

THE OREGON PINK SHRIMP FISHERY,
MANAGEMENT HISTORY AND RESEARCH ACTIVITIES

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by

Malcolm H. Zirges
Jack G. Robinson

Oregon Department of Fish and Wildlife

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Oregon Pink Shrimp

The pink shrimp (*Pandalus jordani*), also called ocean shrimp, is the target species of Oregon's commercial shrimp fishery. This species is distributed over the continental shelf from Unalaska to San Diego, California at depths ranging from 20 to 250 fathoms (37 to 457 m), with commercially important concentrations present from Vancouver Island to the area off Morro Bay on the south-central California coast. The center of distribution is off the Oregon coast where most commercial catches are made from 2 to 25 miles (4 to 46 km) offshore, at depths ranging from 40 to 140 fathoms (73 to 256 m), over green mud or green mud and sand bottoms.

There are four primary areas, or "beds", where shrimp occur along the Oregon coast: the northern bed from about the Columbia River to Cape Foulweather, the central bed from about Heceta Head to north of Cape Blanco, a small bed just south of Cape Blanco, and the southern bed off Brookings and Crescent City, California (Figure 1). Although the pink shrimp attains a maximum age of about five years in the northern portion of its commercial range and three years in the southern portion, only a small proportion usually reach age four off Oregon. Maximum size of pink shrimp off Oregon is about 28 mm head length, but they become available to trawl gear at about 12-13 mm head length and 11-13 months of age. Biologists use this measurement instead of total length to avoid measurement difficulty with broken-off tails.

Pink shrimp are protandrous (=first, male) hermaphrodites, and normally function (mate) first as males at about 1½ years old and about 13-18 mm head length. Transition into females usually is complete by the following October at about age 2½ and 17-24 mm head length when they again mate, after which 1,500 to 3,000 eggs are extruded and held on the abdomen. Females do not revert to

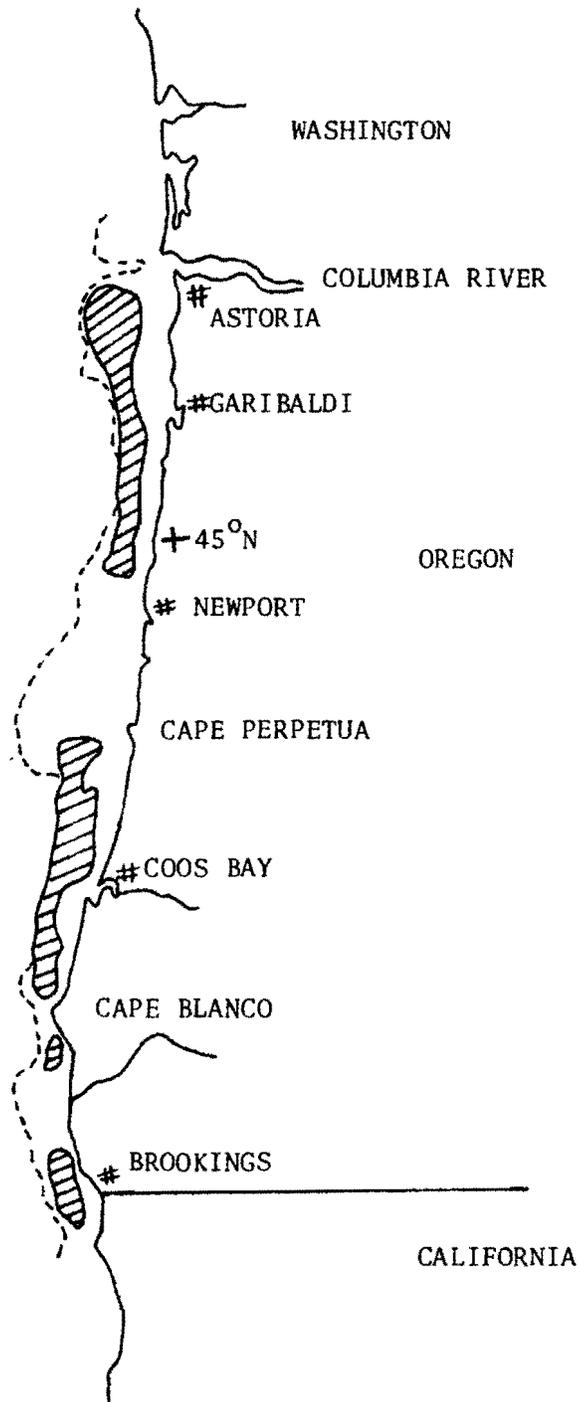


Figure 1. Principal shrimp producing areas along the Oregon coast.

