v. 4, n. 1, 2024

International Journal of Biological and Natural Sciences

EVALUATION OF THE RELATIONSHIP BETWEEN SURFACE AND BACKGROUND TEMPERATURE IN SITU, REGARDING CATCH PER UNIT EFFORT (CPUE) IN TRAPPING FOR WHITE SPOT SHRIMP (P. PLATYCERUS) ON THE WESTERN COAST OF BAJA CALIFORNIA, MEXICO

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Abstract: This study makes it possible to make predictions of potential fishing areas and save resources in daily operations. It provides technical information that relates the surface and bottom temperature measured with Hobos and the capture per unit of effort (CPUE). Trap fishing yields obtained around the western coast of Baja California are consistent with maximum and minimum values found elsewhere in both California and Alaska. This places at an intermediate level the 0.400 kg/trap determined as the general average in the capture of P. platycerus around the western coast of Baja California when using the trap designs with which satisfactory yields were obtained. These correspond to the square traps (0.93 kg/trap) and the rectangular trap (0.165 kg/trap). The average in situ temperature measurements recorded in the fishing hauls showed a temperature variation between 16ºC and 5 °C. Likewise, a variation is observed in the surface and bottom temperature between the months July-October in which the tests were carried out, finding a sustained increase of 16ºC for the surface temperature and 10°C for the bottom temperature. A high availability of this resource has been determined from 100-360 m depth. With the trap selected in this investigation it is possible to obtain average catches of 0.300-0.500 grams per trap. It is concluded that it is feasible to exploit this resource at significant levels where only lobster, urchin, sea cucumber and fish that constitute the bait for the traps used for the extraction of this pandalus are captured.
Keywords: Fishing with traps, P. platycerus, surface temperature, bottom temperature.

INTRODUCTION

To date, there has not been much interest in the fishery for organisms of the genus Pandalidae, although some species of the genus Heterocarpus have been caught abundantly in some areas of the Gulf of California

(Hendrickx et al. 1998, 2003, 2004). Some are exploited in various places around the world, constituting fisheries of some importance, all intended for human consumption.

These crustaceans are large and heavy organisms that live in deep waters. Several species of Pandalus known from the Pacific Northwest (USA and Canada) have been located in the southern part of California, very close to the border with Mexico, in the waters of the California Current, there is not much published information about the presence of these species in our country.

White spot shrimp (Pandalus platyceros) on the western coast of Baja California are captured using trawl nets and traps, but as of October 2005, different extractive activity efforts were authorized on an experimental basis using mainly traps that are usually built with wire or net cloth. The distance between traps varies based on the designs and shapes of the traps.

The genus Pandalus contains 15 species and has a boreal-arctic distribution in the Pacific and the Atlantic. It is represented in the northeast Pacific by eight species (Austin 1985): P. borealis; P. danae; P. goniurus, P. hypsinotus; P. Jordani; P. platyceros (Brandt, 1851)|; P. stenolepis and P. tridens. Pandalus gurneyi, cited in Austin's (1985) list, is a synonym of P. danae. Of these species, P. platyceros is the largest in the genus.

The species of the genus Pandalus belong to the family Pandalidae which, as a whole, has represented in the Eastern Pacific a fishery of the order of 6,000 to 37,000 tons per year in the United States and 900 to 8,000 tons per year in Canada (period from 1984 to 1998) (Otto & Jamieson 2003).

The biological cycle of the species shows that this resource presents a sex change (protandric hermaphroditism) with the transformation of males, after a period of 18 to 30 months. The female phase lasts 3 to 5 months.

JUSTIFICATION

One of the most important coastal regions worldwide in primary productivity per unit area is the coast of the Baja California Peninsula, which is why this project was carried out in order to search for alternative fishing resources to traditional ones, taking into account that the Distribution and abundance of deep resources are affected by changes in environmental parameters, such as temperature and dissolved oxygen.

