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## INTRODUCTION

Ocean pink shrimp (*Pandalus jordani*) are distributed from San Diego, CA, to Unalaska, AK, (Butler 1964), with the commercial harvest centered off the Oregon coast (Zirges and Robinson, 1980). The shrimp fleet is quite mobile and vessels routinely fish and land shrimp in different states. In recognition of the regional nature of this fishery, the Pacific Fishery Management Council in the late 1970's developed a draft Fishery Management Plan for pink shrimp. The affected states are currently using this plan as the basis for shrimp resource management through mutually consistent state regulations. The Shrimp Resource Assessment project was initiated to supplement the state of Oregon's fishery monitoring activities and to specifically address the need for an interjurisdictional management approach for pink shrimp.

### Project Objectives

The primary objective of the Shrimp Resource Assessment project is to provide scientific information and alternative resource use strategies for the management of the pink shrimp fishery resource. To accomplish this objective, we developed five specific annual tasks:

1. Collect and code shrimp fishery logbook data, match logbook information to official landing records, and summarize in a form readily useable in mathematical models,
2. Collect shrimp market samples dockside and compile age, sex, maturity, length, and weight data,
3. Analyze fishery catch data and biological market samples,
4. Provide fishery managers in neighboring states with reports describing location of catch, total catch, catch per unit effort (lb/trip, lb/h, lb/vessel), and the total effort in describing biological parameters of the shrimp caught in the fishery, and
5. Communicate fishery and research problems and strategies to other state and federal agencies and provide management recommendations for the entire harvest area.

#### FY 89 Accomplishments

We completed all of the planned annual tasks in 1989 and eliminated the backlog of unsummarized logbook data from previous years. Logbook summarization and analysis for 1987 and 1988 has been completed. Summary data has been submitted to the Pacific States Marine Fisheries Commission. For the 1989 fishery we completed logbook collection and coding, and are in the process of summarizing the data. A new simplified database management system was implemented which allowed for summarization of most of the 1989 shrimp logbook data within the 1989 calendar year.

season. This compares with a 1988 landed catch of 41.5 million pounds from 172 vessels and 2,558 deliveries.

Table 1. Catch and effort statistics (preliminary) for the Oregon pink shrimp fishery for 1988 and 1989.

	April	May	June	July	Aug.	Sept.	Oct.	Total
Catch (x 1000 lb)								
1989	8,254	9,372	7,013	3,542	8,263	7,321	5,349	49,115
1988	3,292	5,064	8,152	5,990	7,343	6,070	5,935	41,846
Effort (trips)								
1989	442	520	392	154	489	449	395	2,841
1988	238	305	473	377	395	383	402	2,573
Catch/Trip (x 1000 lb)								
1989	18.7	18.0	17.9	23.0	16.9	16.3	13.5	17.3
1988	13.8	16.6	17.2	15.9	18.6	15.8	14.7	16.2

The 1989 season began quickly with fishable weather and no price disputes. Effort and landings remained strong until late June when a price dispute developed between fishermen and processors. The dispute lasted into the fourth week of July. Strong 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 mid-season market. Processors apparently wanted to avoid exceptionally large inventories, and consequently dropped the price to offset storage costs and reduce inventory. Fishermen in most ports responded by tying up for nearly a month before accepting a slightly lower price.

A two-tiered price structure was again in effect this year. The opening price was \$.40/lb for shrimp larger than about 140 count-per-pound and \$.25/lb for smaller legal shrimp. The price structure was stable until late June. It dropped to a \$.35 - \$.20 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.

Count-per-pound problems were minimal during 1989. Only one citation was issued, for a load from state statistical area 30, landed during September in Astoria. Early season problems were alleviated by the presence of a fairly high percentage of two year olds from the 1986 brood.

#### BIOLOGICAL DATA COLLECTION

##### Sampling Methods

We attempted to collect 4-6 samples of approximately 100 shrimp from each of Oregon state statistical areas 19-32 during each month of the fishing season. Statistical areas 19-32 encompass the area from the Oregon-California border to the U.S.-Canada border. Shrimp samples were obtained at the docks prior to processing. For each sample we measured carapace lengths and determined average weight expressed as the number of whole shrimp per pound. 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).

