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IN-SITU OBSERVATIONS ON THE SMALL-SCALE DISTRIBUTION OF JUVENILE SQUIDS (CEPHALOPODA : LOLIGINIDAE) ON THE NORTHWEST FLORIDA SHELF

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CEPHALOPODA
SQUID
LOLIGO
SUBMERSIBLE
VIDEO
DISTRIBUTION

ABSTRACT. — We examined 38 hours of videotapes recorded with a remote-controlled submersible at about 60 m depth on the northwest Florida continental shelf. Juvenile squids were among the most abundant organisms identified on the tapes. The larger individuals were identifiable as *Loligo* sp. Whereas behavior typical of obligate schooling was seen in adult *Loligo* in the tapes, the juveniles seldom were aggregated on a small scale (metres) and did not often appear to "orient" together. Consistent variability was noted, however on a larger scale of hundreds of metres. Variability in numbers of sightings along standardized sections of transects was usually independent of the total number of sightings per transect. Thus, as abundance increased, relative variability decreased. The juveniles seemed to be most abundant very near the bottom at night but were rarely seen during the day. While there are many advantages in working with videotaped observations from submersibles, problems remain to be resolved. These problems include standardization of submersible operation among different operators, identification of specimens, determination of size, and estimation of sightings per unit of effort.

CÉPHALOPODES
CALMAR
LOLIGO
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VIDÉO
DISTRIBUTION

RÉSUMÉ. — Nous avons examiné 38 heures de bandes vidéo enregistrées à bord d'un submersible téléguidé à une profondeur de 60 m sur la partie nord-ouest du plateau continental de la Floride. Les Calmars juvéniles figuraient parmi les organismes les plus abondants identifiés sur les bandes. Les plus grands individus ont pu être identifiés comme *Loligo* sp. Le comportement typique de la vie en banc des *Loligo* adultes a pu être observé, mais les jeunes ne montrent pas ce comportement grégaire, du moins pas dans un espace restreint (mètres). Les jeunes semblent être plus abondants près du fond pendant la nuit; ils ont été rarement vus pendant le jour. La méthode de travail, utilisant l'enregistrement sur bandes vidéo à partir d'un submersible téléguidé offre certains avantages, mais bien des problèmes restent à résoudre.

INTRODUCTION

Cephalopods do not undergo a true metamorphosis (Boletzky, 1974), but during development they do experience a change in ecology (Vecchione, in press) which is correlated with morphological changes (Vecchione, 1981 ; 1982). For loliginid squids, one aspect of this ecological change is the shift from the planktonic lifestyle of the early juveniles to the social structure of the adults, which are schooling demersal nekton.

Field studies using traditional methods have not successfully elucidated this shift in loliginid behavior because it occurs at a size range at which the squids are large enough to avoid plankton nets, yet small enough to be extruded through the mesh of a nekton trawl. Furthermore, even very brief tows with either type of gear cannot be used effectively to distinguish distributional patterns on spatial scales of metres to hundreds of metres.

An approach to rectify this problem is direct observation, *in situ*. SCUBA has been used successfully to observe the behavior of cephalopods (e.g. Hanlon *et al.*, 1979; Griswold and Prezioso, 1981), but is of limited use for surveying distribution and relative abundance because of decompression requirements and limited mobility. Submersibles are particularly appropriate for such a study because they do not have the time-at-depth limitations of SCUBA. Observations on cephalopods from manned submersibles have been published (Waller and Wicklund, 1968) but are limited in number.

We analyzed squid occurrence and distribution in 38 hours of videotapes recorded by a remotely operated submersible on the northwest Florida continental shelf. This project allowed us a first look at the small-scale distribution of juvenile loliginids, as well as an opportunity to assess the usefulness and problems associated with such observations.

MATERIALS AND METHODS

This study was designed as a photodocumentation survey for "live bottom" communities in an area leased for oil-drilling off the northwest coast of Florida (29°50' N, 86°05' W). The tethered, unmanned, 20 horsepower submersible was equipped with a 360 degree scanning sonar, black and white and color video, 35 mm still camera, four 500 watt variable-intensity flood lights, and a five-function manipulator. During September 1984, this submersible was navigated at ca. 1.9 km/h along a preplanned survey route (Fig. 1) by use of a surface console aboard a host vessel.

Position of the host vessel was established by a high-precision radio-positioning system. Position of the submersible was monitored relative to the host vessel by an acoustic reference system. The acoustic system and the surface radio-positioning system were integrated by on-board computer to establish the absolute position of the submersible. Real-time positioning coordinates of the submersible, its heading, and the time of day were then superimposed on the color video display.

The study area averaged 60 m depth. Coralline algae covered much of the sand bottom but small areas were characterized by emergent rocks of relic coral with "live-bottom" sponge-coral assemblages established on them.

