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Management implications of a coconut crab *(Birgus latro)* removal study in Saipan, Commonwealth of the Northern Mariana Islands.

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Abstract—Coconut crabs *(Birgus latro)* were removed from an area and relocated as a form of mitigation to off set land clearing activities. It was found that a 3.3 ha area could be cleared of crabs in a four night period using standard crab hunting techniques and that the area stayed clear for 15-20 days but was fully repopulated within a three month period. Density calculations estimated a population of 16 crabs/ha in secondary forest habitat. Morphometric data and CPUE rates showed that Saipan's coconut crabs are small in size and consistent with a severely overharvested resource.

Introduction

The coconut crab *(Birgus latro)*, is found throughout the western Pacific and eastern Indian Oceans and appears to be mainly restricted to islands. Closely related to hermit crabs, it does not require a mollusk shell for protection as an adult. It lives a purely terrestrial existence scavenging in the forest, only returning to the ocean to release its larvae (Amesbury 1980, Fletcher et al. 1991). Older crabs usually have an established burrow and presumably an established territory. Coconut crabs can grow large, to 4kg, and ages in excess of 40 years have been suggested (Fletcher et al. 1991). Like all crabs it must periodically shed its exoskeleton. This is done underground and can last a month or more. They have been found to be diurnal on islands with no human occupation and nocturnal on islands with humans (Reyne 1939, Fletcher et al. 1991).

Due to the excellent quality of the meat, coconut crabs are gathered for consumption throughout their range and are an important natural resource. They are easily caught by hand and require no specialized equipment. These qualities have resulted in adverse impacts on populations near developed areas (Amesbury 1980, Wells et al. 1983, Fletcher et al. 1991, Schiller 1992). Crabs are gathered not only for recreational and subsistence reasons, but for commercial purposes as well and is thus a special concern to wildlife managers. This has prompted some wildlife agencies to try various management techniques based on established methods for other resource species. Specific management tools and goals for coconut crabs are deficient though, and good scientific data is lacking. Many have looked at the feasibility of raising crabs, but this seems improbable due to the querulous nature of the crabs and the long period required reaching a harvestable size.

In the Commonwealth of the Northern Mariana Islands (CNMI) the coconut crab or ayuyu, is an important food species and has both an economic and cultural significance. Over-harvesting, coupled with habitat loss, is believed to be severely impacting this population. Currently the CNMI – Division of Fish & Wildlife (CNMI-DFW) requires a license be obtained and harvest regulations adhered to. Legal hunting can only take place between 1 September and 30 November, with a legal size of 3 inches across the back (cephalothoracic length of 76 mm), a 5 crab bag limit, and a 15 crab season limit. Additionally no female crabs with eggs may be taken. Unfortunately, enforcement is difficult and poaching is chronic. As a result crabs are continually gathered year-round regardless of size or sex.

In 1996 a project was undertaken to remove coconut crabs from a five hectare plot as a form of mitigation for an expanding rock quarry on the island of Saipan. The land was leased by Hawaiian Rock Products Obyan Quarry. Their original land clearing permit stated that the area in question was an important molting ground for crabs. This sentence was added by previous DFW biologists probably based on information gained from local crab hunters during the initial biological assessment. Following consultation with the CNMI – DFW, the company agreed that the removal and transplanting of this valuable resource would be attempted and that information on population characteristics would be recorded to help future biologists manage this species.

Study Area

Location

The removal plot was located in the Commonwealth of the Northern Mariana Islands on the island of Saipan, in the area of Naftan Point on the south end of the island (15º 06' N 145º 45'E).

The study area's outline and location were dictated by the legal boundaries of quarry's leased land agreement. The parcel of land was a rectangular area of five hectares orientated in a northeast to southwest direction. A paved country road with tangan-tangan *(Leucaena leucocephala)* forest on the opposite side defined the northeast boundary. The rock quarry occupied the full length of the southeast boundary. The southwest side bordered on to a remote section of the Naftan Point Conservation Area. On the northwest boundary was an identical five ha parcel covered with tangan-tangan. Over the years the rock quarry's operations had encroached on some sections of the study area, while leaving others wild. The result was that the southeast side was irregular. This left a rough rectangle with an average length of 400 meters and a width of 125 meters. Furthermore, a slag pile of clay occupied a substantial area in the southeastern most corner. This pile covered approximately 1.7 hectares and was 15 meters in height. It was considered not suitable habitat for crabs or other wildlife.