Individual samples within a month and statistical 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 statistical 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 is observed late in the season, complicating the analysis. In these instances the bimodal distribution usually develops slowly from August through October and is easily recognizable. After the age and sex of each shrimp were assigned, age and sex composition and mean length at age were compiled for each month and statistical area.

## Results And Discussion

We collected market sample data for most months and statistical areas. Effort was minimal in area 29 so market samples could not be obtained during some months.

As in 1988, age 3 shrimp comprised a very small fraction of the shrimp sampled (Table 2). Age 2 shrimp were well represented in the catch in all areas during the opening months of the season. The percentage of age 2 shrimp declined progressively through October, but remained higher than in 1988. During October of this year for example, the percentage of age 2 shrimp was 28.5%, 18.3% and 14.0% in areas 28, 22 and 19 respectively. During October 1988, the percentage of 2's in the same areas was 14.5%, 16.0% and 9.7%. Age 1 shrimp remained the dominant age class in the landings, comprising well over 50% of mid and late season landings in most areas. Zero age shrimp were notably absent in market samples taken during September and October. Many fishermen expressed concern over this and accordingly, predicted a poor 1990 shrimp season. California and Washington experienced the same phenomenon in their market samples. Although seemingly not a good sign, a prior investigation of our historical data showed no correlation between the abundance of zero's in market samples and incoming year class strength.

Preliminary data indicate that age 1 shrimp made up a large fraction of the shrimp harvested during 1989, but lower than in

Table 2. Monthly pink shrimp age composition (percent), count per pound (ct), and number sampled (N) by Oregon state statistical area, 1989.

State Area	Age	April	May	June	July	August	September	October
32	0	-	0.0	0.0	0.0	0.0	0.0	0.0
	1	-	32.0	35.4	70.9	44.6	62.2	69.3
	2	-	56.9	53.5	26.2	53.5	32.7	25.7
	3	-	11.1	11.2	3.0	2.0	5.2	5.0
	Ct	-	150.6	138.0	147.4	116.3	123.2	136.0
	N	0	406	591	302	101	300	101
30	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1	11.2	28.9	51.5	59.6	70.6	76.2	81.0
	2	78.1	66.3	46.5	35.9	27.9	23.1	17.3
	3	10.7	4.7	2.0	4.6	1.5	0.7	1.7
	Ct	125.3	130.3	143.4	137.6	144.5	145.8	161.3
	N	606	401	299	403	401	403	294
29	0	0.0	-	0.0	-	0.0	-	-
	1	13.0	-	60.4	-	69.8	-	-
	2	71.0	-	38.6	-	28.2	-	-
	3	16.0	-	1.0	-	2.1	-	-
	Ct	104.7	-	150.8	-	124.2	-	-
	N	100	0	101	0	387	0	0
28	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1	21.7	36.5	45.0	56.9	59.4	74.8	71.3
	2	70.2	53.9	53.6	42.9	40.1	24.7	28.5
	3	8.0	9.6	1.3	0.2	0.5	0.5	0.2
	Ct	116.4	116.2	117.2	119.0	108.9	119.0	105.1
	N	299	395	302	601	397	401	600
26	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1	34.2	30.4	59.4	55.5	65.1	68.9	80.0
	2	58.0	66.9	39.2	44.3	31.9	29.5	19.8
	3	7.8	2.7	1.4	0.3	3.0	1.6	0.2
	Ct	99.4	100.4	117.1	107.6	98.9	101.2	112.9
	N	603	700	503	400	505	499	499
24	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1	49.1	57.3	68.9	75.0	85.6	81.5	81.6
	2	49.1	40.7	29.4	25.0	13.4	18.0	18.0
	3	1.7	2.0	1.7	0.0	1.0	0.5	0.4
	Ct	125.2	127.1	127.3	130.1	124.8	111.8	113.9
	N	696	501	599	100	792	601	902

Table 2. Continued.

