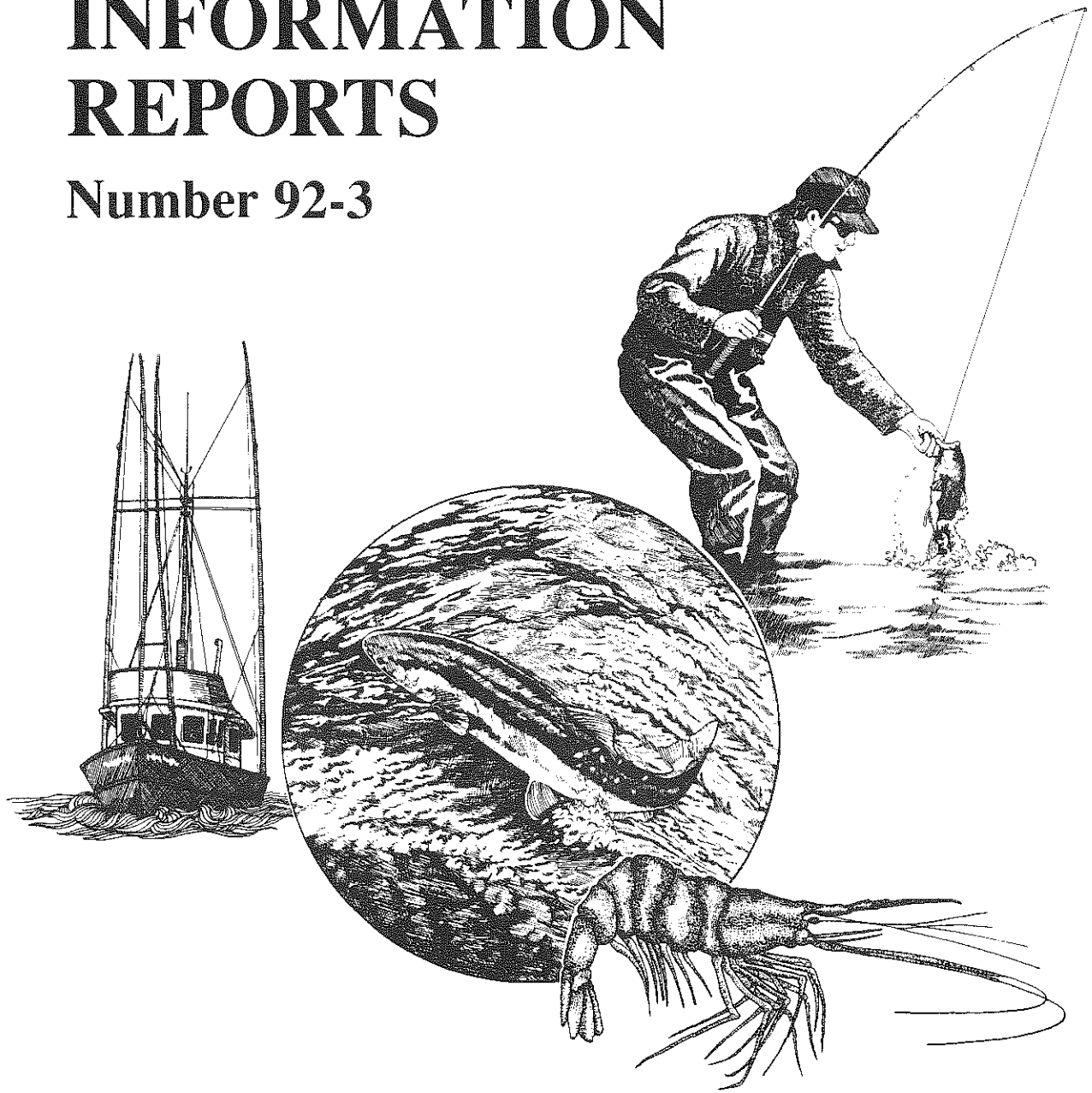


INFORMATION REPORTS

Number 92-3



FISH DIVISION

Oregon Department of Fish and Wildlife

The Oregon Pink Shrimp Fishery: 1985-1989

**The Oregon Pink Shrimp Fishery:
1985-1989**

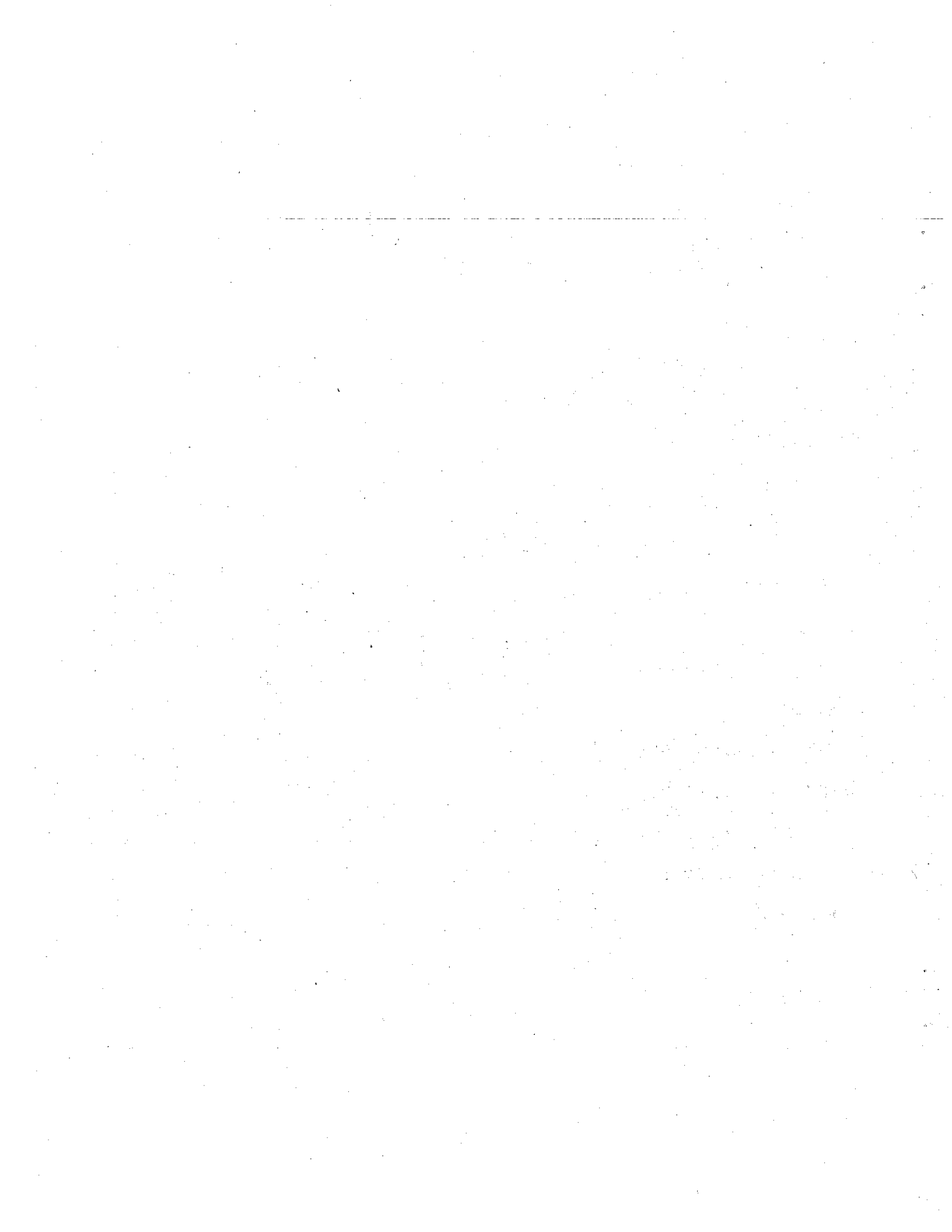
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INTRODUCTION

