OREGON Fish & Wildlife Marine Resources

32nd annual

Pink Shrimp Review

2021: Already one better than 2020

What's Inside

Have Questions?

Contact:
Scott Groth: Scott.D.Groth@state.or.us
Jill Smith: Jill.M.Smith@state.or.us
Eric Anderson: Eric.S. Anderson@state.or.us

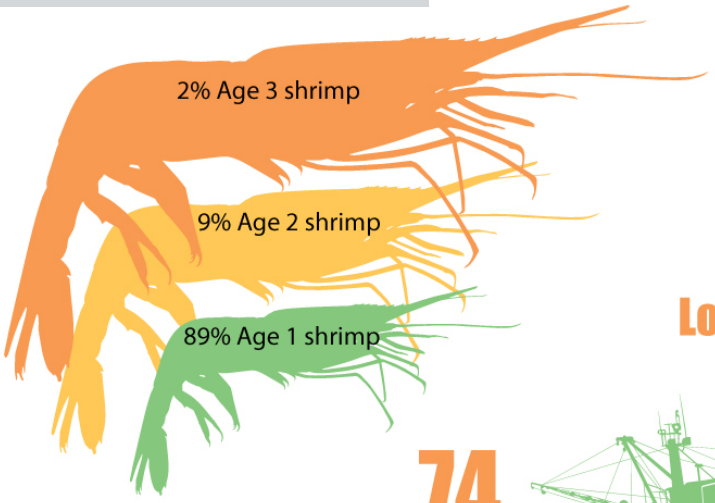
Visit Our Website:
www.dfw.state.or.us/MRP/shellfish/commercial/shrimp

This newsletter provides a summary of Oregon's 2020 pink shrimp (*Pandalus jordani*) season including trends in the fishery, its stock, and information relevant to stakeholders. Oregon's pink shrimp fishery is managed as a sustainable fishery in cooperation with fishermen, processors, scientists and managers.

The 2020 pink shrimp season was much better than expected! A large volume of age one shrimp fueled the fishery to 43.1 million pounds, in the top 10% of season volumes. Count per pound issues were minimal due to careful fishing and early season delays. Price was lower in 2020 compared to recent years, however catch rates were high. The value of the fishery was high, at 22.6 million USD.

Overall, it was an impressive year, where the shrimp industry overcame many COVID-19 related issues to deliver sustainable foods to the world supply. Our hats are off to the industry which worked carefully and safely to fill their essential role.

2020 Season

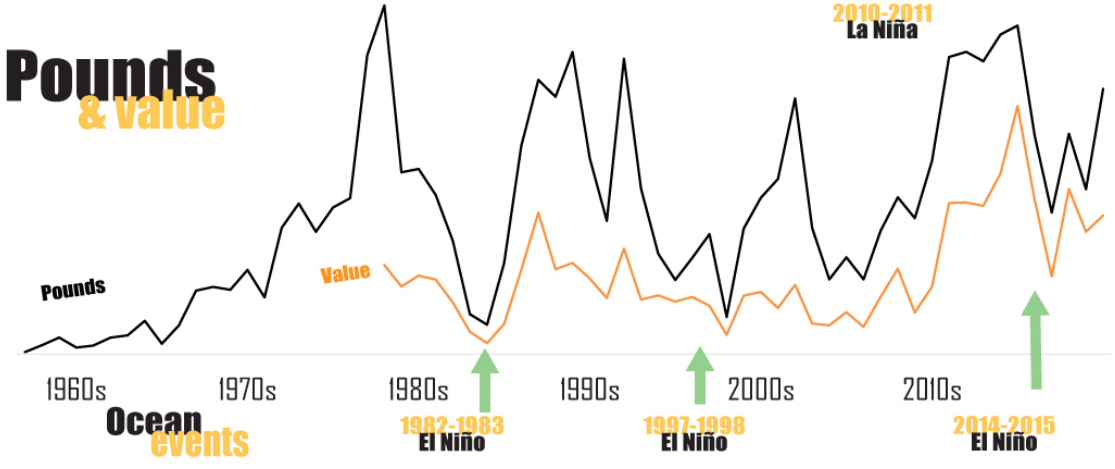


43.1 million pounds landed

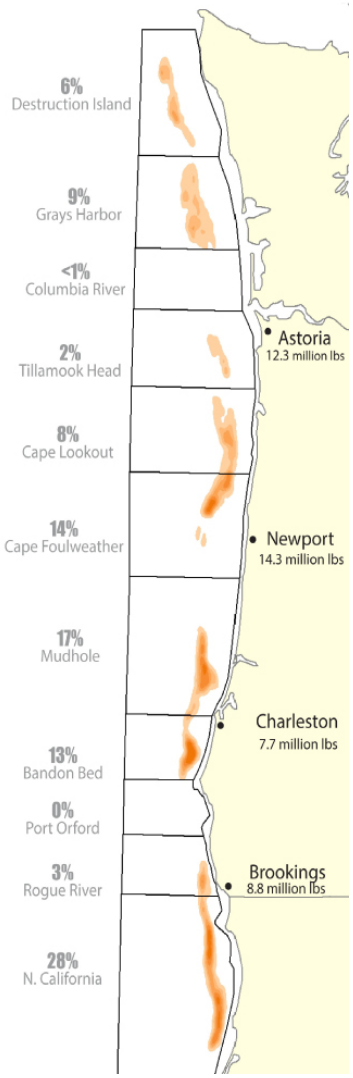
$22.6 million ex-vessel value

Highest catch rate Since 2015

Lowest price per pound Since 2013



Catch area



Shrimp season issues

In 2020, ODFW further investigated shrimp season considerations by compiling data and communicating with stakeholders. We worked to clean up a single dataset containing logbook data for the years 1980-2019. We asked the fleet about season changes and got their perspectives. Last, we have stayed in communication with other states fishery managers to assure that we are working together.

2020 ODFW questionnaire

In 2019, Oregon Trawl Commission (OTC) sent questionnaires to each Oregon pink shrimp permit holder. Findings of this survey indicated a split between start dates of April 1, April 15 and May 1. In 2020, ODFW followed up on this survey to further understand fleet opinion.

We sent a questionnaire to all (138) Oregon pink shrimp permit holders via both email and US mail to understand their feelings on changing the season and if so, when would be acceptable.

The questionnaire included information on the biological, economic value, and orderly start concerns that have triggered conversations on the suitability of the April 1 starting date. See a copy of this questionnaire here.

There was a good response rate, 71 out of the 138 (51%) questionnaires were returned.

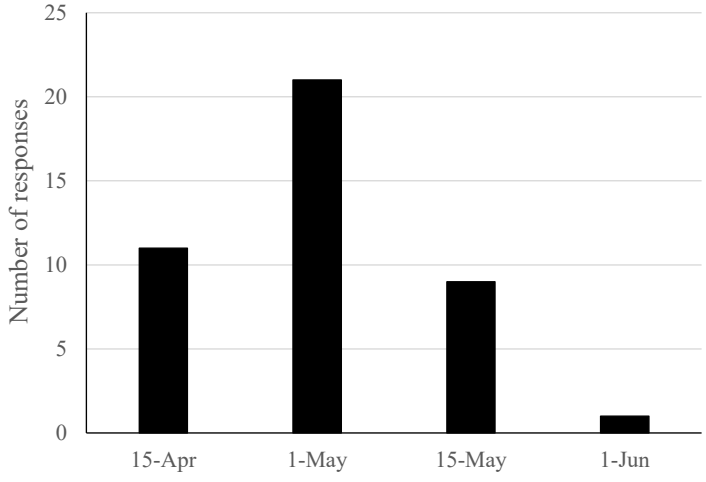
Questionnaire results

Question #1
"Do you support a shrimp season start date later than April 1?"

59% said Yes, 41% said No

Question #2:
"If you prefer a later season start date, which do you prefer?"

The most popular answer was May 1, then April 15, then May 15 (see graph below).



Preferred starting date of respondents in favor of shrimp season start date change (n=42).