males. Eggs are carried by the female into the next spring, when they hatch. Sometimes some pink shrimp skip the male phase and develop directly into 1-year-old females. Although the stimulus for this action is not understood, it is probably an adaptive mechanism which allows the species to compensate for some special environmental or population conditions such as in the California and southern Oregon beds where life span is short and many shrimp may not live long enough to go through the "normal" male to female development cycle.

The Fishery

The Oregon shrimp fishery began in 1957 although scattered small landings were made before that year at Garibaldi. Seven vessels from Astoria harvested less than a million pounds in 1957 using beam trawls. Early landings increased slightly with the allowed change to Gulf of Mexico style semi-balloon trawls in 1958 and increased effort, but stayed at a relatively low level due to processing limitations until the mid-1960's (Figure 2).

During this early period the typical shrimper was a western-seiner type vessel from 50 to 70 feet (15 to 21 m) long fishing a single Gulf of Mexico semi-balloon trawl with a 57 ft (17 m) headrope and 4 ft (1.2 m) vertical opening.

After 1966, catch levels again increased as processing capacity increased, notably with the introduction of pre-steam blanch peeling machines, and processing facilities were located in more ports which improved access to the shrimp beds. These new peeler machines adequately matched the quality of hand-peeled shrimp and opened up the lucrative restaurant market to volume production.

The first double-rigged shrimp vessel (Fred Karthaus's Owners Joy) entered the fishery in 1969, and demonstrated increased catch capability. These results led to conversion of many single-riggers or the importation of vessels from the Gulf of Mexico which were not only already double-rigged but larger as well.

