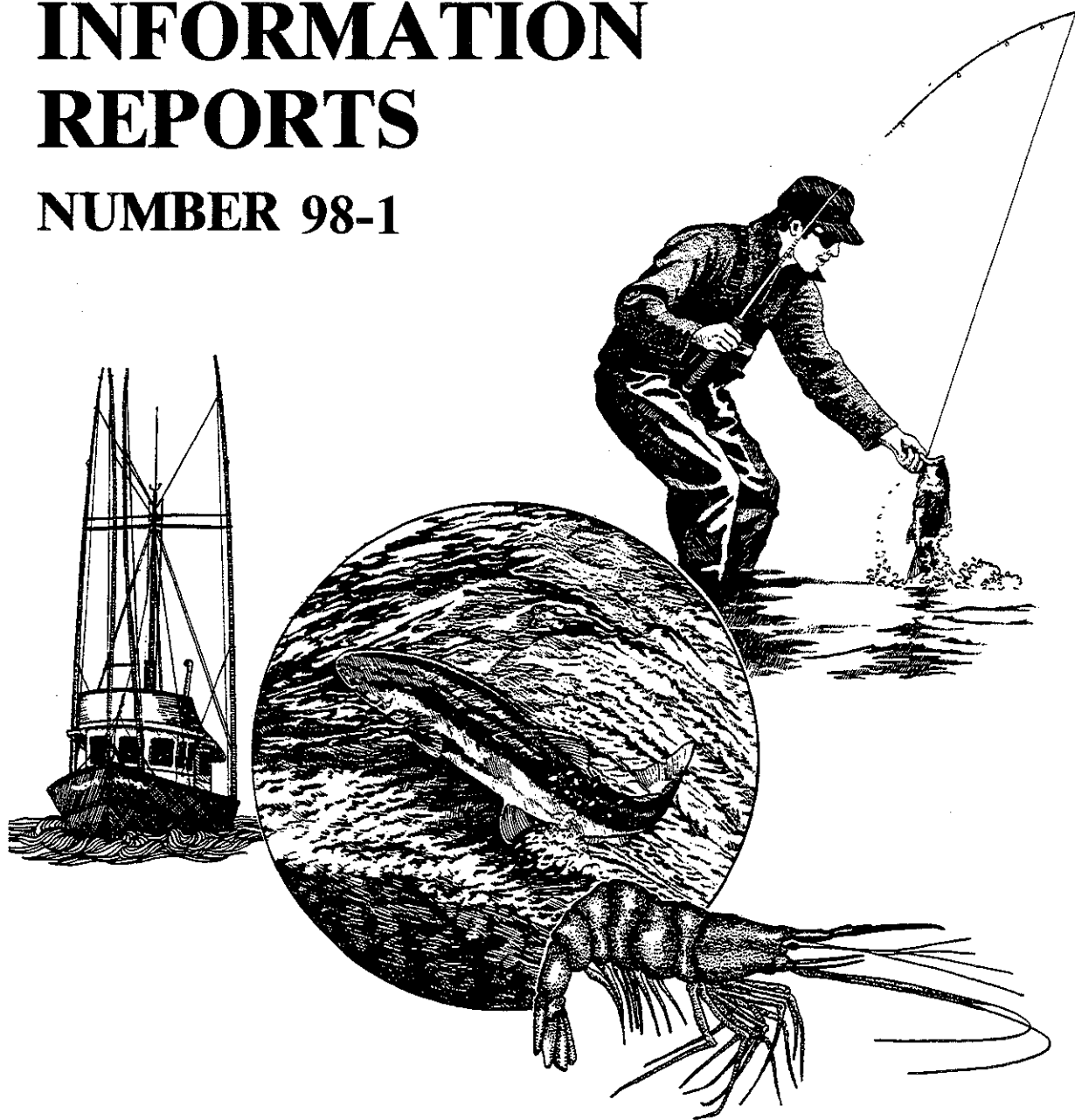


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FISH DIVISION

Oregon Department of Fish and Wildlife

The Oregon Ocean Shrimp Fishery: 1990-1995

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The Oregon Ocean Shrimp Fishery: 1990-1995

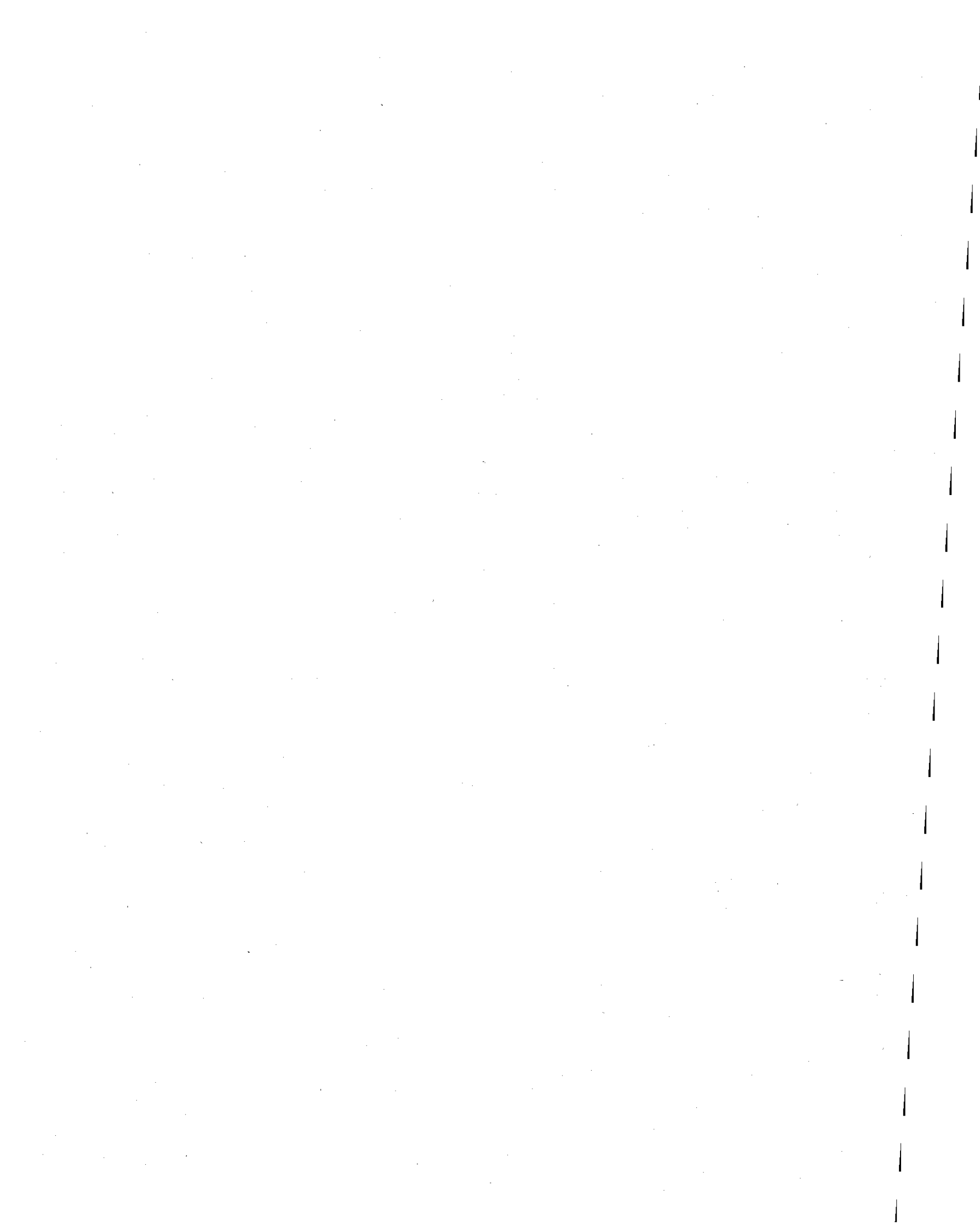
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January 1998

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INTRODUCTION

In 1981, the Pacific Fishery Management Council (PFMC) produced a tri-state ocean shrimp management plan that identified five biological points of concern for evaluating ocean shrimp stocks (PFMC 1981). The five indicators of over-exploitation are;

1. Long-term (3 years) statistically significant increases in average count-per-pound (count) and/or increase in the incidence of high counts coupled with equal or increasing fishing effort.
2. Long-term decreasing average age of females and/or increasing numbers of primary females.
3. Long-term trend toward decreasing annual catches with equal or increased effort.
4. Long-term increase in the extent of barren or void areas of formerly productive fishing grounds.
5. Indication, through sampling, of two year-class failures in a three year period.