In 1981, the Pacific Fishery Management Council (PFMC) produced a proposed tri-state pink shrimp *Pandalus jordani* management plan that identified five biological points of concern for evaluating stress on pink shrimp stocks (PFMC 1981). These five indicators of potential over-exploitation are:

1. Long-term (3 years) statistically significant increases in average count-per-pound and/or increase in the incidence of high counts-per-pound 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 shrimping grounds.
5. Indication, through sampling, of two year-class failures in a three-year period.

Hannah and Jones (1991) analysed data from the pink shrimp fishery for 1966 to 1988 to evaluate changes in the population structure of pink shrimp in relation to the growth of the trawl fishery. Their analysis showed increased size at age after 1978. The increased size at age was concurrent with a large drop in catch per unit of effort indicating density-dependent growth. They also described a trend toward younger mean age at harvest and increasing levels of 1-year-old pink shrimp that are female (primary females), satisfying Number 2 above.

The primary objective of this report is to analyze fishery and biological data from the 1985-89 trawl fishery for pink shrimp and to evaluate the evidence of potential over-exploitation as specified in the tri-state management plan. A secondary objective is to update the existing series of summary reports detailing annual catch and effort for 1977 to 1984. We documented trends in the fishery and compared them with those noted prior to 1985. Some California, Washington, British Columbia, and Alaska information is included to add a regional perspective.

METHODS

Market conditions and fisheries events of interest for each year were gathered from shellfish program annual reports, marine region newsletters, Pacific States Marine Fisheries Commission data series, newspaper articles, landing reports, and personal communications.

Catch and effort statistics by month and state statistical area (area) were summarized from trawl logbooks, landing tickets, and biological samples (market samples) collected at seafood processing plants. Both single-rig and double-rig effort is reported in single-rig

equivalent hours (SRE) and will be referred to simply as "hours" in this report when no other distinction is made.

Each month during each season, we attempted to collect 4-6 market samples of approximately 100 pink shrimp from each area (Figure 1). Samples were obtained at the docks. We counted and weighed the shrimp to determine count per pound (count), and measured each carapace length. 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, after Tegelberg and Smith (1957).

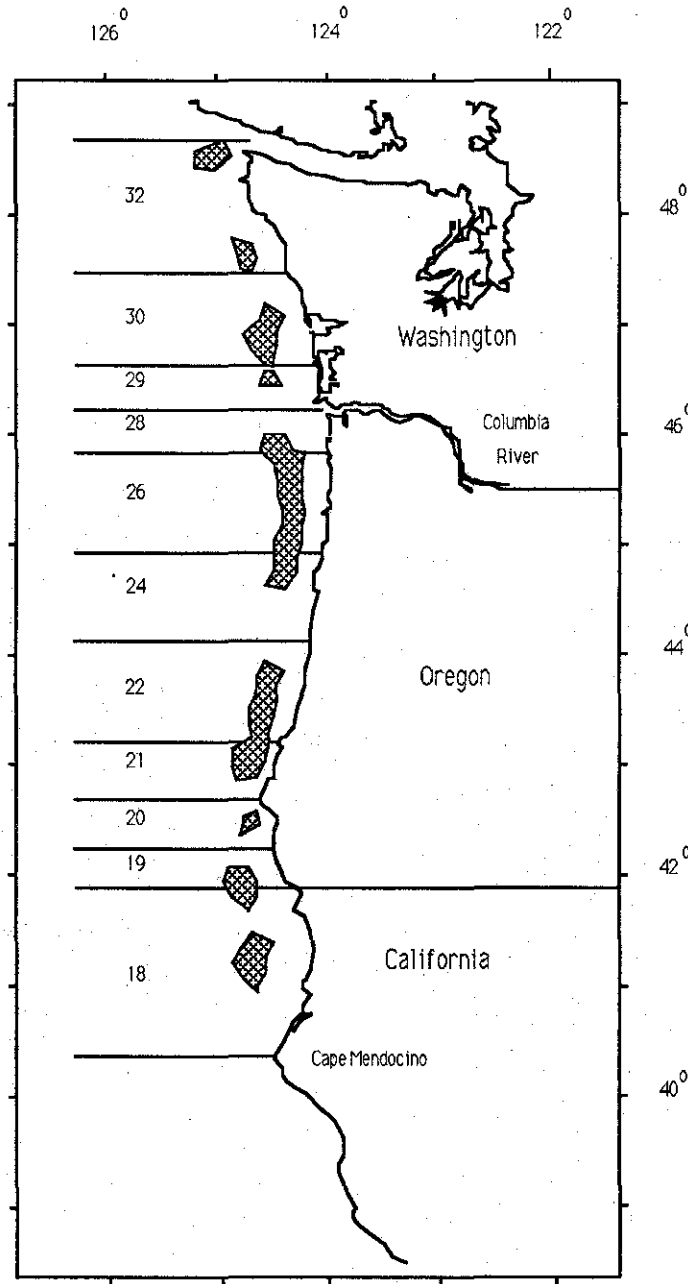


Figure 1. Oregon state statistical areas (18-32). Commercially fished pink shrimp beds along the Washington, Oregon, and northern California coasts are shown in crosshatching.

We combined data from individual samples within a month and area for analysis of age composition and sex composition. Raw length- and sex-frequency data were rescaled proportionally to a sample size of 100 before they were combined with other samples when sample size deviated substantially from 100 shrimp. Hence, samples were given equal weight in determining age and sex composition.

