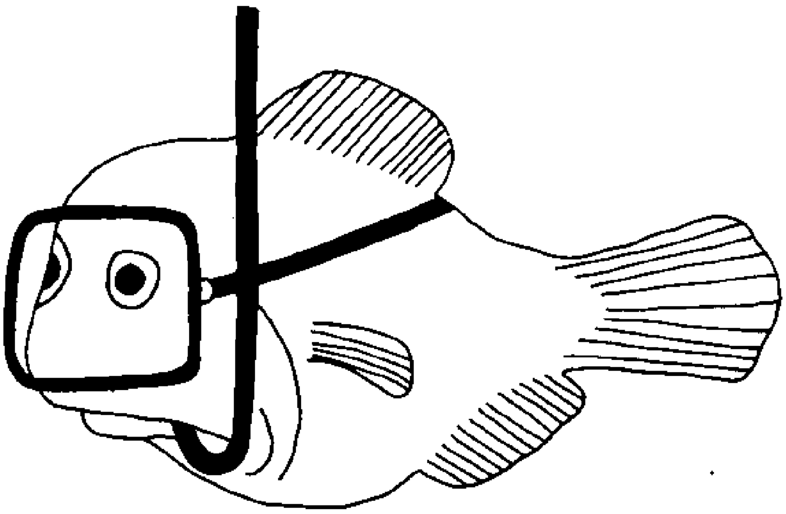
THE VISUAL ASSESSMENT OF FISH POPULATIONS IN THE SOUTHEASTERN UNITED STATES:

1982 Workshop



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The Visual Assessment of Fish Populations

in the

Southeastern United States:

1982 Workshop

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Sponsored by:

South Carolina Wildlife and Marine Resources Department

Marine Resources Division

and

American Fisheries Society, Southern Division

Marine and Estuarine Resources Committee

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INTRODUCTION

by

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Recent developments in both equipment and techniques continue to indicate that visual counting methods will be of great value in estimating the abundance of some groundfish populations. In addition, visual counting methods supply species specific behavior/distribution information necessary for fish assessment by other techniques. Problems exist, as with all enumeration techniques, which must be identified in detail, quantified, if possible, and solved prior to their dependable, routine application for fish population assessment.

A workshop on visual fish assessment was held on 16 and 17 November, 1982 in Atlanta, Georgia to extend communications among researchers within the southeastern region of the United States. The workshop was co-sponsored by the South Carolina Wildlife and Marine Resources Department and the Marine and Estuarine Resources Committee of the American Fisheries Society, Southern Division. Sessions on field techniques and data handling and analysis included descriptions of recent research accomplishments and interests, identification of problems and suggestions for the direction of future research.

The objectives of the present publication are to report, in brief, the results of the workshop and to make a directory of participants available to others interested in the field of visual fish assessment.

FIELD TECHNIQUES SECTION

RESULTS OF THE GRAY'S REEF NATIONAL MARINE SANCTUARY VISUAL REEF FISH CENSUSING WORKSHOP 6-9 July 1982

by

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Gray's Reef National Marine Sanctuary

Georgia Department of Natural Resources
Coastal Resources Division

A study of the reef fish community at the Gray's Reef National Marine Sanctuary (GRNMS) was conducted in July 1982 by the Georgia Department of Natural Resources, Coastal Resources Division (DNR-CRD) in conjunction with the National Oceanic and Atmospheric Administration's Sanctuary Programs Office (NOAA-SPO). The purpose of the workshop was to:

(i) develop a reliable field survey method of GRNMS fish communities utilizing a non-destructive, non-consumptive technique;

(ii) provide data which can serve as a baseline for future studies and Sanctuary monitoring programs;

(iii) quantify the reef fish community at GRNMS and, over time, assess possible impacts by user groups upon that community; and

(iv) encourage increased cooperation between Sanctuary managers and members of the scientific community.

With these goals in mind, the species/time random count technique of Jones and Thompson (1978), or a modification thereof, was recommended for evaluation at GRNMS.

Nine regional scientists familiar with contemporary visual censusing techniques participated in the workshop. Over the two days of field testing at GRNMS, a total of 62 fish species were observed during the 25 dive team counts conducted at Gray's Reef. Limited statistical analysis on the resulting data was possible. A simple percent similarity index (Krebs, 1977) was used to test variability between fish counts recorded at each station. The figures generated ranged from 0 - 96 percent. Duncan's multiple range test was also used to test for variance between counts conducted at the ledge break stations and a series of fish counts taken above the ledge break on the plateau area. Results from this test indicated no distinct separation between the ledge break area fish counts and the adjacent plateau fish counts.

METHODS OF ESTIMATING POPULATIONS OF DIMINUTIVE DEEP WATER REEF FISH SPECIES BY USE OF A RESEARCH SUBMERSIBLE

by

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Dauphin Island Sea Lab.

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During September, 1981, a 0.5 km^2 reef of the Florida Middle Grounds, at 25-30 m depths and isolated by extensive sandy areas, was subjected to intensive sampling. Five dives by the submersible, Johnson-Sea-Link, were designed to generate population estimates by direct visual census. Each was several 200 m censusing transects, plus ten-minute point counts at origin and termination of each transect. Observers were positioned at bow and aft-starboard view ports.

Quantitative cluster analysis to identify patterns resulting from variables which might distort estimates indicated no bias based on differences between the two observers or on viewing location. Data from transects generally clustered together, well separated from clusters of point counts, because of greater area of transects. Larger, mobile species were more accurately counted during transect runs, while point count data were more precise for diminutive, less mobile species. These latter data allowed total reef population estimates for about 10 small reef species including (*Chromis scotti*: 1,538,000±346,000; *Chromis enchrysurus*: 265,000±154,000; *Hypoplectrus puella*: 20,600±4,500; *Pomacentrus variabilis*: 67,900±19,500.

A RANDOM POINT CENSUS TECHNIQUE FOR VISUALLY ASSESSING CORAL REEF FISHES

by

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Southeast Fisheries Center

and

Scott P. Bannerot
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University of Miami

The two most common goals of visual sampling studies of reef fish populations are to quantitatively monitor reef fish composition and abundance over time and to compare fish populations between reefs and other habitats. To meet these goals we developed and tested a fixed point visual census technique to quantitatively sample fishes in diverse coral reef communities. We found other published visual techniques inadequate. In this abstract, we will summarize the method and evaluate its advantages and disadvantages compared to more traditional transect or random search methods. Bohnsack (1982) used this method to compare reef fish populations between reefs.

The sampling technique was based on censuses taken at randomly selected sample points. The distance between points was measured by the number of swimming kicks determined by a table of random numbers. At each point we first recorded all species observed in five minutes within an imaginary cylinder extending from the surface to the bottom with a pre-set radius from the observer. We used and recommend a 8 m radius in areas with visibility greater than 12 m. This radius allows observation of small cryptic species and large shy species that are often present but rarely approach a diver. Smaller distances can be used in areas with poor visibility, but for comparative purposes the distance used should be constant. The sample radius is estimated using a fiberglass tapemeasure.

We used a rigorous sampling protocol to avoid bias and prevent counting individuals more than once. We began each sample by facing seaward and listing all species within the field of view in the sample radius. New sectors are scanned and new species listed by rotating to the left. At the end of the sample period we recorded the estimated number of individuals observed for each species and the minimum, maximum, and mean estimated length for each species. For most species, only a few individuals appeared within the sample radius during the census and their numbers are easy to remember. Species that are always present in the sample radius were counted after the five minute sample period by starting at one point and rotating 360° until the entire area is scanned. We recommend counting only one species at a time by working systematically up the list from the bottom to avoid overlooking a species and to avoid bias caused by a tendancy to count each species when it is particularly obvious or abundant. Schools of fishes that remain within the sample area only briefly are counted as they appear during the five minute sample period. For these species the maximum number of individuals seen at one time is used for abundance estimates to avoid counting the same individuals more than once. Only a few species are in this category. When large schools of fish are present it is necessary to count by 10's, 20's, 50's, or even 100's. Absolute accuracy is not required because the method relies on detecting relative abundances.

Data was taken on bottom features within the sample radius and photographs taken where necessary for later reference. Fish lengths were estimated using a measuring device consisting of a 1 m rod with a ruler attached perpendicularly to the far end. This device helps avoid refraction problems in estimating fish sizes. Data was recorded in pencil on plasticized paper. Scientific names were abbreviated by using the first three letters of the genus and the first four letters of the specific name. We avoided preprinted forms because they tend to waste time in searching for the right line and they bias observers by reminding them to search for particular species.

The method presented, if carefully followed, provides quantitative data on frequency of occurrence, fish length, abundance and community composition. Biomass can be estimated from length data. The method is simple, objective, repeatable, fast, and easy to use. Species are rapidly accumulated for listing purposes, and large numbers of samples can be easily obtained for statistical treatment. Compared to most transect methods, more samples can be obtained from the same expended effort. Although we sampled all observable species, the method can be modified to count specific species of interest.