Topography

Topography of the removal plot consisted of a low flat area in the northeast gradually rising until it became a sloping limestone cliff or ridge, which rose approximately 15 meters. On top of this ridge the land flattened out again and continued on a level plain. The ridgeline ran northwest/southeast and bisected the 5-ha plot into approximately two equal halves. On the high ground, near the cliff edge, were numerous limestone-karst outcrops (to 4 meters high) containing many holes and crevices. These outcrops were more abundant close to the ridgeline and became less in number until absent as the distance to southwest increased.

Vegetation

On the ridge and above (the southwest 2.5 ha) the habitat consisted primarily of introduced secondary forest with trees averaging less than 12 inches (<30 cm) in diameter at breast height (d.b.h.), but larger than or equal to 5 inches (>12.5 cm) in d.b.h., with a medium crown closure of main canopy between 30 and 70 percent (Falanruw 1989). Ground cover was largely absent with no understory. Tangan-tangan tree *(Leucaena leucocephala)* was the predominate species with a few scattered native *Ficus* species. Below the ridge (northeast 2.5 ha) the habitat was recently disturbed from over-grazing by cattle and supported an understory of Lantana *(Lantana camara).* This understory formed a thick barrier from ground level to about 3 meters in height. The tangan-tangan crown closure was below 30 percent. This section had only about 0.8ha of habitat due to the encroaching 1.7 ha of the quarry's slag pile.

Methods

The plot was divided into ten transects 40 m apart and bait in the form of coconuts was set at 20 m intervals for a total of 49 coconuts. Bait was checked at night (beginning at about 2200 hours) and coconut crabs were captured and removed from the area. The complete survey took up to three hours when done by one person, depending on the number of crabs encountered. Surveys occurred during all moon phases and during rainy and dry conditions.

Baiting

Whole coconuts were brought to each station where they were notched on three sides with a machete to provide a secure hold for the wire. They were wired onto a rock or tree and an opening would be punched through the coconut meat exposing the milk. It is desirable to leave as much liquid in the coconut as possible. This small hole was big enough for a crab to just reach the coconut meat with one claw, allowing the scent to escape, but preventing the crab from quickly eating the contents. A three-person team could bait the entire site in four hours. The coconut bait would last one to two weeks depending on the season. We replaced coconuts as needed. Baiting stopped after the last July survey and resumed again

in early October. Baiting techniques had changed slightly between surveys. The June/July surveys used aged coconuts that were opened away from the site and allowed to ripen, then brought to the site and wired on station and filled with liquid. For the October survey, fresh coconuts were wired directly to the station and opened retaining the liquid inside. This greatly reduced the amount of effort needed to bait the area.

Search Period

Initially, we attempted the June/July surveys to experiment with techniques and establish a protocol. After the initial three surveys crab capture rates neared zero and were restricted predominately to edge stations, the area was then considered cleared although surveys continued for an additional three nights and then stopped. No baiting was conducted until word was received from the landowner in October that clearing operations would start shortly. The result was that surveys were performed in two separate monthly periods, with six surveys completed in June/July and five surveys in October.

Measurements

Crabs were weighed to the nearest five grams using a 500-g Pesola spring scale. Measurements in millimeters were taken using standard calipers. Length was measured as the cephalothoacic length and did not include the rostrum (CTL-r). This measurement was across the back, from the eye grove beside the rostrum to the posterior border of the thoracic groove. Cephalothoracic length is the CNMI-DFW measurement to determine the legal size of a crab. Width was a straight-line measurement to the nearest 0.5 mm using a caliper. It was the widest point from gill cover to gill cover without bending the shell. These data were documented by station for each crab.

Disposal

Crabs were confined overnight. Once morphometric data was recorded, the crabs were then transported to either the Marpi Commonwealth Forest or to Kagman Conservation Area and released. Five crabs were retained for telemetry and PIT tag experiments. Ten crabs died while in captivity from wounds inflicted by other crabs.

Results

A total of 107 coconut crabs were caught and removed from the plot. The June/July period produced a total of 57 crabs, and the October period had a total of 50 crabs. Only eight crabs were over the CNMI legal size (CTL-r) of 76 mm; 77 were in the mid-size group (50–74 mm) and 22 were in the smallest size class (25–49 mm). Of the captured crabs 92 survived to be released into public conservation areas. The total project required approximately 250 man-hours.