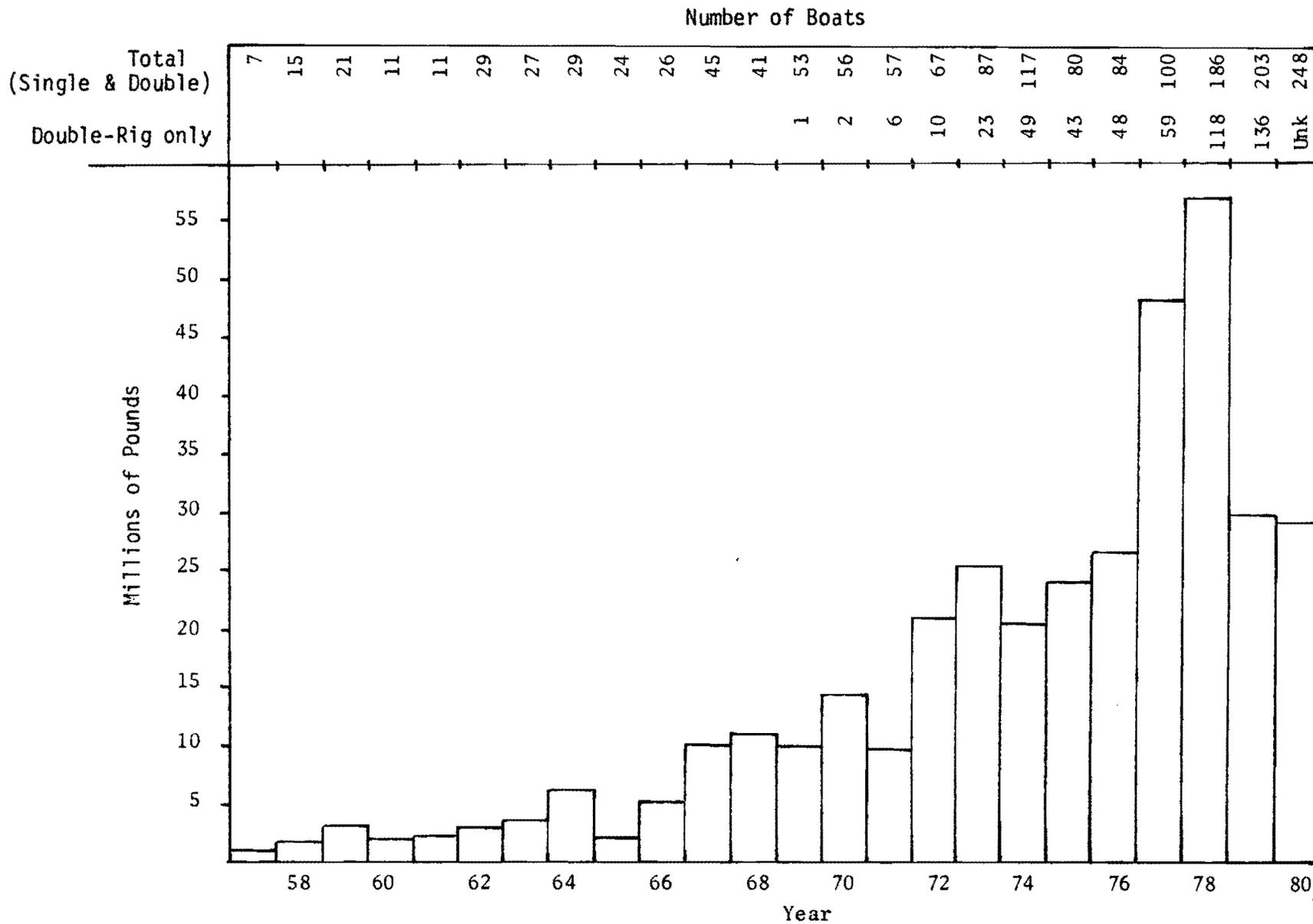


Figure 2. Annual Oregon shrimp landings and number of boats with number double-rigged boats broken out. 1980 figures preliminary.

For the period 1972 to 1976, increasing fishing power, due initially to the shift to double-rigged vessels and later to the introduction of large high-opening box trawls, good market conditions, and a shift in vessels to shrimp from the depressed crab fishery, raised Oregon landings to an average of nearly 23 million pounds per year.

This buildup in fishing power, coupled with an available, strong year class and unlimited market boosted 1977 Oregon landings to 48 million pounds. Then the large harvest in 1977, along with Federal tax incentives, encouraged a 50% increase in the number of vessels participating in the fishery in 1978, and also spurred investment in new gear and electronics technology which continued to increase the fishing power of the fleet. New vessels were typically in the 70 ft (24 m) range and fished two box trawls with headropes and footropes from 80 to 100 feet (146 to 183 m) in length and vertical openings from 12 to 18 feet (3.6 to 5.5 m).

Oregon shrimp landings reached a record peak of nearly 57 million pounds in 1978. But harvests have not continued to increase, and in 1979 and 1980 decreased to the 29 million pound range. Effort however, in terms of numbers of vessels, has continued to increase, to 203 vessels in 1979 and then to at least 248^{1/} by mid-August 1980, although under the Oregon shrimp fishery vessel moratorium, 343 vessels were eligible for shrimp licenses in 1980. The 248 vessels represent all boats that made at least one landing in Oregon - actual "Oregon" fleet size is somewhat smaller.

Development of management strategy

The status of Oregon shrimp stocks has been monitored through annual survey cruises, market (catch) sampling, and commercial fishing catch and effort information from logbooks. No evidence has yet surfaced which suggests overexploitation

^{1/} Preliminary

of Oregon pink shrimp stocks and therefore regulations under which the shrimp fishery operates continue to be quite liberal.

When the fishery began in 1957 there was no season closure, but gear was limited to beam trawls to reduce catch of other fish species; however, fishermen claimed the beam trawl was inefficient and unsafe so the Oregon Fish Commission (now Oregon Department of Fish and Wildlife) conducted experimental work in the fall of 1957 comparing beam trawls with Gulf of Mexico-style semi-balloon shrimp trawls. Both shrimp and incidental species catches were higher with the semi-balloon trawl, but the quantity of fish caught did not appear to be harmful to the stocks and the beam trawl rule was rescinded in late 1957. Some concern was expressed at that time by draggers that the small-mesh shrimp trawls would be used on small flatfish for the then-large mink ranch feed market, but landed catches of fish remained quite small.

