Traps as a Survey Tool for Animal Density

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ABSTRACT

Las nasas es un arte atractivo para el muestreo por muchas de las mismas razones que son un arte atractivo en la pesca. Estas pescan solas, pueden estar distribuidas a lo largo de un gradiente amplio de profundidades, pescan lomismo en fondos rocosos que en fondos blandos, así como desde botes pequeños o grandes, no son caras, son durables y las capturas se mantienen vivas. La limitación en el uso de nasas para estudios sobre abundancia de una especie en particular estriba en los múltiples factores que afectan la tasa de captura, como por ejemplo, escape de los peces, tamaño de las nasas, número y sitio en donde se pone la entrada a la nasa, cantidad de la carnada, la calidad de ésta, el tiempo en que la nasa se mantiene sumergida, el sexo del animal en cuestión, su tamaño, depredadores en la nasa, fase de la luna, velocidad de la corriente y temperatura. El biólogo puede estandarizar su muestreo para algunos de estos factores pero no para otros. La calibración de las nasas referente al área efectiva de pesca por peces y dec podos, ha fluctuado de cerca de 100 a 4,000 metros cuadrados. En los pocos estudios que se han hecho sobre abundancia absoluta de animales en relación a las tasas de capturas por las nasas, no se han encontrado buenas correlaciones estadísticas entre las mismas.

INTRODUCTION

Traps are the principal commercial gear in most Caribbean reef fisheries and in most crab and lobster fisheries worldwide. They are convenient for evaluating animal density because they:

1. Fish unattended.
2. Fish a large area per unit of effort.
3. Can be handled from large or small boats.
4. Are inexpensive and robust.
5. Are suitable for most bottom types.
6. Can fish over the depth range of the resource.

The catch is usually live (Miller and Hunte, 1987). Limitations of traps as survey tools are:

1. Effort must be calibrated to convert catch rates to indices of absolute animal density.
2. Numerous factors other than density affect catch rates.

This paper reviews common methods for measuring animal density on rough bottoms, trap effort calibrations, and factors affecting catch rates. Most target species were lobsters or crabs and a few were demersal fish.

METHODS OF MEASURING ANIMAL DENSITY

Visual Enumeration

Methods of surveying fish on coral reefs have been reviewed by Sale (1980). Diving offers the advantages of identifying species, searching under cover, and measuring accurately the area surveyed. Disadvantages include depth limitations, a maximum survey area of a few thousand square meters per diver day, fish sizes can only be approximated, and many species are either too cryptic or too active to be counted accurately.

Recently, Miller and Hunte (1987) described a method for counting demersal fish on coral reefs with low relief. A preliminary survey is used to categorize species as:

1. Cryptic, to be counted with a "slow" method.
2. Easily counted, to be counted with a "quick" method.
3. Uncountable.

Most species were in the last category either because they were too cryptic or because they entered the study area only at night. Even for the first two categories, the diver's judgment on the completeness of his counts was the only protection against bias. Photography or television are limited to exposed species and equipment can be expensive to purchase and operate. Elner (1986) reviewed visual survey methods with several examples of their application. Poisoning is limited to very small areas (Brock, 1982) and may be opposed on conservation grounds.

Mark-Recapture

A mark-recapture study (Morgan, 1974a) using baited traps for Australian rock lobster is instructive. Density on a limestone reef was estimated for 34 of 38 successive months by both single and multiple mark-recapture methods. Both methods relied on trapping for marking and recapturing. Diver counts of the true ratio of marked to unmarked animals on the reef showed that marked animals were 1.6 times more vulnerable to trapping. As a consequence, the multiple mark-recapture methods would have underestimated density by an average 37 percent if results had not been corrected for unequal probability of capture. Because of violations of the assumptions that animals were captured with equal probability, a single population was being sampled, and the population was closed, the single mark-recapture method underestimated density by an average 44% for 10 months of the year and overestimated density by 150% for 2 months of the year.

