Preliminary Analysis of Results from Fishery Independent Handline and Trap surveys Conducted in the U.S. Caribbean for Two Commercially Important Species: Yellowtail Snapper and Red Hind

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Executive Summary

Catch records obtained from fishermen are often sparse, and influenced by a variety of factors including economic conditions, change in gear design, and the alteration of fishing strategy. These problems with catch record reflect an inherent bias in fishery dependent data, for which fishery independent data is needed to compensate (Rosario, et. al. 2004). Two sets of fishery independent data collected in the U.S. Caribbean were analyzed: one by the Puerto Rican Department of Natural and Environmental Resources (DNER) and the other through the Southeast Area Monitoring and Assessment Program (SEAMAP). The focus of this report is to compare the stock trends of yellowtail snapper *(Ocyurus chrysurus)* and Red Hind *(Epinephelus guttatus)* as revealed by the fishery independent surveys. In addition, recommendations will be made on the potential application of these survey and data analysis techniques to the future collection and analysis of similar data specific to spiny lobster *(Panulirus argus)* in the U.S. Caribbean.

Description of Sampling Programs

Department of Natural and Environmental Resources (DNER)

The Puerto Rico Department of Natural and Environmental Resources has been collecting fishery independent information on reef fish from 1988 to 2001. Sampling was carried out using fish hooks (size six) baited with squid, and fish traps baited with sardines. During the earlier surveys, fish traps were a mesh size of 1.25" and constructed out of hexagonal wire, while during the later years, the traps used were mesh size 1.5" and constructed out of square mesh vinyl coated wire (Figure 1). Effort was concentrated off of the West Coast of Puerto Rico where sub-quadrants of 0.5 by 0.5 square miles were established. Each sub-quadrant was located by GPS and stratified by depth. Quadrants were selected at random for a particular week's sampling. An individual research vessel within the 0.5 by 0.5 square mile area set at least 12 fish traps. The distance between adjacent traps was at least 150 feet to avoid interference and three traps would be set per string; the traps were soaked for five to six hours. While traps were soaking, three lines each with three hooks were set for four to five hours. The following data was recorded: date, time, fishing location (latitude and longitude), depth, number of hooks fished, traps set and number of the trap in the set, and fish weight, length, species and sex (Rosario, et. al. 2004).

Sampling intensity was variable from one year to the next (Figure 3) with a peak in sampling activity occurring in the late spring (Figure 4). Sampling effort was concentrated on the west coast of Puerto Rico from Rincon to Cabo Rojo (Figure 6). The predominant species caught during the surveys were red hind (40.81%), coney (24.01%), sand tilefish (8.33%) and squirrelfish (3.63%) (Figure 7). The DNER fishery independent surveys targeted reef fish and as a result, there are no records of crustacean catch precluding analysis of Caribbean spiny lobster, one of the two species undergoing assessment this year. Consequently, the focus of this report will be to compare the stock trends of yellowtail snapper, the other species undergoing assessment this year, with the stock trends of red hind. Like yellowtail snapper, red hind is commercially important to the U.S. Caribbean fishery and was chosen for analysis because it was one of the predominant species captured during this assessment. It should also be noted that the number of yellowtail snapper captured was low in comparison to the other species caught; this factor should be considered when following the subsequent analysis.

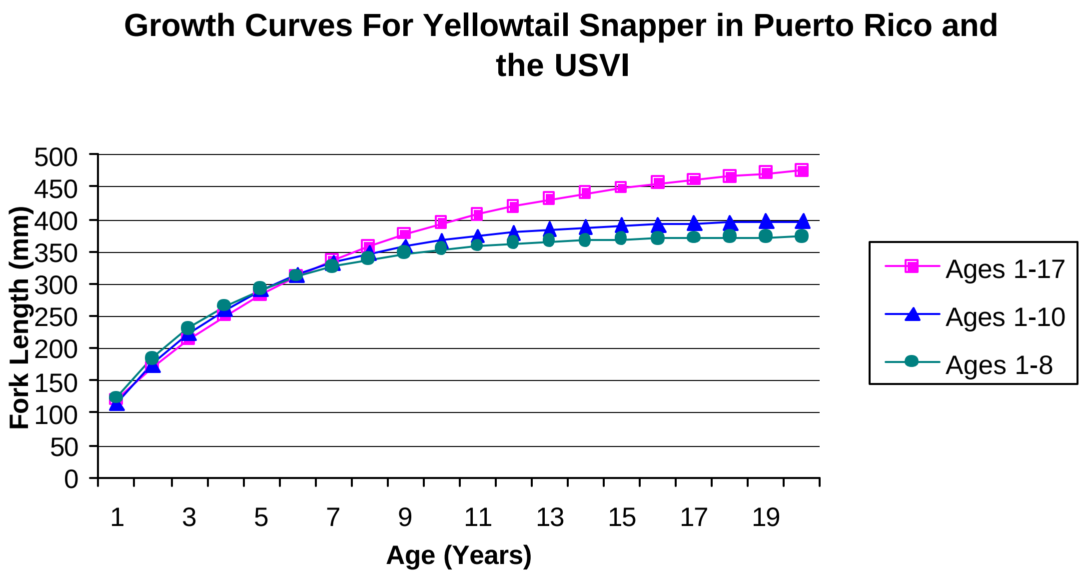
Southeast Area Monitoring Program (SEAMAP)