In order to carry out the search through exploratory fishing for cold water shrimp in the Mexican Pacific, it was proposed to find the relationship between the catch per unit of effort (CPUE) and the temperature of the site, both surface and bottom of the where the target species is located.

In these experiences and during two stages into which this research was divided, surface temperature meters were used and compared with in situ bottom temperatures, measured by temperature sensors called HOBOS. These data were related to the CPUE in each fishing haul for each of the study phases into which the project was divided (exploratory and experimental phase).

With this information, the correlation indices between surface and bottom temperature and catch per unit effort (CPUE) were determined to make predictions of potential fishing areas possible.

GOALS

GENERAL OBJECTIVE

Determine the correlation indices between in situ surface and bottom temperature with respect to catch per unit effort (CPUE) in the trap fishery of white spot shrimp (P. Platycerus) on the western coast of Baja California, Mexico, which make it possible to

International Journal of Biological and Natural Sciences ISSN 2764-1813 DOI 10.22533/at.ed.813412402011

make predictions of potential fishing areas.

SPECIFIC OBJECTIVES

A). Record and review sea surface temperature (SST) in real time at the same capture site.

B). Record and review bottom temperature, fishing depth, and geographic location during trapping of P. platycerus.

C). Determine the catch per unit of effort of P. platycerus (CPUE kg/trap).

D). Determine the correlation indices between in situ surface and bottom temperatures and catch per unit effort (CPUE).

STUDY AREA

The fishing area was developed in the industrial area north of Rosarito, BC,which is located at the first extreme geographical point1: 32°31.328 117°16.27; point 2: 32°34.341 117°29.062; point 3: 32°12.6507 117°16.8972; point 4: 32°01.2918 117°02.5948; point 5: 32°07.9848 116°55.0682; point 6: 32°13.4653 116°57.6746; point 7:32°18.8626 117°07.7516. Figure 1.

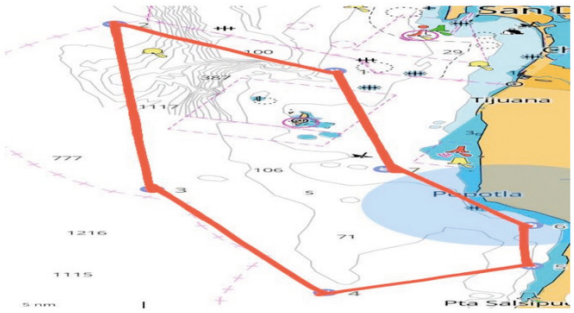

Figure 1. Study area north of Rosarito Baja California for fishing *P. platycerus* with traps.

MATERIALS AND METHODS

To carry out this study, two smaller fiberglass boats equipped with a line-collecting machine were used to handle the traps, figure 2.

Figure 2. Vessels and machinery used in the trapping system of *P. platycerus*

Taking into account the operational times of setting, resting and turning carried out under ideal conditions, the maximum number of traps that a vessel could set and turn in one day of operation was 25 units per vessel. With measurements of 30 cm high, 95 cm long and 60 cm wide, with 22.5 cm conical side entrances. Made with 1x1 inch wire mesh and attached with biodegradable staples, figure 3.

Figure 3. Rectangular trap design proposed for the experiment to capture P. platycerus.

The setting time of the traps in the line of 25 traps is between 15 and 18 minutes, that is, one trap every 20 seconds. The downwind draft allows better resolution of the bottom,

the working platform is more stable, figure 4.

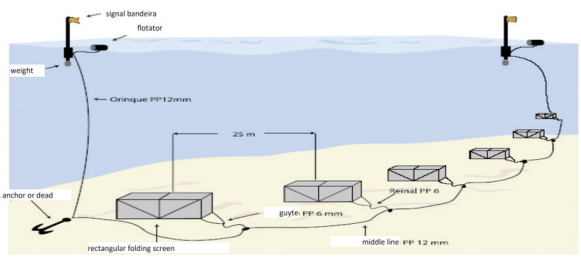

Figure 4. Distribution scheme of the trap longline ready for capture during the study.