Jones and Hannah (1992) analyzed fishery and biological data from 1985-89. They concluded that Oregon ocean shrimp stocks had experienced record high exploitation levels during this period, with catches dominated by age-1 shrimp. They suggested that future annual harvests could be highly variable and vulnerable to the effects of year class failure due to this dependence on age-1 shrimp.

The primary objective of this report is to analyze fishery and biological data from the 1990-95 trawl fishery for ocean shrimp and to continue our efforts to evaluate the evidence of potential over-exploitation as specified in the tri-state management plan. We documented trends in the fishery and compared them with those prior to 1990. Some California, Washington and Alaska information is included to add a regional perspective.

METHODS

The data summaries presented in this report were generated from trawl logs, landing tickets and market samples. Information concerning market conditions and points of interest for each year was gathered from Shellfish Program annual reports, Marine Program newsletters, newspaper articles, landing reports and personal communications.

Each month during each season, we attempted to collect 4-6 samples (approximately 100 shrimp/sample) from each state statistical area (Figure 1). Sample size was sometimes increased when samples were scarce. Samples were obtained at the docks prior to processing. We defined sample coverage as the percentage of area-months in which at least one sample was collected. For each sample, we measured carapace lengths and determined average weight expressed as the number of whole shrimp per pound. During April, September and October, each shrimp was classified as male, female or transitional based upon close examination of the inner ramus of the first pleopod as described by Tegelberg and Smith (1957).

Individual samples within a month and area were combined for analysis of age composition and sex composition. In some cases, sample size deviated substantially from 100 shrimp. In these instances the raw length and sex frequency data were rescaled proportionally to a sample size of 100 prior to combining with other samples. As a result, samples were given equal weight in determining age and sex composition.

Age composition for each month and area was then determined by identifying modes in the combined length frequency histogram. Using nadirs in the histograms to set a range of carapace lengths corresponding to each age group, ages were assigned to individual shrimp. Sometimes a bimodal distribution of age-1 shrimp was observed late in the season complicating the analysis. In these instances the bimodal distribution developed slowly from August through October and was easily recognizable. After the age and sex of each shrimp was assigned, age and sex composition and mean length at age were calculated for each month and area.

Catch and effort statistics by month and statistical area (area) were estimated from trawl logbook and landing ticket data. Landing tickets provide a complete summary of catch but no information on area of catch. Logbook data gives information on area of catch and also information on fishing effort and catch-per-unit of effort (CPUE), but is often unavailable or unusable from some trips. To estimate total catch and effort by area, the pattern of catch and effort from the available logbooks is used to allocate the landed pounds and the associated effort to individual areas, on a port and month basis. Logbooks and landing tickets were collected for all years, providing tow by tow data on date, location, tow duration, hailed catch and actual pounds landed. Usable logs were subsampled by trip at a variable rate according to the number of usable logs from each gear type (single- or double-rigged trawl) and port. The subsampling routine is a staged systematic approach designed to yield at

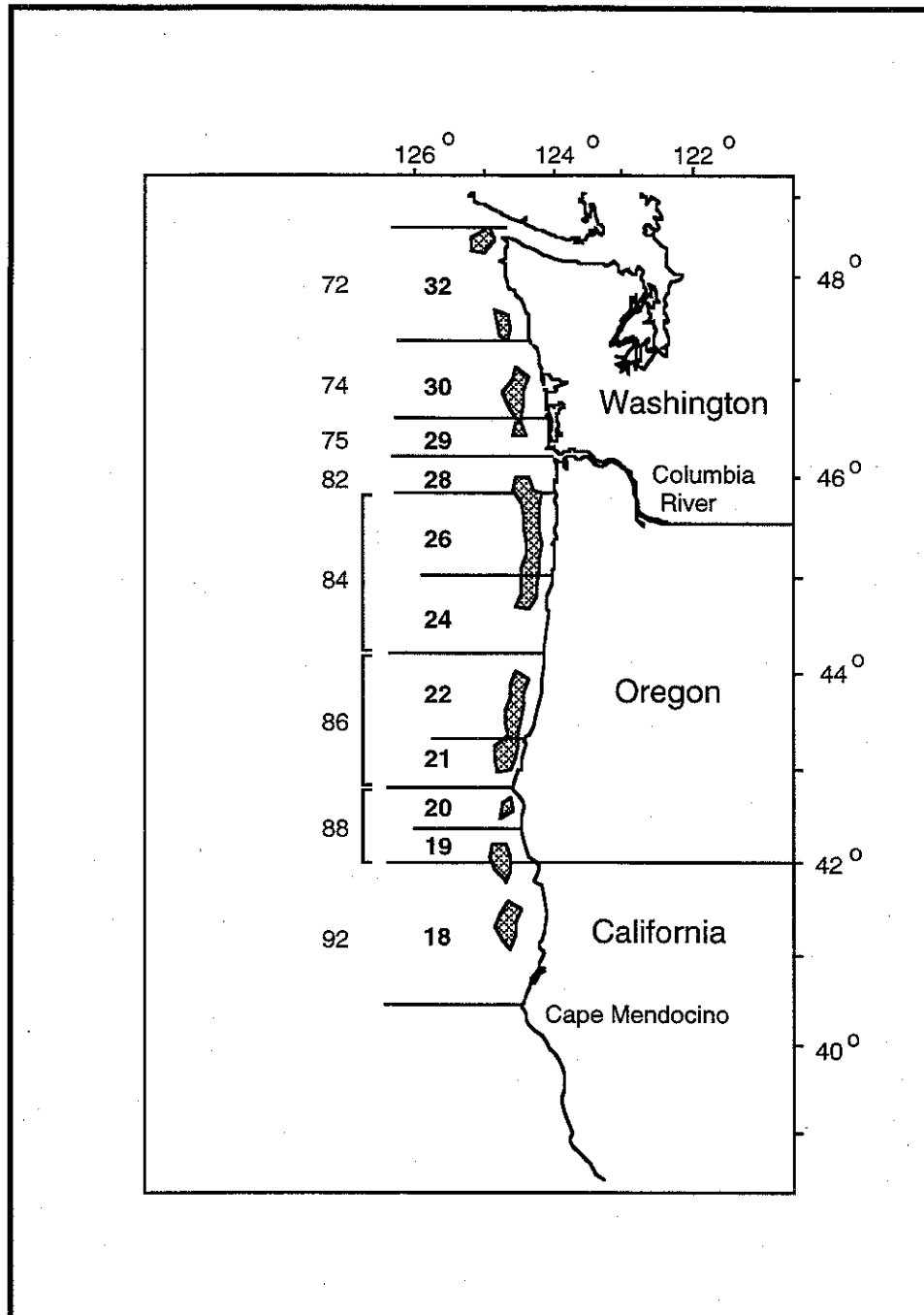


Figure 1. Location of commercial concentrations of ocean shrimp (*Pandalus jordani*) along the U.S. Pacific coast (shaded areas), Pacific States Marine Fisheries Commission (PSMFC) statistical areas 72-92 and Oregon state statistical areas 18-32 (bold).

least 20 logs per port, month and gear strata whenever possible. From 1990 through 1994, logbook summary data and fishticket information were then recorded on trip summary sheets and entered into a FOXBASE+/MAC database for processing. In 1995, we performed the same subsampling routine and catch and effort analysis, but entered each trip on a tow by tow basis instead of constructing trip summaries. The database was filtered, discarding those trips whose hauls differed from the landed pounds by 50% or more. Poundage and effort was allocated by port to the appropriate area. Single-rig and double-rig effort were analyzed separately. Both single-rig and double-rig effort is reported here in single-rig equivalent hours (1 double-rig hour = 1.6 single-rig equivalents) and will be referred to simply as "hours" in this report.

THE 1990-1995 FISHERIES

Catch, Effort and CPUE

Annual Oregon landings of ocean shrimp varied widely from 1990 through 1995, ranging from a low of 12.1 million pounds in 1995 to a high of 48.0 million pounds in 1992 (Figure 2). The annual harvest was below 17.0 million pounds during 1994 and 1995.