This method has many advantages over most swimming transect methods because the observer remains relatively stationary. With SCUBA more bottom time is available for data collection because stationary divers tend to consume air very slowly. At a depth of 7 m we collected 4 to 7 samples per standard 72 cu ft SCUBA cylinder in just over 2 hours. We found that a stationary diver can easily keep track of events and record data but that a moving diver has a more difficult time in complex coral reef environments because of the great abundance and diversity of species. Usually only a narrow band of reef can be adequately searched using most transect methods. Stationary sampling also reduce bias that results from some species being attracted to or repelled by moving divers. For example, species such as *Epinephelus cruentatus* hide and are often overlooked during transect surveys. However, in the presence of a stationary diver, *E. cruentatus* often comes out of hiding and is counted within the 5 minute sample interval. Certain species such as *Ocyurus chrysurus*, that are attracted to moving divers, produce high abundance estimates. With the stationary method these species radiply lose interest in the diver and by the time they are counted, their numbers more closely approach ambient levels. Finally, point sampling, because it only includes small portions of bottom, reduces statistical problems caused by transects crossing different habitat patches or zones.

We found the method suitable for all encountered habitat types although it is not effective under conditions of very low visibility, strong wave surge, or very strong currents. The method has limited usefulness in deeper water because of decompression problems. As with all visual assessment techniques, divers must be very familiar with the visual characteristics of the species encountered. This is usually not a problem thanks to the numerous identification guides available for most areas.

The data produced are indicies of abundance and should not be confused with actual abundance estimates. Most abundance estimates are low because some individuals are not seen. This bias is more pronounced in high relief areas and with small, secretive and cryptic species that hide or can be seen from only a few feet away. This is not a problem in most comparative studies because the biases are consistent and apply to all samples. When the desired goal is only to rapidly produce a species listing, we recommend using a rapid visual assessment technique (Thompson and Schmidt 1977, Jones and Thompson 1978). However, under most conditions the method presented here should be more suitable than transect or general survey methods for quantitative studies.

COMPARED RESULTS OF SOME VISUAL CENSUS METHODS FOR ESTIMATING FISH ABUNDANCE

by

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Relative abundance for 80 species in a fish community were estimated using three visual assessment methods. Results of two species-time methods, the Rapid Visual Census of Jones and Thompson (RVC) and a new method, the Visual Fast Count (VFC), are compared to the traditional transect method. The VFC is similar to the RVC but attempts to improve on the quantitative nature of the results. Results from each method were significantly correlated, but important differences between methods were found. With an equal number of replicates both RVC and VFC methods yielded significantly more species than the transect method. Relative abundances estimated by the RVC were significantly different than those determined by either VFC or transect methods, but VFC and transect results were not different. A qualitative similarity index using presence/absence data was calculated and compared among methods. Values ranged from 84.3% to 85.9%, illustrating a consistent level of similarity for the faunas counted regardless of census method. Quantitative similarities (percent similarity), however, ranged from 45.8% to 85.7% and suggest a closer agreement between the transect and the VFC methods than between these methods and the RVC. If transect results are assumed to be the most accurate, the comparison suggests that the VFC method yields more accurate relative abundances than does the RVC. Ranges in percent similarity values calculated within each method (8 replicate samples) suggest that transect and RVC scores are slightly more precise (ranges of 3.10% and 2.20% respectively) than the VFC method (range = 4.89%).

Each of the above visual census methods may be applicable to the needs of a specific project or researcher. Projects requiring integral level measurements (# indiv./area) would profit most by use of the transect method. Those interested in ordinal (relative abundances) or nominal level measurements (rank order) should rely on the VFC and RVC methods, respectively. Each method has its practical shortcomings concerning equipment needs, support personnel, field time, safety, etc.

VISUAL CENSUSES OF COMMERCIAL REEF FISH FROM A SUBMERSIBLE ON THE FLORIDA MIDDLE GROUNDS

by

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University of South Alabama

Population estimates of commercially important reef fish were generated from visual strip transects and 10-min. point counts and mark/recapture techniques on an isolated reef area on the Florida Middle Grounds. Visual data were recorded by two observers, each located in either the bow or aft compartments of the Johnson-Sea-Link underwater submersible. Visual estimates were made by extrapolating the average number of individuals per sample to the entire reef area. Point count estimates tended to be at least an order of magnitude greater than the strip transect estimates of the four species for which both estimates were made. All individuals observed during the entire 10-min. point counts were counted, inflating the number of individuals present in the field of view. This is believed to have caused the large differences between the two visual methods. For one species, *Epinephelus morio*, the mark/recapture estimate (855 individuals) was similar to the visual strip transect estimates from the bow and aft compartments, 574 and 1010 individuals, respectively. It was concluded that strip transects were more effective in estimating the mobile, wide-ranging commercial species than were the 10-min. point counts.

A TECHNIQUE FOR DETERMINING LENGTH OF FREE-SWIMMING FISHES USING UNDERWATER STEREO TELEVISION

by

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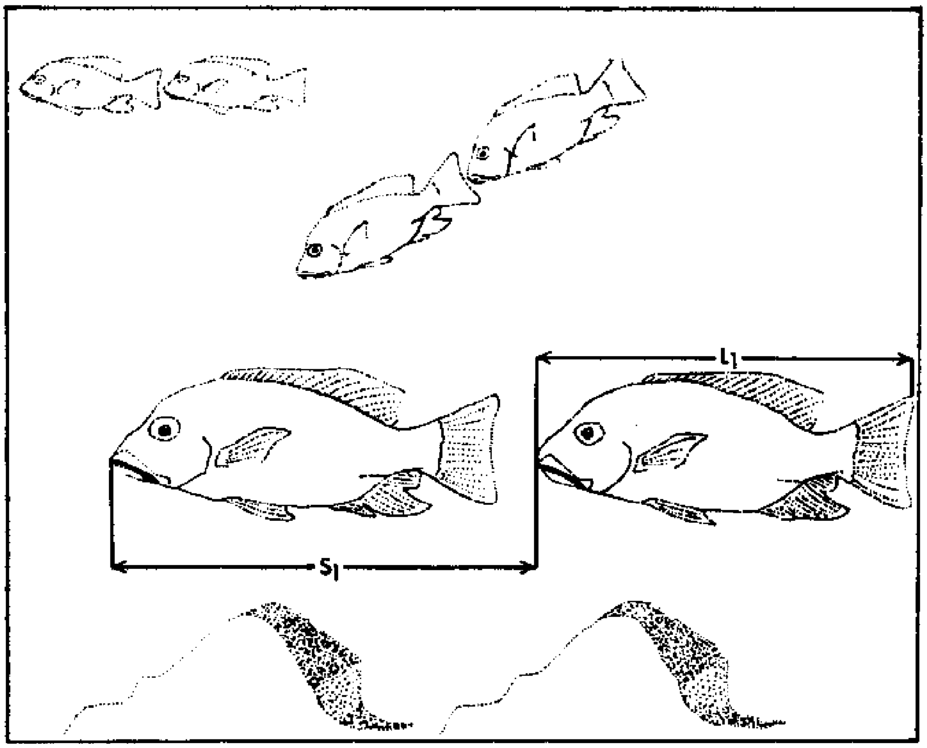
Quantitative assessment of reef fish populations has always been a formidable task. The limiting factor is obstructions which prevent standard trawling procedures. Alternate techniques involving direct observation include submersibles, towed or drifted remote cameras and divers. Benthic camera sleds capable of censusing a known bottom area are also not usable on high relief benthic environments for the same reason trawls cannot be used.

Survey techniques which are necessary over rough topography normally require the point of observation to be highly variable, e.g. as submersibles move about or video cameras are raised and lowered over obstacles or divers swim along a transect. A new technique developed and described here utilizing stereo-paired low-light underwater television cameras overcomes these problems. The concept is essentially as described by Boyce (1964) but using double video images as opposed to still photographs. Stereo-pair video images can be used for remotely determining fish lengths in situ and additionally for verifying width dimensions of transects.

Both remote measurements of fish lengths and calculation of transect census widths are obtained from images produced by two video cameras parallel to each other. The two parallel cameras are fixed at an arbitrary distance from each other. With special multiplexing circuitry the two camera's images are superimposed onto the same TV screen and can also be recorded on videotape. Measurements of objects are obtained directly from a monitor screen as the dual images are displayed. The separation of paired images on the screen changes with the distance from the cameras but always represents the same physical separation of the two cameras, assuming the cameras remain optically parallel. With TV monitor screen measurements of image separation and image length, and the known camera separation distance, the true object size can be calculated through a simple ratio equation. Calculation of transect width can be made in a similar manner. Additionally, a reference list of image separation distances is required for a particular TV screen and a consistant camera separation must be used in the field. The separation distances of TV images decreased with the distance away from the cameras and by using the reference set of separation measurements the actual distance can be determined.