Fishing Success

Leslie and DeLury fishing success methods (Ricker, 1975) have also given low estimates of population size in trapping studies. These methods use catch per trap and cumulative catch or cumulative effort to estimate population size at the start of fishing. In the above study, Morgan (1974a) found that the DeLury method underestimated the number of lobsters by 75%. Morrissy (1975) conducted controlled experiments using hoop nets on the marron, a freshwater decapod, in a 0.01 hectare pond. He found that the Leslie method underestimated true population numbers by 61%, 47%, and 53% in different months. True numbers were obtained by direct counts after draining the pond. The biases were again due to unequal vulnerability of animals to capture, i.e. catch rates decreased faster than population size because the most vulnerable animals were caught first.

In two studies, traps were fished at a range of distances to calculate areas of attraction. Eggers *et al.*, (1982) fished minnow traps for small sculpins and Sinoda and Kobayasi (1969) fished large commercial traps for spider crabs. The radius of attraction was estimated by increasing spacing to a distance where catches no longer increased. This was the distance at which fishing areas did not overlap. The radius was then used to calculate the circular area fished by a trap. This method included two unlikely assumptions:

1. That the area of attraction was circular.
2. That 100 percent of the target species was captured from within the area.

These concepts are discussed below.

Traps can also be calibrated for the catchability coefficient (q) (Chittleborough, 1970), also referred to as the effective area fished (Miller, 1975). This is simply the ratio of catch per trap (C/f) and animal density (D) with units as shown:

$$q = \frac{C/f}{D}$$

Where $q = m^2$ per trap haul
C/f = number animals per trap haul
D = number animals per m^2

This differs from the usual definition of catchability in that D and q include area dimensions instead of the usual stock size and fraction of the stock taken by a unit of effort respectively. The catchability coefficient is estimated by measuring density directly (as by diver counts) followed by fishing traps in the same place. Subsequently, depending on the robustness of the estimate, q can be used to convert trap catches to absolute animal density for other times and places. Note that q is not the actual area fished as this would require that 100 percent of the target species be captured from inside and none from outside the area. In fact, a measurement of q reveals little about the distance or direction animals travel to enter a trap. For a baited trap placed in a current, the probability of capturing an individual would be distributed approximately as shown in Figure 1. Random movements of animals independent of the bait odor plume would alter this pattern.

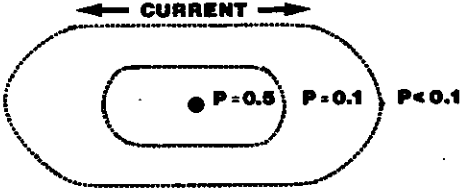

Figure 1.

Table 1 lists maximum and minimum estimates for the catchability coefficient. The large values for the spider crab, *Chionoecetes opilio*, are from depths of about 200 m on flat mud bottom; whereas the other studies were all in depths of < 12 m on limestone reefs or on boulder strewn bottom. Note that the ranges are not small for any study.

Table 1. Catchability coefficient (q) in a m²/trap.

Species	Size	q	Source
Panulirus cygnus	> 3 cm cl	25-174	Chittleborough (1970)
Panulirus cygnus	> 5 cm cl	40-200	Morgan (1974b)
Chionoecetes opilio	> 9 cm cw	2500-5300	Miller (1975)
5 taxa of tropical reef fish	> 10 cm to > 20 cm fl	140-350	Miller & Hunte (1987)
Cancer irroratus	> 8 cm cw	210-580	Miller (unpublished)

CORRELATION OF CATCH/TRAP AND ANIMAL DENSITY

For the studies referenced in Table 1, correlations between density and trap catches range from good to poor.

Over five years in one to three locations, Chittleborough (1970) determined density of juvenile rock lobsters by a mark-recapture technique, then measured catch per trap at a standard soak time, moon phase, and month (so temperature and stage in the molt cycle would be constant). Even with this standardization, only 26 percent of the variation in density was explained by variation in catch per trap ($n = 9, r^2 = 0.262$).

Morgan (1974a,b) also determined juvenile rock lobster density using multiple mark-recapture techniques as discussed above and measured catch per trap. Soak time and moon phase were standardized. The correlation between catch rate and density was good ($r^2 = 0.74$), although their ratio, the catchability coefficient, was far from constant (range: 38-196 m², c.v. = 38%). Bottom temperature, salinity, and percentage of the catch in a premolt condition were all significantly correlated with the catchability coefficient, illustrating the potential for reducing its variation by adjusting for these factors.