To analyze the distribution of white spot shrimp, the capture per unit of effort formula was used:

$$CPUE_1 = \frac{\sum_{i=1}^{n} CT_i}{n\ trap}$$

Where:

CT = Total catch in kg

n trap = Number of traps used in each of the operating variables.

STATISTICAL ANALYSIS

A statistical analysis was carried out to evaluate the normality of the data using Lillíefors (Conover, 1999); with normal data, Bartlett's homoscedasticity test was applied (Zar, 1984). To evaluate if there was a significant difference ($P<0.05$) between the captures. A one-way, one-factor Fisher "F" ANAVA was performed in case the data were not parametric, the Kruskal-Wallis rank ANAVA.

RESULTS IN THE CAPTURE WITH TRAPS OF P. PLATYCERUS

A total of 17,049 traps were set. Each set in the experimental phase corresponded to the setting of 81 lines of 42 traps of two types, 21 folding rectangular and 21 truncated conical. The average distance between the traps was 6.12, 18 m. Subjected to three rest times: 12, 18 and 24 hours. Two types of bait were available in them: sardine and mackerel. The experimental fishing operations were carried out in the range between 100 and 360 m deep. The choice of said range is related to the bathymetric distribution of the target resource. During the prospecting operations carried out in October and November 2022 and December-August 2022/2023, a total of 1,500 and 2,015 traps were set, respectively. From these operations, P. platycerus was located on the seabed between 100 and 351 m deep, being captured in almost the entire surveyed area (Figure 5).

Figure 5. Capture of white spot shrimp in trap fishing for the period 2023.

In total, the vessel made 588 experimental and promotional fishing hauls, in which the limitation was referred to adverse weather conditions and maintenance of the vessel. Table 1 shows the total monthly catch of P. platyceros recorded during the period from October 7, 2022 to August 19, 2023, where a total of 4,651 kilograms was recorded. The maximum catch occurred in the month of January 2023, with 722 kilograms and the minimum in July 2023, with 190 kilograms. An increase is observed in the month of May of 406 kg, in June 434 kg, rising to 500 kg in August.

					CPUE		
		Capture. (KG)	Days of fish	Number of organizati on	Capture/ strike	Capture/ day	Capture/trap
Experimental phase	October	197.3	15	50	3.95	13.15	0.09
	November	207	10	31	6.68	20.70	0.17
Promotion fishing phase							
	December	447	14	51	8.76	31.93	0.292
	January	722	14	71.5	10.10	51.57	0.337
	February	650.5	15	63	10.33	44.86	0.344
	March	511.5	12	47.5	10.77	42.63	0.359
	April	385.5	10	41.5	9.29	40.58	0.31
	May	406	16	68	5.97	25.38	0.199
	June	434	10	59	7.36	45.68	0.245
	July	190	8	42	4.52	23.75	0.302
	August	500	12	64	7.81	41.67	0.52
		4650.8	136	588.5	7.90		

Table 1. Operational regime used in deep-sea shrimp capture, period 2022/2023.

POPULATION COMPOSITION

The specimens were between 100 and 250 mm in total length. The size frequency distribution of males is polymodal, with the mode centered around 185, 205, and 225 mm of total length. The low proportion of specimens with sizes smaller than 105 mm and larger than 140 mm stands out. In the case of captured females, they were distributed mainly at 195 and 255 mm. (Figure 6).

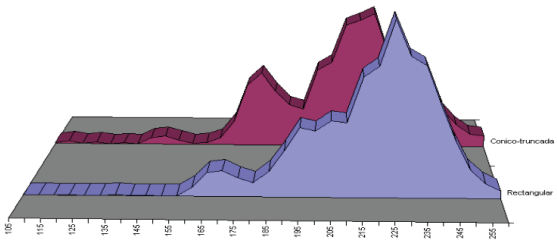

Figure 6. Size structures of white spot shrimp obtained in catches using the two types of traps (January-August 2023).