Accurate perception of distance underwater can be difficult. This fact forces many biological surveys to be only qualitative. With the use of parallel camera stereo image separation measurements, the judgement of transect width dimension or distance can be verified as often as necessary without objects of known size in the field of view. The principal advantages of a stereo video system are as follows:

1. Relatively low cost
2. Depth capabilities beyond SCUBA
3. Real time feed back
4. Short logisitics time - rapid deployment retrieval
5. Remote measurements of fish
   e.g. - For standing stock assessments
   - Rare or uncollectable species
6. Remote measurements of distance at any time to establish accuracy of operator determinations of transect width. (without objects of known size along transect)



Double video image used in determination of actual fish lengths. Measurement of image separation, S_1 can be taken at any common point on the object being measured. L_1 = for length.

The equation used for determining actual object length L is:

$$L = \frac{L_1 \, S}{S_1}$$

Where L_1 = Image length on screen
S_1 = Image separation on screen
S = Known physical separation of twin video cameras

REMOTE ASSESSMENT TECHNIQUES FOR LARGE BENTHIC INVERTEBRATES

by

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During 1980 and 1981, an underwater television camera system was deployed to remotely assess bottom topography and fauna at several hard bottom study sites. This effort was part of a larger study of hard ("live") bottom areas in the South Atlantic Bight, funded by the Bureau of Land Management. Techniques used in both the field and laboratory are as follows:

All study areas were initially reconnoitered through television transect surveys using a Hydro Products television system suspended from the research vessel in the frame. These surveys were primarily intended to provide information on the distribution and occurrence of large macrofauna and flora, but they also provided information on bottom characteristics of each study site. Transects were completed while the vessel was drifting across the study areas with the camera frame suspended approximately one meter above bottom. During each transect, bottom type was continuously observed on the television monitor, and was recorded every two minutes in data logs along with simultaneous Loran C bearings. Fathometer tracings were recorded throughout the transect. Together with Loran C positioning, this provided an accurate record of the path and depth profile for each transect. The videotape recorder was activated when an estimate of greater than five percent bottom cover of sessile fauna or rock was detected. Recording continued until six continuous minutes (minimum of 140 m) of sand with less than five percent bottom cover had been observed. Transect paths were selected to minimize overlap and provide adequate assessment of fauna and bottom types present. If visibility was adequate for bottom assessment, at least three transects were attempted at all sites.

Videotapes were reviewed in the laboratory to eliminate those which were unsuitable for interpretation due to poor visibility. Duration of tape segments was noted, and replicate 20-min segments were selected for analysis. The point at which analysis of a particular transect commenced corresponded either to the beginning of the videotape recording or to the Loran C position (recorded on the audio track) closest to the initial evidence of live bottom (> 5% bottom cover of rock or sessile fauna). Analysis ended at the Loran C position immediately following the last evidence of live bottom or when the videotape recording was ended. Absence of live bottom for three consecutive Loran C readings (6 min, minimum of 54 m) was the criterion used for selecting the last evidence of live bottom. However, when smaller patches of sand were interspersed within live bottom areas, they were included in the analysis.

The bottom type at each study area was assessed by noting the presence or absence of live bottom during 10-sec intervals along the entire analyzed portion of each transect. Since vessel speed was relatively constant for a particular transect, these 10-sec intervals divided the transects into numerous, short, approximately equivalent intervals of actual distance. A mean proportional estimate of bottom type was obtained for each study area by determining the number of intervals representative of each of the three following categories of bottom type: (1) thin sand cover with hard bottom fauna, (2) rock outcroppings, and (3) sand without evidence of hard bottom fauna. In order to reduce variability caused by poor visibility and fluctuations in the height of the camera above bottom, only the lower middle third of the television monitor was viewed during this assessment.

Epibenthic taxa analyzed in the videotaped segments included large sponges (*Spheciospongia vesparium*; *Cliona* spp., gamma stage; *Ircinia campana*; *Haliclona oculata*), soft corals (*Leptogorgia* spp., *Titanideum frauenfeldii*, *Muricea* sp., *Lophogorgia* sp., *Stichopathes* sp.), hard corals (*Oculina* spp., *Solenastera hyades*) and algae. Estimates of frequency of occurrence were obtained for the above species by noting the presence or absence of each species during ten second intervals along the transect paths. Assessments made during each interval were restricted to the center third of the television monitor to minimize variability in estimates due to poor water visibility and also, to minimize variability in bottom surface area assessed due to variations in the height of the camera above bottom. When poor visibility made it impossible to accurately determine the presence or absence of a certain species during an interval, the interval was not included in the frequency estimate of that species. Thus, frequency estimates represent the proportion of intervals in which a species was present relative to the total number of intervals analyzed for that species along a transect. Since octocorals and algae are generally smaller than the sponges and hard corals, these taxa were assessed by two observers for each transect and an average of their frequency estimates was computed. Also, certain genera were difficult to distinguish from each other on the monitor and were lumped together in the analysis. These included the fan corals *Muricea* sp. and *Lophogorgia* sp. and the large barrel-shaped sponges *Spheciospongia vesparium* and *Cliona* sp. (gamma stage).

PROJECT SUMMARY CONCERNING THE DISTRIBUTION AND COMPOSITION OF THE NORTH CAROLINA REEF ICHTHYOFAUNA

by

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North Carolina Division of Marine Fisheries

The reef ichthyofauna in N.C. waters has been documented from inshore intertidal areas to depths of 188 m. with the majority of the effort taking place between the intertidal and 55 m. Most sampling took place in Onslow Bay, which is the location of the majority of the live bottom habitat. Collections and observations have involved numerous techniques and gears, including SCUBA, trawls, submersible, photography, ichthyocides, and anesthetics.

At each location sampled visually (SCUBA or submersible) all possible fish species were identified. Notes on relative abundance, behavior, and habitat associations were also made. At many of these sites collections were made to supplement the observations. In addition to the above qualitative data, more quantitative trawl data were collected at numerous locations. Information on reproduction of some reef fishes was assembled from trawl and SCUBA surveys. Although most surveys were conducted during summer and fall, some data were obtained during winter and spring on selected reefs.

Over all years and locations of the study 265 fish species were identified on N.C. hard substrates. Of these, 163 can be considered primary or secondary reef fishes. Over the whole depth range the ichthyofauna was dominated by the families Serranidae (28 species), Priacanthidae (3), Carangidae (16), Pomadasyidae (4), Sparidae (8), Sciaenidae (5), Pomacentridae (11), Labridae (12), and Gobiidae (10). Many tropical species were well established and formed permanent populations. The fact that the tropical component of the fauna was so well developed and contained resident species had been previously unkown or underestimated.

Reef ichthyofauna shallower than 34 m was characterized by seasonal changes in biomass and species diversity displaying a maximum in the fall (September-October) and a minimum in the late winter (February-March). The more stable environment beyond 34 m contributed to the maximum species diversity which occurred between 31-92 m. Regardless of depth, areas with the highest profile generally contained greater numbers of species and individuals.

COMPARISON OF UNDERWATER VISUAL TECHNIQUES FOR REEF FISH CENSUSING

by

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Three methods of censusing reef fish populations were compared during 14 dives in the summer and fall, 1980. Three divers familiar with the fauna of the study site, the Suloide wreck 15 km off Bogue Banks, North Carolina, enumerated species (1) while swimming 20 m transects, (2) while swimming randomly for prescribed lengths of time, or (3) as the fishes moved into their field of view within a prescribed sampling area. Species were scored on underwater paper for relative abundance (tens, hundreds and thousands; when less than ten individuals were observed, the actual number was recorded). A daily species list was compiled from the results of each day's dives. The number of species observed on each dive for each method for each recorder was expressed as a proportion of the day's species total. In the latter two methods, each 20 minute dive was divided into four 5-minute intervals. Additional observations were made on each day to supplement the species list compiled from the census methods.

Bottom water temperatures during the study ranged from 24°C to 29°C. Bottom horizontal water visibility (measured by secchi disk) was 7.5 m on all but one day when it was 12 m. There was no correlation of total species numbers with either water temperature or visibility within the narrow ranges observed. Of the total 45 species (36 genera and 21 families) observed throughout the study, 34 species (26 genera and 14 families) were observed while conducting the censusing methods.

The transect method consistently produced a smaller species list, averaging 34% of the day's total. Fish generally exhibited an avoidance of swimming diver(s). This behavior, also apparent in method number 2 and somewhat in method number 3, decreased the visibility of the individual and frequently changed the fish's location relative to the transect line (within 1 m or outside the 1 m of the line). The transect method required the diver to concentrate on following the line and scoring fish in relation to the line position and did not give the diver the opportunity to examine visible habitats in any detail. Cryptic and rare species were the ones not observed while swimming the transect.