The coastal distribution of Oregon landings were erratic from 1990 through 1995 (Table 1). The percentage of the annual catch landed in southern ports varied over 30% during this period, peaking in 1994 at 63.1%. Central coast percentages varied less than 10% from 1990-'95. The north coast share varied more than 25%, with a low of 17.5% in 1994.

Effort in the Oregon shrimp fishery declined steadily from 1990 (123,000 h) to 1993 (75,000 h). Shrimp fishing effort has been fairly stable since then, remaining between 69,000 and 79,000 hours (Figure 3). The number of vessels landing shrimp in Oregon annually decreased from 1990 through 1995. The number of double-rig vessels remained fairly constant, while the number of single-rig vessels declined (Figure 4).

Average CPUE fluctuated widely from 1990 through 1995. The rate ranged from a high of 522 lb/h in 1992 to a low of 175 lb/h in 1995 (Figure 5). The average CPUE in 1995 was the lowest rate since 1984. Both of these years were preceded by major ENSO (El Niño Southern Oscillation) events.

Market Conditions

1990 Summary

Market conditions were good in 1990, driven by steady demand, moderate volume and low shrimp counts. Shrimp inventories were low at the beginning of the season. Processors had initial concerns about buying small shrimp and proposed a split price (a different price for small and large shrimp). Intra-industry disputes over split pricing delayed the first landings for up to two weeks in some ports. However, small shrimp proved to be scarce, eliminating the rationale for a split price. Shrimp inventories were reportedly low at the end of the 1990 season.

The opening ex-vessel shrimp price was 45¢/lb, a 5¢/lb increase over what processors paid for 140 count and larger shrimp during 1989 (Jones and Hannah 1992). Low count shrimp and declines in volume as the season progressed helped to gradually increase the price to 60¢/lb during September and October (Table 2).

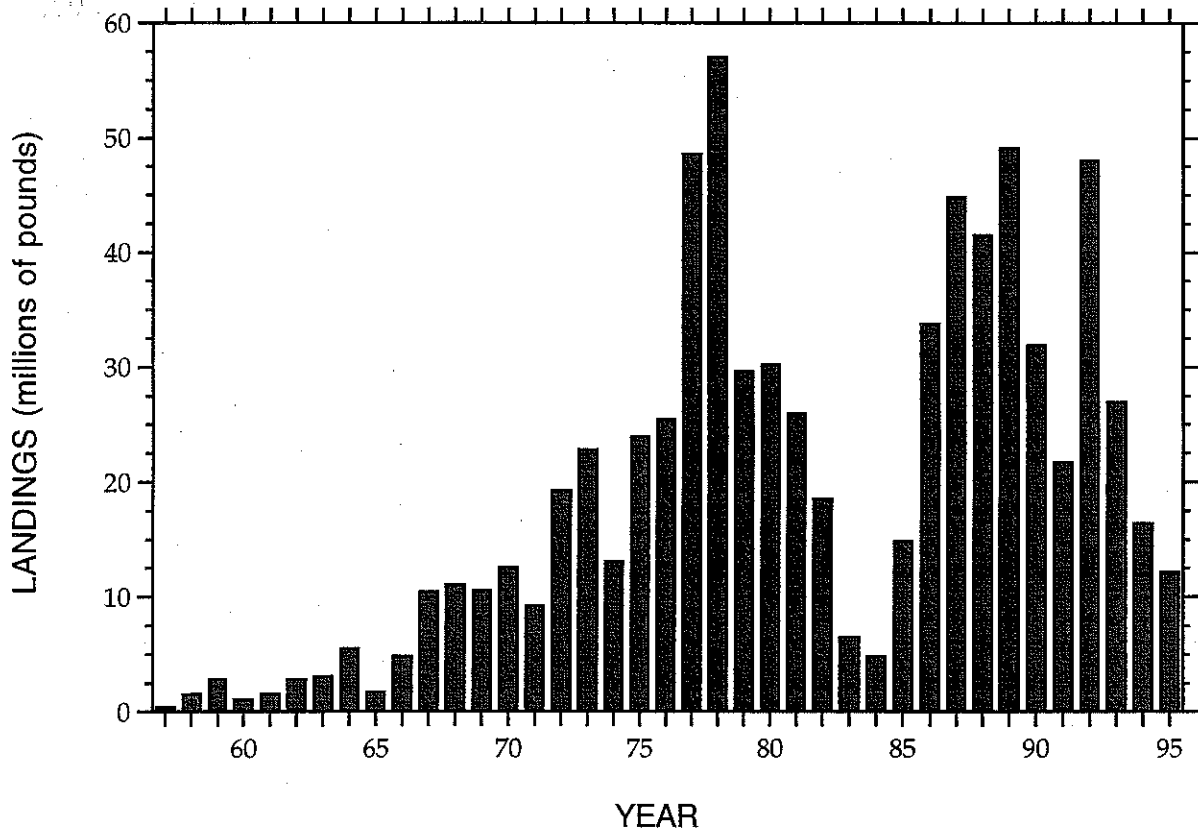


Figure 2. Oregon commercial landings of ocean shrimp, 1957-1995. Includes all ocean shrimp landed annually into Oregon ports.

Table 1. Oregon ocean shrimp commercial landings (thousands of pounds) by coastal region and port, 1990-1995.

Port, coastal region, percent by region	Year					
	1990	1991	1992	1993	1994	1995
Astoria	9,258	5,953	8,433	8,878	2,450	2,768
Garibaldi	2,796	1,956	2,874	3,006	414	956
north coast total	12,054	7,909	11,307	11,884	2,864	3,724
percent of total	37.8%	36.4%	23.5%	44.1%	17.5%	30.8%
Newport (central coast)	9,446	5,075	12,340	5,366	3,180	2,904
percent of total	29.6%	23.4%	25.7%	19.9%	19.4%	24.0%
Florence	0	0	13	16	13	1
Winchester Bay	148	48	14	0	0	0
Coos Bay	6,928	4,661	15,964	5,606	5,526	4,275
Bandon	2	75	34	43	0	0
Port Orford	156	184	30	46	53	17
Brookings	3,181	3,758	8,331	3,961	4,743	1,184
south coast total	10,415	8,726	24,386	9,672	10,335	5,477
percent of total	32.6%	40.2%	50.8%	35.9%	63.1%	45.2%
Total all ports	31,915	21,710	48,033	26,922	16,379	12,105

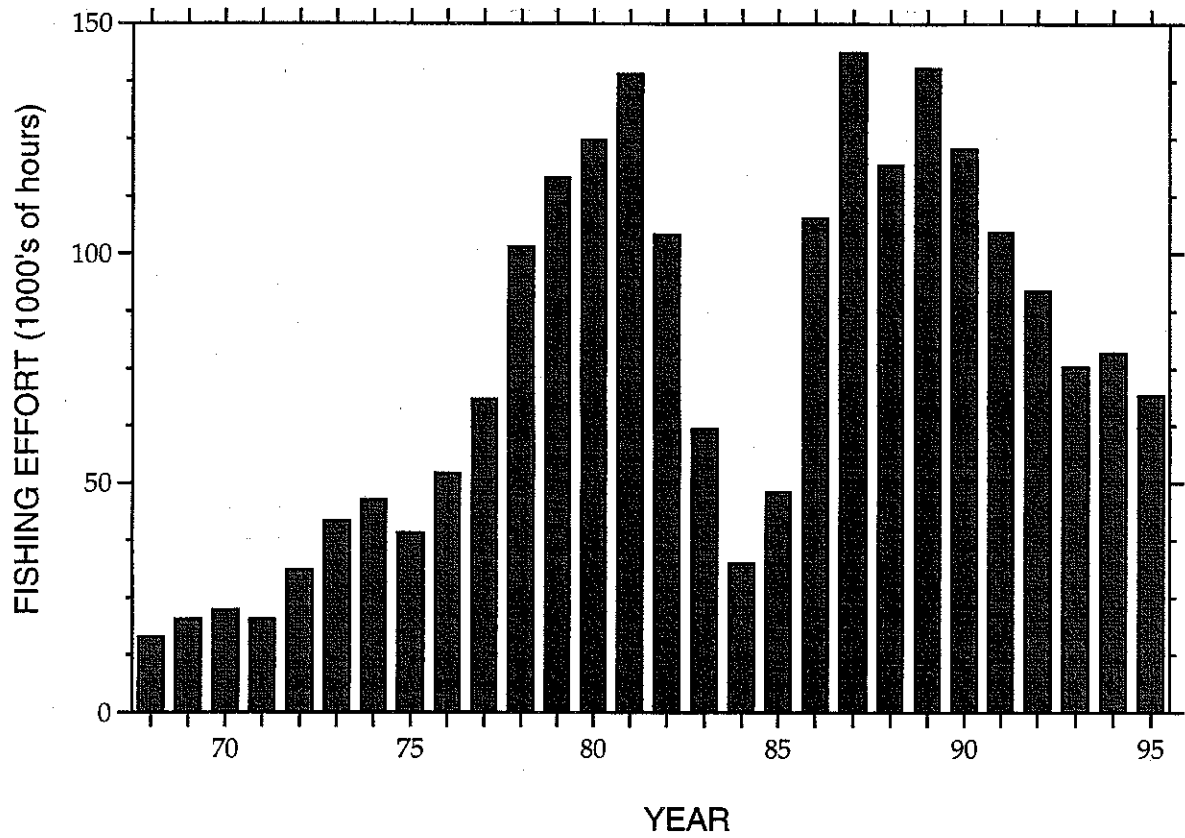


Figure 3. Fishing effort of vessels landing ocean shrimp into Oregon ports 1968-1995.