*Capture by trap type.*For the evaluation of abundance, the capture value per trap obtained in the rectangular design was used, since this was the model determined to be most appropriate for fishing this resource. It is considered that the CPUE obtained with this gear is representative of the abundance in the corresponding bathymetric fishing range and also in all areas around the northern part of the western coast of Baja California. Said CPUE is 7.9 Kg/line or 58 specimens/line of traps (Table 2).

Type of trap	Total capture (KG)	Number of silent traps	CPU (KG/trap)
Truncated troconic	207	2218	0.093
Rectangular	197.3	1198	0.165

Table 2. Relationship of the total capture with the type of truncated conical and rectangular trap.

Figure 7 shows the catches and average yield by type of trap in the experimental fishing of P. platyceros, according to the lunar effects, highlighting that in the new moon phase a CPUE of 190 (Kg/line) was obtained, while that in the third quarter of the lunar phase only a CPUE of 50 (Kg/line) was recorded. Likewise, in the full moon phase the CPUE was 70 (Kg/line).

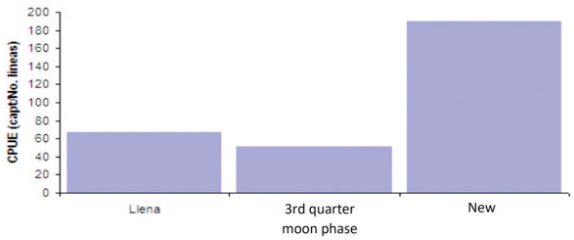

Figure 7. Yield in CPUE (Kg./line) of white spot shrimp and its relationship with the lunar effects obtained in the experimental phase (January and March 2023).

When comparing the average sizes of white spot shrimp, captured by depth range, they were shown to be statistically similar between 168 and 289 m. The averages determined at 107, 168 and 229 m, as well as at 351 m, are statistically different from each other and greater than those observed in the range 168 to 228 m. This shows that the largest specimens are distributed mainly over 290 m and below 351 m depth. At the depth of 168-228 m., 5.75 kg/l were observed. At the depth of 229 to 289 m., 2 kg/l were recorded. At the depth of 290 to 351 m., its result was 11 kg/l (Figure 8).

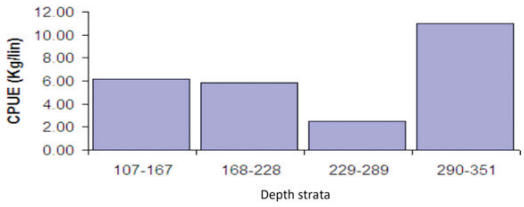

Figure 8. Relationship between catch per unit of effort (CPUE; Kg/line), and depth strata in trap fishing, period 2022/2023.

Figure 9 shows the accompanying fauna found. Another species of lobster (Munida quadrispina) appears, in relation to that reported in trawling cruises I and II, as well as a greater presence of octopus which, according to what has been investigated, is in high demand in the USA market. It is important to highlight the appearance of abundant juvenile hake (Merlucius productus). Another resource is the record of the lupon (Scorpaena guttata) of certain commercial interest, especially in the area of San Diego, USA. Other species of accompanying fauna are illustrated, highlighting the box crab (Lopholithodes foraminatus), the lingcod (Ophiodon elongatus) and the king crab (California king crab).

Figure 9. Accompanying fauna in shrimp fishing with traps in the study sites.

RELATIONSHIP OF SURFACE AND BOTTOM TEMPERATURE WITH THE CPUE OF DEEP-SEA SHRIMP TRAPPING

The average surface temperature measurements recorded in the fishing hauls showed a fluctuating behavior during the time that the fishing gear was kept in the water, showing a monthly variation from June to October between 17 ° C and 5 ° C. Likewise, a marked variation can be observed between the months June-July, where July was warmer than June, especially in the surface temperature, presenting records of 11 degrees Celsius and the month of July of 16-17 degrees Celsius. On the other hand, in terms of background temperature, an increase was recorded for the months of August and September, with temperatures above 10 degrees Celsius. Likewise, in the month of October the background temperature remains at 10 degrees Celsius, Figs. 10 and 11.