The method where species were recorded in five minute intervals of diver swimming time produced the most species. This method averaged 59% of the day's total number of species. Plots of the cumulative number of species observed against time for each dive showed that the curve did not appreciably decrease in slope before 15 minutes of observation. This method allowed the diver to census a variety of microhabitats and to approach/pursue questionable individuals to confirm identifications.

In the last method, divers mentally noted "landmarks" on the wreck at the maximum edge of visibility 360° from their assigned central location. This created a circular shaped sampling unit with a radius equal to the visibility. The diver was allowed to move about the circle to enumerate species occurring within it. These observations were also recorded in five minute intervals. This method identified an average of 52% of a day's total number of species. The plots of cumulative number of species against time indicated the beginning of saturation before 15 minutes of observation time. This method did not allow the diver as much flexibility, and since the amount of area covered per unit observation time was less than the previous method, the number of species observed in the 20 minute dives was less. The estimates of average species abundance on the same day were rarely different between observers when either of the last two methods were used although they did vary between time units of a dive. Abundance of pelagics and secondary reef fish often varied markedly throughout the study.

Frequently, observations from more than one diver are used as replicate observations. I found that although the observers were equally able to correctly identify the species, the total number of species scored/dive was dependent on the experience of the observer with underwater censusing (and indirectly how fast they were able to identify species). The data from each observer could not be considered a replicate of another observer's. Using Montford's similarity index to compare paired observations/day for the species/time methods it was found that the highest similarities in the reported fish fauna were recorded by the same observer making two dives, regardless of methods. Paired observations for the same methods but different observers were generally more similar than data taken with underwater censusing. From these data it is demonstrated that the experience and ability of the observers may be even more important than the method chosen for censusing. Assuming the observer's ability and experience are equal, the species/diver swimming time method (method number 2) is recommended over the other two methods compared.

ANALYSIS AND DATA SYNTHESIS SECTION

DIVER-SUMBERSIBLE REEF FISH OBSERVATION COMPARISONS[1]

by

Pete Parker
National Marine Fisheries Service

Two submersibles were used to observe and count North Carolina reef fishes during August and September 1979. Diver and submersible observation comparisons were made on two occasions during this period. Although data were not extensive, there was an indication that the SCUBA teams consistently counted more individuals than were counted from the submersible. When we compared the groupers observed from the submersible to those observed by scuba divers and adjusted the data for the difference in area surveyed, counts from the submersible were 65% and 63% of the diver counts at two replicate stations. The restricted view of the submersible observer and the fact that observations were made from only one side of the submersible are the reasons for this difference. SCUBA teams observed no remarkable fish behavior illicited by the submersible. Although at times certain large species, such as amberjack and gags, seemed to be alternately attracted and repelled by the submersible, no consistent behavioral patterns were revealed. Small species seemed almost oblivious to its presence.

On one other occasion we were able to compare diver and submersible observations. Divers made a 25 minute stationary count in the same area that a submersible ran a 26 minute transect. Since the submersible was able to cover more area it had the opportunity to observe more of the large species than the stationary SCUBA team. However, the SCUBA team was more mobile and had a better field of view, allowing it to observe and identify small and partially hidden species better than the sub.

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[1] From "Observations from Submersibles of the Reef Ichthyofauna of offshore North Carolina" by R. O. Parker, Jr. and S. W. Ross (in preparation).

THE IMPORTANCE OF HABITAT FRACTIONATION

by

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Walter Nelson
Gary M. Russell
National Marine Fisheries Service Laboratory

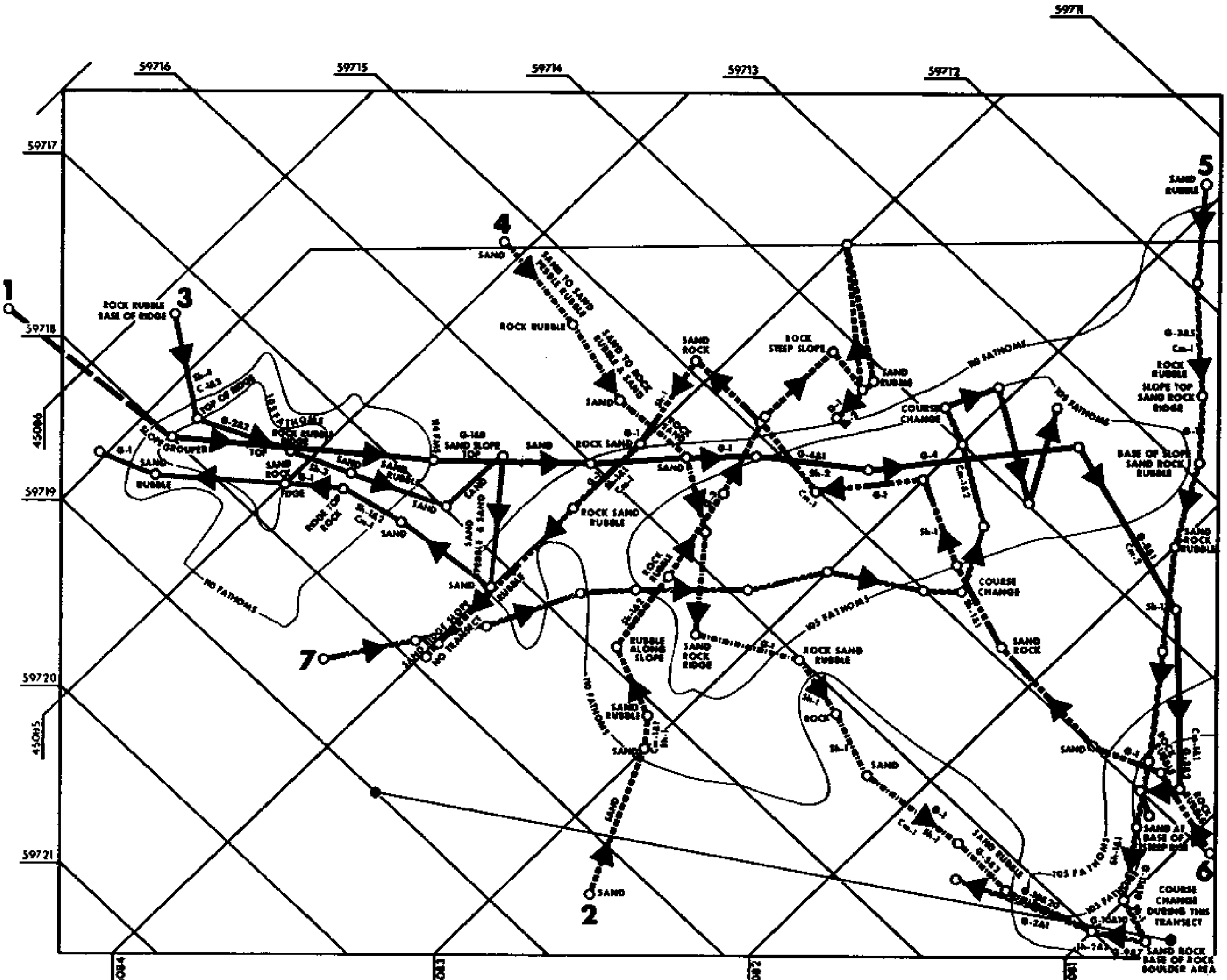
Introduction:

The purpose of this report is to stress the importance of habitat fractionation when developing species population estimates using submersibles to assess deep water reef fish stocks. Species are somewhat habitat specific therefore habitat definition and species associations are paramount to accurate population estimates. Visual estimates of the deep reef habitat and population levels incorporate and integrate both photographic and video records with observer judgements. All visual techniques in deep water are fraught with problems and shortcomings, however these are somewhat minimized with submersibles. Sampling methodology, observer techniques and data collections were enhanced from previous efforts on the Florida Middle grounds.

Field Techniques:

The survey was conducted in depths of 188 to 220 meters in a ½ sq n m area approximately 80 miles east of Charleston, S.C., and utilized the Harbor Branch submersible Sea Link I and its support vessel the R/V Johnston. Seven transects were randomly selected throughout the survey area (Fig. 1). Two dives have been detailed in terms of habitat and species observed with the remaining five dives still to be evaluated (Figs. 2-5). Initial plans were to transect the survey area each morning for species population estimates and each afternoon to evaluate and observe the on and off bottom longline fishing gear. Species population estimates based on data collected on the submersible were to be derived from both transect and point estimate counts. Survey techniques included an initial point estimate consisting of 3 one minute counts at the start of each new transect and a final estimate at the end of the last transect. The submersible came to rest on the bottom and after an appropriate interval during which the bottom "stabilized" the counts started. Organisms were identified to the lowest taxon and enumerated. Upon completion of the third point estimate the submersible received a new heading for the next transect from the surface support ship. The submersible then got under way on its new heading and transect counts began. The first population dive consisted of seven 200 yard transects and 8 point estimates (Figs. 2 and 3).

SEA LINK DIVES 1-7 AUG 2-8, 1982 100 TO 125 FATHOMS, EAST OF CHARLESTON, S.C.