Comments

•End the season Oct 1st.
•This will increase value and overall sustainability of our pink shrimp fishery. Our average season should improve long term.
•Only in favor if California does the same.
•This ODFW analysis supports the benefits of a start date of May 1st. Industry has benefited with a starting date of May 15th, in the last 4 years. May 1st would be a better option to insure the resource is harvested responsibly.
•May 1st sounds good to me.
•The later the better. The only way this will work is if all 3 states start at the same time for the same price.
•This should be done with an out to go back to April 1st should the science or markets warrant.
•April 15th at the earliest May 15th at the latest. May 1st could work also. April 1st is too early.
•Should end Oct 15th.
•With ocean conditions the way they are, we need the extra time to let these shrimp grow to a more legal size. It will also help us economically and provide the market with a better-quality product.
•I would like the season to be later so the shrimp can finish spawning.
•Hope permit holders understand, that starting May 1st will only benefit our fishery, and have no bad effects. Thanks for your help.
•I support a later start date. May 1st but not opposed to May 15th either.
•Close season Oct 15th to avoid late season egg-bearing shrimp.
•Help the growth of the shrimp! Also allow the shrimp to drop eggs.
•Start of April 15th and an end date of Oct 15th.
•Will give the female shrimp a chance to spawn and better-quality shrimp if we have a later starting date.
•If the shrimp fishery has been going well since 1964 why add extra hardships on us now?
•Keep it the same.
•We never start April 1st as it is now and price negotiations start 4/1. If you prolong season opener price negotiations will also be delayed even longer. If the shrimp are not ready the canneries will not buy.
•Please don't put small operations out of business.
•Conditions change year to year, leave start date alone.
•Leave as is unless for sure there is a problem, biologically or economic. Will stop "derby type season", longer for us to plan.
•Rules need to be reviewed by the fleet over time and not set in stone. Processors and buyers should not have any vote or influence on this ever!
•Bad Move! We in Washington need seven months to fish shrimp, we don't have the luxury of fishing crab into the spring. Our crab are caught in 2-4 weeks. The shrimp population has sustained itself for many years. Please leave the fishery as is!
•I've been fishing all my life on the west coast - 30+ years in pink shrimp. This fishery has been sustainable year after year. Yes the fleet has grown but won't remain in the low economical year. I don't understand why we have to take something that's works for years and critique it to fit others agenda. Pink shrimp fisheries have been a self-sustainable resource, from the time it has been harvested. I support the April 1st start & the Oct 31st closure.
•Every year is different no need to change.
•Please don't limit our opportunity to make our living and payments by shortening our season we have payments to make.
•I am not in favor in getting state involved with this. I think the industry is better suited to these changes when I do not see a clear biological concern with the stock.
•April is one of my best months, the grade is good if you look. I don't think it will help for everybody to start on time.
•April 1st through Sept 31st would be my choice.
•Most who don't start on April 1st is the fact that they aren't ready. Reason why most want to change starting date, is because they are active in other fisheries. It is all about personal gain and nothing else.
•Absolutely do not support a late start.
•No changes needed.
•No change because everyone just keeps on taking more + more time. We already don't start on April 1st because of the fish plants. If we agreed to a later start they would just put us another month out making an already 5.5 to 6-month season to a 4.5 to 5-month season.
•Shorter season in the fall if you are concerned about egg bearing shrimp.

2020 Season Summary

Landings Data

In 2020, total catch of pink shrimp in Oregon was very high (43.1 million pounds), among the highest volume years (Figure 1).

Seventy-four vessels landed shrimp into Oregon in 2020 (Figure 2) and made 1,098 individual trips (Figure 3). These rates were similar to recent years.

On average, 39,283 pounds were landed per trip, a little higher than previous years (Figure 4). This high catch-per-trip average indicates that few trips were a bust in 2020; most often, trip limits were caught in a couple days.

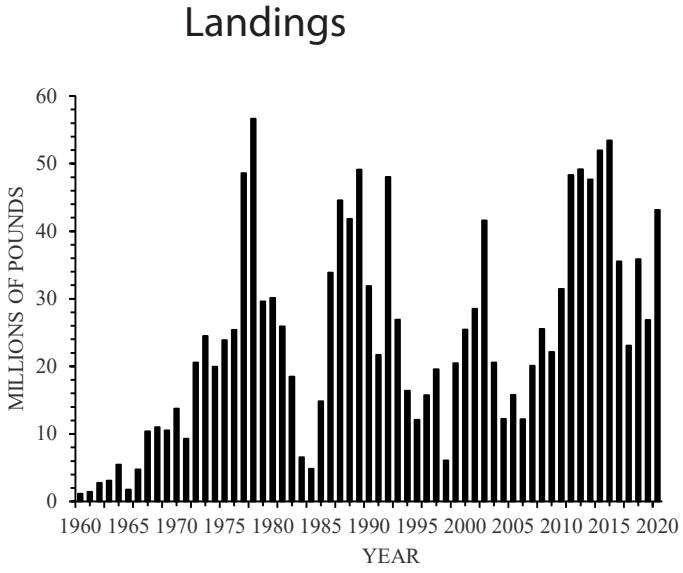


Figure 1. Landings of pink shrimp into Oregon by year: 1957-2020.

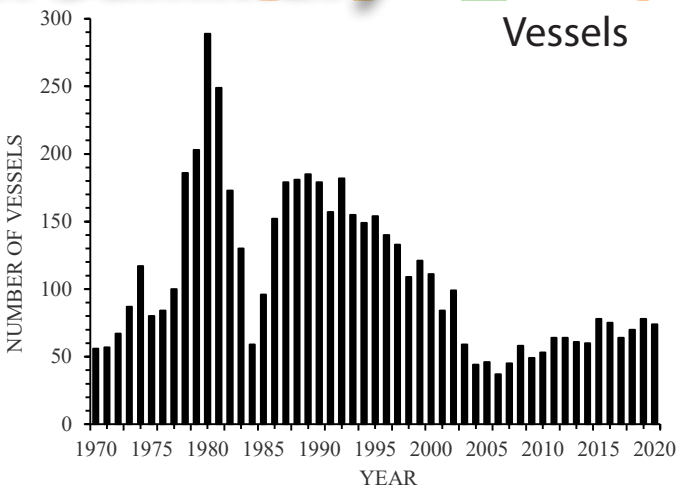


Figure 2. Number of vessels landing pink shrimp into Oregon, by year: 1970-2020.

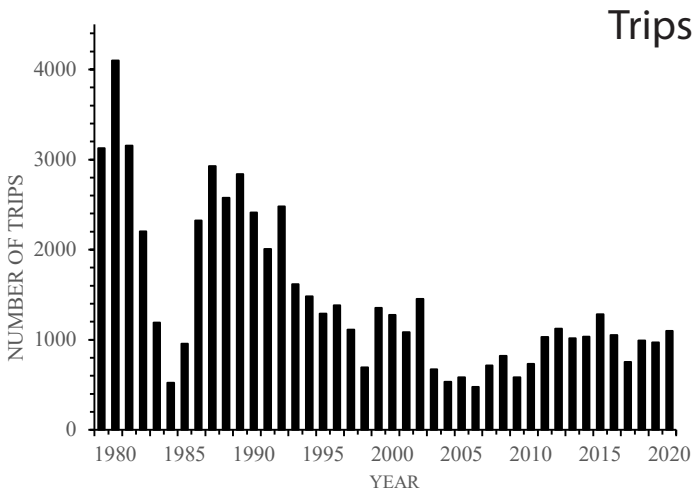


Figure 3. Number of trips landing pink shrimp into Oregon, by year: 1979-2020.

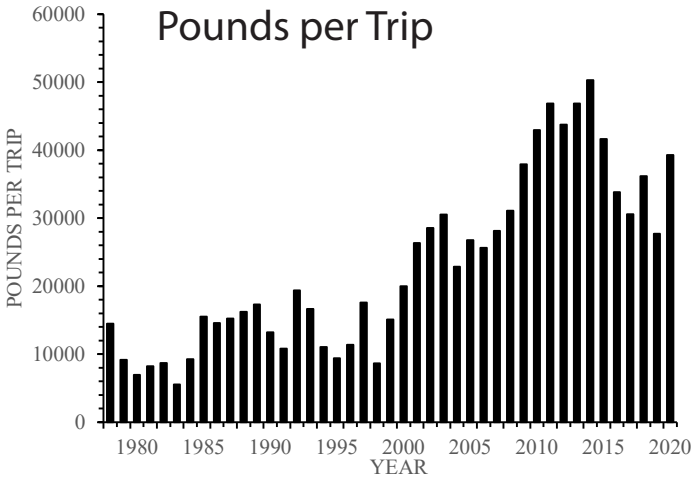


Figure 4. Average catch-per-trip (pounds) for pink shrimp vessels landing into Oregon, by year: 1978-2020.

2020 Catch Area

Catch in 2020 was highest in southern areas, but very good throughout the region and the season. Catch actually increased throughout the season due to some less common circumstances (high percentage age one shrimp, market issues, etc.) (Figure 5). Figure 7 shows a heat map of Oregon landed pink shrimp catch along the coast.

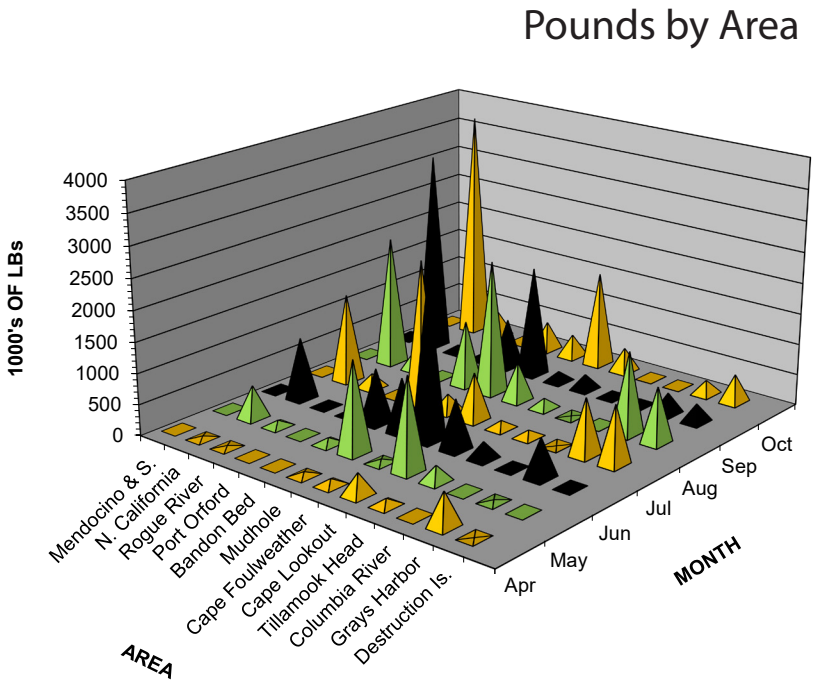


Figure 5. Total pounds of pink shrimp caught in each area and month landed into Oregon, 2020.

