital in crab production, for instance, was $1.67; the use of one more dollar in this manner would add $1.67 to the total value of crab landings.

Table 9. Average levels of output, resources and resource productivity.

	Crab production	Noncrab production
Average value of production per firm ($)	22,464	31,171
Average resources per firm		
labor (man-days)	202	241
operating capital ($)	5,716	7,134
boat capital ($)	41,365	46,586
Marginal value products (at mean values)		
labor ($ per man-day)	41.67	70.39
operating capital ($)	1.67	1.28
boat capital ($)	0.28	0.51

Efficiency of Resource Allocation (Tables 10, 11, and 12)

Table 10 shows the "marginal value product" (MVP) and the corresponding "marginal factor cost" (MFC) for each resource; it also indicates the difference between the MVP and MFC. If MVP is greater than MFC, the use of additional units of the resource would increase net returns. If the marginal productivities of all resources are equal to their factor costs, then fishermen are utilizing their resources efficiently.

Although the MVP exceeds the MFC for all resources in Table 10, the tests of the differences between MVP and MFC are generally not statistically significant. With $30 as the factor cost of labor, however, there are significant differences between the MVP and the MFC of labor in noncrab production. This indicates that labor could be increased to yield a greater value of landings (with the same capital investment) in noncrab fishing. Possible types of adjustment would be to add an additional crewmen to the boat, or to fish more days, or both.

If the MVP of a resource in crab production were significantly different from its MVP in noncrab production, the resource could be reallocated to maximize profits. Gross returns could be increased by shifting the resource from one enterprise to another. As Table 11 shows, fishermen have allocated their capital resources in an efficient manner between crab and noncrab production, but the MVP of labor used in noncrab production is significantly greater than that used in crabbing. If it were possible to do so, shifting a slight amount of labor away from crabbing toward noncrab production would increase profits. This opportunity may not always exist. For example, if crab and noncrab fishing seasons do not overlap, labor withheld from crab fishing season may not be available for the noncrab fishing season. Also these conclusions hold only where the prices of the different products are the same as in the 1972 season.

Table 10. Marginal value products (MVP), marginal factors costs (MFC), and their differences.

ITEM	Crab function			Noncrab function		
	MVP	MFC a/	MVP-MFC	MVP	MFC a/	MVP-MFC
Labor ($ per man-day)	41.67	40.00 30.00	1.67 11.67	70.39	40.00 30.00	30.39 40.39*
Operating capital ($)	1.67	1.09	0.58	1.28	1.09	0.19
Boat capital ($)	0.28	0.15	0.13	0.51	0.15	0.36

a/ Marginal factor cost is the cost of hiring an additional unit of the resource, or its price in alternative uses. These costs are assumed to be as follows:

Labor: $40.00 and $30.00 per day per fisherman.
Operating capital: $1.09 per dollar (based on 9% interest rate)
Boat capital: $0.15 per dollar (based on 9% interest rate and 6% depreciation on the boat and gear)

* Significant at 10 percent probability level.

Table 11. Comparison of marginal value products between crab and noncrab enterprises.

Resources	Crab production	Noncrab production	Difference	Value of t
Labor ($ per man-day)	41.67	70.39	-28.72	-3.42***
Operating capital ($)	1.67	1.28	0.39	0.93
Boat capital ($)	0.28	0.51	- 0.23	-1.10

*** Significant at 1 percent probability level.

It should be noted that the conclusions drawn above with respect to resource productivity, and enterprise profitability, are based on 1972 data. If fish prices and total landings in 1972 had both been far above average, for example, the estimates of enterprise profitability and resource productivity would exceed reasonable long-term expectations. In fact, 1972 appears to have been a fairly typical year with respect to prices paid to fishermen for the major fish species (Table 12). Total landings were below-average for crab and salmon, and above-average for tuna and shrimp.

Table 12. Price per pound and total landings: Dungeness crab and other major fisheries in Oregon.

	Chinook salmon	Coho salmon	Crab	Shrimp	Tuna	Bottomfish
Price per pound ($)						
1969-1973 average	.57	.46	.46	.14	.29	.09
1972 season	.57	.50	.42	.14	.31	.09
Percent difference 1/	(0)	(+9%)	(-9%)	(0)	(+7%)	(0)
Total landings (million pounds)						
1969-1973 average	6.248	8.718	9.740	15.633	24.703	22,284
1972 season	5.085	6.483	6.762	20.731	29.234	22.801
Percent difference 1/	(-19%)	(-26%)	(-31%)	(+33%)	(+18%)	(+2%)

1/ 1972 season relative to 1969-1973 average.

summary

This report has provided information on resource productivity and profitability in Oregon's Dungeness crab fishery for the 1972 season. Cross-section data from 37 commercial crab fishermen were used to analyze profitability and production functions. The findings are summarized below:

(1) The total number of crab pots and crab vessels has increased sharply in recent years.

(2) About half of Oregon's resident crabbers fished for salmon and/or tuna in addition to crab.

(3) Specialized crab and salmon-tuna/crab fishermen averaged about 80 to 100 days in crab fishing; those drag fishermen who landed crab averaged 49 days in crab fishing and 115 days in other fisheries.

(4) Specialized crab fishermen averaged $25,656 in gross returns and $16,960 in total costs during 1972; their average net return was $8,696.

(5) Salmon-tuna/crab fishermen received an average net return of $11,680 from crabbing and $4,096 from salmon and/or tuna fishing.

(6) Drag fishermen had higher net returns from noncrab fishing ($29,722) than from crabbing ($5,505).

(7) Gross returns and gross returns per day fished were significantly correlated with profits in crab enterprises.

(8) Physical characteristics of the vessel, gross returns, and gross returns per day fished were significantly correlated with profits in noncrab enterprises.

(9) The equality of marginal value product (MVP) and marginal factor cost (MFC) was used as a criterion to measure the efficiency of resource use. Operating capital and boat capital appear to be efficiently allocated between crab and noncrab enterprises.

(10) If the MFC of labor were $30 there would be a significant difference between the MVP and MFC of labor in noncrab production. This indicates that if labor use were increased, a greater total value of noncrab landings would result.

(11) The MVP of labor in noncrab production was greater than the MVP of labor in crab production. Gross returns could be increased by shifting some amount of labor from crab to noncrab fishing, if it were possible to do so.

(12) The marginal value of all resources in crabbing exceeded marginal factor costs, although the differences were not statistically significant. There is, however, more evidence that additional resources will *enter* the crab fishery than there is evidence that existing resources will *leave* the fishery.