LEGEND

DIVE 1 (1243)
DIVE 2 (1244)
DIVE 3 (1246)
DIVE 4 (1248)
DIVE 5 (1252)
DIVE 6 (1253)
DIVE 7 (1254)

Figure 1

SEA LINK DIVE 1242
8-2-82
TRANSECTS 200 YDS/TRANSECT

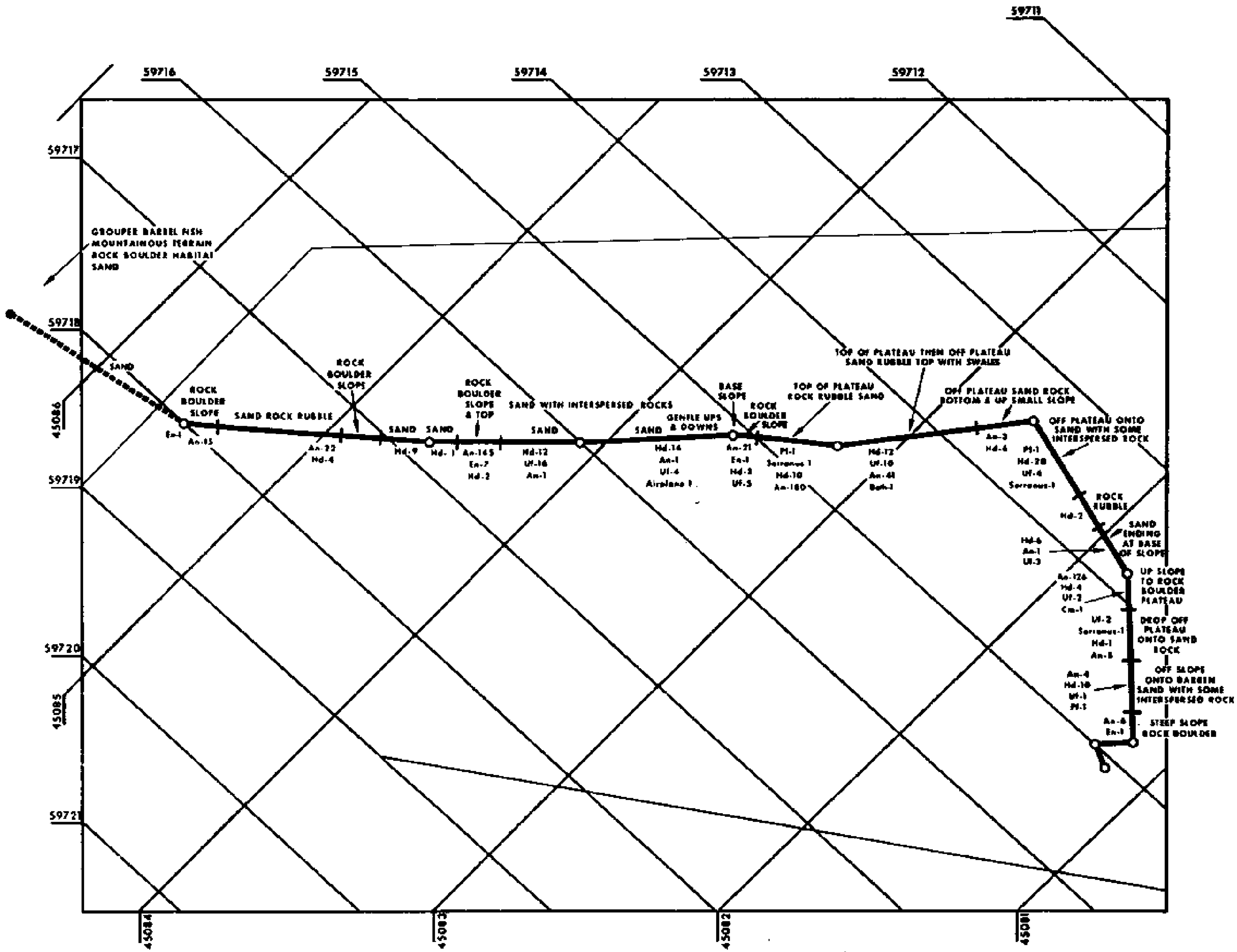


Figure 2.

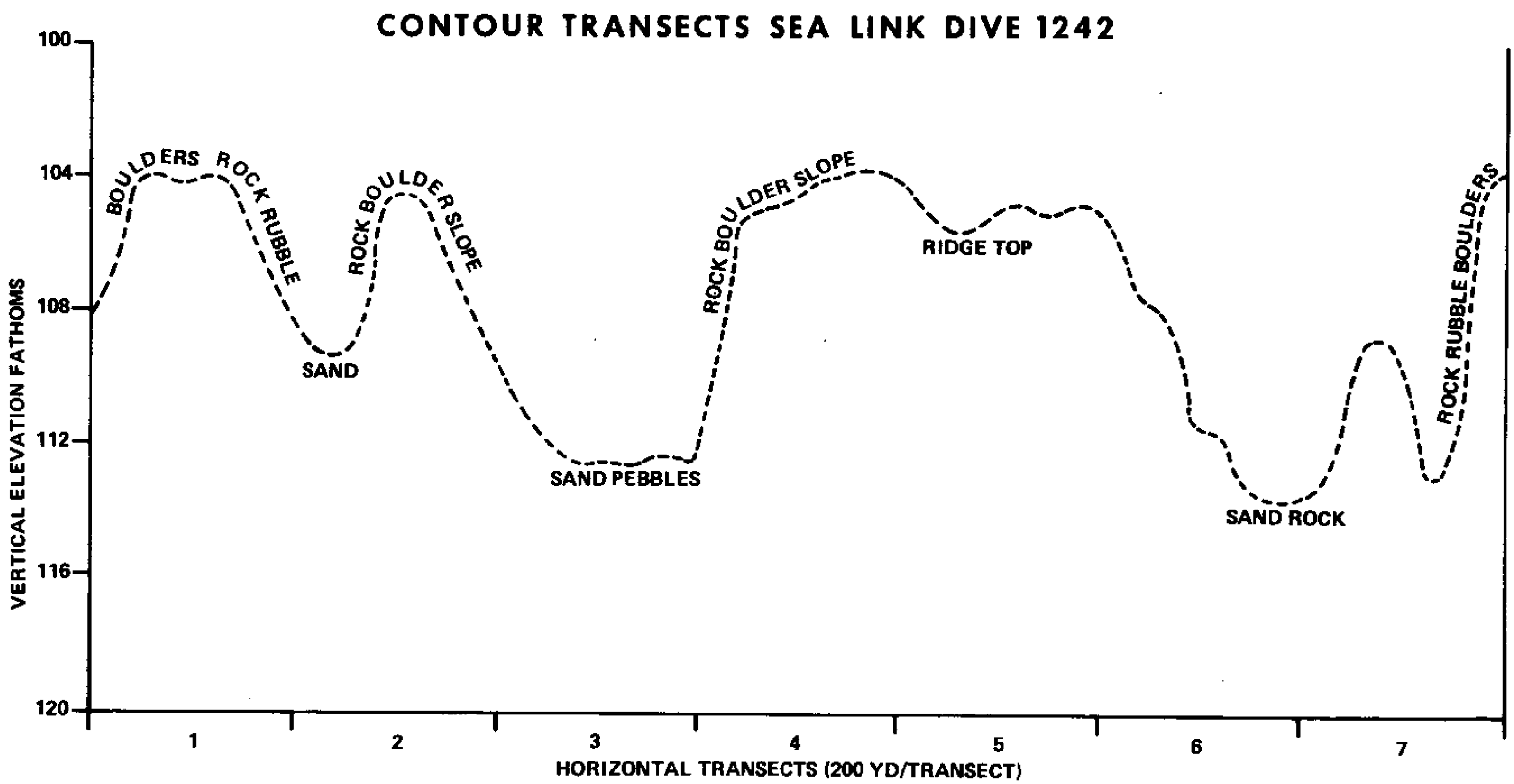

CONTOUR TRANSECTS SEA LINK DIVE 1242
VERTICAL ELEVATION FATHOMS
100
104
108
112
116
120
BOULDERS
ROCK RUBBLE
SAND
ROCK BOULDER SLOPE
SAND PEBBLES
ROCK BOULDER SLOPE
RIDGE TOP
SAND ROCK
ROCK RUBBLE BOULDERS
1
2
3
4
5
6
7
HORIZONTAL TRANSECTS (200 YD/TRANSECT)

Figure 3.