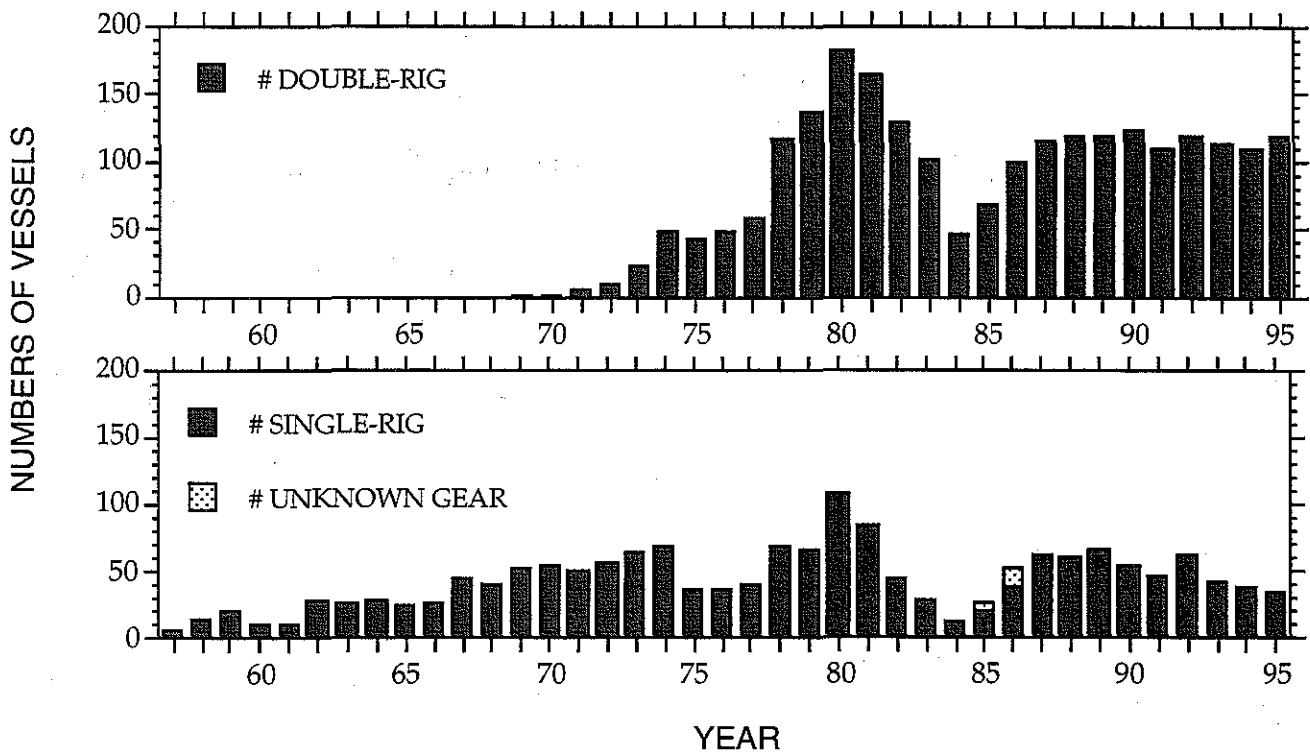


Figure 4. Number of vessels, by gear type, landing ocean shrimp into Oregon ports, 1957-95.

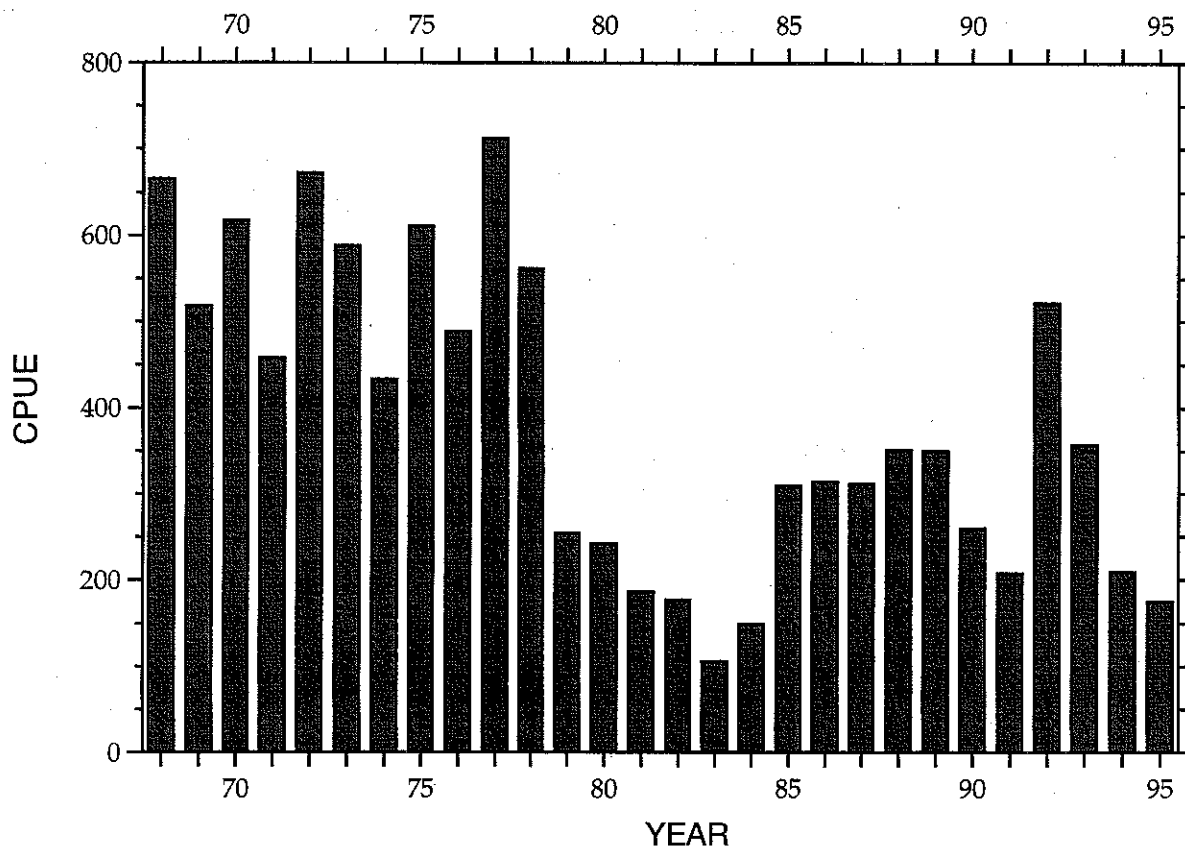


Figure 5. Catch per unit of effort (CPUE=pounds/single-rig equivalent hour) for vessels landing ocean shrimp into Oregon ports, 1968-1995. Includes CPUE for all landings of ocean shrimp into Oregon ports.

Table 2. Selected market conditions for ocean shrimp landed in Oregon, 1984-1995.