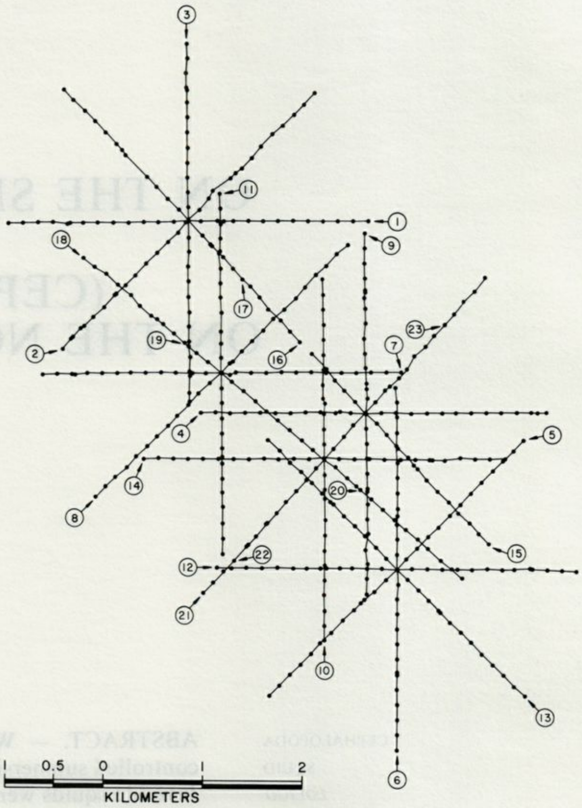

Fig. 1. — Path navigated by the remote-controlled submersible. Dots indicate high-resolution navigation fixes. Numbers designate start points for numbered transects.

After completion of the cruise, 38 h of videotapes recorded along the entire survey route were reviewed to note the occurrence and small-scale distribution of cephalopods. Because navigation fixes were recorded every 152 m along each transect, squid distribution was determined based on 152 m sections of transect along the surveyed bottom. The squids were subjectively categorized as small, medium, or large by comparison with objects of known size (discarded beer cans {12.5 cm length} and an abundant sea urchin, *Eucidaris tribuloides* {10-12 cm diameter}). Thus, we estimated these size categories to include squids of total length < 4 cm (small), 4-12 cm (medium), and > 12 cm (large). We also noted if the squids appeared to be schooling by defining schooling behavior as aggregation on a scale of 1-2 m and coordinated swimming or orientation of aggregated squids (Hurley, 1978; Mather and O'Dor, 1984).

OBSERVATIONS

In total, 1837 squids were sighted, the great majority of which (1657) were in the small-size category. Sightings of medium-sized squids totaled 159, and 22 large squids were seen. Whereas 27 % of the large individuals appeared to be schooling (2 schools of 3 individuals each; 22 large squids sighted in all), and 23 % of the medium-sized squids were similarly aggregated (5 schools of 3-11 individuals per school; 36 schooling squids out of 159 individuals), only 9 % of the abundant small squids fit our definition of schooling (12 schools of 4-18 individuals per school; 149 total squids schooling from 1657 individual sightings). All of the large and many of the medium-sized squids were easily recognizable as the genus *Loligo*. The large squids often swam along with the submersible, sometimes in company with carangid fishes. However, such behavior was not observed in the medium or small individuals.

The remainder of this paper concerns the distribution of the small-sized juveniles, which also appeared to be *Loligo*. Considerable variability in numbers of individual sightings existed both among transects and among 152 m sections of each transect. Although almost half of the survey was conducted during daylight hours, only two probable squid sightings were recorded during the day. The high variability among night transects is demonstrated by the different scales on the vertical axes of graphs in Figure 2.

On all transects where small squids were seen, it appeared that the submersible was passing through patches of squids that extended over several 152 m sections (Fig. 2). Regardless of the total number of sightings per transect, the linear dimensions of these patches appeared to be fairly constant, approximately 610-1370 m. The consistency of this variability also can be seen by comparing the mean number of individual sightings per section along each transect with the standard deviation of the number of sightings per section (Fig. 3, A). Because this variability was independent of the number of sightings for nine out of twelve complete nighttime transects, the relative variability (coefficient of variability : CV = standard deviation/mean number of sightings per section on each transect) decreased as overall abundance increased (Fig. 3, B).

A few anomalies existed in these patterns, apparently a result of interactions between the small

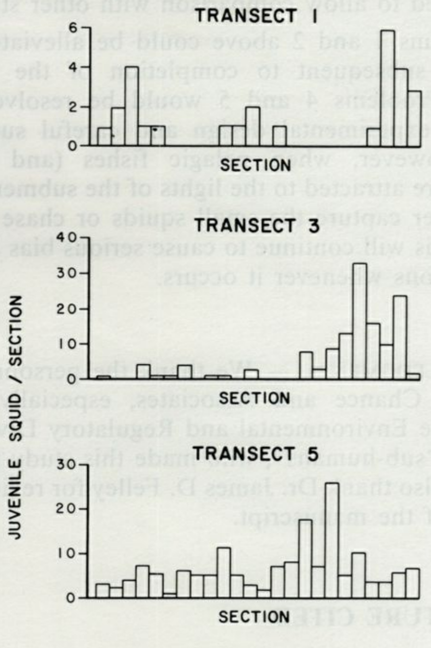

Fig. 2. — Distribution of sightings of small squids along selected night transects. Each vertical bar represents a 152 m section between navigation fixes. Note change of scale in vertical axes.