Figure 10. Relationship of surface and bottom temperature for the months June, July, August and September 2023 of trap fishing in deep-sea shrimp fishing.

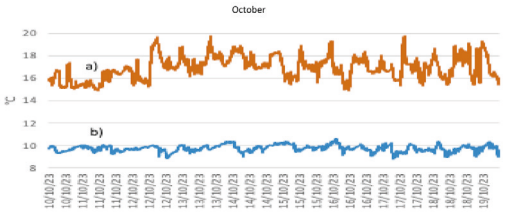

Figure 11. Relationship of surface and bottom temperature for October 2023 of fishing with traps in deep-sea shrimp fishing.

The monthly temperature measurements with Hobos and their relationship with the CPUE that are recorded are for the month of June, temperature of 8 ° C with a CPUE of 0.400 kg/trap. For the month of July the surface temperature was 14° C and the bottom temperature was 10 degrees Celsius with a CPUE of 0.5 kg/trap, in October the surface temperature record was 14° C and the bottom temperature was 9.7 ° C , with a CPUE of 0.5 kg/trap. With the data obtained from the temperatures and depths where the product was captured and that determines the trend of environmental variability of the average monthly SST compositions and its relationship with the background temperature in the study area. The relationship between bottom temperature, depth and CPUE is observed in fig. 12. Where it is observed that the bottom temperature fluctuated from 10-5 °C and the depth was 50-350 m. and the capture per unit of effort fluctuated between 0.4–0.5 kg/trap, showing a positive trend as the depth increased and the bottom temperature remained at 9.7 °C.

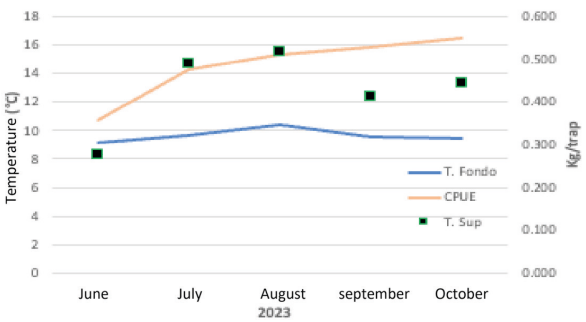

Figure 12. Relationship of surface and bottom temperature with respect to CPUE period June-October 2023 of fishing with traps in deep-sea shrimp fishing.

DISCUSSION

The presence of P. platycerus was first described by Flores et. al, (2005), in trawling and exploratory fishing operations carried out on the western coast of Baja California, the depth range in which this species was located was between 100 and 360 m. This pandalid is occasionally caught when fishing with traps and these are exceptionally set at more than 400 m depth. Fishermen who also sporadically carry out rockfish extraction operations in the lower San Quintín in Baja California indicate that specimens appear when they set traps at depths of less than 400 m.

This deep-sea pandalid is exploited with some intensity in various places around the world, for example, on the coast of British Columbia, 1,440 tons in 2003; in California, with 700,000 pounds in 2000 and 200,000 pounds in 2004; For its part, Japan records catches of 3,000 tons in 1993 and 4,000 tons in 2000; and on the coast of Alaska, catches of 2,000 tons in 1995 and 1,300 tons in 2003 have been recorded.

Despite the scarcity of information on this resource, the presence of P. platyceros in the waters of the extreme portion of Northwestern Mexico, off the coast of Baja California, suggests that a well-managed fishery could be carried out; some companion species (for example: Sicyonia ingentis and Crangon nigromaculata) are also of commercial interest despite having a more limited acceptance in markets. The information collected during the study, although imitated, allows defining a distribution zone of P. platyceros in the extreme north of the Mexican portion of the California Current zone. However, it is necessary to refine the sampling patterns, analyze the samples obtained in detail and increase their size.