By 1964 the fishing industry became concerned over the rate of increase in landings in the shrimp fishery as it might affect the stocks as well as a number of other problems not related to conservation, and recommended a winter closure to protect gravid shrimp. Fishermen in the Coos Bay area were not happy with the annual late-winter pilgrimage into "their" beds by California shrimpers before the California season opened in April each year. It was thought that a closure from October on would not be overly restrictive because winter weather normally restricted wintertime shrimping with the comparatively small vessels used at that time. Many crab fishermen who were interested in plying their fishery somewhat later into the spring without having to worry about losing their shrimp markets and processors who found it difficult to process large volumes of both shrimp and crab simultaneously also were sympathetic to a winter closure on shrimping. And finally, the eggs carried by female shrimp during the winter

resulted in processing problems and reduced meat yield per pound landed.

After reviewing the situation, including a staff determination that no biological need could be identified at that time for protecting shrimp with eggs, the Oregon Fish Commission established a winter closure period coinciding approximately with the egg-bearing period. Open season (effective first in 1965) was from March 1 to October 31.

A minimum net (stretch) mesh size of $1\frac{1}{4}$ inch (32 mm) was in force during the early years of the shrimp fishery. In the late 1960's, however, the Bureau of Commercial Fisheries (now National Marine Fisheries Service) developed a separator trawl designed to separate fish from shrimp which had one-inch mesh in the body and codend. ODFW staff had no biological or other documented justification for retaining the existing minimum mesh size, and so to encourage use of the separator trawl the minimum mesh size restriction was eliminated in 1969. This net was not widely used and minimum mesh size restrictions were never re-established. Shrimp fishermen typically use nets that average close to $1\frac{1}{2}$ inches (38 mm) stretch measure between the knots anyway. The increasing cost of web and other disadvantages seem to prevent use of excessively small mesh.

As landings continued to increase into the 1970's, it was found that substantial numbers of egg-bearing females were still being harvested. Because of a growing concern for the basic productivity of the resource the Fish Commission's technical staff recommended, with substantial but not unanimous industry support, that the winter closure be extended to provide near complete protection for gravid females. The Commission responded in 1972 by reducing the open shrimp season to April 1 to October 15. No further changes have been made in season length.

Large landings of one-year-old shrimp, "pinheads", have also created considerable discussion within the industry, particularly during the 1980 season. Although

processors have generally discouraged landings of small shrimp in the past (due to recovery and marketing difficulties), strong market conditions and poor availability of larger shrimp have altered this attitude and resulted in some shrimpers systematically targeting on the small shrimp. Preliminary examination of this issue by Oregon Department of Fish and Wildlife staff has not provided a clear-cut answer to whether this practice is good or bad for the resource or increases or decreases yield, and no recommendations have been made. This issue involves two distinct problems--the productivity of the stocks in terms of whether or not enough shrimp live long enough to spawn, and the yield to the fishery in terms of maximum usable poundage and dollar value.

There is no evidence yet to suggest that protecting pinheads or egg-bearing females is necessary, i.e. that there are not enough shrimp spawning to maintain the productivity of the stocks. However, if Oregon shrimp stocks should begin a steady decline in apparent productivity which appears to be related to increasing fishing pressure (overharvest), for example, then some sort of protective measure will be necessary--which might include some means of reducing the catch of pinheads or increased protection for spawning (egg-bearing) females.

Basically, any shrimp caught is a female or future female due to the species' unique habit of changing sex. Because many of the "pinhead" shrimp already are functioning as males, they are immature only with respect to becoming females. Assuming it is practical or even possible through minimum mesh size restrictions or other means to protect only age-1 shrimp, this alone may not add to the female spawning population. Shifts in fishing effort, if some or all of the fleet tried to make up for lost poundage represented by protected pinheads, would likely result in any savings being harvested as prespawning two-year-old females. Presently available data does not allow us to predict whether the number of spawners (females) would increase significantly following

protection of immature shrimp. One of the things this will require is an improved understanding of the availability of each age-class to trawl gear.