State	Area	Age	April	May	June	July	August	September	October
22		0	0.0	0.0	0.4	0.0	0.0	0.0	0.0
		1	47.5	59.4	79.7	76.2	81.1	80.6	81.1
		2	47.7	37.8	19.3	22.6	18.4	19.1	18.3
		3	4.9	2.8	0.5	1.1	0.5	0.2	0.7
		Ct	119.2	126.4	132.6	116.1	105.9	100.0	100.8
		N	701	502	407	800	201	202	597
21		0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		1	39.4	63.1	46.0	69.0	84.2	89.5	78.8
		2	55.6	33.7	52.0	30.2	15.3	10.5	20.2
		3	5.0	3.2	2.0	0.8	0.5	0.0	1.0
		Ct	114.8	151.4	120.3	119.0	126.7	126.4	106.2
		N	601	401	400	504	393	401	605
20		0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		1	47.3	64.2	44.3	76.5	68.4	62.8	74.5
		2	52.7	35.1	52.2	23.5	31.6	37.2	24.8
		3	0.0	0.7	3.5	0.0	0.0	0.0	0.7
		Ct	140.9	138.8	101.4	120.6	107.8	94.4	99.1
		N	150	148	201	400	393	199	604
19		0	0.0	0.0	0.0	0.0	0.0	0.0	0.6
		1	42.8	50.6	76.2	73.7	91.8	94.3	84.0
		2	53.2	45.9	22.3	24.8	7.8	5.7	14.0
		3	4.0	3.5	1.5	1.6	0.5	0.0	1.4
		Ct	99.9	114.4	132.1	110.0	122.1	117.0	97.0
		N	502	401	404	505	400	401	499

1988. However, the total harvest in numbers of age 1 shrimp in 1987 and 1988 was unprecedented in the history of the fishery (Figure 1). The trend seems to have continued, and is probably due in part to strong recruitment from the 1985 through 1987 year classes. It may also result from age 1 shrimp being larger at age (see research activities) and hence fully recruited to shrimp gear for a larger proportion of the season than in the past.

Shrimp growth in 1989 (Table 3) was similar to that seen in 1988 in most areas. However, shrimp from areas 30 and 32 were notably smaller at age during 1989. Large numbers of small shrimp reportedly were present in these areas during 1989; indeed our only citation arose from catches in area 30. High shrimp densities may have contributed to slower shrimp growth in these areas.

Pink shrimp sex composition by state statistical area for April, September and October 1989 is shown in Table 4. The percentage of primary females in October ranged from 6.7% in area 30 to 32.9% in area 19. For the period 1965 through 1980, the average percentage of primary females in October for state statistical areas 18-28 (including northern California) ranged from zero to 35.2 % and averaged 10% (Zirges et. al. 1982). The percentage of primary females in October was above average this year, but was not as high as in 1988. As noted previously, the percentage of age 2 shrimp at the end of the season was higher this year. Charnov et al. (1978) showed that reductions in the population of