In most years, catch rates in Oregon's pink shrimp fishery begin high, then reduce slowly. Typically, this pattern is due to a "fish-down" of age 2 and 3 shrimp, before the fleet focuses on age 1 shrimp. In 2020, there were few age 2 and age 3 shrimp available; however, age 1 shrimp were highly abundant. For this reason, catch rates actually increased during the season as age 1 shrimp grew larger (Figure 6).

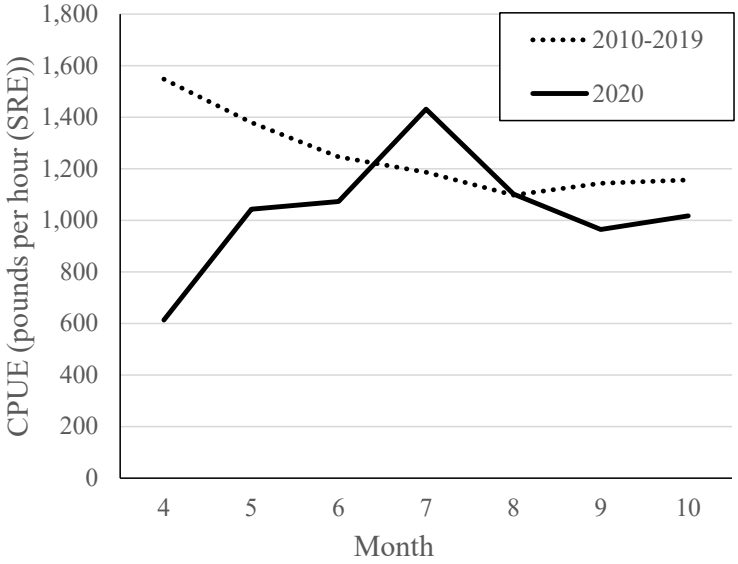


Figure 6. Catch rates by month in 2020, compared to previous years (2010-2019) for pink shrimp landed into Oregon.

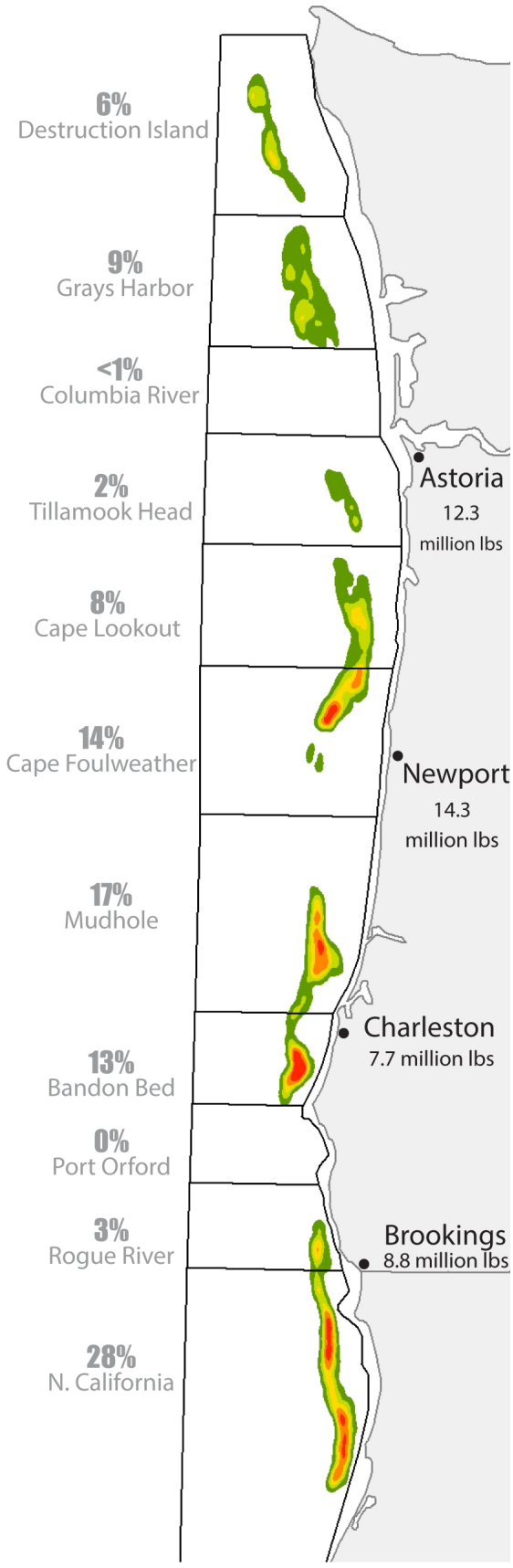


Figure 7. Heat map of pink shrimp catch by state statistical areas for 2020 Oregon landings, and amount of pounds delivered to each port.

Effort

Effort (number of hours the fleet fished) has remained much lower than historic numbers. In 2020, effort was similar to the great fishing years of 2009-2015 when trips were short and efficient. (Figure 8).

Effort started out low, however once markets were fully open remained relatively even. Typically, effort drops off in the fall months, but the robust population of age 1 shrimp kept fishing conditions and effort strong (Figure 9).

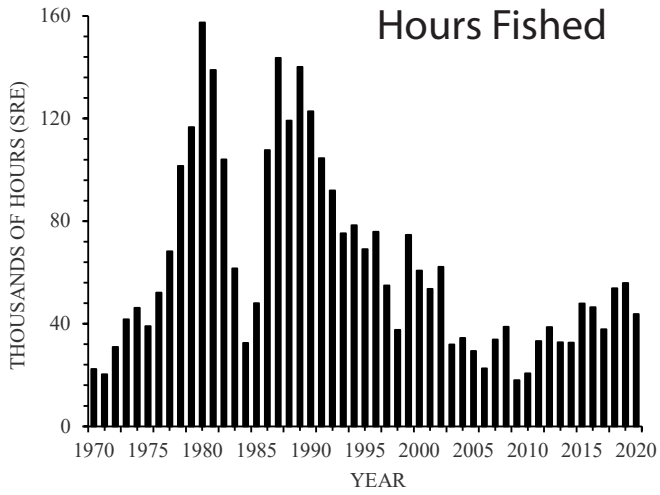


Figure 8. Total hours (SRE) fished for pink shrimp landed into Oregon, by year: 1968-2020.

Hours of effort are displayed in units of Single Rig Equivalent (SRE) hours, meaning that single rig hours are counted 'as is' and double rig hours are multiplied by 1.6.

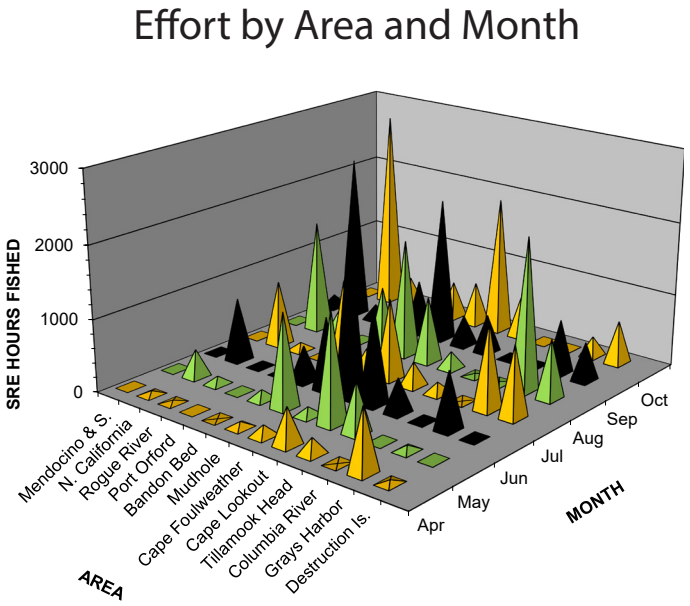


Figure 9. Total hours (SRE) fished for pink shrimp landed into Oregon, by area and month, 2020.

Efficiency

Efficiency, expressed in Catch Per Unit of Effort (CPUE) was 985 lbs of shrimp/ hour SRE (615/ hour in double rig terms). This figure was DOUBLE last year's efficiency, and more like those great 2009-2015 seasons (Figure 10).