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

We estimated catch and effort statistics by area for 1985 through 1989 using logbook and landing ticket data. Landing tickets provide a complete summary of catch, but no information on area of catch. Logbook data gave information on area of catch and also information on fishing effort and catch per unit of effort (CPUE), but was often incomplete. The pattern of catch and effort from the available logbooks was used to allocate the landed pounds and the associated effort to individual areas on a port and month basis. The exact methods used in 1985 and 1986 to obtain these estimates differed from those used after 1986. 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. During 1985 and 1986, all landing ticket information and useable trawl logs were entered into a REVELATION© data base and expanded on a tow-by-tow basis. Single-rig and double-rig effort and CPUE were not expanded separately, but were standardized to double-rig equivalents (1 SRE = 1 single-rig hour = 1 double-rig hour X 1.6). Trawl logs were summarized by trip from 1987 through 1989 to provide hours fished and the pounds hailed for each area fished within a trip. Trawl log summary data and landing ticket information were then recorded on trip summary sheets and entered into a FOXBASE+/MAC® data base for processing. Trips whose hauls differed from the landed pounds by 50% or more were discarded from the data base. Poundage and effort was allocated by port to the appropriate area. Single-rig and double-rig effort were analyzed separately. Additionally, in 1987 and 1989, useable trawl logs were systematically subsampled at a 50% rate (100% for single-rig effort in north and central coast ports) because of the large volume of logs and limited staff time. Subsampling was not used in analyzing data from 1988.

THE 1985-1989 FISHERIES

Catch

Annual landings of pink shrimp in Oregon showed a generally increasing trend from 1985 through 1989. The single decline during this period occurred in 1988, probably resulting from a slow start of the season rather than lower abundance. The 1986 through 1989 Oregon landings showed the longest sustained high yields in the history of the Oregon fishery (Figure 2). Landings from 1986 through 1989 were each above 34 million pounds. Prior to 1986, landings above 31 million pounds had occurred only twice.

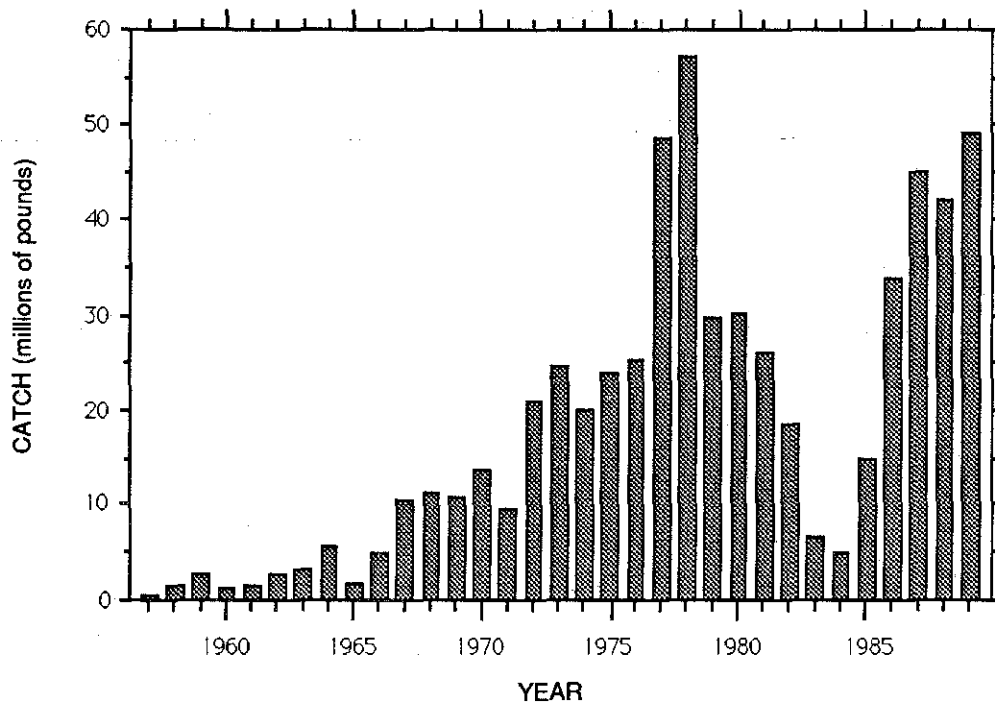


Figure 2. Oregon commercial catch of pink shrimp, 1957-89. Includes all pink shrimp landed annually in Oregon ports. From ODFW archived data.

The distribution of landings on the Oregon coast changed from 1985 through 1989. The percentage of landings into north coast ports declined from 1987 through 1989, after three consecutive annual increases (Table 1). The central coast showed a steady increase after 1986. The south coast also showed an increasing trend.

Table 1. Oregon pink shrimp commercial catch (thousands of pounds) by coastal region and port, 1984-89. From ODFW archived data.

Coastal region, port	Year					
	1984	1985	1986	1987	1988	1989
North coast:						
Astoria	1,625	4,199	12,767	19,293	11,447	10,232
Garibaldi	281	1,927	4,412	4,004	3,541	2,241
Central coast:						
Newport	1,276	5,780	7,765	11,574	13,400	18,364
South coast:						
Winchester Bay	0	5	6	29	38	76
Coos Bay	1,554	2,737	7,346	7,809	10,399	13,283
Bandon	0	0	28	0	0	0
Port Orford	0	11	93	63	140	302
Brookings	108	150	1,418	1,817	2,881	4,631

Effort

Fishing effort increased sharply from 1985 to 1986 and increased to a record high level in 1987 (Figure 3). The sharp effort increase in 1986 was the greatest annual effort increase in the history of the Oregon fishery. Many vessels that had fished for shrimp in the late 1970s and early 1980s returned to the fishery after participating in other fisheries, such as squid and scallops, in 1982, 1983, and 1984.

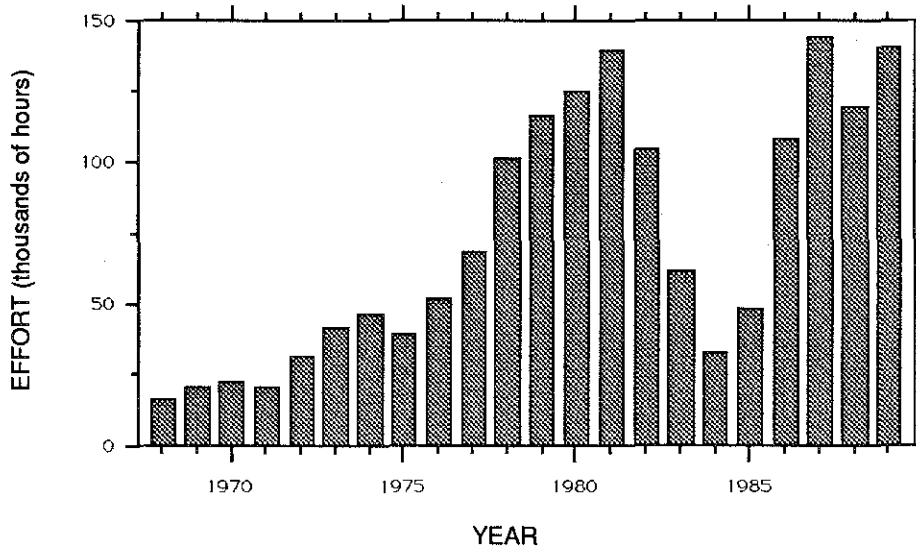


Figure 3. Fishing effort of vessels fishing for pink shrimp that were landed into Oregon ports, 1968-89. From ODFW archived data.