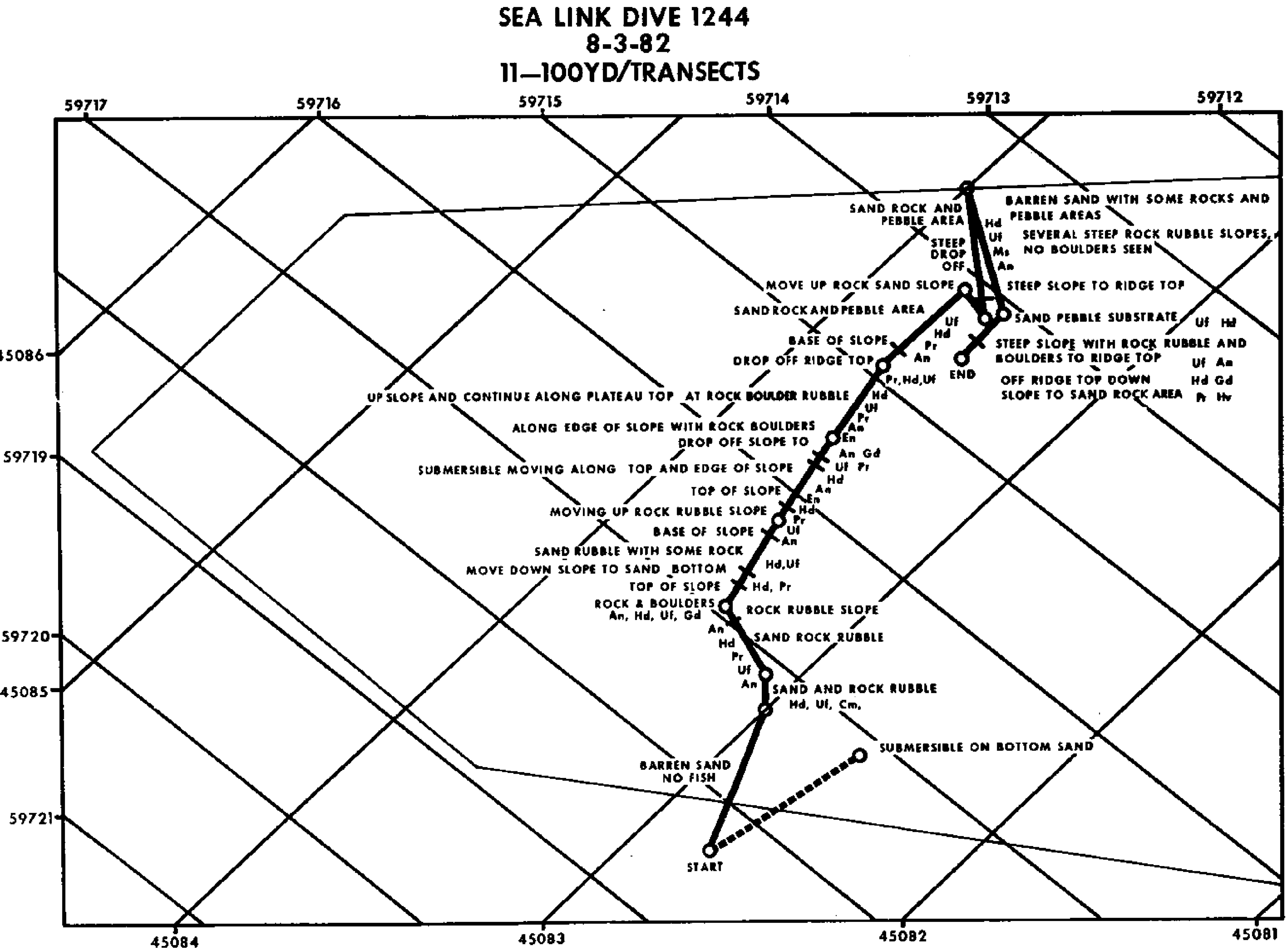

SEA LINK DIVE 1244
8-3-82
11—100YD/TRANSECTS
59717
59716
59715
59714
59713
59712
45086
59719
59720
45085
59721
45084
45083
45082
45081
SAND ROCK AND PEBBLE AREA
BARREN SAND WITH SOME ROCKS AND PEBBLE AREAS
Hd Uf Ms An
STEEP DROP OFF
SEVERAL STEEP ROCK RUBBLE SLOPES, NO BOULDERS SEEN
MOVE UP ROCK SAND SLOPE
STEEP SLOPE TO RIDGE TOP
SAND ROCK AND PEBBLE AREA
SAND PEBBLE SUBSTRATE
Uf Hd
BASE OF SLOPE
STEEP SLOPE WITH ROCK RUBBLE AND BOULDERS TO RIDGE TOP
Uf An
DROP OFF RIDGE TOP
END
OFF RIDGE TOP DOWN SLOPE TO SAND ROCK AREA
Hd Gd
Pr Hv
Pr, Hd, Uf
UP SLOPE AND CONTINUE ALONG PLATEAU TOP AT ROCK BOULDER RUBBLE
ALONG EDGE OF SLOPE WITH ROCK BOULDERS
DROP OFF SLOPE TO
SUBMERSIBLE MOVING ALONG TOP AND EDGE OF SLOPE
TOP OF SLOPE
MOVING UP ROCK RUBBLE SLOPE
BASE OF SLOPE
SAND RUBBLE WITH SOME ROCK
MOVE DOWN SLOPE TO SAND BOTTOM
TOP OF SLOPE
ROCK & BOULDERS An, Hd, Uf, Gd
ROCK RUBBLE SLOPE
SAND ROCK RUBBLE
SAND AND ROCK RUBBLE Hd, Uf, Cm,
SUBMERSIBLE ON BOTTOM SAND
BARREN SAND NO FISH
START

Figure 4.

CONTOUR TRANSECTS
SEA LINK DIVE 1244

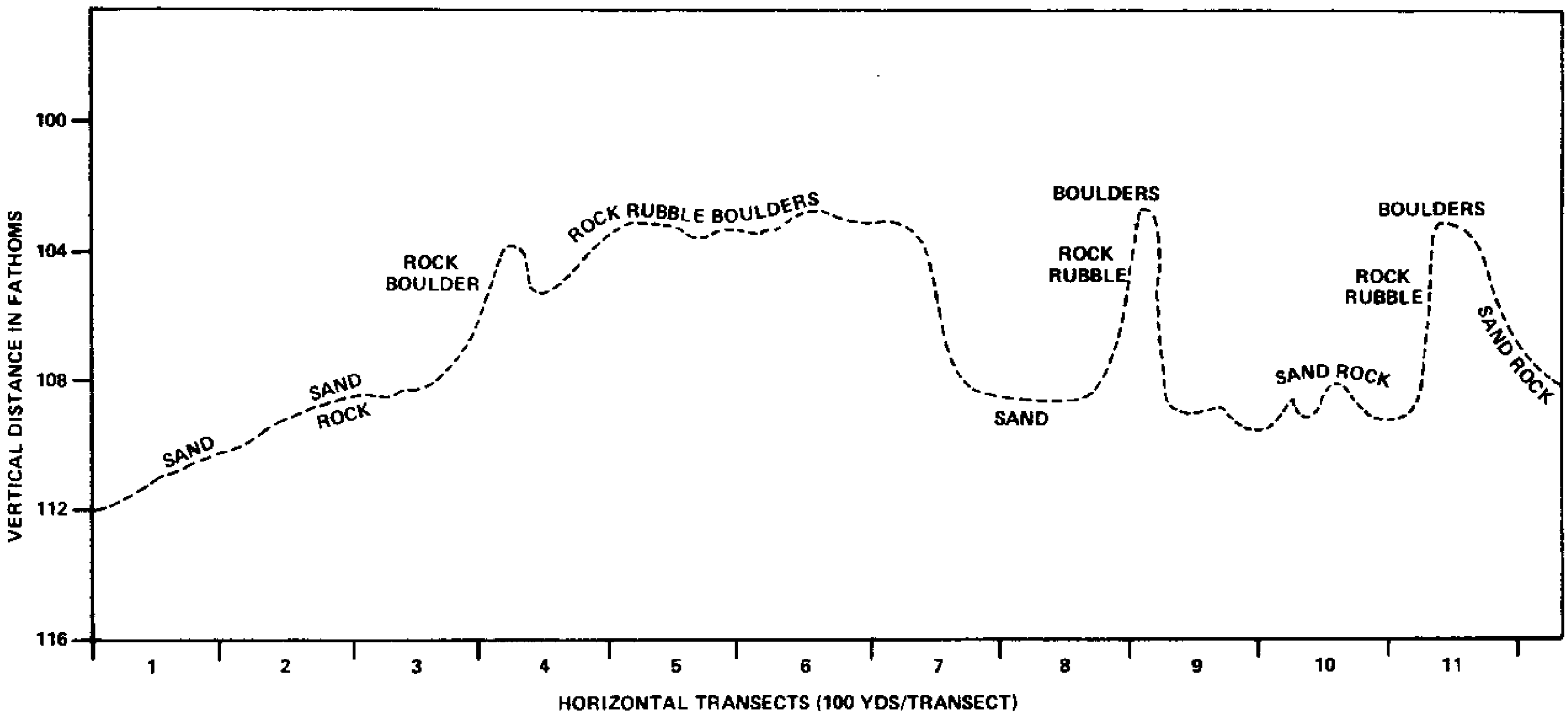


Figure 5.

