APPROACHES TO RESOURCE ASSESSMENT FOR LOBSTER, BOTTOM FISH, MONK SEAL, AND GREEN TURTLE STOCKS IN THE NORTHWESTERN HAWAIIAN ISLANDS

by

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1. INTRODUCTION

The Honolulu Laboratory, Southwest Fisheries Center, National Marine Fisheries Service (NMFS), is assessing the stocks of spiny lobster, *Panulirus marginatus*, a snapper (Lutjanidae) and grouper (Serranidae) complex of bottom fishes, the Hawaiian monk seal, *Monachus schauinslandi*, and the green turtle, *Chelonia mydas*, in the Northwestern Hawaiian Islands (NWHI).

The NWHI is an area of reefs, banks and islands located northwest of Honolulu stretching from Nihoa Island 1 250 n mi northwest to Kure Atoll. The spiny lobster and bottom fish resources support a modest fishery in the NWHI. The monk seal is an "endangered" species breeding only in the NWHI and the green turtle is considered a "threatened" species under the US Endangered Species Act.

2. SPINY LOBSTER

The spiny lobster fishery began in 1975 when the NOAA ship TOWNSEND CROMWELL, a research ship assigned to the Honolulu Laboratory, documented good catch rates of spiny lobster, at the lower end of the chain. In 1975 the commercial catch was 2 000 kg. Each subsequent year the catch has increased and the current catch for 1981 is estimated at 300 000 kg (Skillman and Ito, 1981). The rapid development of this fishery has raised concern that overfishing may occur and work to develop a fishery management plan (FMP) was initiated by the Western Pacific Regional Fishery Management Council. The Honolulu Laboratory has contributed to this FMP by undertaking work to: 1) Determine the distribution of the resource throughout the NWHI chain, and 2) estimate the sustainable yield of the resource. The data available for these analyses consist of sampling data collected on research cruises of the TONWSEND CROMWELL, and some commercial catch and effort data.

The data collected by the TOWNSEND CROMWELL represent a systematic sampling survey with catch and effort data collected from 0.1° squares around the banks and islands of the NWHI. This catch-per-unit-effort (cpue) data were used to prepare charts of the relative abundance of the spiny lobster stock throughout the NWHI (Uchida *et al.*, 1980).

The estimation of sustainable yield for the region was based on the commercial catch and effort data base. There currently is no regulation that requires commercial vessels to report their catch and effort and, hence, only an intermittent catch and effort data series submitted on a voluntary basis was available. While the catch and effort time series were too short and sporadic for surplus production analyses, a series of catch and effort data which represented intensive trapping applied to a previously unexploited population was available for analysis. Based on this intensive catch and effort data, an estimate of pre-exploitation population size (N_0) and catchability (q) could be obtained by computing a regression of cpue on cumulative catch (Leslie method, Ricker 1975, p. 150).

Another approach to estimate pre-exploitation biomass was applied to data collected from Necker Island at the lower end of the chain where much of the earlier commercial effort was directed. This approach was based on a method proposed by Allen (1966) in which population size and catchability are estimated in a manner which minimizes the sum of squares between the actual catch and the predicted catch, given effort. In its most general form, this model assumes that the rate of natural mortality is constant while recruitement may vary over time. This most general form requires that the user supplies estimates of the natural mortality and recruitement rates. We did not have any estimate of recruitement rate and hence modified Allen's model. We assumed that the ratio of the rate of natural mortality to the recruitement rate was constant over the two-year period for which data were available. This ratio together with population size and catchability are then estimated by least squares. Application of this method to 24 months of commercial catch and effort data from Necker Island produced estimates of catchability and population size which were in agreement with the estimates obtained from the same site by an intensive fishing analysis (Polovina and Tagami, 1980).