The number of vessels landing shrimp in Oregon increased steadily from 1985 to 1987 (Figure 4). The percentage of single-rig shrimp vessels was 21% in 1985 and increased to 36% in 1989. The increase in the number of single-rig vessels may reflect increased vessel participation on the south coast after decreased participation in the early 1980s.

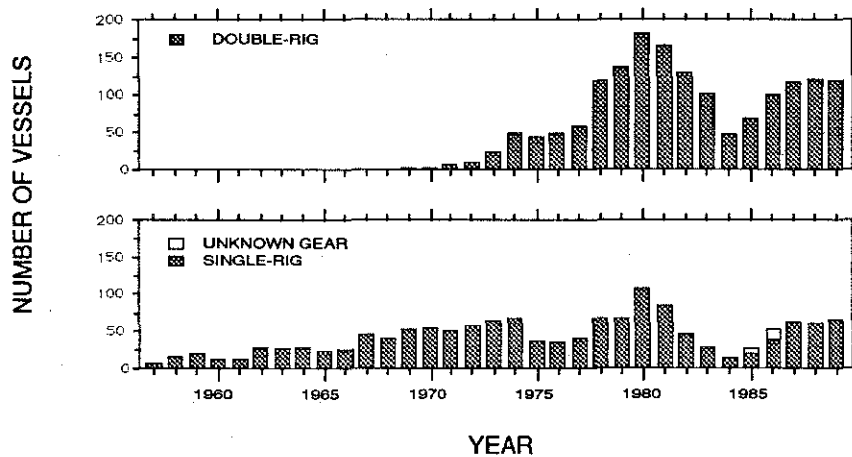


Figure 4. Number of vessels , by gear type, landing pink shrimp into Oregon ports, 1957-89. From ODFW archived data.

Catch Per Unit of Effort

Combined single-rig and double-rig CPUE is shown in Figure 5. Average CPUE from 1985 to 1989 was well above the average from 1979 to 1984. However, average CPUE remained well below the high levels seen prior to 1979.

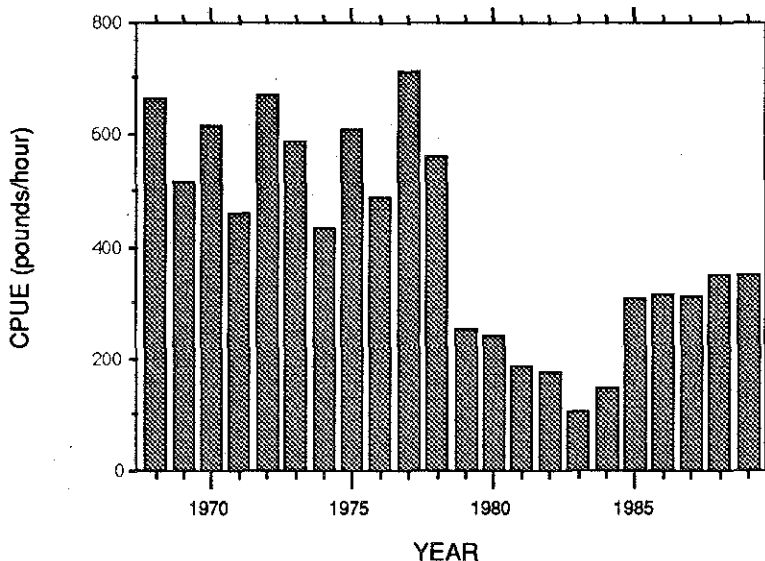


Figure 5. Catch per unit of effort (CPUE=pounds/hour) for vessels landing pink shrimp into Oregon ports, 1968-89. Includes CPUE for all landings of pink shrimp into Oregon ports. From ODFW archived data.

Market Conditions

1985 Summary

Market conditions were more favorable in 1985 than in 1984 partly because of reduced amounts of Norwegian shrimp competing on the market. The count of Oregon shrimp was good throughout the season, further improving marketability.

Fishermen received an average price of \$0.35/lb for shrimp sold during 1985 (Table 2). Most of the shrimp sold brought \$0.35/lb. The ex-vessel value of shrimp landed in Oregon was approximately \$5.2 million (Lukas and Carter 1987).

1986 Summary

The shrimp market was strong in 1986. Fishermen received an opening price of \$0.45/lb. As monthly catches slowed, the price increased gradually through the season to a high of \$0.76/lb. The price structure represented a dramatic change from the 1985 season. A good market, an above average volume, and a relatively high ex-vessel price provided the industry

with an economic boost. The ex-vessel value of shrimp landed in Oregon was approximately \$18.1 million (Lukas and Carter 1987).

Table 2. Selected market conditions for pink shrimp landed in Oregon, 1984-89. From ODFW archived data.

Year	Mean price	Minimum price	Maximum price	Number of buyers	Value (millions)
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

1987 Summary

The shrimp market was very strong in 1987. Depressed foreign shrimp fisheries improved demand for West Coast pink shrimp. Processors bought as much shrimp as vessels could harvest until a midseason market slowdown. Processors attempted to reduce large inventories in July with trip limits and reduced price, but landings remained strong through the season.

The large landings early in the season included a high percentage of age-1 shrimp. Loads with a high average count (close to or over the 160 count/lb limit) were common. The volume of small shrimp led processors to develop new markets for small shrimp at relatively low prices. In the past, Oregon processors had concentrated on keeping the count of shrimp as low as possible to ensure a high-priced product. The new markets for lower-priced shrimp reduced demand for the higher-priced product later in the season. As a result, processors were left with large inventories of good-grade, high-priced shrimp at the end of the season.

Fishermen received an opening price of \$0.65/lb. The price increased to \$0.80-\$0.85/lb by June. The midseason market slowdown caused a price drop in July to \$0.60-\$0.65/lb. The price remained at this level through October. The ex-vessel value of shrimp landed in Oregon during 1987 was approximately \$30.3 million (Lukas and Carter 1987).