Catch Per Unit Effort

Catch Per Unit Effort or CPUE is an estimate of relative density defined as the number of crabs caught on a transect as a proportion of the number of baits set (Fletcher et al. 1991).

CPUE's in this study are based on nine survey nights of 49 coconuts each or a total of 441 coconuts checked throughout the survey. For the whole survey a total of 107 crabs were caught for 441 coconut baits set. This equates to CPUE = 0.24. This is for nine survey nights over a period from June to October. For the June/July surveys, CPUE = 0.23;, for the October surveys CPUE = 0.24. Legal size crabs (>76mm) comprised only 7% of the catch when looked at separately, and had a CPUE = 0.02.

Density

Crabs caught for the period of June/July totaled 57 crabs for about 3.3 hectares or an average of 17.3 crabs/ha. For the October period a total of 50 crabs were caught or 15.2 crabs/ha. If averaged together the density for mixed habitat on Saipan is about 16 crabs/ha.

Density by Habitat

The plot can be further broken into two separate habitat types. One habitat type consists of 2.5 ha of homogeneous secondary growth, primarily tangan-tangan *(Leucaena leucocephala).* The crabs per hectare for this habitat type were 19.2 crabs/ha for June/July and 16.4 crabs/ha for October or 18 crabs/ha average. The second habitat type found on the plot was disturbed tangan-tangan with an understory of lantana. This habitat accounted for about 0.8ha of the plot (this section included the 1.7 ha of slag pile). The crab densities for this section were 8.8 crabs/ha for June/July and 11.3 crabs/ha for October for an average of 10 crabs/ha.

Morphometric Data

Crabs caught had a cephalothoracic length (CTL-r) that ranged from 35.5mm to 83.0mm or thoracic length (TL), using Helfman's (1973) conversion factor (TL x 2.1 = CTL-r), of 16.9mm to 39.5mm. Crabs were found to be nearly symmetrical in their cephalothoracic length vs. carapace width measuring an average length of 58.8mm and an average width of 59.7mm. Only six crabs had a difference between the two measurements greater than 5 mm, the greatest difference being 14 mm. The weight range was from 40g to 520 g and the average weight was 188.1 g. Females outnumbered males 5:2. Males had a slightly greater average cephalothoracic length at 62.2 mm (TL = 29.6mm) as compared to 57.4 mm (TL = 27.3) for females. Only one female with eggs was found on 8 June.

Discussion

Implications

On Naftan point, Saipan, it was found that in tangen-tangen habitat there is about 16 crabs per ha and that 93% of the crabs were under the legal size limit (CTL-r = 76 mm, TL = 36mm, or 300g). These figures when compared to different island studies reflect a severely harvested population. Unharvested populations or those with a low exploitation history have recorded densities of 300/ha Diego Garcia, BIOT (pers. comm. S.Vogt), 190/ha Taiaro Atoll, French Polynesia (Chauvet & Kadiri-Jan. 1999), and 142/ha Igurin Islet, Marshall Islands (Helfman 1973) and 85 % of the population above a CTL-r = 76mm. It should be noted however that the densities for unharvested populations are from atolls; the raised limestone island of Saipan may not be able to support as large a number of crabs as habitat on atoll islands. A survey of an unharvested population from the Marianas is needed to better determine the status of the Saipan population. This might be accomplished on Guguan or Asuncion Islands, though these are volcanic islands in the Marianas. On similar limestone islands with heavily harvested populations, densities of 28/ha for Loyalty Islands, New Caledonia (Kadiri-Jan 1995) and 46/ha for Niue, New Caledonia (Schiller 1992), are recorded. Although this is closer to what was found at Naftan Point, it is still indicative that the Saipan population is overharvested. When the average sizes of the different populations are compared (Table 1), it again points to Saipan as severely overharvested. Additionally the CPUE of 0.24 found on Saipan is at or below CPUE's recorded in Vanuatu for heavily harvested areas (Fletcher et al. 1991). These three factors support the current thinking that Saipan's coconut crab resource is in trouble and requires stronger and better laws and management practices to be implemented in order to continue harvesting.

Table 1. Comparison of the average thoracic length (TL) in mm and harvest history for *Birgus latro* on different islands.