Shortly after transecting began it became obvious that 200 yard transects were too long and encompassed several habitat variations. Transect length was then reduced to 100 yards with the resultant 12 point estimates and eleven transects per dive. Reducing transect length allowed for more replications and greater accuracy in terms of population levels and habitat definition. After completing the third dive, suspicions persisted that 100 yard transects were also too long, as several habitats were still traversed during most transects. Each population dive on which organisms were enumerated and from which population estimates were to be computed consisted of 11 transects and 36 individual point estimates.

Available to the forward observer was a 35 mm still camera with strobe lights and a video recorder. Both of these photographic devices were used to record and document habitat type and species for future evaluation. Data was also collected by each observor on voice tape. This data included species numbers, changes in habitat, depth, and time through the transect for future evaluation. Dive duration ranged from 3½ to 4 hours with the submersible generally in the water by 8:00 a.m. and back on deck of the R/V Johnston by noon. Data was extracted from both video and voice tapes on a daily basis immediately after completion of the dive.

In addition to the acquisition of visual data from the submersible for population estimates, fishing was conducted to determine species composition of longline catches and to reduce the populations of snowy groupers, blue line tile fish, and rose fish. Intensive fishing efforts were conducted throughout the dive period and for several days after the submersible departure (7000 hooks fished). Longline sets were of 2 hour duration and were scheduled to include 50 on bottom hooks and 120 off bottom hooks placed on 20 PVC poles, however, not all sets had the preplanned number of hooks due to gear handling and/or vessel problems. All hooks were baited with squid or mackeral. Data collected during fishing operations were summarized and evaluated using a DeLury removal statistic. In addition to the catch effort data biological data was taken from species of interest, including length, weight, sex, maturation stage, and scales and/or otoliths for age growth evaluation.

<u>Analysis techniques</u>:

Submersible data is presently undergoing separation into its appropriate dive, transect, and habitat components. Population estimates will be computed based on each of these components for each observor, along with estimates computed from the point estimates. Population estimates will be determined using a mean density value per species multiplied by the total area within the specified components. Population estimates have not yet been computed based on data from submersible counts, however population estimates of snowy grouper, blue line tile fish and rose fish have been completed based on catch effort data (Table 1).

Seven independent population estimates will be available for comparative ble 1.

CATCH PER UNIT EFFORT DERIVED POPULATION SIZE AND CATCH OF DEEP REEF FISHES ON 1/2 SQUARE MILE STUDY AREA IN 100-120 FATHOMS OFF SOUTH CAROLINA (7,000 HOOK EFFORT).

SPECIES	ESTIMATED NO. IN POPULATION	CATCH	PERCENT OF POPULATION	CATCHABILITY COEFFICIENT
SNOWY GROUPER	123	87	70.7	0.010
BLUELINE TILEFISH	192	144	75.0	0.011
BLACKBELLY ROSEFISH	1,512	925	61.2	0.009

purposes: (1) Catch/effort, (2) submersible transects, (3) submersible divers, (4) total submersible, (5) submersible habitat, (6) submersible point estimates total, (7) submersible point estimates by habitat. Statistical analysis of field data will entail a determination of differences between observer, position in the submersible and population levels of select species. Differences will then be evaluated as to levels of significance.

SUGGESTIONS FOR A GENERAL PROCEDURE FOR ANALYZING REEF FISH CENSUS DATA

by

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In general, the following procedure should be followed in analyzing any problem scientifically:

1. establish a hypothesis
2. define all variables
3. transform the data if necessary
4. generate descriptive statistics
5. perform factor analysis
6. construct predictive and/or descriptive models
7. test the hypothesis

Reef fish visual census data can and should be treated with the above procedure, however, there are several features unique to reef fish census data that require special considerations with regard to the transformation of these data. Transformation of a variable such as species should be conducted for two main reasons:

1. to meet the assumptions necessary to permit the valid use of parametric statistical analysis;
2. to remove some of the influence extremely over or under abundant species may have on the analysis

The assumptions which should be met in a parametric statistical analysis are: the samples (visual assessments) are taken randomly; the variation in population estimates introduced purely by sampling error should not correlate among each other; the variance among samples are homogeneous (that is the variances among samples are equal within some range of statistical acceptability); the distribution of the dependent variable (species abundance) is normal; the effects of the independent variables are additive and non-interactive. The valid use of a parametric statistical analysis such as analysis of variance depends on meeting the above assumptions or at least minimizing the effect of not meeting them. A random sampling design as well as exact duplication of the sampling procedure will satisfy the assumption of independence and will help meet the assumption of normality.

Often, however, there are some features of the data which can only be relieved by a transformation. The effective use of a transformation may permit the assumptions of homogeneity of variances and normality to be met. For example, transformations can remove the relationship between mean number of fishes recorded in a sample and the sample variance (this is important so that the variation in the magnitude of the abundances recorded in a sample is not a function of the sampling method). Ideally one would like the variance to be independent of the mean in a sample. To determine if this relationship exists one could simply plot the variances versus the means and note if there is an obvious correlation. If such a correlation is found then a transformation such as logarithmic, square root, or arcsine may remove or reduce the relationship between sample mean and variance.

Very often one would like to minimize the over or under weighting that abundant or rare species may have on an analysis. This would especially be true if one were interested in determining how the variation in an independent variable, such as temperature, influences the variation in species abundance in a reef fish community. Transformations can also be effective in reducing the biases due to an artifact of the assessment procedure which may tend to record rare species less than they should or abundant species more than they should. Transformations may also be applied to species abundance data to help normalize the frequency of abundance distribution (i.e., give the frequency distribution of species a bell shaped curve).

If all the species in a reef community had, and maintained, predictable unimodal population abundances then a transformation could be applied to create a normal distribution of the species abundance and thus meet the assumptions of normality. Behaviorly, however, species may occur in normal, positively or negatively binomial, or Poisson distributions. Species may also occur in multimodal distributions as well as in a combination of all of the above. Additionally one must recognize that the frequency distribution of a population is dynamic and often changes temporally as noted by differences in daily and seasonal social activities within populations of reef fishes.

It is doubtful then that any one transformation could be applied to all species. Thus the use of a single transformation is incorrect and the use of separate species specific transformations is presently unjustified. In recent years the procedure of standardization has been applied to species abundance data. Standardization merely takes each data point, substracts it from the mean and divides it by the sample standard deviation. Thus all the abundance data are analyzed in standard deviation units. The problem of unequal weighting (i.e., some species abundances overemphasized in an analysis) is reduced because all species now have a mean abundance of 0 and a variance approaching 1. The assumption of homogeneity of variance is met because the data generally cannot form pattern with the means. The assumption for normality, while not met, is at least approximated in that the normal-shaped distribution curve is approached by all species.

Transformations can be an effective way of meeting the assumptions necessary for parametric statistical analysis. But because of the obvious and significant behavioral differences among and between reef fishes, any general transformation would merely confuse the inherent variation present.

Standardization, on the other hand, allows most of the assumptions to be met. If one chooses to use the more powerful parametric statistics, then standardization may provide an acceptable form of "transformation" which still allows us to meet most of the necessary assumptions. In lieu of standardization, it is suggested that non-parametric types of statistical analyses be used.

STATISTICAL ANALYSIS OF COMMUNITY DATA

by

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National Marine Fisheries Service

Statistical analysis of species abundance data from a multispecies community frequently results in a separate univariate analysis of each species abundance pattern. Since communities are multispecies situations, multivariate analysis may provide a method of testing for differences among entire assemblages and a means for reducing complex data into an interpretable form. Prior to analysis, it is frequently necessary to eliminate rare species from consideration and to transform the species abundance data. Criteria for eliminating the rare species are left to the investigator; criteria for the use of appropriate transformations in both univariate and multivariate situations are discussed by Green (1979). Ideally the entire data set should be divided into two subsets: a hypothesis generating set and a hypothesis testing set. The hypothesis generating set may be used to group similar samples (transects, rotenone stations, etc.) via cluster analysis; the second subset may be used to test the statistical significance of the groups via multivariate analysis of variance procedures. Stepwise multiple discriminant analysis offers a method for selecting index species which provides the maximum separation of the cluster groups and eliminates redundancy in the data. Calculation of confidence ellipses around group centroids of the discriminant scores can be used to illustrate the separation and/or overlap of the cluster groups and also indicate the relationship of all samples to the groups and to other samples (Timm 1975; Green 1978). Various ordination techniques are useful for detecting underlying environmental gradients which affect the distribution and abundance of the fishes in the community (Gauch 1973; Gauch, Chase and Whittaker 1974; Gauch, Whittaker and Singer 1981).