1988 Summary

Demand for premium grade shrimp was weak in 1988. Processors had developed markets for small, relatively low-priced shrimp during 1987. These markets were seeking more of the same. Processors had accumulated large inventories of high-priced, good-grade shrimp toward the end of the 1987 season. They were forced to sell these inventories at lower prices at the beginning of the 1988 season. Processors wanted to regain their premium shrimp markets and actively encouraged fishermen to catch larger shrimp.

At the start of the season in 1988, fishing was delayed by price negotiations. Fishermen finally accepted a \$0.50-\$0.25/lb split price during mid-April. The higher price was paid for shrimp larger than about 140 count/lb. Counts were good during the first week of fishing. At first, fishermen were able to find good-grade shrimp and reported large amounts of small shrimp in many areas. However, counts increased after the first week of fishing, and processors reduced the price. Fishermen refused to fish again from late April to early May. Fishing resumed again with a \$0.40-\$0.25/lb price, split at about 140 count. Many processors also began paying \$0.50/lb for shrimp larger than 100 count during May and continued this practice through the season. The ex-vessel value of shrimp landed in Oregon was approximately \$17.2 million (Oregon Department of Fish and Wildlife, unpublished data).

1989 Summary

Market conditions in 1989 improved over those seen in 1988. Demand for shrimp was strong, and the industry was able to produce good-grade product throughout the season. Shrimp inventories at the end of the season were adequate for demand over the winter. However, inventories were low at the beginning of the 1990 season.

The 1989 season began quickly with fishable weather and no price disputes. Effort was high and landings were large until late June when a price dispute developed. The dispute lasted into the fourth week of July, although some vessels in Astoria fished during this period. Large landings resumed in late July and continued through October.

The price dispute was influenced heavily by the large landings seen from April through June combined with a slow midseason market. Processors apparently wanted to avoid exceptionally large inventories and lowered the price to reduce inventory and offset storage costs. Fishermen in most ports responded by not fishing for nearly a month before accepting a slightly lower price.

A two-tiered price structure was in effect this year. The opening price was \$0.40/lb for shrimp larger than about 140 count/lb and \$0.25/lb for smaller legal shrimp. The price structure was stable until late June, dropped to a \$0.35-\$0.20/lb split price during July, and remained fairly stable through the remainder of the season. Most shrimp landed were sold at the higher of the two prices. The ex-vessel value of shrimp landed in Oregon was approximately \$17.9 million (ODFW, unpublished data).

Count problems were minimal during 1989. Only one citation was issued and that was for a load from Area 30 during September in Astoria. A fairly high percentage of 2-year-olds from the 1987 brood provided for a good grade of shrimp throughout the season.

Market Samples

Sample Collection

The number of market samples collected increased each year from 1985 through 1989 with the exception of 1987 (Table 3). Area-month coverage increased in the same manner.

Table 3. Abbreviated summary of pink shrimp market samples, 1984-1989. From ODFW archived data.

Year	Number samples collected	Count per pound						Catch weighted average count per pound	Range % October primary females	Range % October age-0
		Max-imum	State Month	Min-imum	State Month	State area	State area			
1984	118	212	Apr	32	70	Sep	19	130.3	02.1-19.5	0.3-20.6
1985	119	154	May	32	73	Apr	24	104.0	28.9-31.4	2.0-04.5
1986	216	155	Apr	32	80	Sep	26	105.8	00.8-43.1	0.0-29.0
1987	150	186	May	32	83	Aug	19	134.9	20.7-48.1	0.0-46.5
1988	249	158	Aug	32	88	Sep	19	125.9	19.5-57.5	0.0-19.4
1989	280	161	Oct	30	94	Sep	20	115.0	06.7-32.9	0.0-00.6

Count Per Pound

The average count (catch weighted) for each season varied widely from 1985 through 1989 (Figure 6). The peak for this period occurred in 1987, a year with an abundance of 1-year-old shrimp from the 1985 spawn year and markets willing to buy small shrimp. The weighted average count declined from 1987 to 1989, probably because of industry efforts to increase the size of shrimp landed and apparent large carry-over of 1-year-olds to the following season. Long-term (1966-89) catch weighted averages show that 1987 and 1988 ranked high. This corresponds roughly with the large percentage of age-1 shrimp landed during these years.

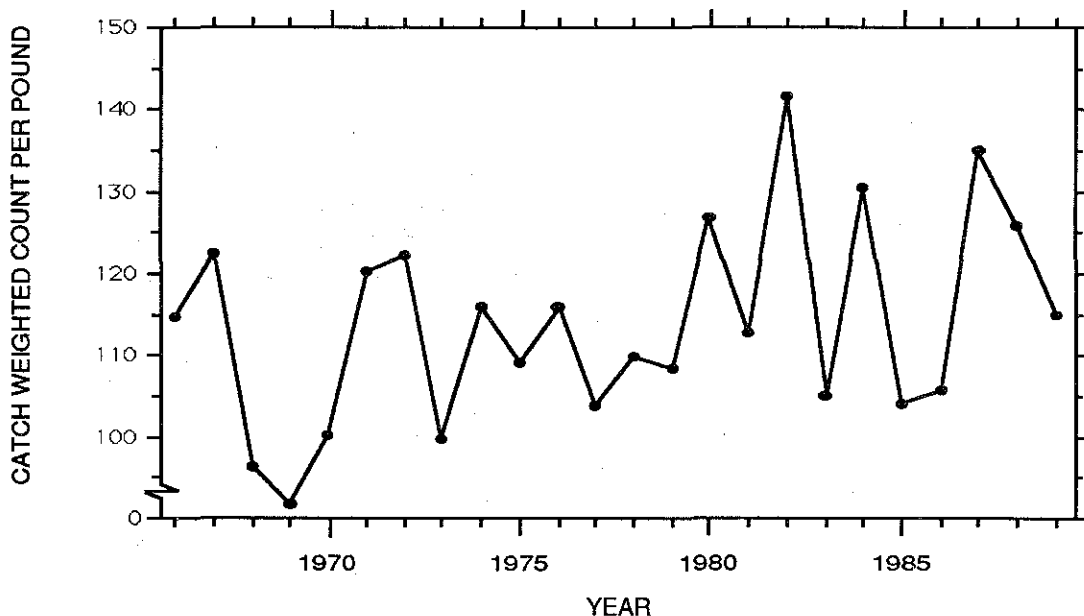


Figure 6. Average count per pound of pink shrimp from Oregon state Statistical Areas 18-28, 1966-89. Counts per pound weighted by area-month catches. From ODFW archived data.

The maximum counts seen in market samples from the 1985 through 1989 seasons came from Areas 30 and 32 and were taken over a wide range of months (Table 3). High counts late in the season probably resulted when shrimpers fished northern areas with relatively large proportions of small, age-1 shrimp, in response to declining catch per unit of effort in other areas or to higher prices. The lowest counts came predominantly from southern areas during the latter half of the season, where the growth rate is more rapid.