With a strong stock dominated by age 1 shrimp, CPUE peaked mid-summer when those shrimp were relatively large and populations were high (Figure 11).

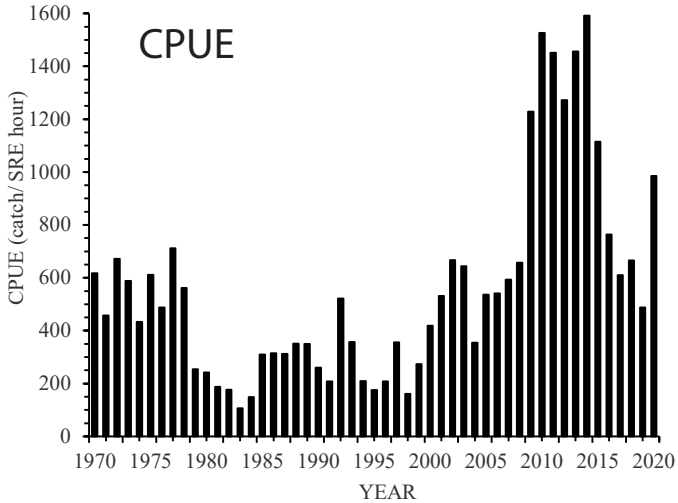


Figure 10. Average CPUE (SRE) for Oregon pink shrimp landings, by year: 1968-2020.

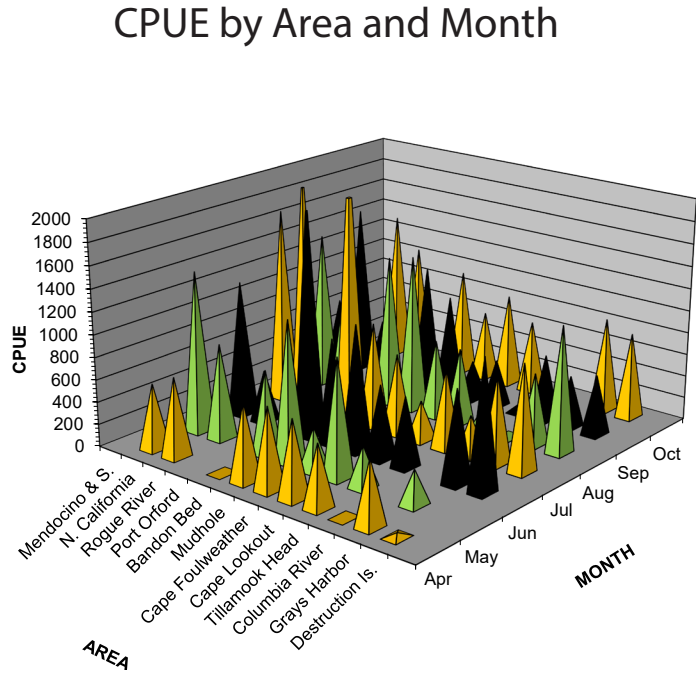


Figure 11. Average CPUE (SRE) by area and month for Oregon pink shrimp landings, 2020.

Value

Value was high in 2020 (22.6 million USD), anchored by high volume. The fishery value was the 8th highest value of all time, about 3 million dollars more valuable than 2019 (Figure 12).

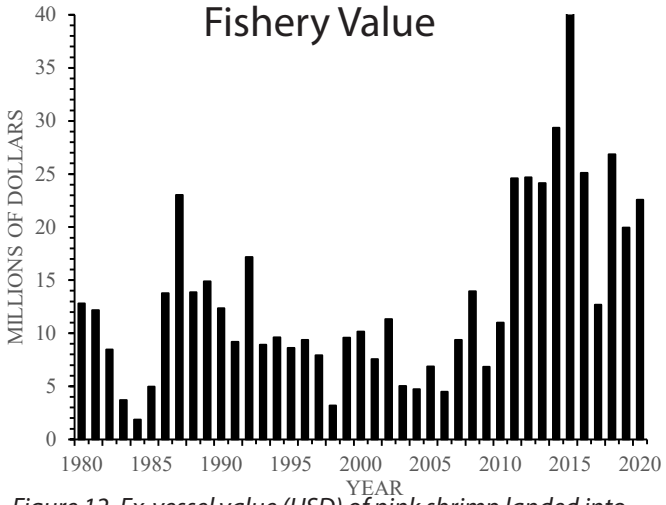


Figure 12. Ex-vessel value (USD) of pink shrimp landed into Oregon, by year: 1978-2020.

At $0.52 per pound, the average price was the lowest since 2013 (Figure 13).
Values are nominal (i.e. not adjusted for inflation).

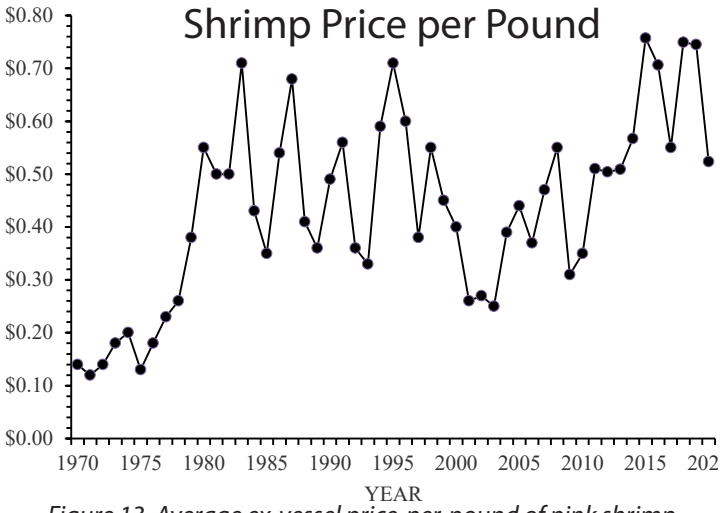


Figure 13. Average ex-vessel price-per-pound of pink shrimp landed into Oregon, by year: 1968-2020.

Age and Size

Pink shrimp live short lives and grow quickly; catch is typically composed of 3 year classes (age 1, 2 and 3). In most years, catch depends heavily on age 1 shrimp.

In 2020, numbers of (individual) shrimp in the catch were composed of 89% age 1 shrimp, 9% age 2, and 2% age 3; more dependent on age 1 shrimp than average (Figure 14).

By weight, older shrimp (age 2 and 3) make up about 27% of the catch (Figure 15), despite only being about 11% of the catch by numbers.

Despite being quite a different age composition than 2019, mean count per pound in 2020 was almost identical at 125 shrimp per pound (Figure 16).

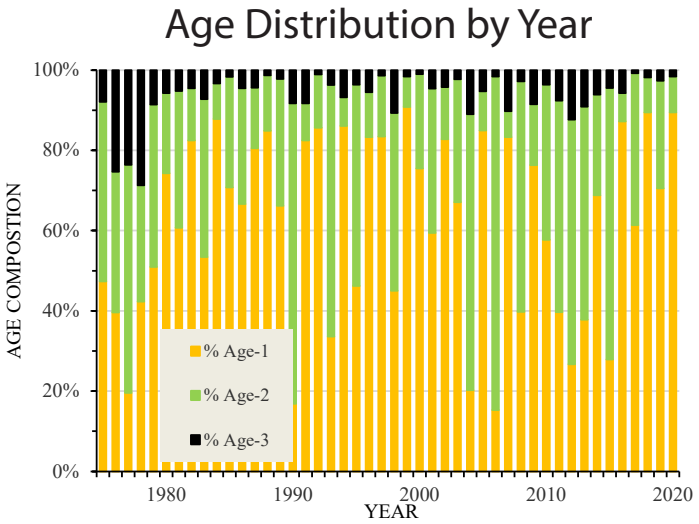


Figure 14. Age composition of pink shrimp landed into Oregon, by year: 1975-2020.

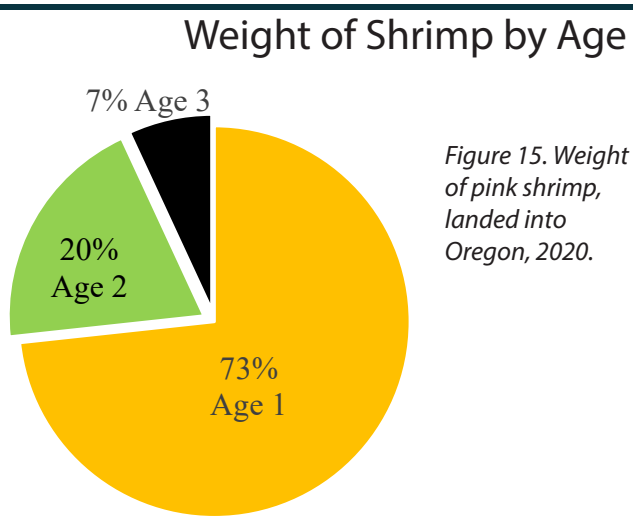


Figure 15. Weight of pink shrimp, landed into Oregon, 2020.