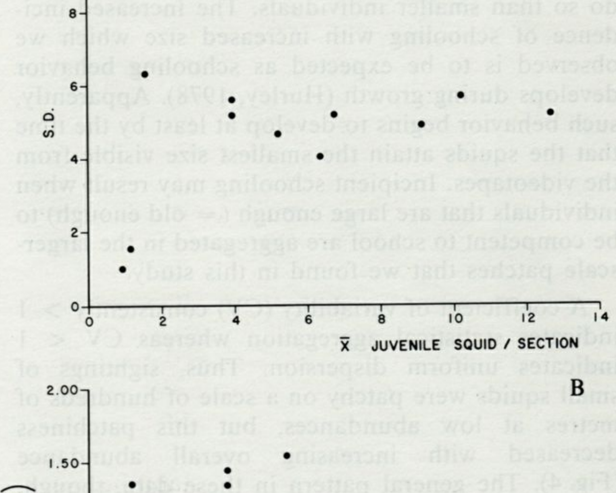

Fig. 3. — A, Mean and standard deviation of number of sightings of small squids per section. Each data point represents a transect. B, Comparison of total number of sightings of small squid along a transect with the Coefficient of Variability (standard deviation/mean number of sightings per section) for each transect.

squids and carangid fishes, which sometimes schooled in the lights of the submersible. Small squids were rarely seen on the few occasions when schools of carangids (and on one occasion, large squids) swam along ahead of the submersible. The small squids may have avoided the carangids or they may have been consumed by the carangids without being seen on the videotape. Another problem was that the operators sometimes experienced trouble controlling the submersible; no squids were seen on any of the occasions that the submersible gained altitude above the bottom.

DISCUSSION

Our observations, though limited in time and space, lead to some generalizations and to the development of several questions. The logarithmic distribution of sightings among size categories parallels the size-distribution pattern described for trawl-caught specimens (Summers, 1968) indicating that the observed distribution may result from age-dependent mortality rather than sampling error. An alternative explanation could be that the large squids are actively avoiding both submersibles and trawls, and that larger individuals are better able to do so than smaller individuals. The increased incidence of schooling with increased size which we observed is to be expected as schooling behavior develops during growth (Hurley, 1978). Apparently, such behavior begins to develop at least by the time that the squids attain the smallest size visible from the videotapes. Incipient schooling may result when individuals that are large enough (= old enough) to be competent to school are aggregated in the larger-scale patches that we found in this study.

A coefficient of variability (CV) consistently > 1 indicates statistical aggregation whereas CV < 1 indicates uniform dispersion. Thus, sightings of small squids were patchy on a scale of hundreds of metres at low abundances, but this patchiness decreased with increasing overall abundance (Fig. 4). The general pattern in these data, though, indicated that absolute variability (as opposed to relative variability indicated by CV) was independent of abundance. Therefore, these data fulfill one of the major requirements for parametric statistical testing, homogeneity of variances. As a result, we believe that similar video surveys for juvenile loliginids would be useful for testing hypotheses about spatial and temporal patterns of distribution.

We do not feel, however, that we have enough data from this study to test for statistical trends in spatial and temporal variability, although several patterns are suggested by these data. Variability among transects may be a function of time, with the squids aggregating very near bottom late at night after vertical dispersal during the early night. It was quite surprising that no squids were seen near bottom during the day, the time when *Loligo* presumably schools near bottom (Summers, 1969). Although several explanations of this paradox can be suggested (e.g. daytime avoidance of the submersible, burial in the sediment, chance that the submersible did not happen to be in the vicinity of any squids during the day, etc.), none are testable with the present data set.

We found that a videocamera-equipped submersible was a useful alternative to trawling as a method for surveying small-scale distribution of juvenile squids at an interface such as the sea bottom on the continental shelf. Several problems with this method were apparent, however :

1) Absolute determination of animal size was not possible.

2) Individuals could not be positively identified to species.

3) Pelagic fishes interfered with observations of juvenile squids.

4) Operation of the submersible (e.g., speed and altitude) lacked standardization among operators.

5) Units of sampling effort have not yet been established to allow comparison with other studies.

Problems 1 and 2 above could be alleviated by trawling subsequent to completion of the video survey. Problems 4 and 5 would be resolved by directed experimental design and careful supervision. However, when pelagic fishes (and large squids) are attracted to the lights of the submersible, they either capture the small squids or chase them away. This will continue to cause serious bias in the observations whenever it occurs.

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