Sex Composition

The percentage of primary females (percentage of age-1 shrimp that are female) seen in October market samples varied widely within and between years from 1985 through 1989. The minimum and maximum levels seen in 1987 and 1988 indicate that overall levels peaked during these years (Table 3). These high percentages are evidence that age-1 shrimp were abundant in 1987 and 1988. As described by Charnov et al. (1978), pink shrimp population dynamics allow for the development of a roughly balanced sex composition each year just prior to spawning. The high level of primary females in 1987 and 1988 suggests that the age-1 component of the population during these years was large relative to the other age classes. Primary females were abundant because 1-year-old males were relatively numerous.

Age Composition

One-year-old shrimp represented a high percentage (by number of shrimp) of the landed catch from 1985 to 1989 and reached a near record high percentage in 1988 (Figure 7). The 2-year-old component increased in 1989, probably a result of the large recruitment from the 1986 spawn year. The 3-year-old component was variable, but remained at the lowest levels since 1967.

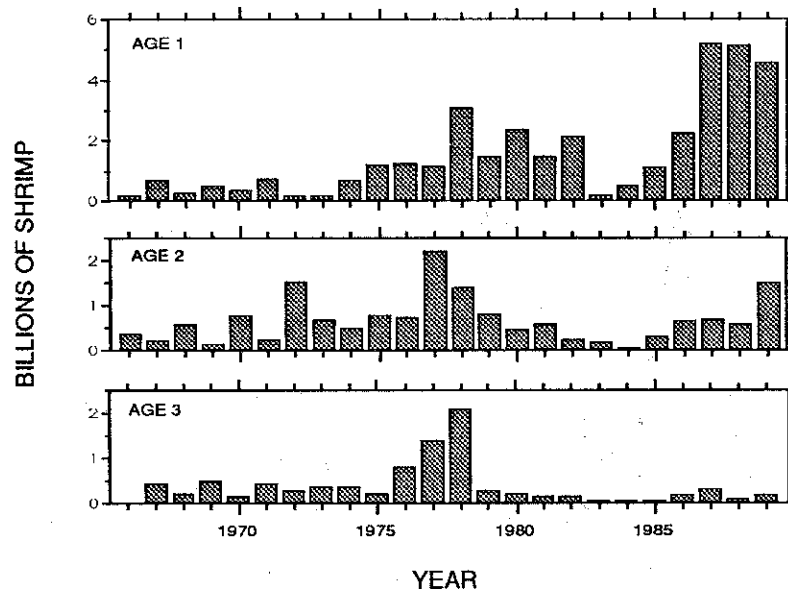


Figure 7. Age composition of the pink shrimp catch from Statistical Areas 18-28 landed in Oregon ports, 1966-89. From ODFW archived data.

The percentage of age-0 shrimp in October varied widely from 1985 through 1989 (Table 3). Our analysis of years prior to 1985 shows that the percentage of age-0 shrimp in market samples is probably not a reliable indicator of incoming year class strength. However, the low percentage in 1989 is sharply lower than those seen in recent years, even with improved sampling. Several biologists and fishermen expressed concern that a weak upcoming year class was indicated.

DISCUSSION

The Oregon pink shrimp fishery rebounded rapidly from 1985 to 1989 after the low landings and effort seen in 1984. The increased landings and effort probably resulted from the production of several strong year classes and the return of a more beneficial ocean environment after the 1983 El Niño southern oscillation (ENSO) event. A concurrent trend of decreased annual catches with increased effort has not occurred.

Near record landings occurred in 1987, 1988, and 1989, each above 40 million pounds. Age-1 shrimp were harvested in unprecedented numbers during these years (Figure 7). These two factors suggest that the year classes were strong. The increased landings from 1985-1989 (Figure 2) and increased harvest of age-1 shrimp suggests that no year class failures occurred. However, the large catches in 1987 through 1989 must have been due, at least in part, to near record effort levels. Ocean conditions also may have enhanced catches through the reversal of the northerly shift of Oregon shrimp stocks experienced during the 1983 ENSO event (Saelens and Zirges 1985).

The sharp increase in catch per unit of effort in 1985 may be explained by the return to more typical ocean conditions after the 1983 ENSO. A higher abundance of age-1 shrimp and an increased harvest rate on this age class may have contributed as well. Increased fishing efficiency that resulted from gear improvements may have helped to maintain recent CPUE levels. The effects may have been subtle and have not been evaluated, but we have seen some increase in mean vessel size and numerous modifications in trawl design during the last few years. Stable annual CPUE since 1985, combined with increased proportions of age-1 shrimp in the catch, suggests that the recent strong year classes have been harvested at high levels.

The long-term implications of high harvest levels are unclear. Pink shrimp are now harvested primarily at age-1, and the yield per recruit may have been improved by pre-empting natural mortality. We believe that growth has improved, possibly in response to stock reduction (Hannah and Jones 1991). Hence age-1 shrimp, which now typically compose a large fraction of total annual landings, are larger at age. Even with improved size at age and increased reliance on age-1 shrimp, we have not seen three consecutive years of increased average count.

We found no indication that the high harvest levels have negatively influenced the spawning stock, although primary females now contribute heavily to the spawning stock. Sex composition at the end of each season has been stable (Hannah and Jones 1991).

The reliance of the pink shrimp fishery on age-1 shrimp has made the fishery more susceptible to the effects of year class failure. A weak or absent year class could theoretically

reduce a potential annual harvest (the number of shrimp harvested) by as much as 80%. Harvest during the following year would also be reduced. The low relative abundance of age-2 shrimp the following year could cause prohibitively high average shrimp counts and would probably reduce early season harvest. Continued harvest of a depressed year class could also reduce subsequent recruitment. Hence, a failed year class could potentially affect production for two or more seasons. We are uncertain as to how small the spawning stock can be and still support a fishery of this magnitude, because a stock-recruitment relationship has not been demonstrated for pink shrimp (Gotshall 1972).

REGULATION CHANGES

No regulation changes occurred during the years 1985 through 1987. The regulations enacted in 1982 and described by Saelens and Zirges (1985) remained in effect. During 1987, Senate Bill 843 was passed, which enacted regulation changes pertaining to pink shrimp vessel permits and single-delivery licenses. The new laws became effective on January 1, 1988. The legal changes are described below:

1. The shrimp permit annual fee was raised from \$1 to \$10 and must now be purchased prior to December 31.
2. Vessel licenses are now required on permitted vessels; this license must be purchased before or at the same time as the permit. Vessels landing under a single delivery license are exempted.
3. The maximum number of shrimp permits was temporarily raised to 235 from 188. No new permits will be issued until the number of permits drops below 188. A lottery will be conducted when the number of permits drops below 188.
4. Two years are now allowed for replacing a permit on a replacement vessel if the original vessel was lost.
5. A single delivery license may be used by an individual to land pink shrimp only six times in any calendar year.