The determination of where maximum yield occurs relative to shrimp size is also vague at this time since accurate estimates of natural mortality and growth rates are required--but are presently still imprecise. Basically, maximum yield occurs at the point in the lifespan of a brood of shrimp where the total poundage (or value) of the whole brood has peaked but has not begun to decline as pounds lost due to natural mortality of individuals begins to exceed pounds gained through growth. And this may also be subject to the time-wise availability to trawl gear. The situation is analogous to putting money into a savings account at 5% when inflation is 12%--there is a net loss of value--shrimp growth is less than loss from natural mortality by age 1 so a loss is actually experienced.

The application of certain mathematical models to shrimp, using presently available estimates of natural mortality and growth rates, have indicated no net benefits from 'protecting' pinheads--assuming some pinheads were processable. Although estimates of natural mortality rates contain the biggest potential error in this analysis, rates used have been conservative. If anything, even larger net losses would be indicated if mortality rates are higher than used, as is likely.

It is difficult to foresee future management direction in the shrimp fishery since few of the problems are purely biological in nature. The pinhead issue, for example, involves also the economic aspects of poor recovery rate and small shrimp simply not feeding through peeler machines. And pressures from outside the shrimp fishery such as gear conflicts, market conflicts, and even the debate over shrimp as a forage animal for other species will undoubtedly have some impact on shrimp management. Improved biological and fishing effort data will

be required to insure that the productivity of Oregon's shrimp stocks can be accurately assessed and thus remain available in the future.

Research Activities

Investigation of the pink shrimp resource off Oregon was directed at first towards stock distribution and abundance studies. The extent of the stocks were studied through information gathered from survey cruises (to 250 fm) and the commercial fishery. Since 1971 Oregon has also conducted annual surveys of the major shrimp areas to obtain an index of shrimp biomass.

The first research surveys were conducted off Oregon in 1951 and 1952, and were of an exploratory nature designed to determine the extent and abundance of pink shrimp off Oregon. These surveys revealed several areas of potential commercial concentrations of shrimp between the Columbia River and the Rogue River off Southern Oregon. In 1957 and 1958 exploratory cruises were resumed off Oregon by the Oregon Fish Commission and the Bureau of Commercial Fisheries. These surveys were more intensive than the earlier surveys but covered the northern Oregon area only. In 1960 further exploratory work was conducted along the south central Oregon coast. These surveys aided the developing fishery as new areas with commercial quantities of shrimp were found.

In 1966 and 1967 another series of shrimp cruises began. The primary objective was to survey the entire coast of Oregon and close any gaps of knowledge in known shrimp distribution especially between the Coquille River and the California-Oregon border. These surveys were conducted in the spring and fall, and comparisons of biomass estimates between areas and time periods suggested north-south and east-west drifts in abundance. The biomass of the Oregon shrimp resource in spring, 1967 was estimated at about 111 million pounds (50,362 mt).

Following completion of coast-wide shrimp surveys in 1967 emphasis shifted

to studies on life history and behavior. A project was initiated to study the vertical distribution of shrimp off Tillamook Head utilizing baited traps, a midwater trawl and a semi-balloon trawl. It was determined that shrimp moved off the bottom at night and dispersed throughout the water column. The extent of their vertical distribution varied, apparently influenced by time of year, water temperature and sex and/or age composition. Midwater trawling results were discouraging.

In 1969 a one-year study was conducted off Tillamook Head to investigate the seasonal movements of shrimp, the distribution of age 0 shrimp (shrimp of the year), and to investigate the effects of light intensity on the vertical distribution of shrimp during the daytime. Data collected during the study indicated that shrimp were not dispersed in a random pattern within the study area, but were at times grouped by sex or age in certain areas. Further, they moved out of the study area in an apparent offshore migration in the fall and returned to the study area from the south in the spring. It was also found that juvenile pink shrimp (age 0) were not restricted to specific nursery areas but were mixed with other age classes soon after they ended their larval phase and had settled to the bottom. Finally it was determined that shrimp respond to decreased light intensity caused by murky water and/or heavy cloud cover and move at least as high as 12 feet (4 m) off the bottom during such "dark" periods. A prior study by the NMFS concluded likewise.