The Southeast Area Monitoring and Assessment Program (SEAMAP) collects and manages fishery independent data from the southeast of the United States to assess the status of marine resources within U.S. jurisdiction. In the U.S. Caribbean, the Puerto Rico Department of Natural and Environmental Resources (DNER) administers the program, however data collected through the SEAMAP program is kept separate from data collected directly by DNER and no mixing of data occurs. Sampling technique used in the collection of data from reef fish surveys was similar to that used by the DNER. The predominant gears used were traps mesh size 1.25 inches and 1.5 inches, and hook and line (Figure 2). Experimental use of longline and bottom grab was carried out, however no fish captured during this effort, if any, were included in the data. Effort for this survey was more broadly distributed compared to the DNER survey, with sample locations in Puerto Rico and the Virgin Islands. For each location surveyed, quadrants 0.5 miles by 0.5 miles were established. Twelve traps, baited with dwarf herring or redear sardine were deployed on each sample day 150 feet from one another and allowed to soak for about six hours. During this time period, three individuals fished using handlines with three hooks each baited with cut squid and fished for six hours. For each trip, date, time, quadrant, trap soak time, number of traps hauled and lines fished, weather observations, water depth and substrate type were recorded. Biostatistical measurements and gonad analysis were performed on each fish captured (Tobias, et. al. 2002).

Trips were conducted over a period several weeks or months. Hours fished were measured for a given fishing event on each individual boat, at each unique station that was fished on that trip. Consequently, sampling intensity can be measured as a given number of minutes fished on each research trip and was found to be variable from one trip to another and from one boat to another (Figure 5). The predominant species caught during the SEAMAP surveys were red hind (44.06%), coney (28.26%), sand tilefish (5.69%) and squirrelfish (2.51%). The relative abundances of the species sampled during the SEAMAP survey correlates well with the relative abundances of the species sampled during the DNER survey (Figure 8). As such, the low number of yellowtail snapper captured should again be considered when following the subsequent analysis. In addition, the SEAMAP survey, like the DNER survey, targeted reef fish and consequently, few records of crustacean catch and no records of lobster are present. The SEAMAP data will be analyzed in a similar fashion to the way the data collected by the DNER is analyzed, and will also focus primarily on yellowtail snapper and red hind.