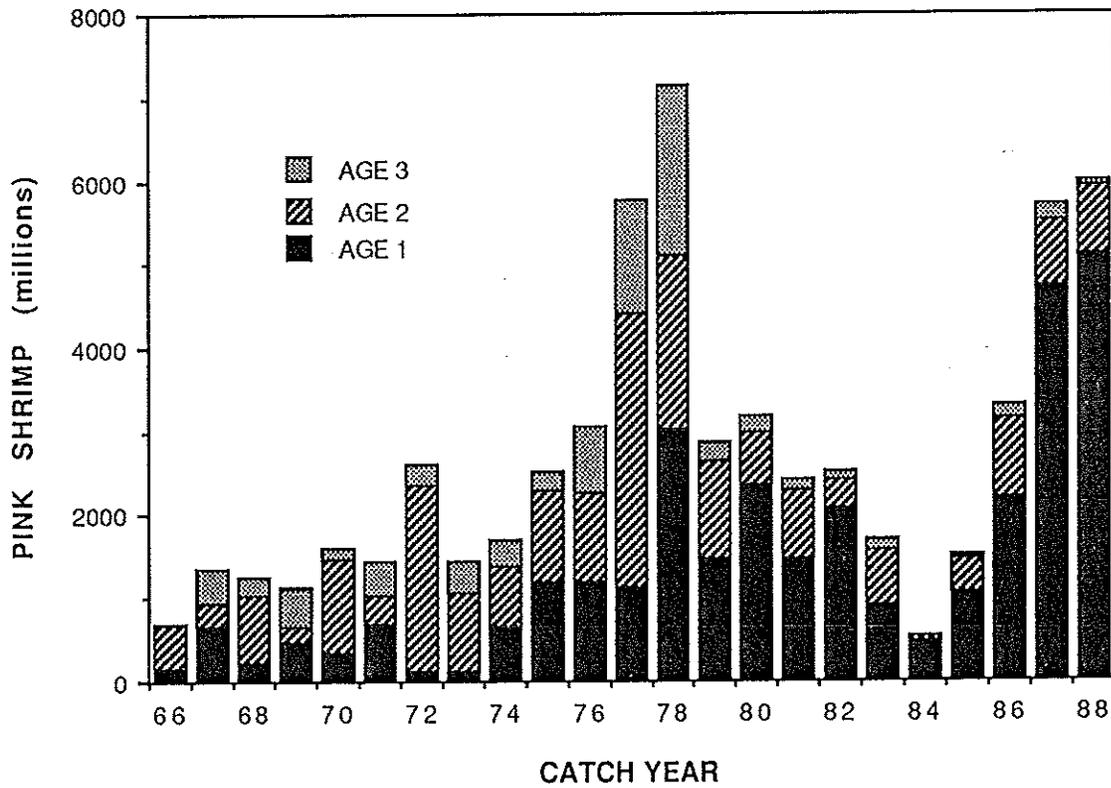


Figure 1. Age composition of the pink shrimp catch by number for Oregon state statistical areas 18-28 for the years 1966-88.

Table 3. Mean pink shrimp carapace lengths (mm) at age, by month and Oregon statistical area during 1989.

Area	Age	April	May	June	July	August	September	October
19	0	-	-	-	-	-	-	9.0
	1	15.0	15.5	16.0	16.5	17.0	17.5	18.0
	2	20.4	20.3	21.1	21.5	22.0	22.5	23.0
	3+	24.7	24.6	24.8	25.4	24.8	-	25.9
20	0	-	-	-	-	-	-	-
	1	14.7	14.9	15.7	16.5	17.0	17.5	17.7
	2	19.2	19.4	20.4	20.8	20.9	21.7	22.0
	3+	-	23.0	24.7	-	-	-	24.4
21	0	-	-	-	-	-	-	-
	1	14.4	14.7	15.3	16.4	16.6	16.8	17.3
	2	19.5	19.5	20.1	21.0	20.9	21.7	21.8
	3+	22.9	22.9	24.8	24.5	24.5	-	24.3
22	0	-	-	-	-	-	-	-
	1	15.1	15.8	16.0	16.6	17.0	17.3	17.5
	2	19.5	20.2	20.4	20.9	21.2	22.6	22.2
	3+	23.3	23.5	23.3	24.1	24.0	25.5	24.8
24	0	-	-	-	-	-	-	-
	1	15.1	15.1	15.7	16.3	16.7	16.6	16.6
	2	20.0	20.2	20.6	20.4	21.5	21.7	21.9
	3+	23.1	23.2	23.3	-	24.6	24.2	26.0
26	0	-	-	-	-	-	-	-
	1	15.0	15.2	15.4	15.8	16.8	16.9	16.7
	2	20.1	20.2	20.5	20.8	21.7	21.9	21.6
	3+	23.2	23.2	23.4	24.5	24.2	24.3	24.5
28	0	-	-	-	-	-	-	-
	1	13.6	14.0	14.7	15.3	16.0	16.0	16.5
	2	18.6	19.3	19.5	20.0	20.6	21.3	21.2
	3+	21.8	22.1	22.6	23.5	24.8	24.3	24.5
29	0	-	-	-	-	-	-	-
	1	14.0	-	14.4	-	15.7	-	-
	2	18.3	-	19.1	-	20.6	-	-
	3+	22.6	-	23.5	-	24.1	-	-
30	0	-	-	-	-	-	-	-
	1	13.1	13.4	14.2	14.9	15.2	15.3	15.1
	2	17.8	18.3	18.7	19.4	19.6	20.2	20.1
	3+	21.0	21.6	21.8	22.0	23.1	23.0	22.1
32	0	-	-	-	-	-	-	-
	1	-	12.6	13.2	14.6	15.1	15.2	15.3
	2	-	17.4	17.9	19.4	19.1	19.8	19.6
	3+	-	20.6	21.0	22.3	22.3	22.5	21.7