Year	Mean price (\$/lb)	Minimum price (\$/lb)	Maximum price (\$/lb)	Number of buyers *	Value (millions of \$)
1984	0.43	0.40	0.65	15	2.1
1985	0.35	0.30	0.40	18	5.2
1986	0.54	0.45	0.76	26	18.1
1987	0.68	0.60	0.85	23	30.3
1988	0.41	0.25	0.50	23	17.2
1989	0.36	0.20	0.40	23	17.9
1990	0.49	0.45	0.60	26	15.6
1991	0.56	0.53	0.60	25	12.0
1992	0.36	0.20	0.53	26	17.2
1993	0.33	0.20	0.50	26	8.9
1994	0.59	0.55	0.70	31	9.6
1995	0.71	0.65	0.85	24	8.6

* # of individual shrimp buying stations in Oregon ports.

1991 Summary

Favorable market conditions persisted into the 1991 shrimp season. Low inventories at the end of the 1990 season, combined with consistent but modest monthly landings and good grade shrimp, helped keep the demand up and the price relatively high.

The opening ex-vessel price was 54¢/lb, an increase of 9¢/lb over the opening price in 1990. The price increased gradually to a high of 60¢/lb from late June to early July (Table 2). There was an erratic decline to about 53¢/lb by the end of the season.

1992 Summary

Market conditions appeared to be favorable at the beginning of the season, with inventories low and the general expectation of a poorer than average season. April landings were exceptionally large, indicating that the 1992 harvest would be larger than expected. The scenario caused some caution in the market, culminating in the lowest ex-vessel shrimp price in this time series.

The opening ex-vessel price was 53¢/lb, the same price paid in October 1991. The average price of 36¢/lb remained stable through mid-May (Table 2), then dropped to 20¢/lb for some loads. The price was about 40¢/lb by the end of the season.

1993 Summary

A fairly large inventory remaining from the 1992 season contributed to a poor shrimp market in 1993. Good landings in April, May and June of 1993 added to the inventory and were followed by a sharp price drop. Very low catches during September and October of 1993 helped to reduce inventories accumulated over the season.

The opening ex-vessel price was low, at about 35¢/lb. The price quickly dropped to as low as 20¢/lb and remained low until mid July. It rose steadily through the remainder of the season to a high of about 50¢/lb, accompanied by steadily declining landings (Table 2).

1994 Summary

The shrimp market was favorable in 1994, with virtually no inventory available from the previous season (Talley 1994). Landings were small during early April due to weather, price negotiations and relatively low shrimp abundance. Processors apparently were cautious about setting a price before getting some indication of what the volume of shrimp and the grade of shrimp might be.

The ex-vessel shrimp price was sharply higher this year than it was during 1993. The opening price varied between 55¢ and 60¢/lb, with most catch sold at 55¢/lb. The price remained fairly stable until August, when it increased to about 65¢/lb. By late October it had risen to a high of 70¢/lb (Table 2).

1995 Summary

Markets were easily able to absorb the relatively low volume of shrimp harvested this year. Inventories were low at the beginning of the season. Processors were initially concerned about the possibility of high counts and most shrimpers were idle until April 12, asking for a higher price. Initial landings were modest and had low counts, facilitating a price settlement. Several price increases as the season progressed reflected a strong demand for a relatively scarce product. Inventories were reportedly very low at the end of the season.

The ex-vessel shrimp price was relatively high this year. The opening price was 65¢/lb in most ports of the coast and remained stable through May. The price increased to about 75¢/lb during June and July, then gradually increased to a high of 85¢/lb in October (Table 2).

Market Samples

Sample Collection

The number of market samples collected declined annually from 1990 through 1995 (Table 3). The relatively low numbers collected during 1993, '94 and '95 reflect the low landing totals during these years. Many state areas experienced little or no fishing effort during some months, making sample collection difficult.

Count-Per-Pound (count)

The average count (catch-weighted) for each season varied widely from 1990 through 1995 (Figure 6; Table 3). The average count of 85.8 shrimp/lb in 1990 was the lowest estimate recorded in Oregon since the beginning of this data series in 1966. The counts in 1993 and '95 were also below 100, correlating well with relatively low percentages of age-1 shrimp in the catch (Figure 7). Average counts in other years ranged from 120 to 126, reflecting higher percentages of age 1 shrimp in the catch.

Sex Composition

The percentage of primary females (percentage of age-1 shrimp that are female) seen

Table 3. Abbreviated summary of ocean shrimp market samples collected in Oregon, 1985-1995.

Year	Number samples collected	Count-per-pound						Catch weighted average count-per-pound	Range % October primary females	Range % October age-0
		Maximum	Mo.	State area	Minimum	Mo.	State area			
1985	119	154.0	May	32	73.0	Apr	24	104.0	28.9-31.4	2.0-04.5
1986	216	155.0	Apr	32	80.0	Sep	26	105.8	0.8-43.1	0.0-29.0
1987	150	186.0	May	32	83.0	Aug	19	134.9	20.7-48.1	0.0-46.5
1988	249	158.0	Aug	32	88.0	Sep	19	125.9	19.5-57.5	0.0-19.4
1989	280	161.0	Oct	30	94.0	Sep	20	115.0	06.7-32.9	0.0-00.6
1990	278	161.2	May	32	58.0	Sep	22	85.8	0.6-01.9	0.0-02.1
1991	266	222.1	May	30	63.6	Jul	24	126.3	06.7-38.3	0.3-24.0
1992	234	213.4	Aug	32	66.0	May	24	119.9	32.2-55.8	0.0-01.3
1993	170	144.7	May	32	66.7	Jul	22	88.1	0.0-2.60	0.0-19.4
1994	158	184.7	Jun	32	63.0	Apr	26	122.3	09.9-45.7	9.5-12.5
1995	133	172.2	May	28	56.6	Jun	19	92.7	05.9-37.1	0.0-00.9

Note: Ranges of % primary females and age-0 shrimp represent values over all state statistical areas.

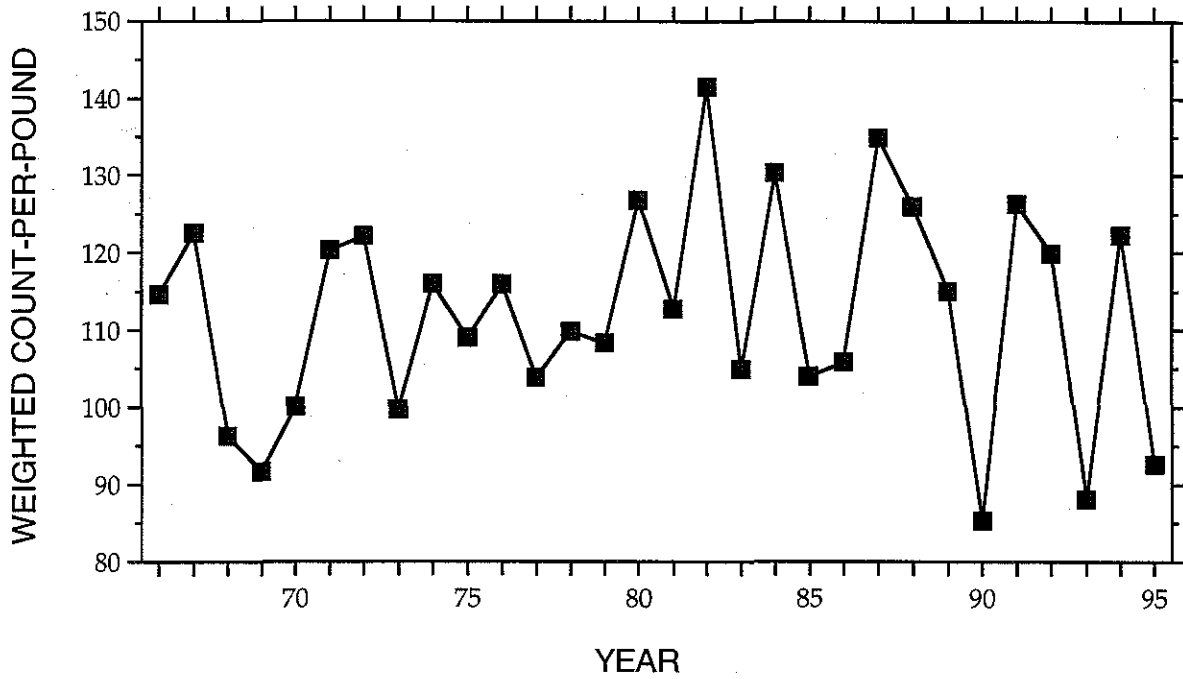


Figure 6. Average count-per-pound of ocean shrimp landings from Oregon state statistical areas 18-28, 1966-1995. Counts-per-pound weighted by area-month catches.