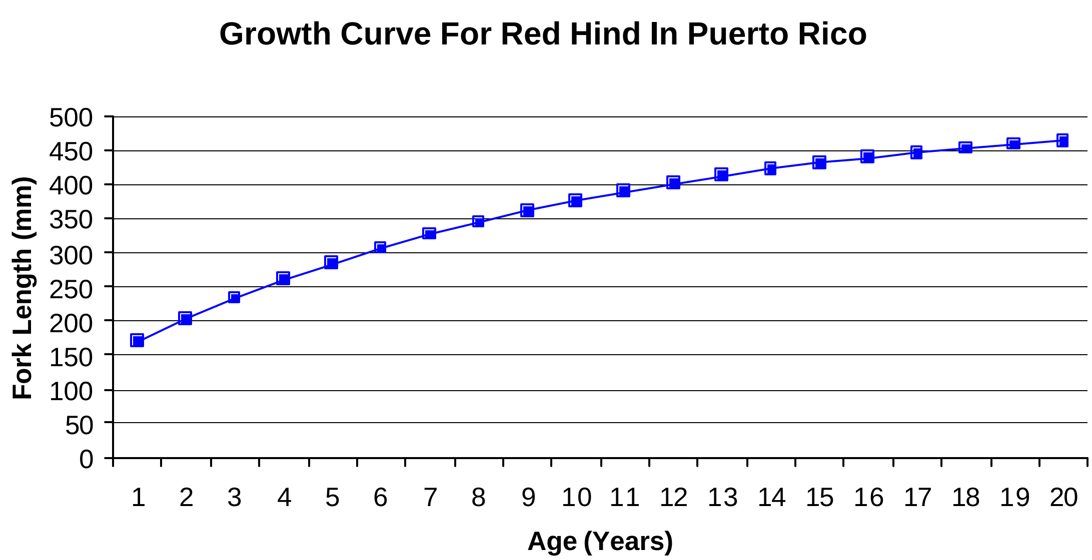
Size and Age of Catch

Analysis of the size and age of individuals caught may provide insight into the status of a particular species. A study on age and growth analysis of yellowtail snapper collected from the U.S. Virgin Islands and Puerto Rico provides a von Bertalanffy growth curve for individuals caught in the area.



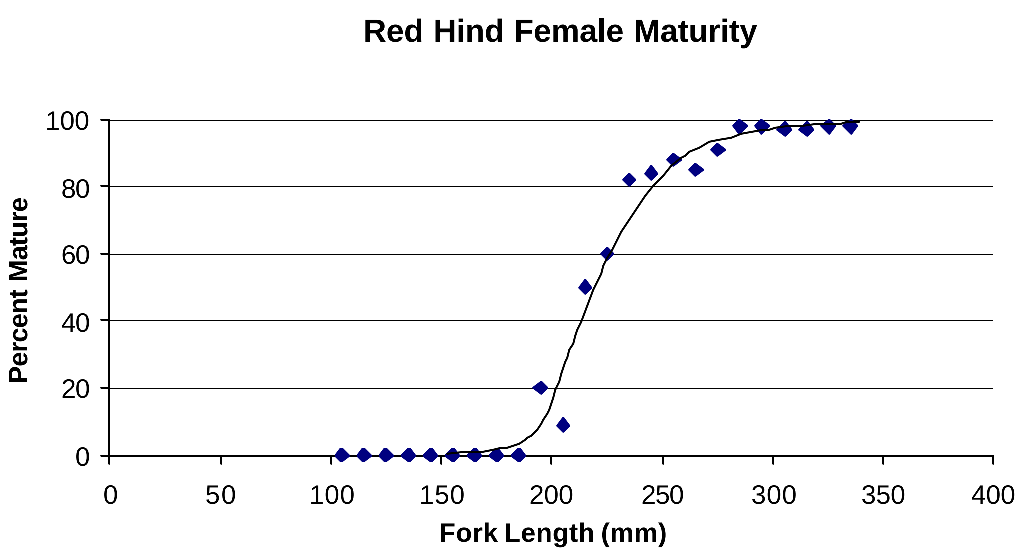
Graph 1: von Bertalanffy growth curves for yellowtail snapper collected from the U.S. Caribbean (Manooch and Drennon 1987).

A similar study conducted in the U.S. Caribbean on the age and growth of red hind collected from Puerto Rico and St. Thomas (U.S. Virgin Islands) provides a von Bertalanffy growth curve for individuals caught in the area.