A shrimp tagging feasibility study was conducted in 1971 involving observations of shrimp held in containers aboard a fishing vessel and under varying conditions in laboratory aquaria. It proved difficult to obtain and maintain live shrimp captured in trawl nets due to handling-related stress. Salinity and temperature changes also affected survival. Because of these results, and the necessity to tag or mark very large numbers to obtain a reasonable recovery

rate, plans for a mark and recovery program at that time were abandoned.

Commercial shrimp vessels have been chartered during recent years and supplied with trawl nets for the survey. Survey nets were originally of semi-balloon design with 41-foot (11 m) headropes and 52-foot (16 m) footropes and were constructed with 1-1/8 inch (29 mm) mesh in the body and intermediate and 1-1/2 inch (38 mm) mesh in the codend with a 1/2 inch (13 mm) liner. More recent surveys have also used the chartered vessel's own square box trawls of 75 and 90-ft head- and footropes with 1-1/2 inch (38 mm) mesh. Survey area boundaries were established as the limit of known shrimp (Figure 3) as determined from commercial and research fishing activity. Stations within the survey areas were at the intersections of four-mile grid lines. Initially surveys were conducted in the fall but were switched to a spring period to obtain pre-season biomass estimates (Table 1). Much work remains to refine and interpret this technique, however, since it can be seen that in at least one year, 1977, our estimate of biomass was so much smaller than actual catch that it is obvious we either need to improve our survey design or somehow better account for several important variables--probably changing availability to shrimp trawl nets at certain times and places and changing shrimp distribution with changing conditions.

Ongoing projects include improvement of natural mortality, fishing, growth, maturity, and recruitment rate estimates so that yield versus age at harvest--the pinhead question--can be examined more precisely. This will include working with shrimp fishermen to gain a better understanding of how gear changes have affected catches, and improving the accuracy of survey estimates. Also, department staff hope to begin examining shrimp environmental relationship data to improve our understanding of factors affecting reproduction, growth, and survival of shrimp, and thus year-class strength. This includes developing a model of