Miller (1975) determined spider crab density, using bottom photography and catch per trap in four locations. The two variables were not correlated ($r^2 = 0.1$), although the ranges of both were small.

Diver counts of squirrelfish (*Holocentrus ascensionis*) in 30 x 30 m areas of coral reef were highly correlated ($r^2 = 0.79$) with catches in traps placed in the center of each area (Miller and Hunte, 1987). However, densities and catches of the wider ranging coney (*Cephalopholis fluva*), angelfish (Chaetodontidae), surgeonfish (Acanthuridae), and parrotfish (Scaridae) were not correlated on this spatial scale.

Rock crabs (*Cancer irroratus*) were censused by divers and fished with two types of traps in each of two areas in Nova Scotia (Miller, unpublished). Densities in the two areas were 600 and 233 crabs/hectare whereas corresponding catches in top entry traps were 20 and 13, and in side entry traps were 13 and 7 crabs per trap. Thus, catch and density were in fair agreement.

Catch rates and densities are often poorly correlated because so many factors affect catchability. The large amount of literature on these factors concerns mostly decapods. Many of these influences are summarized in Figure 2 and the following discussion briefly reviews some of the papers.

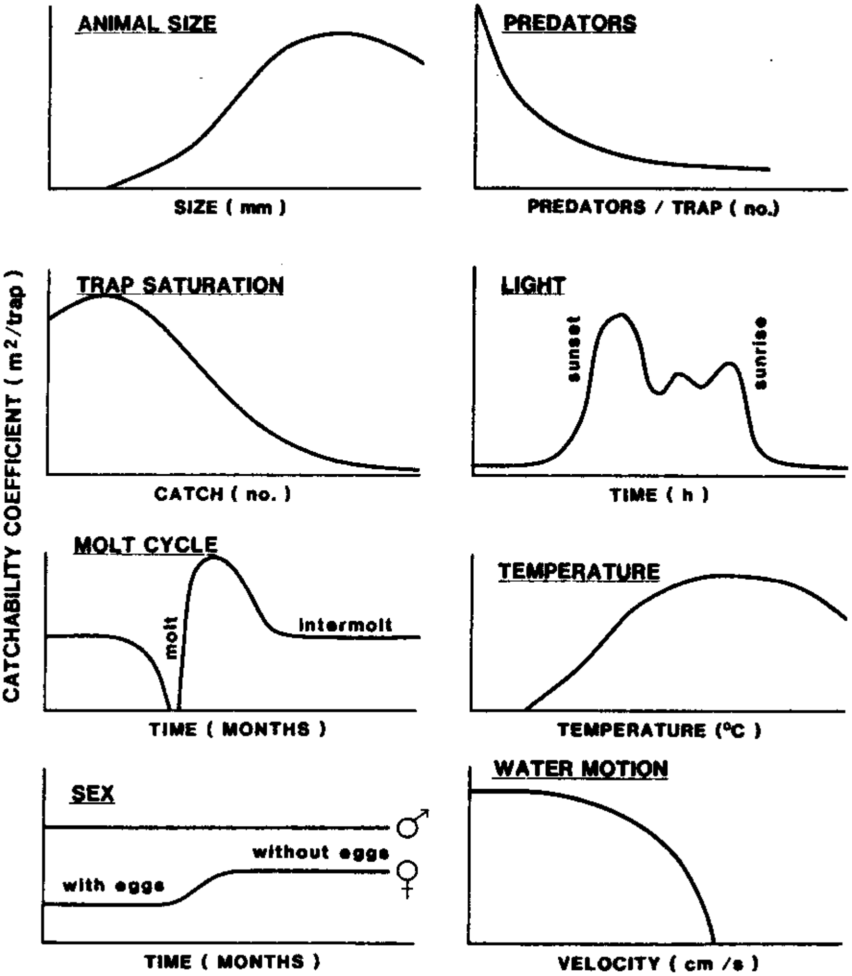

Figure 2.

Animal Size

Catchability of marron increased by a factor of 10 over a fourfold increase in size (Morrissy and Caputi, 1981). Also, Morgan (1979) showed that the largest rock lobsters were under-represented in trap catches relative to diver counts.