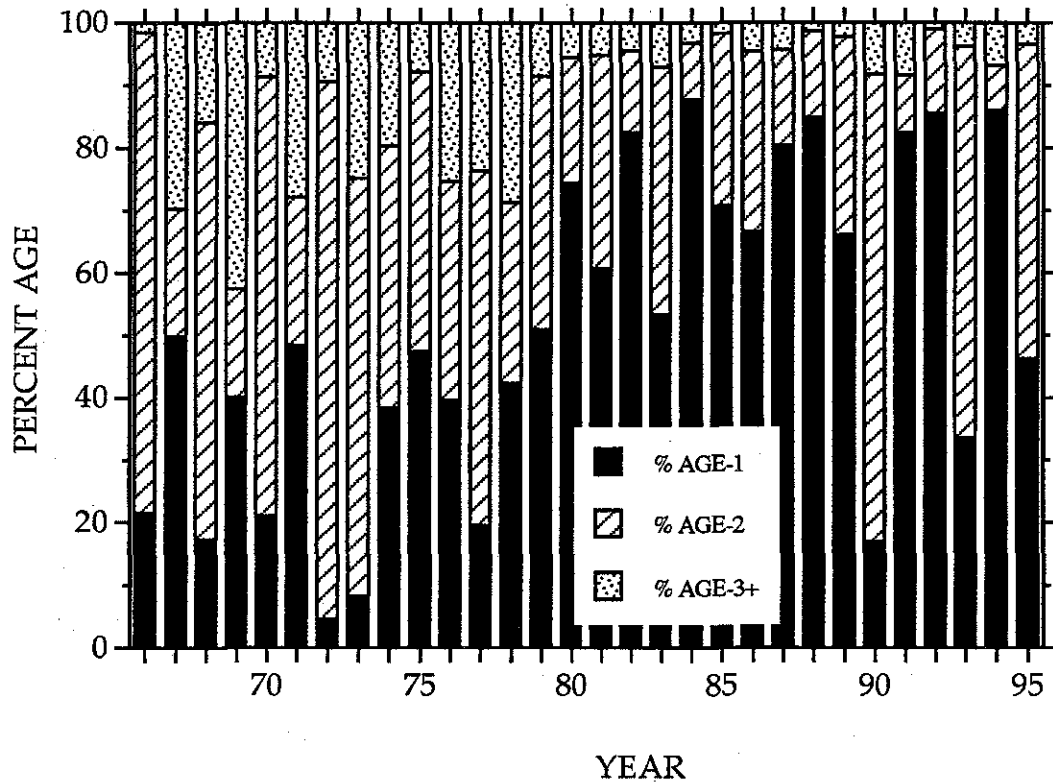


Figure 7. Annual percent age composition of ocean shrimp (#'s of shrimp) landed in Oregon, 1966-1995.

in October market samples varied widely within and between years from 1990-1995, as it did from 1985-1989 (Table 3). The high levels seen in 1991, '92 and '94 reflect the high percentage of age-1 shrimp available for harvest during these respective seasons. As described by Charnov (1978), the high percentage of primary females in late season landings indicates that age-2 and age-3 shrimp were relatively scarce.

Age Composition

The age composition of the catch was highly variable from 1990 through 1995, unlike the relatively stable percentages seen from 1985-89 (Figure 7). The fluctuation resulted primarily from variation in the percentage of age-1 and age-2 shrimp from year to year. The percentage of age-3+ shrimp was variable from 1990-'95, but remained below 10% of the catch, as it has since 1978.

The percentages of age-0 shrimp in October, from 1990-1995, were within the ranges noted from 1985-1989 (Table 3). The highest percentage was noted in 1991, which was a preamble to the very strong recruitment of age-1 shrimp in the 1992 season. The percentage of age-0's in October 1995 was the lowest found since 1989. The 1989 age-0 class later proved to be very weak, resulting in the low percentage of age-1 shrimp harvested in 1991 (Figure 7). A strong statistical correlation between age-0 abundance and the percentages found in market samples has not been demonstrated. Contemporary shrimp nets are not designed to retain age-0 shrimp and many of those that are brought on board are lost through the use of conveyors. However, the weak showing of age-0 shrimp in October 1995 suggests that the abundance of age-1 shrimp may be low in 1996.

DISCUSSION

The Oregon ocean shrimp fishery experienced an overall decline of total landings and effort from 1990-95. With the exception of the large landing total in 1992, Oregon annual landings have declined at a fairly steady rate since 1989 (Figure 2). The decline was very steep from 1992-95. We believe that the widely fluctuating landings from 1990-92 resulted from a combination of the fishery's current reliance on harvest of age-1 shrimp (Jones and Hannah 1992), and environmentally driven fluctuations in recruitment. The sharp decline in landings from 1992-95 demonstrates the severe effect that clusters of weak year classes can have on a fishery that is dependent on new recruits (Hannah and Jones 1991).

Fishing effort declined steadily from 1990-95, continuing a trend beginning in the near record high year of 1989 (Figure 3). The rate of decline appears to have slowed since 1993. Lower shrimp availability resulted in fewer trips, fewer hours fished and some vessels leaving to participate in other fisheries. Also, the proportion of single-rig vessels in the fleet declined, which tends to occur as shrimp abundance declines.

While annual landings and fishing effort have both declined during the 1990-95 period (Figure 2; Figure 3), fishing effort has declined at a lower rate. Over the last few years, the fishery has essentially experienced increased effort relative to total harvest. The apparent trend of increased relative effort suggests that conditions for triggering PFMC point of concern number 3 may have developed.

The percentage of age-1 shrimp in the catch varied widely from 1990-95; a dramatic departure from the 1985-89 period (Figure 7). The weak recruitment of age-1 shrimp in several of the years from 1990-95, caused an increased harvest rate of older shrimp in some years (Hannah 1997). This increased variability in the age composition of the catch is also apparent in the count-per-pound time series (Figure 6), which fluctuated widely from 1990-95.

The ocean shrimp trawl fishery from 1990-95 has been characterized by large fluctuations in total catch and total fishing effort. Although volatility in catch was anticipated for this fishery, based on its modern dependence on age-1 shrimp (Jones and Hannah 1992), the variation was increased by several factors. Shrimp recruitment since 1989 has included one very successful year class (1991) as well as two year class failures (1990 and 1993). Research on the environmental factors which correlate with shrimp recruitment (Hannah 1993) suggests that the variation in recruitment is caused by fluctuation in the ocean environment at the time of larval release. The 1992-93 ENSO contributed to the low recruitments in 1993 and 1994. ENSO events often result in intensified northerly currents and a weak spring transition, elements which are unfavorable for shrimp larval survival (Hannah 1993).

In our review of the 1985-89 ocean shrimp fisheries, we concluded that one of the PFMC's indicators of potential over-exploitation had been observed; consistently high levels of primary females (Jones and Hannah 1992, Hannah and Jones 1991). This trend has continued through much of the 1990-95 period. The high level of primary females (PFMC concern #2) and recent effort increases relative to catch (PFMC concern #3) continues to argue for close monitoring of the ocean shrimp fishery.

Since the publication of our last review of the shrimp fishery, several research efforts have been completed which suggest some qualifications to the PFMC's five indicator's of over-exploitation for this stock. Hannah (1995) has demonstrated that the geographic stock area of ocean shrimp varies positively with shrimp abundance. Accordingly, indicator number four, a "long-term increase in the extent of barren or void areas of formerly productive shrimping grounds" may result simply from environmental forcing of recruitment, not necessarily overfishing. Similarly, now that the factors which coincide with good shrimp recruitment are better known (Hannah 1993), "two year class failures in a three year period" or "increases in count-per-pound...coupled with equal or increasing fishing effort" may not correctly signal over-exploitation.

Recent research does suggest some "new" indicators for monitoring the health of ocean shrimp stocks. First, the variation in geographic stock area suggests that increasing exploitation rates might best be detected from an increasing trend in fishing effort per unit stock area (Hannah 1995). There is also some anecdotal evidence that catching egg-bearing female shrimp in April can have a serious impact on subsequent recruitment; an effect similar to increased exploitation rates in the prior fishing season (ODFW unpublished data). Fishing-related reductions in recruitment might best be detected by recruitment which consistently falls below that predicted by the best environmental indicators of ocean conditions at larval release. The complex technical nature of these new indicators of over-fishing underscores the need for continued collection of logbook and biological data from the shrimp fishery, as well as continued investigation into the recruitment dynamics of ocean shrimp.