Only one regulation change occurred during 1989. One permit became eligible for the permit lottery, dropping the number of permits below 188. The Oregon Legislature reduced the maximum number of allowable permits to 187. A lottery will now be held if the maximum number of permits falls below 187 and if no further legislative action is taken.

REGIONAL PERSPECTIVE

Total commercial shrimp landings for Alaska, British Columbia, Washington, Oregon, and California increased annually from 1984 through 1989 (Figure 8). The largest annual landing during these years occurred in 1989 when 85.6 million pounds were landed, about four

times the total landed in 1984. Even so, 1989 landings represented only 43% of coastwide landings during 1977, when 199.1 million pounds were landed. These data show the dramatic and sustained decline of the Alaska fishery. The relative contribution from each region changed dramatically primarily because of diminished landings in Alaska and increased landings in Oregon (Figure 9).

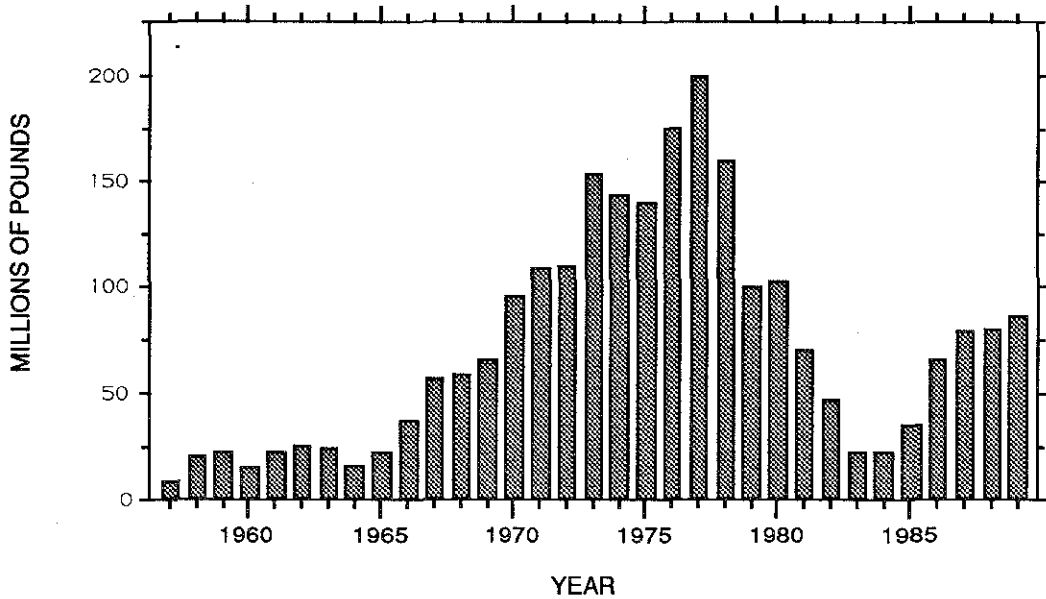


Figure 8. Combined catch of commercial shrimp from Alaska, British Columbia, Washington, Oregon and California, 1957-89. From ODFW archived data; communication with respective fishery agencies.

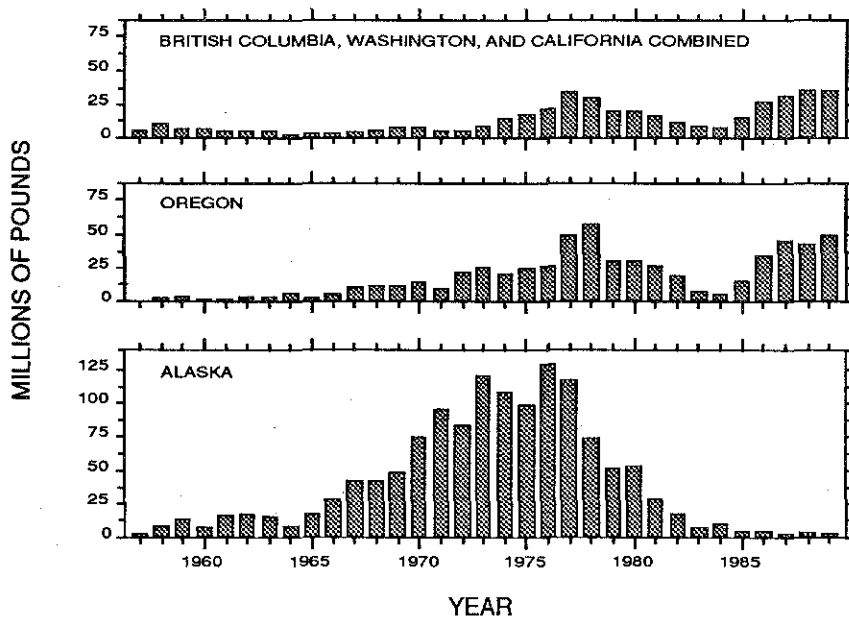


Figure 9. Catch of pink shrimp from Pacific Coast states and British Columbia, 1957-89. From ODFW archived data; communication with respective fishery agencies.

The Alaska 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). The cause of the decline of the Alaska fishery is unclear. However, the fishery experienced a decrease in average age at catch during its decline, and this resulted in increased dependence on age-1 shrimp (Jackson 1980). Recent landings from Washington, Oregon, and California are also composed primarily of age-1 shrimp. Prior to 1978, the tri-state catch contained larger proportions of age-2 and age-3 shrimp. The large catches of the mid to late 1970s can be considered as the "fishing up" of a nearly virgin stock, whereas the catches of the late 1980s cannot. Thus pink shrimp may have experienced record levels of exploitation in the past few years.

Total pink shrimp landings for Washington, Oregon, and California have increased steadily since a low of 9.8 million pounds in 1984. Landings in 1989 for the tri-state region reached 78.3 million pounds, the second highest landing total in the history of the fishery. The highest total occurred in 1978 with 82.5 million pounds landed. Each state reported record or near-record annual landings between 1985 and 1989 (Figure 10). The 1989 landing total was important since it was not part of a "fishing up" process and was composed of smaller shrimp. Oregon dominated tri-state landings from 1985 through 1989, as it has since the early 1960s. The percentage of the catch landed in Oregon increased from 54.3% in 1985 to 62.7% in 1989. The percentage landed in California increased, ranging from 12.3% in 1985 to 17.0% in 1989. The percentage landed in Washington declined from 33.4% in 1985 to 20.3% in 1989.