Trap Saturation

It is well established that catch/trap is asymptotic with time. Munro (1974) attributed this to a balance between a constant rate of entry and a constant percentage escaping for coral reef fishes. Miller (1979) explained it as a decreasing rate of entry with increasing catch for crabs. That is, crabs in the trap were a deterrent to the entry of additional crabs. In the above studies, saturation reduced catches per trap by greater than one-half during soak times typically used in commercial fisheries.

Soak time

If the bait remains attractive and if catches are not limited by saturation, then catch will increase with soak time. Studies by Bennett (1974), Munro (1974) and Miller (1983) are among the many examples.

Molt cycle

Catchability reflects appetite and drops to near zero in premolt and rises rapidly in postmolt for rock lobster (Chittleborough, 1970) and marron (Morrissy and Caputi, 1981).

Sex

For *Homarus gammarus* Brandford (1979) states that "Average food consumption in the laboratory is in the ratio of 3 (male): 2 (unberried female): 1 (berried female) and it is therefore probable that average catchability in baited traps will be in a similar ratio". Sex ratios of diver caught and trap caught rock lobsters were the same for smaller juveniles, but larger juvenile females were under-represented in trap catches (Morgan, 1979).

Animal movements

Individuals of the target species may have a range larger than the survey area. For example, density and catch rates of parrotfish were not related within 30 x 30 m survey areas, but were related when averaged over large Barbados patch reefs. Also grunts dispersed over the reefs being surveyed and entered traps only at night (Miller and Hunte, 1987).

Predators

Richards *et al.* (1982) stocked traps with either zero, three or eight American lobster and found that the presence of this natural predator caused 47—87% reductions in catches of both *Cancer irroratus* and *Cancer borealis*. Chittleborough (1974) found that octopus, which entered traps naturally, reduced the rock lobster catch by one-half.

Light

Both lunar and diurnal cycles affect catchability. Fishermen's catches of *Panulirus sp.* were higher at new moon than at full moon (Sutcliff, 1956; Chittleborough, 1970; Morgan, 1974a), whereas trap catches of reef fish peaked on both new and full moons (Munro *et al.*, 1971). Activity of decapods peaks near dawn and dusk or is simply higher during night than day (*e.g.*, Chapman *et al.*, 1975; Kubo and Ishiwata, 1964).

Temperature

Catchability has been shown to increase quite considerably with temperature for several species; *e.g.*, American lobster (McLeese and Wilder, 1958), European lobster (Branford, 1979) and rock lobster (Chittleborough, 1970; Morgan, 1974b). Probable causes are temperature related locomotor activity and appetite, and greater rate of diffusion of bait molecules (Morrissy, 1975).

Water motion

Near bottom current speeds greater than about 25 cm/s would effectively restrict movement of European lobsters, including response to bait odor. The critical velocity for wave induced water motion would be even lower because reversal of direction every several seconds would defeat a lobster's posturing intended to minimize current drag (Howard and Nunny, 1983). These authors concluded that there are few, if any, British coastal areas where water motion does not affect lobster behavior for a substantial portion of the time.

Traps and bait

Trap shape and size, and bait type and amount are obvious variables affecting catch rates (Munro, 1974; Miller, 1979).

The foregoing is a rather discouraging discussion of how catch per trap is often an unreliable index of abundance of the target species. It also raises the question of the accuracy of catch per unit effort statistics used for monitoring a fishery. Although the sample size and the range of environmental and biological conditions included in such statistics are usually large, these do not necessarily provide protection against bias. This question deserves an ongoing critical review.

CONCLUSIONS

1. Where possible visual counts should be used for censusing a population.
2. Mark-recapture and fishing success methods (Leslie and DeLury) usually underestimate decapod abundance.
3. As many relevant factors as possible (temperature, stage of molt cycle, stage of reproductive cycle, moon phase, soak time, trap design, bait) should be standardized if trap catches are to be used as indexes of abundance.
4. Even the most careful survey design using traps may provide only a gross index of animal abundance because some factors affecting catch rates are unknown or uncontrollable.
5. Most catchability coefficients measured to date for traps are of the order of hundreds of square meters.
6. The monitoring of fish stock size with statistics on catch/trap deserves ongoing critical assessment.

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