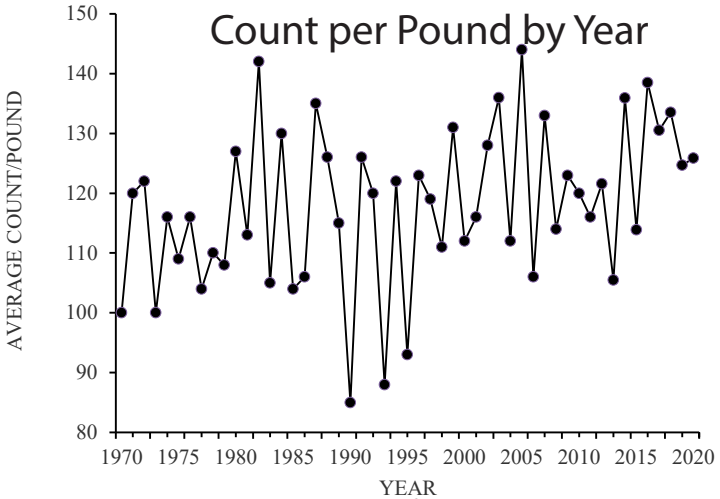


Figure 16. Average count per pound of pink shrimp landed into Oregon, by year: 1966-2020.

2021 Indicators

Here we describe some of the indicators which provide a forecast of what to expect next season.

"All models are wrong, but some are useful"
- George Edward Pelham Box, Statistician

Environmental Conditions

By comparing past pink shrimp population levels to past environmental condition, we can forecast future pink shrimp abundance based on current environmental conditions. Pink shrimp recruitment has a strong relationship to oceanographic conditions during their larval period (Figure 17). Specifically, sea level height at Crescent City, CA during the pink shrimp's larval period has shown a strong link to recruitment levels in Oregon; the lower the sea level, the greater recruitment.

Why sea level? While it may not matter to a pink shrimp if there's a few extra inches of water above their head or not, the average height of the sea does correlate to environmental conditions that are known to affect pink shrimp larvae (larval transport, food supply from upwelling, etc), thus providing a single indicator.

In 2021, pink shrimp catch will be composed of three year classes (those born in 2018, 2019, and 2020).

2020 year class: The environmental conditions which larval pink shrimp experienced in 2020 were excellent. When compared to the past 42 years it was in the 80th percentile (i.e. top 20%). Age 1 recruitment is typically the largest component of the fishery, by number.

2019 year class: In 2021, we're hopeful that a good proportion of the catch will be these two year old shrimp, which should be nearly double the size they were last spring. This cohort showed up in much better than predicted numbers in 2020. Abundance of age 2 shrimp are critical to avoiding count problems in the first months of the season.

2018 year class: In 2021, we expect few age 3 shrimp. This cohort was not strong in the past two years. Age 3 shrimp are large, but few survive natural and fishery mortality to live three years.

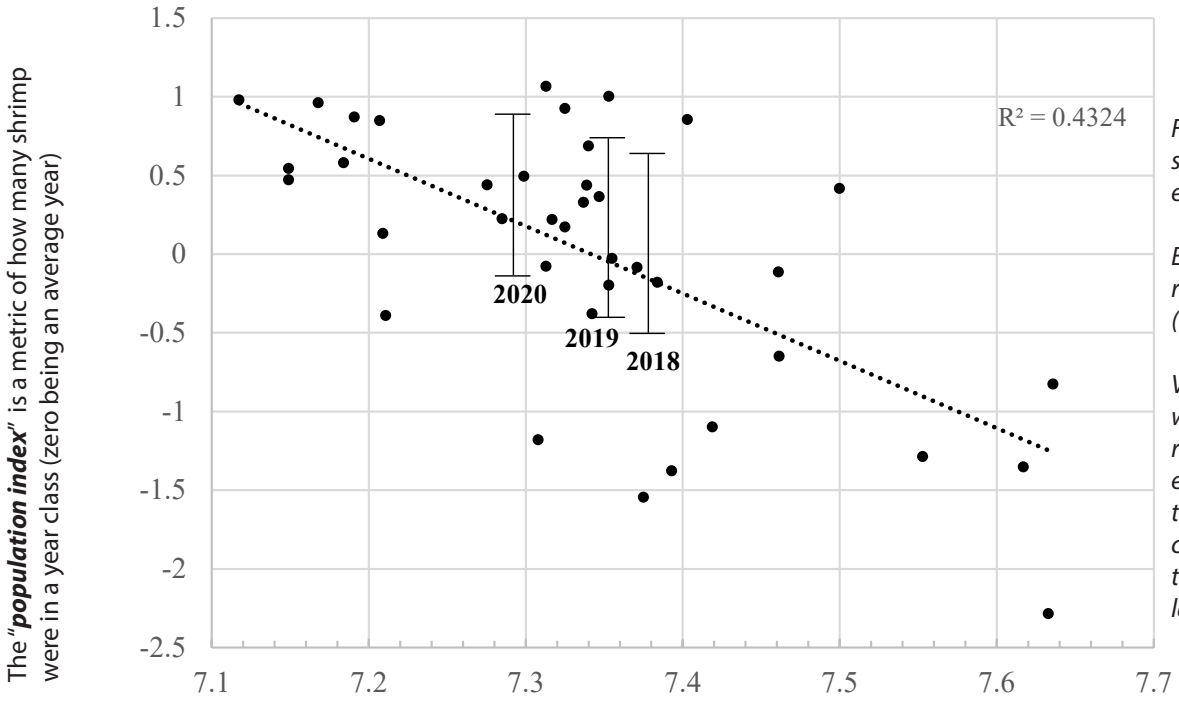


Figure 17. Pink shrimp population/ environmental model.

Each dot on this graph represents a year (1979-2017).

Vertical lines labeled with year represent the range of population expected, given the environmental conditions in the year they are released as larvae.

The "***environmental variable***" used is sea level height (SLH) from April to January in Crescent City, CA.

La Niña
cool waters

El Niño
warm waters

Sampling Data

Crustaceans lack hard structures for aging, such as ear bones (otoliths) used in fish aging; thus other means must be used. Pink shrimp simultaneously release eggs, grow quickly, and live short lives. These three attributes allow for age assignment using statistical (multimodal distribution) analysis. In this way, ages of shrimp are determined by bulk measurement of their size over time. Size measurements (carapace lengths (CL)) are aggregated then compared to other time periods to determine age and growth.

Each graph tells a story; in the example below (Figure 18), there are many age 1 shrimp, then a few age 2 and 3. While a single graph is like a snapshot, comparing changes in these graphs over time tells a story. The horizontal (X) axis of these graphs indicates the size of the shrimp (larger as you move to the right); the vertical (Y) axis shows the relative amount of each size group (not total abundance). The "lumps" of these graphs are caused by the central tendency of each age group; thus changes to relative amounts of age classes can be tracked along multiple graphs. Arrows track year classes and indicate rate of growth as time goes on. These graphs look a little complex at first, but once understood, it becomes easy to visualize (Figure 19).

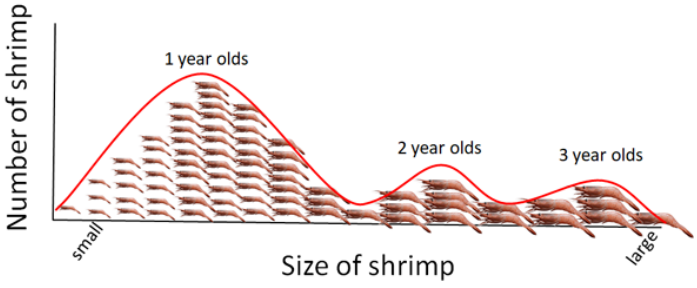


Figure 18. Hypothetical multimodal size distribution of pink shrimp.

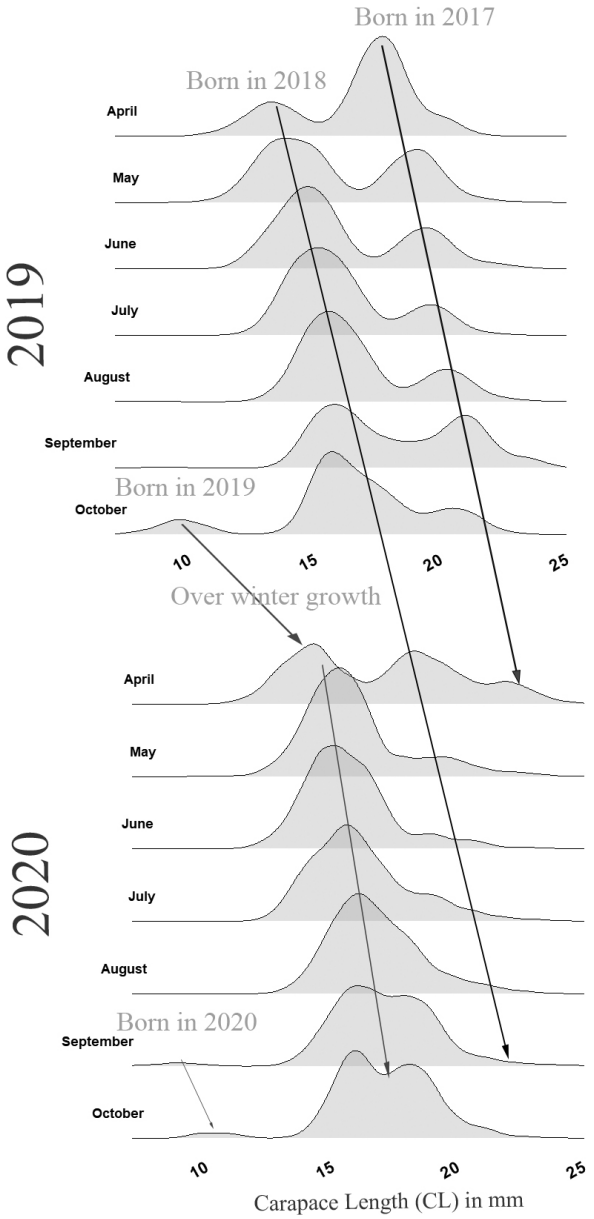


Figure 19. Pink shrimp size distributions by month (2019 and 2020) from Oregon landings. Note: Shrimp born in 2018 (age 1 in 2019 and age 2 in 2020) were a minor component of catch in both years.