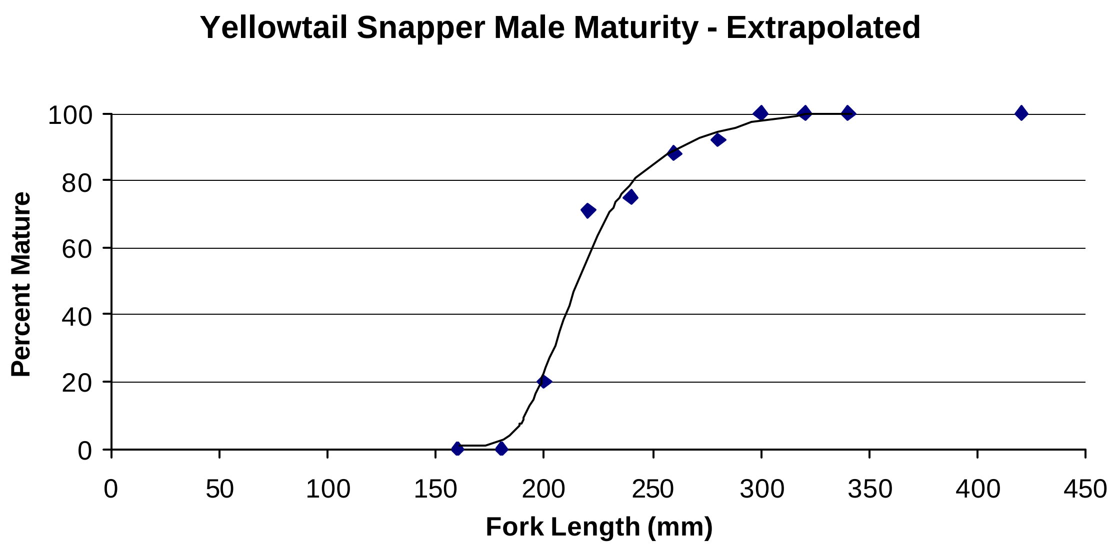


Graph 2: von Bertalanffy growth curve for red hind collected in the U.S. Caribbean (Sadovy, Figuerola, and Roman 1992).

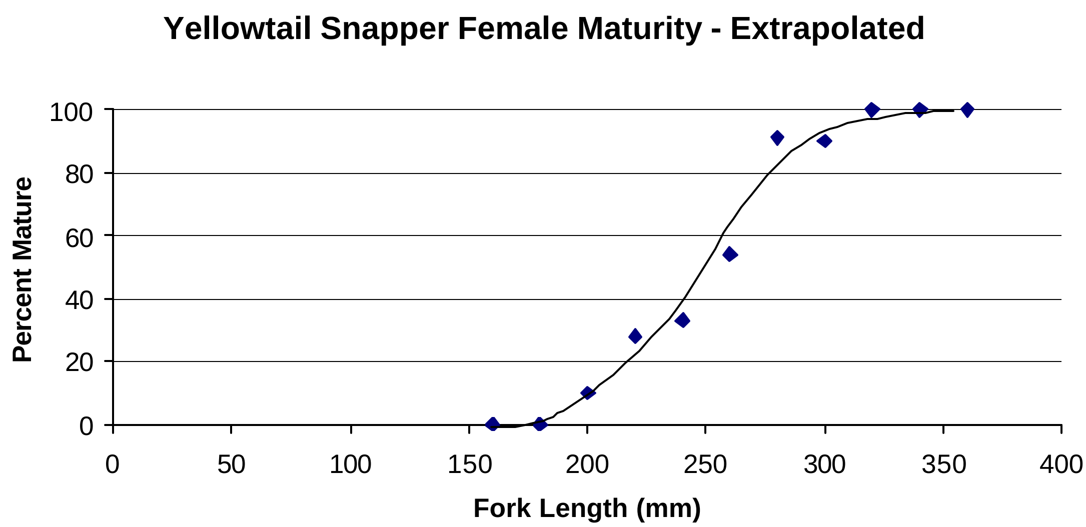
Age and maturity are directly linked to reproductive potential, one factor that can be used to help determine the status of a fish stock. A study conducted off of the west coast of Puerto Rico determined the fork lengths at which red hind became mature. Red hind are protogynous, beginning and initially maturing as females, then possibly undergoing a sex change later in life depending on the environmental need for males in a given population. For this reason, a maturity curve is only available for females (Sasdovy, Rosario and Roman 1994). A similar study conducted off the west coast of Puerto Rico and in the Virgin Islands determined the fork lengths at which yellowtail snapper become mature. Unlike red hind, yellowtail snapper are born either a male or female and remain as such for the duration of their life (Manooch and Drennon 1987). Using the length at maturity curves determined by Sadovy, Rosario and Roman (1994) and Manooch and Drennon (1987), we can look at the lengths of the red hind and yellowtail snapper sampled during the DNER and SEAMAP surveys and determine the approximate number of individuals that were immature at the time of capture.



Graph 3: Maturity curve illustrating length at which red hind sampled off the west coast of Puerto Rico become mature. 50% maturity is achieved at a fork length of 215mm (Sadovy, Rosario and Roman 1994).



Graph 4a: Maturity curve illustrating lengths at which male yellowtail snapper sampled from Puerto Rican waters become mature. 50% maturity is achieved at a fork length of 224mm. Curve derived by extrapolation from Manooch and Drennon (1987).



Graph 4b: Maturity curve illustrating lengths at which female yellowtail snapper sampled from Puerto Rican waters become mature. 50% maturity is achieved at a fork length of 248mm. Curve derived by extrapolation from Manooch and Drennon (1987).