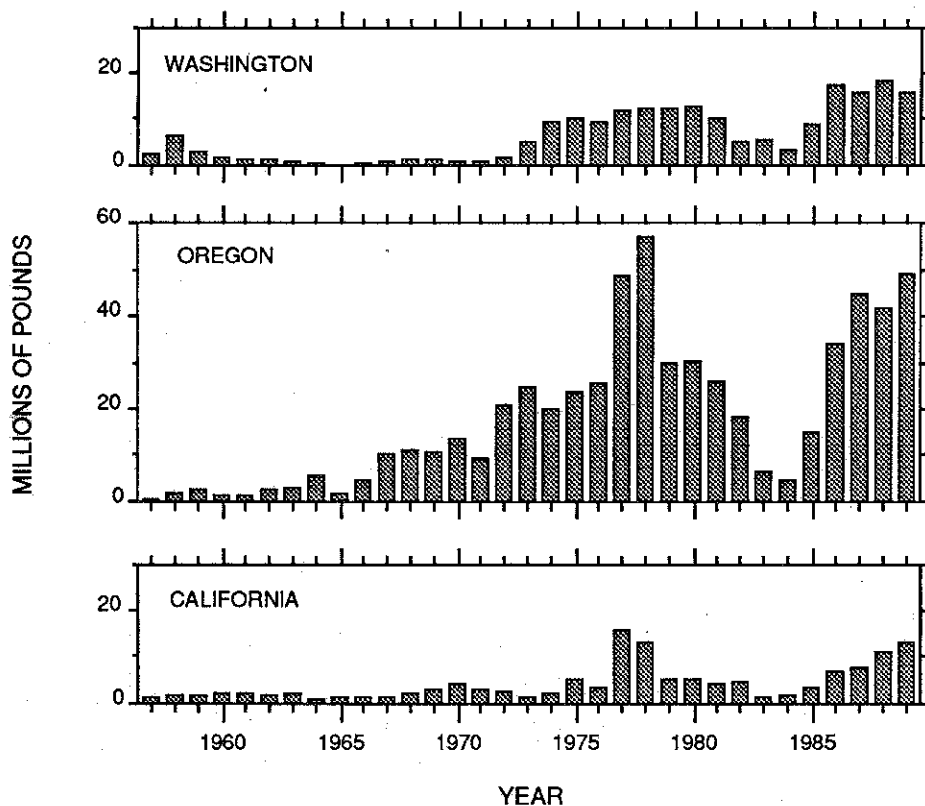


Figure 10. Pink shrimp catch of Washington, Oregon, and California, 1957-89. From ODFW archived data; communication with respective fishery agencies.

Tri-state shrimp vessel effort increased sharply after 1985 (Figure 11). Near-record effort levels occurred in 1987 and 1989. Total effort exceeded 180,000 hours from 1986 through 1989. Prior to 1986, total effort had surpassed this level only in 1980 and 1981. Both Oregon and California reported record or near record high effort levels annually from 1986 through 1989. The percentage of total effort for each state fluctuated annually from 1985 through 1989. The proportion of California effort increased from 9.7% to 12.6% during this time period. The Oregon proportion increased from 45.4% to 62.6% while the Washington proportion decreased from 44.9% to 24.9%.

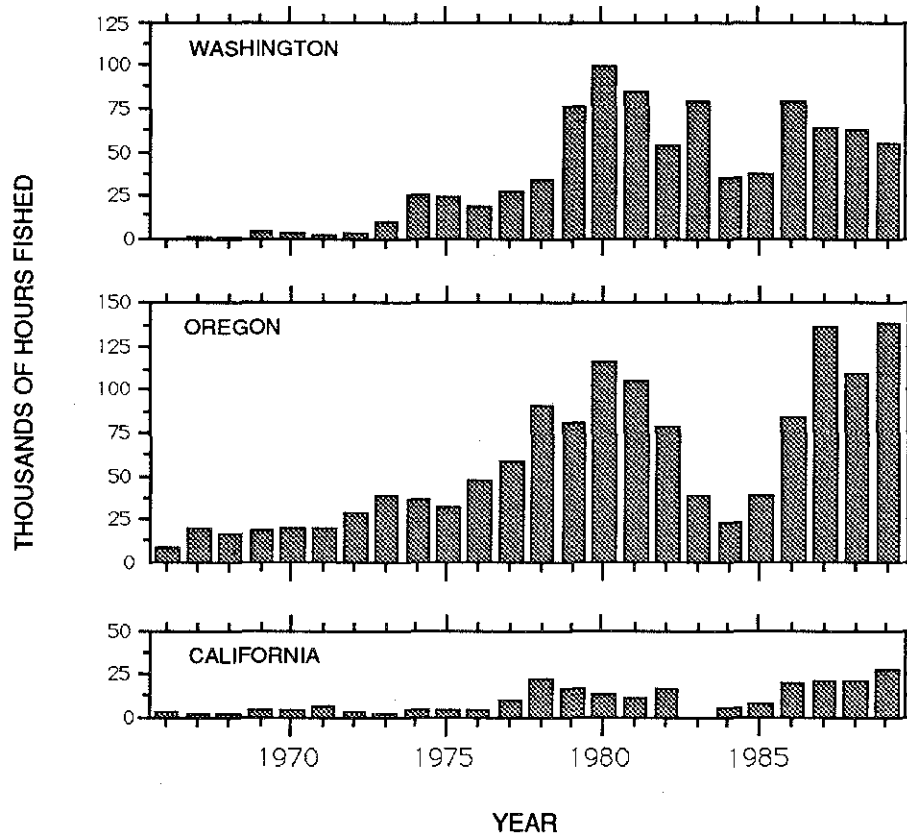


Figure 11. Fishing effort for pink shrimp in waters adjoining Washington, Oregon, and California north of Cape Mendocino, 1966-89. From ODFW archived data; communication with respective fishery agencies.

CONCLUSIONS

Our results show that Oregon stocks of pink shrimp experienced high and perhaps record levels of exploitation from 1985 through 1989. We believe that the contribution of high effort levels and several moderate-to-strong year classes have produced large landings in the last few years. These large landings were dominated by age-1 shrimp, a continuing trend since about 1979. Prior to 1979, landings showed a lower proportion of age-1 shrimp with higher proportions of age-2 and older shrimp. The fishery may be highly vulnerable to the effects of year class failure because of recent dependence on age-1 shrimp.

High levels of primary females that occurred from 1985 through 1989 contributed heavily to the spawning stock. A persistently high level of primary females is one of the proposed Pacific Fishery Management Council indicators of potential over-exploitation. The high percentage of primary females found in late-season landings indicates that age-2 and age-3 shrimp have been heavily harvested, thus reducing their contribution to the spawning stock. These factors point out the need for continued close monitoring of the pink shrimp fishery in Oregon and for research into the importance of spawning stock biomass on recruitment.

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