Forecasting Methods

We forecast next year's catch in two different ways.

1. Forecast from environmental data:
We examine environmental conditions over the past few years then weight a forecast of each year depending on expected contribution of each year class (e.g. age 1 shrimp are typically the primary component of catch; therefore, environmental data from that year are more heavily weighted, whereas environmental conditions from three years ago are less heavily weighted).

2. Forecast from sampling data:
In this forecast, we look at last year's catch of each age class, rank them according to previous generations of shrimp, then weight each rank to project what next season might be like.

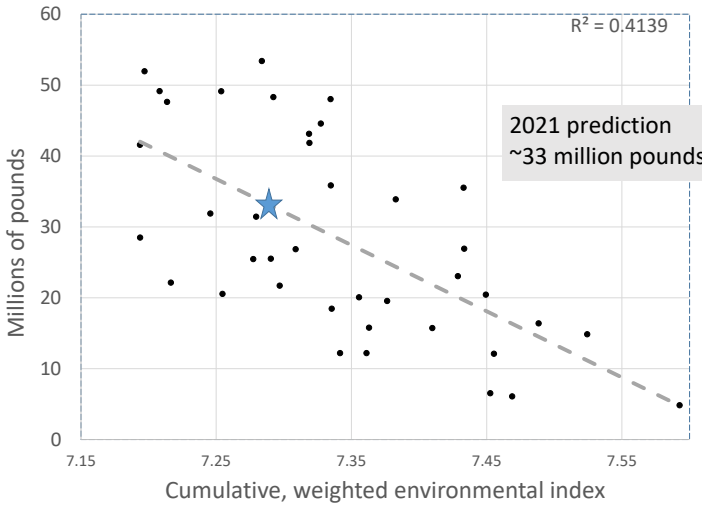


Figure 20. Cumulative, unified forecast of Oregon pink shrimp catch based on environmental factors.

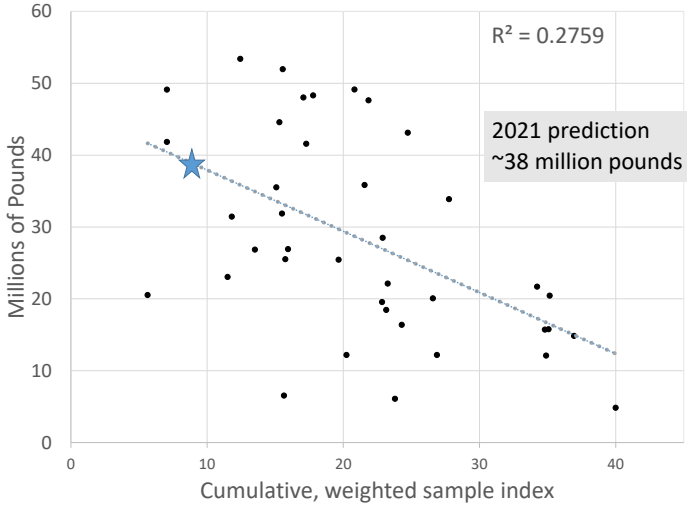


Figure 21. Cumulative, unified forecast of Oregon pink shrimp catch based on sampling data.

This new cumulative, unified forecasting is based on the typical percentage of weight contribution of each age class to the current years catch. The environmental model predicts 2021 to be a 33 million pound season (Figure 20), while the sampling data model predicts a 38 million pound season (Figure 21).

To give some context of the variability expected, for last years ~43 million pound season the predictions were 29 (environmental model) and 25 million pounds (sampling model), so, it's definitely a guess. The error from last year was mostly from a more robust than expected age 1 cohort.

Regulation Info

Key regulations that apply to **Oregon** pink shrimp deliveries				
		Fishing off CA*	Fishing off OR**	Fishing off WA***
Areas	0-3 miles	No fishing	OR permit needed	No fishing
	3-200 miles Key closed areas	Delgada Canyon, Tolo Bank, other closed areas (see CA regs)	Nehalem Bank, Daisy Bank, Stonewall Bank, Heceta Bank, Coquille Bank	Grays Canyon (see WA regs)
Mesh size		Minimum 1-3/8"	No minimum	
BRD		≤ ¾" spaced rigid grate		
LEDs		5 LEDs in central 16 feet of each net, spaced 4 feet apart (More LEDs may be used)		
Count per pound		≤160 shrimp/ pound		
VMS declaration		Required		
Season		April 1- October 31		
Groundfish by-catch****		Groundfish: 500 lb/day, multiplied by the number of days of the trip, not to exceed 1,500 lb/trip. The following sublimits also apply and are counted toward the overall 500 lb/day and 1,500 lb/trip groundfish limits: lingcod 300 lb/month (minimum 24" size limit); sablefish 2,000 lb/month; canary, thornyheads, and yelloweye rockfish are PROHIBITED. All other groundfish species taken are managed under the overall 500 lb/day and 1,500 lb/trip groundfish limits and do not have species specific limits. The amount of groundfish landed may not exceed the amount of pink shrimp landed.		

*CA Regulation details: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=175639&inline, pages 114-117.
**OR Regulation details: https://www.dfw.state.or.us/OARs/index.asp
***WA Regulation details: https://wdfw.wa.gov/fishing/commercial/shrimp#
**** NMFS groundfish limits

Research Priorities

Here, we address three research areas, in priority order: 1) shrimp population dynamics, 2) non-target catch and 3) ecosystem effects. Although we address each priority every year, we don't necessarily have planned activities for all three every year.

Priority 1: Shrimp Population Dynamics

Our documentation and analysis of pink shrimp population dynamics is the highest priority of our program. Understanding changes in the shrimp population and comparing it to past populations, environmental data and other factors is critical to our ability to detect and address overfishing. ODFW's pink shrimp program has a thorough, long term dataset of shrimp populations which is central to our ability to assure it is fished sustainably.

Accomplished in 2020:
We calculated annual indices on the number of shrimp using fish ticket, logbook and biological sample data. ODFW biologists entered data for ***9,969*** shrimp tows and measured ***27,765*** shrimp.

We were able to collaborate with Washington Department of Fish and Wildlife (WDFW) by successfully sharing biological data to bolster and improve both states analysis.

We continued to centralize biological sample data. Currently, we have 75% of samples collected between 1980 and 2020 entered into a single dataset, stored in raw format, allowing for maximum analysis.

Shrimp staff worked with Dr. Eric Charnov to publish the 3rd analysis (Charnov, Gotshall and Robinson, 1978 and Charnov and Hannah, 2004) of shrimp sex transition theory, titled "Fluctuating age distributions and sex ratio tracking in a protandrous shrimp" in Evolutionary Ecology Research. This analysis used data from more than 50 years of pink shrimp biological samples to demonstrate the theory of evolutionary stability strategy.

A pink shrimp pleopod transitioning

We tested our population model using multiple regression (Page 11-12).

Planned for 2021:
We plan to re-evaluate our shrimp population model.

We also plan to complete the entry of pink shrimp biological samples from 1980-2020.

We will continue to work closely with WA and CA to improve sampling and fishery effort analysis.

Priority 2: Non-Target Catch

Accomplished in 2020:

In 2020 we communicated with a manufacturer of LED fishing lights and authorized a new LED fishing light for use. The FishTek Marine "netlight" is now an Oregon legal LED fishing light. www.fishtekmarine.com/netlight/

We completed the 2018 section 6 NOAA grant reducing the bycatch of eulachon.

We developed a report on gear surveys in Oregon's shrimp fishery, currently in review.