<u>Department of Natural and Environmental Resources Data</u>
The majority of the individuals found in the DNER survey had fork lengths between 160 and 380 mm (Figure 9). Reverse calculation using the von Bertalanffy relationship and the growth parameters provided by Manooch and Drennon (1987) indicate that the majority of the individuals caught and sampled were approximately from two to nine years old (Figure 10).

The relationship between the length and weight of red hind caught during the DNER survey indicates that the majority of the individuals had a fork length of between 150 and 490 mm (Figure 11). Reverse calculation using the von Bertalanffy relationship and the growth parameters provided by Sadovy, Figuerola and Roman (1992) indicates that the majority of the individuals caught and sampled were approximately 0.2 to 25.5 years old (Figure 12).

Using the length at maturity determined by Sadovy, Rosario and Roman (1994), we can look at the lengths of the individuals sampled by the DNER and determine approximately how many of the individuals caught were immature (Figure 13). It was found that 5.22% of the red hind surveyed were less than 215 mm, the length at which 50% of maturity is achieved, while 66.51% of the red hind caught were found to be below 300 mm, the length at which nearly all individuals have reached sexual maturity. Maturity data collected during sampling illustrates that the peak of spawning activity for red hind occurs from about December to February (Figure 14). During this sampling it was discovered that the majority of the individuals captured were female and were not ripe (Figure 15). The high number of immature individuals compared to those captured that were mature may be due to the fact that sampling intensity, as shown in Figure 4 was lower during the months that the majority of the red hind were mature. Further, sampling intensity was greatest from April to June, the time immediately following spawning when most of the red hind are spent (Figure 14). The presence of more females than males (Figure 15) is expected given the fact that red hind are sequential hermaphrodites, beginning their life as females and turning into males as required by the population. When looking at the length of red hind caught over time, it is apparent that during the survey years (1988 to 2001), the overall length of red hind caught steadily declined (Figure 13). In addition, the back calculation of red hind age made using the von Bertalanffy relationship, parameters established by Sadovy, Rosario and Roman (1992), and the length information collected during this survey shows a steady decline of age over the survey period (Figure 16).

As was done with red hind, the length at maturity determined by Figuerola, Matos and Torres (1998) can be used to look at the lengths of the individuals sampled by the DNER and determine approximately how many yellowtail sampled were immature. Of the yellowtail snapper sampled, 49.59% of the individuals caught were below the length at which fifty percent of maturity is achieved in that species (which differs by gender) while 81.97% of individuals were less than 300mm in fork length, which is the length at which the majority of the individuals have reached maturity (Figure 17). Maturity data collected during sampling illustrates that the peak of spawning activity for yellowtail snapper occurs from about March to May, though spawning activity seems to occur year round (Figure 18). During this sampling it was discovered that the majority of the individuals captured were ripe and that the gender distribution of individuals captured was about equal (Figure 19). The fact that so many of the individuals captured were mature may be due to the fact that the sampling intensity per month, as illustrated in Figure 4, was greatest from April to June, which corresponds to the time at which the majority of yellowtail snapper were found to be ripe (Figure 18). Yellowtail snapper are not sequential hermaphrodites and therefore equal distribution of males and females captured is expected. When looking at the length of yellowtail snapper caught over time, it is apparent that during the survey years (1988 to 2001), the overall length of yellowtail caught steadily declined (Figure 17). Back calculation of the age of yellowtail snapper sampled using the von Bertalanffy relationship, the parameters established by Figuerola, Matos-Caraballo and Torres (1998), and the length data collected by the DNER survey shows a decline in the age of individuals caught over the survey time (Figure 20).

Southeast Area Monitoring Program Data

The length to weight relationship of yellowtail snapper caught during the SEAMAP survey illustrates that the majority of the individuals captured had a fork length between 200 and 375mm (Figure 21). Reverse calculation using the von Bertalanffy relationship, the growth parameters provided by Manooch and Drennon (1987) and the lengths of the individuals captured indicate that the majority of the individuals captured were approximately from 2 to 8 years of age (Figure 22).

The relationship between the length and weight of red hind caught during the SEAMAP survey indicates that the majority of the individuals had a fork length of between 170 and 460 mm (Figure 23). Reverse calculation using the von Bertalanffy relationship, the growth parameters provided by Sadovy, Figuerola and Roman (1992), and the length information collected during the SEAMAP survey reveals that the majority of the yellowtail caught and sampled were approximately 0.5 to 20 years of age (Figure 24).