When a community is repeatedly sampled through time the autocorrelated errors encountered may invalidate the assumptions of parametric methods. Statistical packages are available in both the Statistical Analysis System (Ray 1982) and the Biomedical Computer Program Services (Dixon and Brown 1979) which can be used to detect autocorrelation of repeated samples and to adjust the data to compensate for the non-independence of the samples.

Time series analysis is also appropriate for detecting seasonal abundance cycles of individual species and for investigating the temporal relationship between trophic levels, predator-prey systems, etc (Mabert 1975). Circular statistics provide an alternative approach to the analysis of seasonal cycles (Batschelet 1965). Multivariate time series models may be useful for predicting a vector of future species abundances within a community (Anderson 1980) and may also provide some insight into the stochastic/deterministic nature of these systems. All time series techniques, however, require that samples be taken at regular intervals and that no sampling periods are missed. Thus a sampling strategy should be planned in such a way as to insure that a complete regular time series is obtained if questions regarding the response of the community through time are to be addressed.

STATISTICAL ANALYSIS OF VISUAL POPULATION ESTIMATES

by

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The biological interpretation of "statistically significant differences" in fish population densities, estimated in different times or places, is difficult to achieve, unless the inherent variability of the species abundance, both in time and space, are taken into account. In as much as such baseline data are seldom available, it is suggested that nested ANOVA or analagous parametric or non-parametric experimental design should be utilized in investigations which attempt to establish whether such differences exist. In this way it can be more clearly established that measured differences in abundance estimates are primarily due to the time/space effects investigated, rather than attributable to the sampling methods, methods of data analysis, or other intangibles.

UTILIZATION OF REMOTELY OPERATED VEHICLES (ROVS) FOR FISH POPULATION ASSESSMENT: ANALYSIS TECHNIQUES

by

M. John Thompson
Continental Shelf Associates, Inc.

Three remotely operated underwater vehicles (ROVS) were evaluated for assessing fish populations of offshore oil and gas production platforms along the outer continental shelf and slope in the northwestern Gulf of Mexico, during the summer and fall of 1980. These three vehicles were: a towed television camera sled system (used only in a stationary mode) owned by Continental Shelf Associates, Inc. (CSA); the Hydro Products RCV-225, a tethered, free-swimming ROV; and the Perry Oceanographic Recon III-B, another tethered, free-swimming ROV. The purpose of this study was to develop remote visual fish population assessment techniques which could be employed in depths precluding conventional scuba observations.

Visual observations were quantified based on the number of fish observed in a known volume of water. Population estimates were made from videotape records of three minutes duration per station. Fifteen replicate samples were taken from each record. A random number table was used to determine where the videotape would be stopped for analysis. When the tape was stopped, all fish within the target volume (i.e., the volume observed between the camera lens and the viewed target) were identified and counted.

Fish populations (fish per cubic meter) were estimated using the mean value for each species reported from each platform surveyed. The actual subsurface volume of each platform sampled was calculated from engineering drawings. An additional ten meters were added (five meters to all sides) to the actual horizontal dimensions of each platform. This addition was made in order to encompass the territory inhabited by such structure-associated fishes as Atlantic spadefish or vermilion snapper, whose schools normally extended outside the platform. The calculated volume surveyed was multiplied by the mean number of individuals per cubic meter to yield a standing stock estimate.

Total standing stock and standing stock per species were correlated with total platform subsurface habitat area, using linear regression and curve fitting equations. Results of these analyses indicated high correlation (linear model: $r=0.89$, exponential model: $r=0.96$) between overall fish abundance and subsurface habitat area.

Data gathered during this study clearly indicates that ROVs can be used successfully for assessing fish species populations and assemblages at offshore structures. To actually perform cost effective assessments, tethered, free-swimming type ROVs are required. Non-free-swimming vehicles do not allow sampling of enough stations (in a reasonable time period) for species distribution variations.

POPULATION AND CONFIDENCE INTERVAL ESTIMATION FROM VIDEO CENSUS OF REEF FISH

BY

W. J. Gazey
LGL Ecological Research Associates, Inc.

Underwater video census of fish are usually recorded by means of strip transects. It is tempting to apply well developed terrestial and aerial statistical methodologies to these data where population point estimates are obtained using simple ratio arguments. And confidence intervals are determined by assuming a binomial, poisson, hypergeometric or normal distribution for the population estimate. In addition, there is a wealth of sophistication available for the determination of variance and degrees of freedom estimates. Unfortunately, simple mean to variance ratio tests demonstrate that these distributional assumptions are patently false for video census data. Indeed, the large variances commonly found in these data (and many other types of biological transect data) lead to absurdly huge confidence intervals with the blind applications of plus or minus some constant number of standard deviations. Obviously, new distributional hypotheses of population estimates must be developed if these data are ever to be utilized to their full potential.

One approach that shows promise is to regard the number of fish observed in a transect as a counting process. For example, a simple, and possibly theoretically justifiable, representation is that each fish (of the species of interest) is observed or counted on a random basis (i.e. each fish is subjected to Poisson events) but the rate varies for different individuals (assume say a Gamma distribution). A necessary complication is that the area covered during replicate transects is not constant. Compounding these processes yields a varying element size negative binomial distribution for the number of fish observed. The distributional parameter estimates are then estimated by maximum likelihood methods with initial estimates determined by the method of moments. These parameters can then be used to generate a population estimate and confidence intervals.

Good results have been obtained with non-schooling reef fish (e.g. creole fish and red snapper). On the other hand, these assumptions are not very attractive for schooling fish or fish that exhibit a clumped distribution and, not surprisingly, the corresponding estimates have been poor.

The most applicable information to determine alternative distributional hypothesis is the rate at which fish are observed or counted during a transect. Since video data is recorded, the determination of "arrival times" is feasible to a high level of accurracy. Therefore a rare opportunity exists to incorporate a large body of theory of counting processes to this transect data. Most importantly, the biological behavior of fish is explicitly integrated into the estimation procedure.

RESEARCH NEEDS*: A COMPOSITE

*Contributors' initials following in parentheses.

Field Sampling

1. Establish one or more methodologies as standard for spatial and temporal comparisons, by simultaneous field evaluation of the most promising, currently applied techniques (CAB, GSB, SAB, GSH, JJK, FLN, WAS).

    a. field testing should be conducted on a real or dummy population under controlled conditions (i.e. at same time of day, year, area, biotype, etc.),

    b. describe criteria and variables most essential to the accurate assessment of fish communities,

    c. develop and use computer models to identify the methods most likely to give optimal sampling efficiency and reduced variability of results during the field testing,

    d. technique evaluations should include: application of statistical techniques, cost/benefit analysis, description of positive and negative attributes and biases,

    e. possibly establish the Jones-Thompson Technique as a standard for inter-biotype or habitat comparisons of fish communities.

2. Consideration should be given to location and time specific calibration of the selected techniques and operators (i.e., divers, pilots, etc.) (CAB, SAB, GSH, WAS, MJT),

    a. develop coefficients which permit a conversion for comparison of results from one field technique to any other,

    b. allow for the correction of results which vary due to the area sampled and amount of observation time.

3. Other techniques (submersible, RCV and UWTV) could be validated and calibrated by shallow water comparisons with the selected standard SCUBA technique (GSB, MJT).

4. Incorporate capabilities necessary for fish enumeration into the design of RCV's (MJT).

    a. reevaluate the new RCV's assessment potential,

    b. careful consideration must be given to all factors in RCV selection.

5. Investigations need to be conducted to determine how underwater visibility and various viewing geometries bias samples (MJT).

6. Use a combination of present techniques at each site for near future comparisons (GSH).

7. Initiate standardized visual monitoring of specific habitat types on a regional basis (CAB, FLN).

8. Continue frequent communications on visual assessment research via participation in workshops, joint proposals, joint research and newsletters (GSH, FLN).

Data Analysis and Synthesis

1. Establish one or more standard statistical techniques (parametric and/or nonparametric) for reporting the results from field enumeration techniques (CAB, GSB, SAB, JJK, FLN, WAS).

    a. continue the adaptation and application of procedures used by other disciplines with similar distributional and variance problems,

    b. evaluate the most promising statistical techniques by their application to data from a number of structurally different fish communities,

    c. identify and describe the assumptions of the chosen statistical techniques,

    d. define confidence limits for all population estimates.

2. Attempt to decrease the variance associated with visual population enumeration estimates (CAB, SAB, GSH).

    a. incorporate information on species specific behavior/distribution patterns into analyses,

    b. incorporate data from operator/technique calibrations,

    c. confine sampling to the fewest number of discrete habitat/community types, preferably one,

    d. identify and correct major sources of variability influencing the sample methods.

3. Develop methods of compiling data from the other visual techniques (submersible, RCV and UWTV) (CAB, GSB, MJT).

4. Develope a standardized way of reporting results to facilitate future comparisons. (i.e., No./water volume vs. No./bottom area) (GSB).

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