Priority 3: Ecosystem Effects

Accomplished in 2020:

In March 2020, shrimp staff embarked on a research cruise with OSU aboard the R/V Oceanus to catch and study larval pink shrimp at sea. Staff collaborated with OSU professor Dr. George Waldbusser and his lab to investigate how ocean acidification and warming ocean temperatures may affect the physiology of pink shrimp in their early life stages, a critical time for growth and development. This is a continuation of research done in 2018 and 2019 with Oregon Sea Grant, in which members of the pink shrimp fleet assisted with collection of gravid shrimp at sea. The resulting larval pink shrimp were tested using different pH and temperature conditions, and the research efforts have shown a decrease in larval growth under low pH and amplified effects when coupled with warmer temperatures.

Michelle Nguyen (OSU) and Leif Rasmussen (ODFW) identify invertebrates found in plankton tows.

Last, we had everything in place (funding and working ROV) to revisit the Nehalem Banks habitat surveys, but COVID got the better of this one, delaying this survey until 2021.

Testing model performance

Introduction:
Periodically evaluating the effects of fishing and the environment on fishery stocks is critical to assuring its sustainability. Oregon's pink shrimp fishery is managed as a sustainable fishery and was the first shrimp fishery certified as "sustainable" by the Marine Stewardship Council (MSC).
In accordance with MSC recommendations, the Oregon Department of Fish and Wildlife (ODFW) published reports in 2014, 2016 and 2018 evaluating recruitment effects for ocean shrimp, for the purpose of documenting ongoing monitoring and analysis (Hannah and Jones 2014, 2016; Groth and Hannah 2018). Here, we make those same analyses with the most recent three years of data. These long-term datasets and analyses provide us metrics that allow us to have confidence in the sustainability of Oregon's pink shrimp fishery.

The mathematical model (Figure 17) elegantly describes the relationship between environmental conditions and shrimp recruitment. The analysis described here tests the continued validity of that model.

The question is: "Is the relationship between environmental conditions and shrimp recruitment still primary?"

Methods:
To understand the effects of fishing compared to environmental conditions on the recruitment of pink shrimp, we employed multiple regression. The methods used are described in several preceding publications (Hannah and Jones 2014, 2016; Groth and Hannah 2018).

Briefly, the methods compare environmental factors (sea level height during larval period and upwelling) to an index of spawning stock levels. Environmental factor data are available through NOAA data sets. Recruitment and spawner indices were developed from Virtual Population Analysis (VPA) and included only the shrimp caught and delivered in Oregon. Indices were then stratified by latitudinal zone (separated at Heceta Head, OR).

To determine the factors affecting the recruitment of pink shrimp, we use the above described variables, chosen from the best performing models found in past publications.

Data used in these analyses can be found on the pink shrimp news and publications site:

www.dfw.state.or.us/mrp/shellfish/commercial/shrimp/news_publications.asp

Essentially, we compare conditions (environment and spawner abundance) to the consequent amount of shrimp recruitment.

Results:
In both the north and south areas, multiple regression models which considered both environmental conditions and the number of spawners were strong (r^2= 0.41 north, and 0.49 south, Table 1).

In northern areas, environmental conditions were the principal driver of recruitment, while spawners did not contribute to recruitment significantly (p= 0.26, model 1 in Table 1).

In southern areas, environmental conditions have historically been the principal driver of recruitment, although spawners have often been a statistically significant contributor. Serial autocorrelation (between spawners and environment) likely influences the statistical relationship between spawners and recruits (as described in Hannah and Jones, 2016).

Table 1: Multiple regression results from north and south pink shrimp recruitment indices, Oregon index areas 1979-2017.

	parameter/ variable	coefficients	standard error	R^2	P>F
Model 1: Log north recruit index	intercept	52.114	9.338		0.000
	Log spawner index (t-2)	0.156	0.135		0.257
	April-Jan SLH (t-1)	-4.740	1.128		0.000
				0.41	
Model 2: Log south recruit index	intercept	35.888	8.639		0.000
	Log spawner index (t-2)	0.479	0.126		0.001
	April-Jan SLH (t-1)	-3.292	1.054		0.004
	April-July Upwelling at 42° N, 125° W	-0.005	0.003		0.189
				0.49	

Despite increased effects by spawning stock levels in southern areas (Table 1, model 2), environmental conditions still have the greatest magnitude of effect. Figure 22 illustrates the relationship between recruitment and spawning stock in three different larval environments. Restraining fishing would have little effect on shrimp recruitment when compared to a good larval environment (e.g. La Niña conditions (dashed line)), however must be considered when larval environments are poor (e.g. El Niño conditions (solid line).

Testing model performance(cont.)

Discussion:
Historically, these models have pointed to environmental conditions driving shrimp recruitment much more than the level of spawning stock.

In the north, the model has held well, showing very little dependence on spawning stock and heavy dependence on environmental conditions during their larval period (Figure 23, North).

In the south, the model has remained strong, explaining around 50% of variation in recruitment during each of the past model tests. Although the model is strong, shifts from the significance towards spawning stock have occurred (Figure 23, South).
In this iteration of model testing, a shift has occurred, and spawners are now a prominent model component. In large part this is due to a single data point, the anomalous year of 2015 when El Niño conditions occurred. Typically, El Niño conditions result in poor shrimp recruitment; however, 2015 recruitment was surprisingly high. Without this single data point, the model does show the clear prominence of environmental conditions.

The results of these analyses show that shrimp recruitment remains principally dependent on environmental conditions and less so from the number of spawners. This confirms an assumption critical to Oregon's pink shrimp fishery management.

In the next year, we plan to revisit this model using some new methods and borrowing from the expertise of ODFW's Marine Fisheries Research Program.

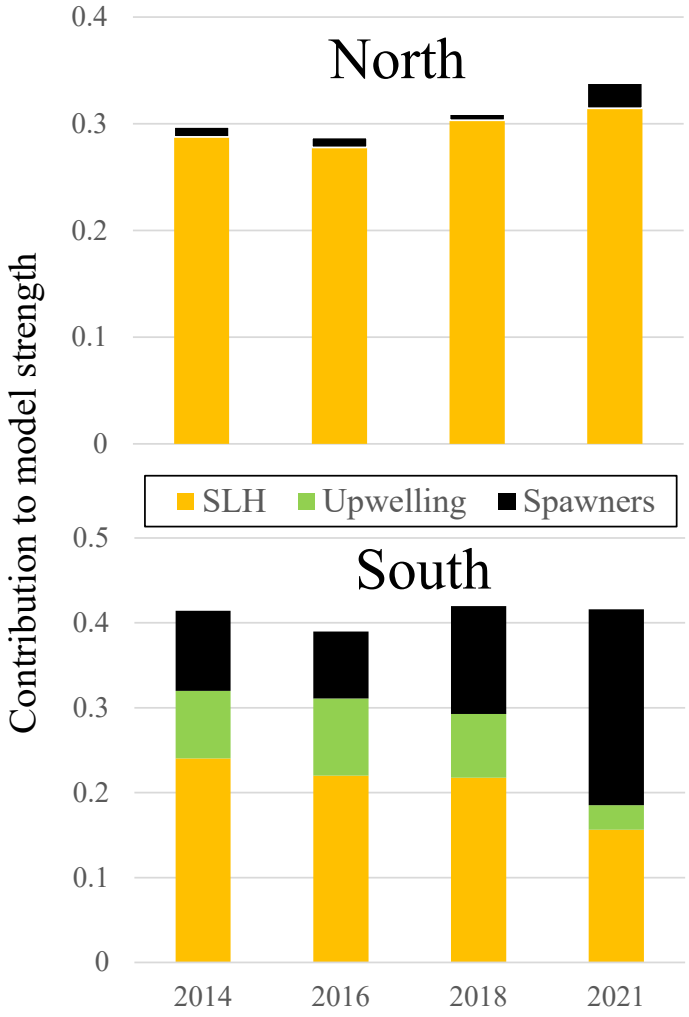


Figure 23. Comparative strength of model components driving shrimp recruitment in northern and southern areas of Oregon in successive iterations of analysis from 2014-2021, using data from Oregon indices 1979-2017.