REGULATION CHANGES

Count-Per-Pound

In 1994, we "tightened up" the wording of our count-per-pound regulation in response to advice from the state district court in Astoria, Oregon. The language change clearly described the working definition of the terms "whole" and "whole and unbroken", which removed a major gray area for those involved in count-per-pound court cases. Previously, these terms were not defined specifically in our regulations, which led to the dictionary definition by default. The strict dictionary definitions of the words "whole" and "unbroken" did not convey the original intent of the count-per-pound regulation. Oregon Administrative Rule 635-05-200 section (3) was changed to read: "For the purpose of determining count-per-pound "whole shrimp" and "whole and unbroken shrimp" are defined as shrimp in which the body is substantially intact, including an identifiable carapace, abdomen, and telson. It is not intended to require shrimp to have an unbroken rostrum, complete set of legs, antennae, or other appendages".

Groundfish Retention

Federal regulations governing retention of groundfish in the ocean shrimp fishery also changed in 1994. Groundfish trip limits established for the limited entry groundfish fishery were extended to all "open access" fisheries, which includes the shrimp fishery.

Interstate Issues

The Washington Department of Fisheries (WDF) officially rescinded its minimum codend mesh size regulation effective 1 April 1995. As a housekeeping measure, the Oregon Fish and Wildlife Commission rescinded Oregon's reciprocal shrimp landing law requiring that Washington shrimp landed in Oregon be caught with Washington-legal nets. WDF also ended its mandatory logbook requirement (1993) for landing shrimp into Washington ports.

Changes In Limited Entry System

House Bill 3444, passed by the 1995 Oregon legislature, included a number of changes regarding the Oregon ocean shrimp limited entry system. Some of the important changes were;

- 1) Single delivery licenses for ocean shrimp may only be obtained by individuals holding valid commercial fishing permits to take ocean shrimp in the states of California or Washington, not any other state.
- 2) A shrimp permit lottery will not be held until the number of permits drops below 150 instead of 188.
- 3) A permit acquired through waiver of eligibility requirements may not be transferred until the vessel for which the permit was issued has been used in the shrimp fishery for three or more consecutive years to land at least 5,000 pounds of ocean shrimp.
- 4) For shrimp vessels greater than 42', permits are transferable only to a shorter vessel, or if the recipient vessel is less than five feet longer than the original vessel.

REGIONAL PERSPECTIVE

Total commercial ocean shrimp landings for Alaska (AK), British Columbia (BC), Washington (WA), Oregon (OR) and California (CA) were erratic from 1990-95, ranging from a low of 33.0 million pounds in 1994 to a high of about 78.5 million pounds in 1992 (Figure 8). The high in 1992 was only slightly above the levels seen during the late 1980's. Alaska remained a small producer during this period, within the range seen from 1985-89 (Figure 9). Oregon landings declined steadily from 1992-95 to the lowest level since 1985. Combined BC, WA and CA landings remained fairly stable from 1990-95, only slightly lower than during the 1985-89 period.

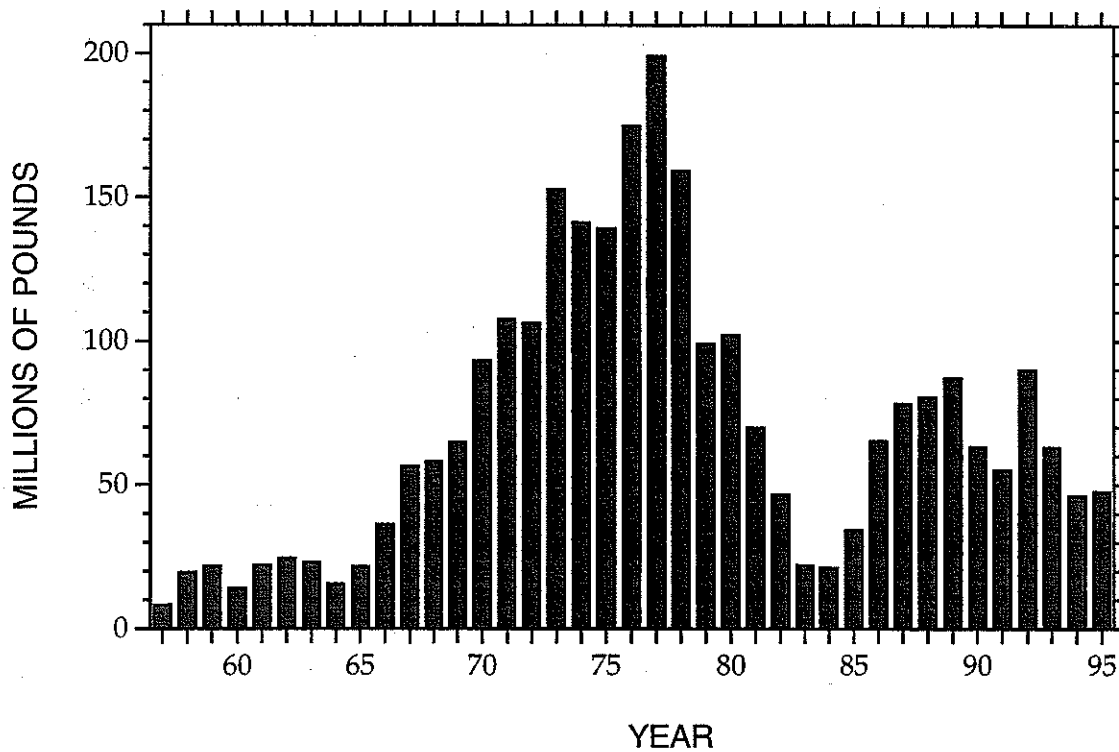


Figure 8. Combined catch of commercial ocean shrimp from Alaska, British Columbia, Washington, Oregon and California, 1957-1995. From ODFW archived data; communication with respective fishery agencies.