Location	Male Average TL	Female Average TL	Harvest history	Citation
Marshall Is.	44.5	34.5	none	Helfman 1973
Vanuatu Is.	53.3	36.8	none	Fletcher et al. 1991
French Polynesia	46.7	40.2	none	Chauvet &Kadiri 1999
Christmas Is.	46	na	none	Schiller 1992
Vanuatu Is.	45	37.4	light	Fletcher et al. 1991
Vanuatu Is.	39.9	30.2	medium	Fletcher et al. 1991
Niue Is.	32.5	26.9	heavy	Schiller 1992
Vanuatu	35.9	30.2	heavy	Fletcher et al. 1991
Saipan	29.6	27.3	heavy	This study

Removal

It appears that the 3.3 ha area (excluding the 1.7 ha slag pile) was effectively trapped out in the first two nights of the survey, 6 & 8 June. The 10 June survey returned no crabs and the 12 June survey caught four crabs on edge stations. When resurveyed 18–23 days latter (30 June – eight crabs, and 5 July – two crabs) the area still was relatively clear of crabs, but migration into the area was documented by captures along the edge stations. During the second period in October we saw a slightly different pattern. The first three nights of trapping produced 50% of the crabs and the fourth night produced 44% of the total. The last night with 6% is ignored for evaluation purposes due to the start of construction. The reason for the large capture on the fourth night is unknown, but weather conditions could be a factor. Wind strength and direction might have shifted dispersing the scent over a broader area. Also the CPUE for the edge stations was much higher on the fourth night suggesting that most of the crabs were migrating into the area. The total of 50 crabs caught during the October period shows that the crabs had fully re-colonized the site in a little over three months.

Migration into the area was not included for density calculations. The reasoning for this is as follows; it is assumed that the crab population is largely in a state of continual migration. Although large crabs might have an established burrow, the smaller crabs, of the size mostly encountered in this project, are continually moving looking for a better burrow in a core area. This pattern is suggested by observations of Fletcher et al. (1990) and Helfman (1978) and also by my own work with telemetry with the Naftan point population of crabs (unpublished). If this is true then some crabs that use the plot will be off the plot at any given time and will be caught on the edge stations as they return. Other crabs that are new to the plot will also be caught on these edge stations. Since this particular plot did not have migration from two sides (the developed sides, shown by lower CPUE's along these transects). It was assumed that any new migration into the area only made up for those crabs that would have naturally overlapped with the two developed sides boundaries. In other words the two forested sides allowing migration into the area were canceled out or made up for the two sides with no migration. Thus the total crabs caught were used for a general density calculation for the project area.

If the CPUE = 0.24 crabs, then theoretically four coconuts are needed to catch one crab. With a density of 16 crabs/ha, it would require 64 coconuts to clear 1 ha of all crabs in one night. This number of coconuts might prove impractical when dealing with large areas. In this study, the area was baited with about 16 coconuts per ha and the entire area was cleared in 2–4 nights. Therefore it is proposed that a minimum of 16 coconuts per ha, spaced 20 meters apart and checked for at least four nights be applied when clearing areas of crabs. This would vary due to weather conditions, habitat, and terrain and should be used only as a minimum general guideline. The removal of crabs in such a manner would be good for 15–20 days after which time another removal survey should be required if land clearing activities have not begun. Using these guidelines, man-

agement agencies in the Marianas could be relatively confident of conserving this important resource from being destroyed during development and would be able to calculate a monetary value based on man-hours and hourly wage to charge land development agencies in order to fund this type of mitigation action.

Relocation

The introduction of displaced crabs into a new area is thought to have no substantial negative effect on either the resident crabs or the introduced crabs. Although crabs can be highly antagonistic to each other and large crabs will occasionally capture and eat smaller ones, they have developed ritualistic displays to avoid such encounters (Helfman 1978). Telemetry studies (Fletcher et al. 1990, Kessler unpublished data) have shown that relocated crabs are not killed and move until they apparently find a suitable site. Radio-telemetry studies have also indicated that smaller crabs are more likely to disperse than large crabs (Fletcher et al. 1990), which suggests that dispersal of crabs throughout an area is a normal condition. Helfman (1973) believed that coconut crabs are generally nomadic but will establish a residence if conditions are favorable. In addition, the densities found on Saipan are well below densities found on other islands and believed to be indicative of a severely over harvested population suggesting that there is sufficient unoccupied habitat for displaced crabs. This evidence supports the management practice of relocating crabs to conserve the resource.

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