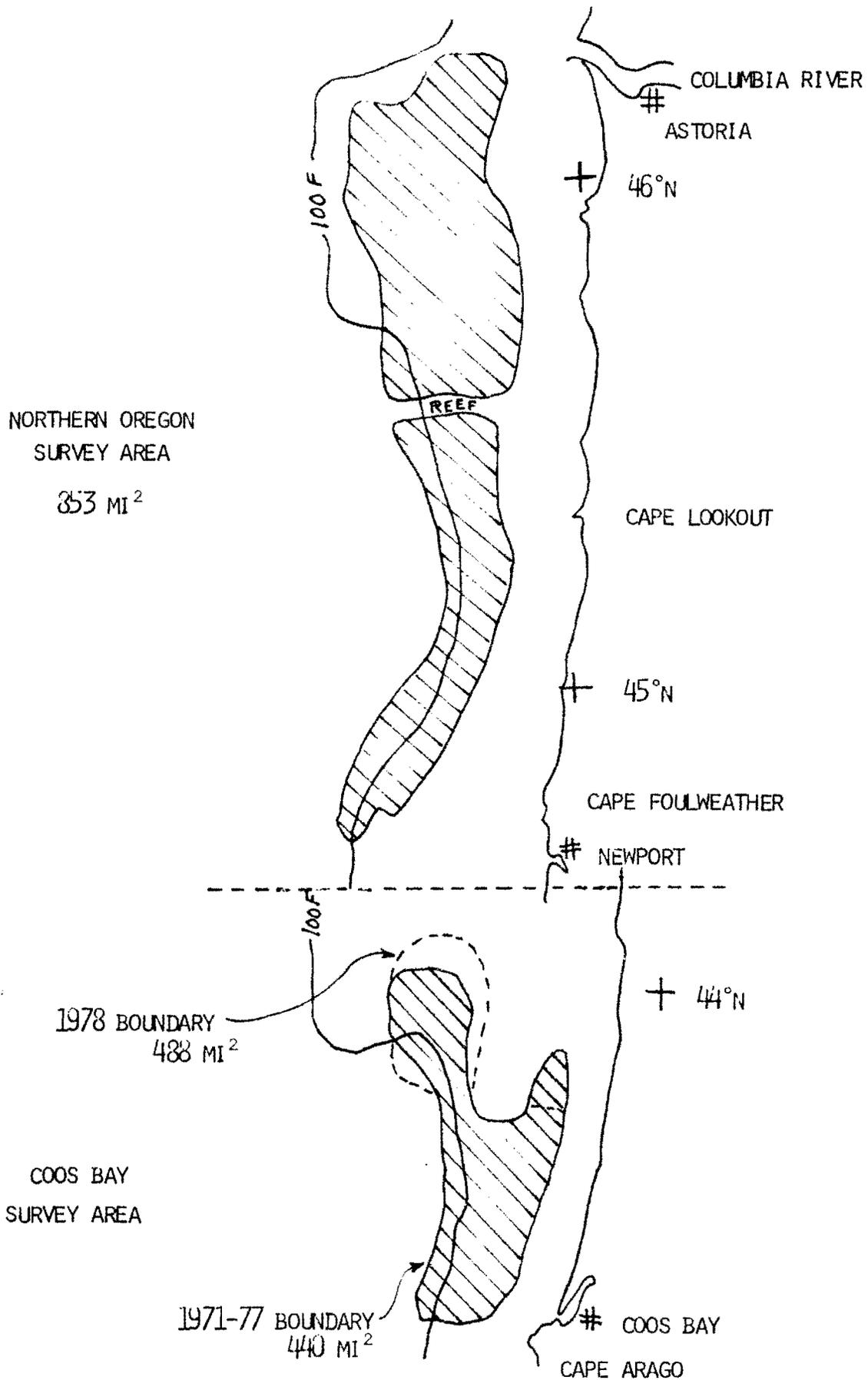


Figure 3. Oregon shrimp stock assessment survey area boundaries for the 1971-78 period.

Table 1. Preseason shrimp total biomass estimates for the northern and Coos Bay, Oregon survey areas compared with commercial landings made from those areas, 1971-1978.

Area	Year	Biomass Estimates (Lbs.)				Commercial Landings
		Spring Survey		Fall Survey		
		Estimate	95% Confidence Limits	Estimate	95% Confidence Limits	
Northern Area	1971	-		12,877,000	±46%	6,054,000
	1972	-		13,027,000	±46%	9,311,000
	1973	-		15,272,000	±30%	8,947,000
	1974	-		13,981,000	±39%	6,071,000
	1975	- N O S U R V E Y -				8,500,000
	1976	21,808,000	±48%	-		12,353,000
	1977	17,148,000	±45%	-		13,638,000
	1978	- N O S U R V E Y -				3,611,000
Coos Bay Area	1971	-		9,029,000	±45%	≈ 1,460,000
	1972	-		13,184,000	±50%	≈ 6,660,000
	1973	-		13,426,000	±28%	≈ 9,680,000
	1974	18,467,000	±58%	11,813,000	±43%	≈ 4,592,000
	1975	16,789,000	±54%	-		9,502,000
	1976	14,157,000	±35%	-		6,752,000
	1977	2,273,000	±42%	-		17,209,000
	1978	18,124,000	±80%	-		21,026,000

how shrimp are influenced by oceanographic features such as current, temperature, salinity, light penetration, etc. as these affect movement of shrimp and their availability to fishing/sampling gear.

All of this information will be needed to determine how to improve biomass estimates and to understand what, given the growth and natural mortality characteristics of pink shrimp, those estimates mean in terms of yield to Oregon's shrimp industry.

Improved predictive capability appears possible using fishermen's knowledge and scientific methods of study. This will not only improve our picture of the status of our shrimp resource, but should allow the industry to better plan ahead for each season's production.

Malcolm H. Zirges
Jack G. Robinson
Marine Region, ODFW
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