Once pre-exploitation population size, and hence biomass, were obtained for several areas where research sampling cpue data were available, a linear regression of biomass per unit area on research sampling cpue was used to obtain an estimate of total biomass for the entire NWHI. Based on this total estimate of pre-exploitation biomass (B_o), rough approximation of lobster maximum sustainable yield (MSY) for the NWHI were obtained based on Gulland's (1971) relationship:

$$MSY = M\ B_o/2$$

where M = annual instantaneous natural mortality,

and a method proposed by Pauly (1981):

$$MSY = 2.3\ \bar{w}^{\ -\ 0.26}\ B_o$$

where $\bar{w}$ is defined as the average of the weight at first maturity and the maximum weight of the lobster in the population (in grams).

To estimate natural mortality (M) for Gulland's relationship, the following relationship (Beverton and Holt 1956) was used on data obtained at sites with little or no fishing:

$$F+M = K(L - \bar{L})/(\bar{L} - L_{min})$$

where $\bar{L}$ is the mean carapace length from the trappable population, L_{min} is the minimum carapace length from the trappable population, and K and L are the parameters from the von Bertalanffy growth equation which were estimated from modal analysis of length-frequency data.

While these methods produced estimates which can only represent rough approximations, it appears that the results nonetheless represent reasonable first approximations. The approach described produced estimates of annual MSY ranging from 100 000 kg to 200 000 kg (WPRFMC, 1981). The yield for 1981 was 300 000 kg; however, the substantial decline in catch rate and lobster size suggests that this yield is not sustainable. Once the FMP is in force and commercial catch and effort data can be collected, it is anticipated that these estimates will be revised.

Two difficulties encountered in this analysis were the availability of only short and sporadic commercial catch and effort data and the difficulty of obtaining precise estimates of growth parameters. Both tagging data and analysis of modes and modal progressions of length-frequency data were used to estimate growth parameters. The tagging approach suffered from insufficient recoveries and relatively slow apparent growth for the animals recovered possibly due to an effect of tagging on growth. The analysis of length-frequency data showed large variances in growth due to the difficulty in identifying modes which was apparently caused by the large variance in size among lobsters of the same cohort.

3. BOTTOM FISHES

The bottom fish fishery exploits a complex of species, especially snappers (*Pristipomoides* spp., *Etelis* spp., and *Aprion virescens*), but including also jacks (Carangidae: *Caranx* spp., *Carangoides* spp., and *Seriola dumerili*) and a grouper (*Ephinephelus quernus*). The fishery is conducted in deep (60-340 m) offshore waters using baited hook-and-line gear, and powered mechanical line-haulers.

Bottom fishes have been exploited around both the main Hawaiian Islands and the NWHI since at least 1945. However, until recently only one vessel regularly fished in the NWHI. Recently more commercial vessels have begun exploiting bottom fish stocks in the NWHI, but the data base of commercial catch and effort for the NWHI is not sufficient to perform a stock-production analysis. A larger data base for comercial catch and effort data around the main Hawaiian Islands is available and a stock-production analysis of the bottom fish resource around the main islands of the State was completed using a 20-year series of catch data collected by the Hawaii Division of Aquatic Resources (Ralston and Polovina, in press). Although fishing effort statistics were not specifically maintained, a computer program sorted through the data base and tallied the number of fisherman-days expended each year in the fishery. The stock was treated as a multispecies fishery and analysed by application of the Total Biomass Schaefer Model (TBSM) (Pope, 1979). Cluster analysis of the data showed that bottom fish species could conveniently be divided into three somewhat distinct groups which appeared to be segregated on the basis of depth and could be analysed by the use of TBSM. Using aggregation theory it was demonstrated that the cluster groups provided a more accurate and biologically meaningful way of expressing production in a multispecies framework. The analysis also showed that the fishery is currently close to MSY.

The chief liability of this study was that the measure of fishing effort which was employed had to be determined after the fact. Interpretation of the statistic used became most difficult as a result. Furthermore, the recreational catch of bottom fish in Hawaii is unreported and thus unaccounted for. Consequently, estimates of surplus production from this analysis can only be considered as a lower bound for yield potential.