Table 4 . Sex composition of the pink shrimp catch during April, September and October 1989.

Month	Area	Percent Males	Percent Trans.	Percent Females	Percent Primary Females**	Number Primary Females*	N	
April	19	63.5	1.8	34.7	0.0	0	502	
	20	74.7	0.7	24.7	0.0	0	150	
	21	50.7	0.8	48.4	0.0	0	601	
	22	72.6	9.8	17.6	0.0	0	701	
	24	51.0	25.3	23.7	0.0	0	696	
	26	41.3	36.2	22.6	0.0	0	603	
	28	37.8	29.4	32.8	0.0	0	299	
	29	24.0	32.0	44.0	0.0	0	100	
	30	29.7	31.5	38.8	0.0	0	606	
	32	-	-	-	-	-	-	0
September	19	54.9	11.5	33.7	29.6	112	401	
	20	45.2	7.5	47.2	20.0	25	199	
	21	71.8	5.7	22.4	13.6	49	401	
	22	59.5	5.2	35.3	20.0	33	202	
	24	68.8	3.8	27.3	11.9	58	600	
	26	61.9	1.0	37.1	9.6	33	499	
	28	68.3	0.5	31.2	8.7	26	401	
	29	-	-	-	-	-	-	0
	30	68.2	1.0	30.8	10.1	31	403	
	32	57.2	0.5	42.3	7.5	14	300	
October	19	53.7	3.4	42.9	32.9	138	499	
	20	55.6	3.5	40.9	20.9	94	604	
	21	59.5	3.5	37.0	20.5	98	605	
	22	60.6	1.7	37.7	23.6	114	597	
	24	69.8	1.6	28.6	12.8	94	902	
	26	74.3	0.0	25.7	8.5	34	499	
	28	64.5	0.2	35.3	10.0	43	600	
	29	-	-	-	-	-	-	0
	30	75.9	0.0	24.1	6.7	16	294	
	32	61.4	0.0	38.6	11.4	8	101	

\* The number of females at age one

\*\* (The number of females at age one/The total number of age one shrimp) x 100

Note: -Individual samples were weighted before being combined by month and area.

-Transitionals with headroe were not combined with females.

age 2 and older shrimp should result in increased numbers of primary females. Conversely, fewer primary females were present this year because the age 2 population was larger.

#### RESEARCH ACTIVITIES

We completed a thorough evaluation of the long-term market sample database from 1966-88 during 1989. The primary finding of this study is that there is strong evidence that pink shrimp are exhibiting density-dependent growth. Also, as predicted by Charnov et al. (1978), the fishery is reducing the numbers of age 2 and older shrimp in the population, and causing accelerated sex change in age one shrimp. The result is higher levels of primary females and a roughly stable sex ratio in the breeding population. The catch is also becoming increasingly dominated by age one shrimp. When considered in light of very high effort levels in 1987 and 1988, this is strong evidence of increased exploitation rates in those years, relative to earlier periods. Further details on the methods employed, and the results of this study are not presented here as they are being prepared for submission to a peer-reviewed journal in 1990.

#### FY-90 ACTIVITIES

We hope to make substantial additional progress in FY-90. In addition to continuing to collect, summarize and analyze data

from the pink shrimp fishery on a current basis, we hope to conduct a thorough analysis of the catch and effort information in an attempt to estimate trends in shrimp recruitment. This work will build on modelling work completed in 1984 (Bernard and Zirges, 1985, ODFW draft). If we are successful in developing reliable estimates of pink shrimp recruitment, this information may directly influence the future management of the pink shrimp fishery.

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