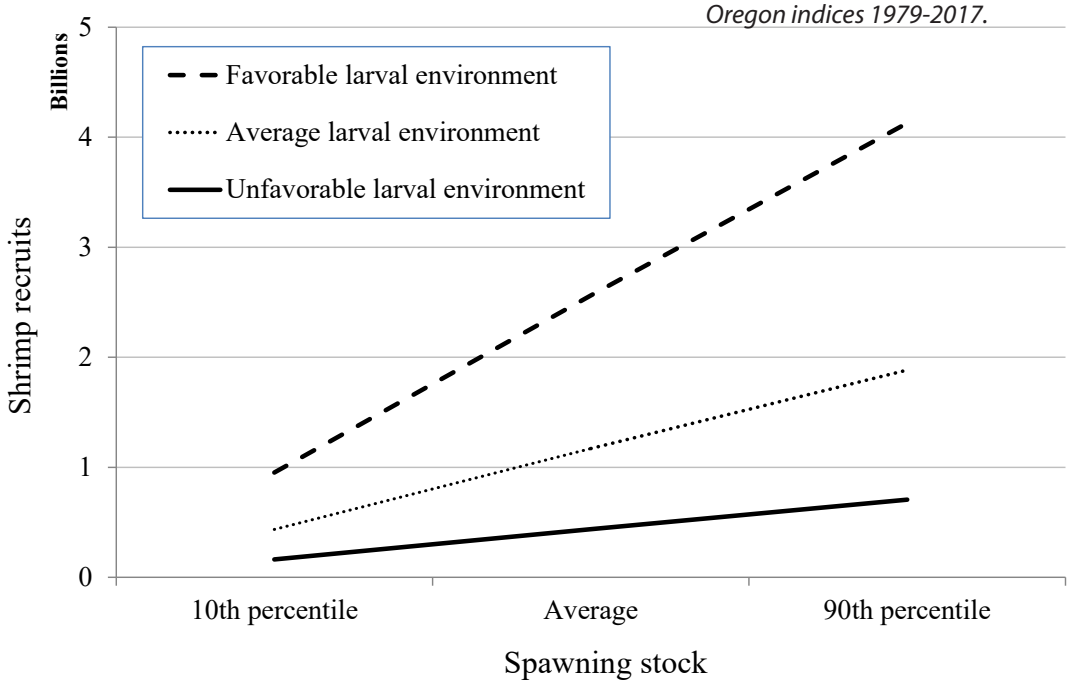


Figure 22. Predicted southern Oregon age 1 pink shrimp recruitment using model 2 in Table 1, profiled across a range of spawning stock indices and larval environmental conditions.

Other Topics

Logbooks

If you are using a logbook that has perforations near the spiral binding (top photo), please see your port biologist and get a logbook that has a perforated tab on the side opposite of the spiral binding (lower photo). Please do not continue to use logbooks that have perforations next to the spiral binding. The pages in these logbooks fall out too easily.

Other logbook reminders:
Please begin a new page for each trip
Please use 24 hour time (e.g. 1500 rather than 3 PM)
Please record your estimated weight of fish discarded (i.e. bycatch) in the appropriate column

MSC News

ODFW staff worked with MSC staff to aid Argentinean fishery managers in improving the sustainability of their red shrimp (*Pleoticus muelleri*) fishery. We described the methods used to develop harvest control rules in Oregon's pink shrimp fishery, enabled by internal teamwork and partnership with industry.

Haitz's law

LEDs are an important tool for the sustainability of Oregon's pink shrimp fishery, however they are not free. The good news is that LED technology has improved in efficiency and decreased in cost consistently since their invention.

Haitz's law states that the amount of light which is generated per light package (per LED) will increase by a factor of 20 every 10 years, and the cost per lumen decreases by a factor of 10 every 10 years (Figure 24, from Wikipedia). According to Haitz's law, we should expect LEDs to get better and cost less in the future.

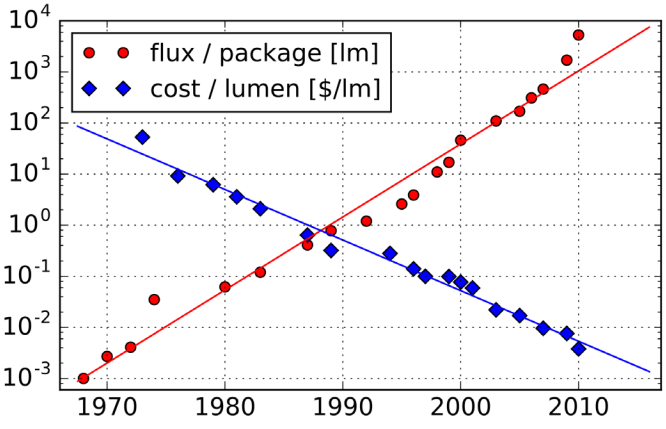


Figure 24. Illustration of Haitz's law. Light output per LED package as a function of time, note the logarithmic scale on the vertical axis: from Wikipedia.

Shrimp sex change

A key theory in evolutionary ecology was proven with real data from Oregon's pink shrimp fishery. Evolutionary ecologist Dr. Eric Charnov has worked with many generations of ODFW biologists to prove this using more than 50 years Oregon pink shrimp biological data.

Evolutionarily Stable Strategy and sex allocation theory seeks to maximize the product of breeders in populations of pink shrimp. First year breeders are often primarily male, but when almost all of the breeders in a population are first year breeders, up to half of these first year breeders will be female. Alternatively, when almost none of the breeders in a population are first year breeders, up to half of the second year breeders will remain male. Pink shrimp appear to have a mechanism for detecting population sex ratios, though how is unknown (Charnov and Groth 2019) .

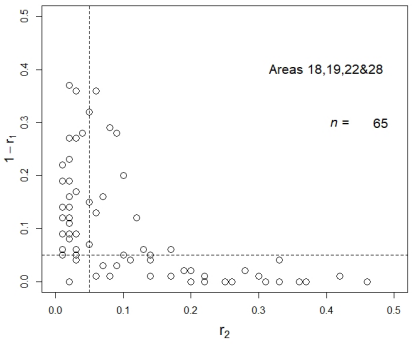


Figure 25. Relationship between two year old males and one year old females in Oregon pink shrimp populations (1981-2019) from Charnov and Groth, 2019.

ICWPF 2020

Oregon's shrimp fishery was represented at the 2020 International Cold Water Prawn Forum (ICWPF), in London. This was a virtual meeting, so it did provide a great opportunity for a collaborative video story on Oregon's shrimp population dynamics. Nick Edwards (F/V Carter Jon) and Scott Groth (ODFW) made a short video regarding the use in condition index to assess shrimp stocks. Conference materials are available on the ICWPF site, however 2020 was not posted at the time of this publication.

Nick Edwards (F/V Carter Jon) presenting video on Oregon shrimp populations on virtual ICWPF 2020.

Acknowledgments

This annual newsletter is created primarily for Oregon's pink shrimp industry. We wish to thank the hard-working fishermen, plant staff, vessel owners and other industry members for their continued cooperation and assistance.

Oregon's Pink Shrimp Project is funded in part by a grant/ cooperative agreement from the National Oceanic and Atmospheric Administration (NOAA). The views expressed herein are those of the authors and do not necessarily reflect the views of NOAA or any of its sub-agencies. This project was financed in part with Federal Interjurisdictional Fisheries Act funds (75% federal, 25% state of Oregon funds) through the U.S. National Marine Fisheries Service (grant # NA15NMF4070412).

Literature

Literature cited:

Groth, S. D. and R. W. Hannah (2018). An evaluation of fishery and environmental effects on the population structure and recruitment levels of ocean shrimp (Pandalus jordani) through 2017. Oregon Department of Fish and Wildlife Informational Report. Salem, OR, Oregon Department of Fish and Wildlife.

Hannah, R. W. and S. A. Jones (2016). An evaluation of fishery effects on the population structure and recruitment levels of ocean shrimp (Pandalus jordani) through 2015. Oregon Department of Fish and Wildlife Informational Report. Newport, OR, Oregon Department of Fish and Wildlife: 30.

Hannah, R. W. and S. A. Jones (2014). Effects of climate and fishing on recruitment of ocean shrimp (Pandalus jordani): an update of recruitment models through 2013. Oregon Department of Fish and Wildlife Informational Report. Newport, OR, Oregon Department of Fish and Wildlife: 24.

New reports available:

Charnov, E. and S. Groth (2019). "Fluctuating age distributions and sex ratio tracking in a protandrous shrimp." Evolutionary Ecology Research 20: 30.

Who We Are

ODFW's mission is to protect and enhance Oregon's fish and wildlife and their habitats for use and enjoyment by present and future generations.

The pink shrimp fishery project is managed with the following long term objectives:

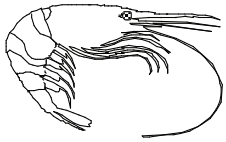
1. Maximize biomass yield from the pink shrimp fishery, consistent with detecting and addressing any significant growth or recruitment overfishing that develops.

2. Operate the fishery, to the extent possible, under a stable regulatory environment that allows vessel operators maximum flexibility in deciding where, when and how to fish for pink shrimp.

3. Through collaborative research with vessel operators and the sharing of research findings, develop and implement measures to minimize direct bycatch mortality, the unseen mortality of animals that escape capture and any adverse effects on seafloor habitat from the operation of the fishery.

Oregon's pink shrimp project is spread out among the major ports of Oregon to:
1. Collect fishery dependent data (biological samples and logbooks)
2. Assist and communicate with shrimpers.

Good Luck Shrimping in 2021!



Questions?

Scott Groth, Project Leader		(541) 857-2388
Eric Anderson, Assistant Project Leader		(541) 961-6227
Jill Smith, Assistant Project Leader		(503) 325-2462
Licensing:		(503) 947-6101
Fish Tickets:	Nadine Hurtado	(503) 947-6247

OREGON Fish & Wildlife Marine Resources

ODFW Pink Shrimp Team

Astoria: Jill Smith

Newport:
Eric Anderson

Charleston:
Kendall Smith,
Dean Headlee and
Scott Groth

Brookings:
Valerie Miranda

Oregon Dept of Fish and Wildlife:
PO Box 5003
Charleston, OR 97420