A yield-per-recruit analysis of *Pristipomoides filamentosus* has also been completed. This is the most important species in the fishery and it was studied in some depth to complement the results of the stock-production study. In an investigation of the growth dynamics of this species, the density of daily increments in sagittal otoliths was integrated to estimate age (Ralston and Miyamoto in press). The daily periodicity of the increments was validated by *in vivo* tetracycline labelling of otoliths and examination of shifts in field-sampled size-frequency distribution. An age-length key was generated from regression statistics derived from the estimated age-length data. This key was then applied to length-frequency samples to estimate mortality rate using the catch-curve method. Experimental fishing trials were conducted to assess the likelihood of severe size bias in these hook-and-line samples. The yield-per-recruit calculations for *P. filamentosus* showed that eumetric conditions currently prevail for this species at a relatively high level of yield (Ralston, 1981). This result is considered compatible with the finding that the fishery is now operating close to its MSY.

A major difficulty in these studies was the labor-intensive nature of working with daily increments in otoliths. In this regard, the growth of *P. filamentosus* remains the topic of ongoing study, as is the growth of other bottom fish species. Furthermore, more extensive length-frequency samples of these fishes would have been desirable.

The results of these stock assessments have shown that the bottom fish resources of the main Hawaiian Island are currently being intensively exploited and yet further expansion of the fishery into the NWHI appears feasible on biological grounds. Ancillary studies concerning the diets and fecundities of selected bottom fish species are also currently being pursued (Uchida, Ito and Uchiyama, 1979), and these should assist in the management of bottom fish stocks.

4. HAWAIIAN MONK SEAL AND GREEN TURTLE

Both the Hawaiian monk seal and the green turtle are protected under provisions of the US Endangered Species Act. Assessing the status of their populations for stock protection and rehabilitation is therefore a major goal of the Honolulu Laboratory.

The programme for assessment of green turtles is in its second year. The long-range objectives are to gather information on reproductive ecology, migratory patterns, growth rates, mortality rates, and other life history characteristics which will lead to an understanding of turtle population dynamics. Mark-and-recapture techniques will be used extensively. Metal flipper tags have been applied by non-NMFS biologists to over 1 100 turtles since 1973, but mostly to adult animals in the NWHI. In 1981 NMFS scientists experimented with tagging of green turtle hatchlings using auto-transplanted tissue plugs. Results were very promising, so in 1982 the Honolulu Laboratory will mark several hundred hatchlings with reversed scute plugs as they leave their nests at French Frigate Shoals.

Honolulu Laboratory research on the Hawaiian monk seal is also in its second year. Past work has been carried on by sientists from the Department of the Interior, the Department of Commerce, and by researchers on contract to the Honolulu Laboratory and to the Marine Mammal Commission.

Part of the 1981 programme involved the development and implementation of a recovery plan for the monk seal population, and this included an outline of research needs for stock assessment and an understanding of seal population dynamics. A variety of assessment techniques might be employed, including aerial and ground counts to develop abundance indices and mark-and-recapture methods using natural marks, bleach marks, or tags.

During 1982 a pilot tagging project at Lisianski Island will be undertaken to test the suitability of plastic cattle tags applied to the hind flippers of about 15 weaned monk seal pups. The tagged pups will also be bleach marked, as will an equal number of untagged pups. Data will be collected on temporal and spatial aspects of haul-out behavior, inter- and intra-specific interactions, and on other aspects of their early life history. If the effects of the tagging procedure and the presence of the tags are judged to be insignificant, a pup-tagging programme throughout the breeding range of the Hawaiian monk seal will be proposed for 1983.

Tags may also be applied to adult seals in future research. The tagging studies will produce critical information on age- and sex-specific mortality rates, age at first reproduction, reproduction rates, inter-island movement, and population size.

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