Flores et al, 2022, making a comparison with respect to the CPUE temperature in the capture of the painted witch with traps on

the western coast of Baja California, it was observed that the records of the average values reported were as follows: month of August 16 ºC at a depth of 200 m, for the month of October the reported temperature was 15 ºC and a depth of 180 m. A CPUE was recorded with a direct positive relationship with cold temperature and an inversely negative relationship with warm temperature.

Flores et al, 2020 in longline tuna fishing in Islas Marías and placing the hobos on the last hooks found that, in the bottom temperature data in the study area, they fluctuated between the range of 20°C and 28 °C, demonstrating due to its significant statistical value (P>0.05) a thermocline in the study area, which is located between 80 and 100 m deep, being key for the capture of tuna with longlines as a good indicator of the presence of this fishing resource.

Taking into account the data from Flores et al, 2020 and Flores et al, 2022, the results of the present study show that the temperature and depth values are in a similar range, the only thing that differs is the CPUE value in kg/ trap, which fluctuated between 0.3-0.52 kg/trap having a lower biomass concentration.

Trap fishing yields obtained around the western coast of Baja California are in agreement with maximum and minimum values found elsewhere in both California and Alaska (Adkins, 1993). With the exception of the high CPUE determined off the coast of British Columbia, the capture range of pandalids of the genera platycerus and danae, recorded between 3.0 and 1.0 kg/trap. This places the value of 0.400 kg/trap determined in these experiences as a general average at an intermediate level. These values corresponded to the square traps (0.93 kg/trap) and the rectangular trap (0.165 kg/trap). The results prove that with the square trap there is a greater range than in the rectangular trap.

In the event that the exploitation of P. platycerus begins on this western coast, the results obtained allow us to foresee the absence of immediate problems associated with the conservation of this resource because the capture of females is relatively low, so it would not be necessary to protect this segment of the population. Furthermore, the white spot shrimp retained in the traps are large, possibly most of them with lengths greater than the corresponding length at first sexual maturity. About,Adkins, 1993, mentions that the California Fisheries Administrative Council uses the equivalent of 135 mm in total length as the minimum capture size for white spot shrimp in that area, which in the case of Baja California, Mexico, P. platycerus would correspond to more than 90% of the captured specimens meeting said minimum size.

As a point to highlight in the temperature trend, it is recommended to use greater effort at temperatures between 14-16°C, in order to obtain the highest biomass concentration, since the CPUE values at depths of 50-150 m. They fluctuated between 0.4-0.52 kg/trap.

CONCLUSION

Fishing for white spot shrimp with traps is technically and economically feasible between 50-350 m depth ranges, particularly using traps. Something that adds to this statement is that the market-destination of P. platycerus is to consume it alive. With the trawling capture method, the target catch only survives 40% and with trap fishing 97% survives.

In relation to the background temperature, it fluctuated from 16-5 C°. with depths between 50-350 m; CPUE fluctuated between 0.300–0.500 kg/trap, having a negative trend as depth increases. The optimal range of CPUE and depth values in relation to temperature ranged from a depth of 50-150 m, a bottom temperature between 9-10 C° and a CPUE of 0.4-0.5 kg/trap.

Regarding the bait, in the experimental

phase it was observed that the chopped sardine presents a significant difference in yields. Other bait alternatives can be used such as pieces or viscera of other fish such as hake, mackerel and anchovy. Another alternative is the use of chopped and salted bait, which allows it to be kept for a longer period of time in the warehouses and facilitates storage in times when bait is scarce.

The hauling operation time for a line of 42 traps lasts on average about 30 minutes under normal conditions, that is, approximately 1.4 minutes per trap.

As a first capture horizon, a total of 200-250 tons/year could be defined, which would represent a landing equivalent to 25% of the total calculated biomass of this resource, which would have a positive impact on the island economy and directly benefit fishermen dedicated to the extraction of this new resource.

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