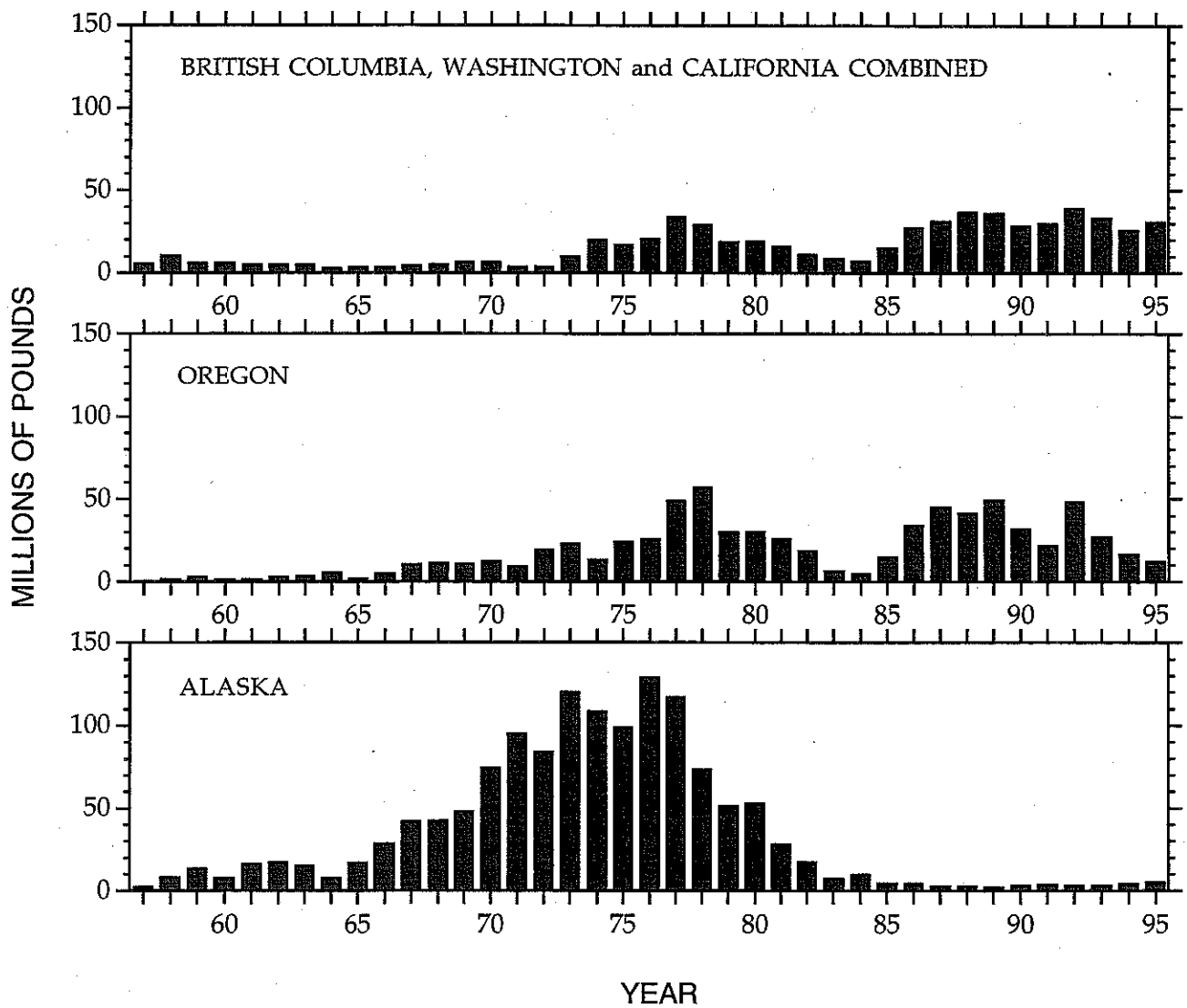


Figure 9. Catch of ocean shrimp from Pacific coast states and British Columbia, 1957-1995. From ODFW archived data; communication with respective fishery agencies.

The AK fishery is distinctly different from the other West Coast shrimp fisheries. Much of the fishery occurs in relatively protected waters inhabited by several shrimp species. Alaska shrimp landings are dominated by *Pandalus borealis* which comprise up to 85% of the catch, with *P. jordani* contributing to a minor extent (Gaffney 1981).

Total ocean shrimp landings during 1990-95 for WA, OR and CA varied widely, and declined from 1992-95 (Figure 10). Oregon had the largest landings during all these years. The landing pattern was similar for each state despite large volume fluctuations.

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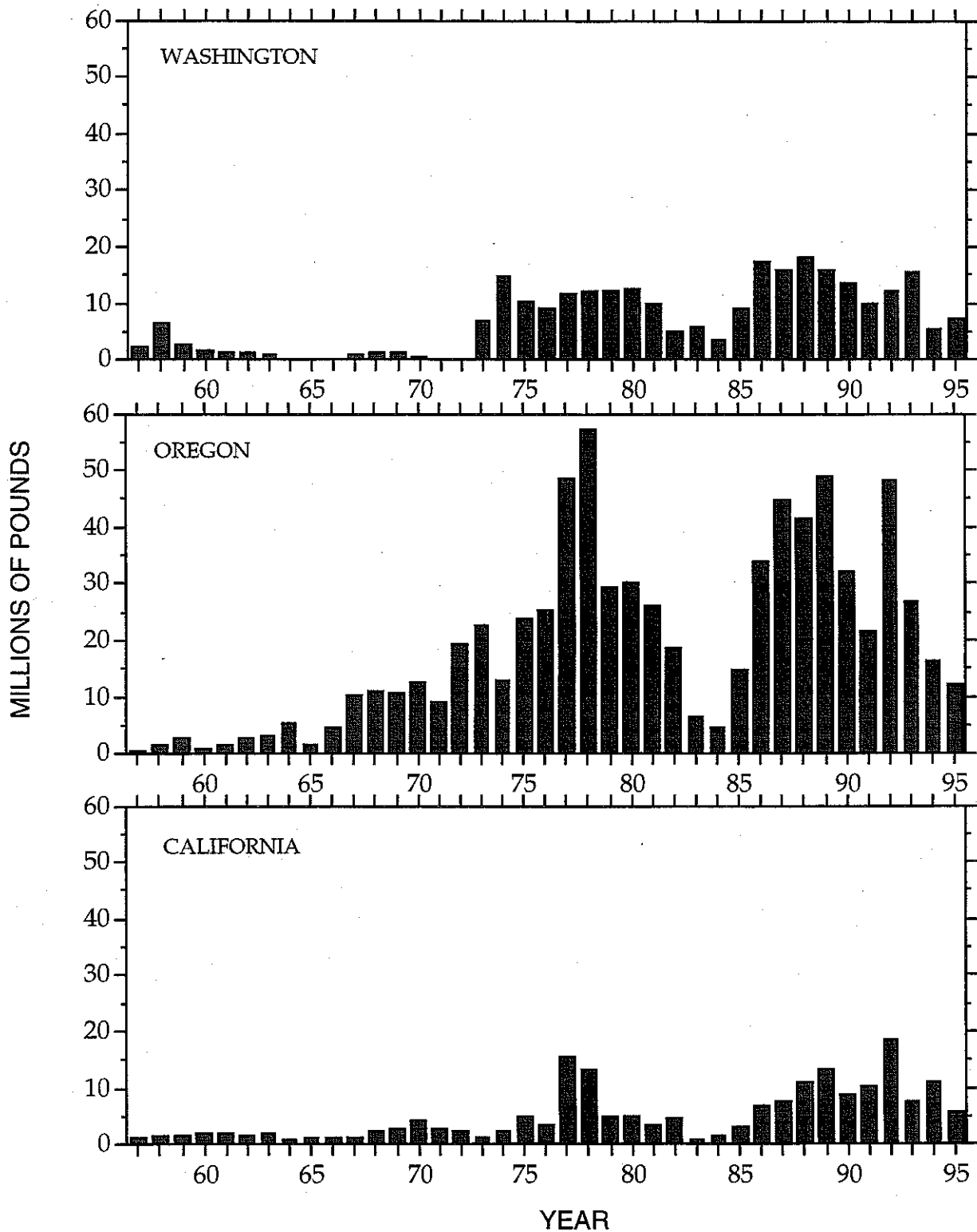


Figure 10. Ocean shrimp landings into Washington, Oregon and California, 1957-1995. From ODFW archived data; communication with respective fishery agencies.

REFERENCES

- Charnov, E.L., D.W. Gotshall, and J.G. Robinson. 1978. Sex Ratio: adaptive response to population fluctuations in pandalid shrimp. *Science* 200:204-206.
- Gaffney, F.G. 1981. History of research and management of Alaskan shrimp. Pages 77-80 in T. Frady, editor. Proceedings of the international pandalid symposium. Alaska Sea Grant Program Report 81-3, University of Alaska, Fairbanks.
- Hannah, R.W. 1993. Influence of environmental variation and spawning stock levels on recruitment of ocean shrimp (*Pandalus jordani*). *Can. J. Fish. Aquat. Sci.* 50: 612-622.
- Hannah, R.W. 1995. Variation in geographic stock area, catchability, and natural mortality of ocean shrimp (*Pandalus jordani*): some new evidence for a trophic interaction interaction with Pacific hake (*Merluccius productus*).
- Hannah, R.W. 1997. Evaluation of methods used to estimate geographic stock area for ocean shrimp (*Pandalus jordani*) from logbook data. Oregon Dept. Fish. Wildf., Newport. Inf. Rep. Ser. Fish. 97-6. 17p.
- Hannah, R.W. and S.A. Jones. 1991. Fishery induced changes in the population structure of pink shrimp (*Pandalus jordani*). *Fish. Bull. U.S.* 89:41-51.
- Jones, S.A. and R.W. Hannah. 1992. The Oregon pink shrimp fishery: 1985-1989. Oregon Dept. Fish. Wildf., Newport. Inf. Rep. Ser. Fish. 92-3. 17p.
- Pacific Fishery Management Council. 1981. Discussion draft fishery management plan for the pink shrimp fishery off Washington, Oregon and California. PMFC, Portland, Oregon. 169 pp.
- Talley, K. 1994. Seafood Report: Significant Market Developments. In: Pacific Fishing. May 1994. Page 11.
- Tegelberg, H.C., and J.M. Smith. 1957. Observations on the distribution and biology of the pink shrimp (*Pandalus jordani*) off the Washington coast. Washington Department of Fisheries Research Papers 2(1):25-34.



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