Using the age and maturity curves for red hind and yellowtail snapper presented in Figures 12 and 17 respectively, we can look at the lengths of the individuals sampled during the SEAMAP survey, and as done with the DNER data, determine the approximate number of individuals that were found to be immature at the time of capture (Figure 25). For yellowtail snapper, it was found that 26.51% of the individuals sampled during the SEAMAP survey were below the length at which fifty percent of maturity is achieved in that species (which differs by gender) while 76.84% of the individuals sampled were below 300 mm, the length at which nearly all of the individuals reach maturity (Figure 25). Maturity data collected during sampling illustrates that the peak of spawning activity for the yellowtail snapper sampled occurs from about April to June with a secondary peak in the late summer, though spawning activity seems to occur year round (Figure 26). The gender distribution of yellowtail captured seems to be somewhat equally represented by males and females, and the apparent fluctuations in this ratio may be due to the small sample size (Figure 27). Looking at the trends in age and length of yellowtail captured during the SEAMAP surveys over time, there appears to be a slight decline in both length and age, however the small sample size renders these observations inconclusive.

For red hind captured during the SEAMAP survey, it was found that 6.01% of the red hind surveyed were less than 215 mm, the length at which 50% of maturity is achieved, while 72.28% of the red hind captured were found to be below 300 mm, the length at which nearly all red hind have reached sexual maturity (Figure 29). Maturity data collected during sampling illustrates that the peak of spawning activity for the red hind sampled occurs from about January to April (Figure 30). It was found that the majority of the individuals captured were female (expected since red hind are protogynous) and not ripe (Figure 31). It is hard to determine why so few ripe individuals were captured because the sampling intensity for the SEAMAP survey can only be calculated by trip rather than by a given month as with the DNER data. Looking at the trends in age and length of yellowtail captured over time, length and age appear to remain steady for the SEAMAP data, showing expected marginal population fluctuations over time (Figures 29 and 32).

Catch Rate

Department of Natural and Environmental Resources Data

The frequency at which individuals are caught may be an indication of the relative health of a particular stock. For the fishery independent data gathered by the DNER survey, catch per unit effort was calculated for the surveys over all and specifically for the two species of interest, yellowtail snapper and red hind. Effort is defined as the hours fished with either hooks or traps. Catch is defined as the sum of the weight of the fish caught in grams. Preliminary analysis of catch per unit effort calculations for the 13 years of sampling generally indicate a slight overall decline from 1988 to 2001 with variability from one year to the next illustrating that some years were more successful than others (Figure 33). For red hind, catch per unit effort was significantly greater than the catch per unit effort obtained for yellowtail snapper (Figures 34). Red hind and yellowtail both show a decline in CPUE over time. The catch per unit effort calculated when using hook and line was significantly greater than the catch per unit effort obtained when using fish traps (Figure 35). The overall decline in catch per unit effort for red hind and yellowtail snapper that occurred during this survey may or may not indicate a decline in stock or deterioration in the present health of the stock.

Southeast Area Monitoring Program Data

Catch per unit effort (CPUE) for data collected during the SEAMAP surveys was calculated for each boat on each research cruise; this is indicated by a cruise landing date, the date a particular boat returned from a particular research cruise. Each cruise landing date is unique for a single boat on a single research trip. Effort is defined as the hours fished with either hooks or traps, while catch is determined by the sum of the weight of the fish caught, in grams. The overall catch per unit effort for all the species captured on the SEAMAP research trips appears to remain stable over the eleven year period that sampling has taken place (Figure 38). Significant peaks occurring in the catch per unit effort calculations (such as on 10/21/92, 12/15/93, 3/4/94 and 10/14/99) tend to correlate with sampling trips that took place in the Virgin Islands. Red hind has a significantly greater CPUE than yellowtail, however neither species shows any significant trend over time (Figure 39). Catch per unit effort for each gear type (traps and hooks) is stable, except for the peaks where surveys were done in the Virgin Islands (Figure 40). In addition, analysis of the CPUE for red hind and yellowtail for each gear type revealed no significant trends (Figures 41 and 42).

Recommendations and Conclusions

Based on the analysis of the two fishery independent data sets from the U.S. Caribbean it remains difficult to definitively determine the present health or status of the reef fisheries for yellowtail snapper and red hind in the U.S. Caribbean. It should be noted, however that the data analyzed reveals some trends that are often characteristic of stock depletion. The locations, and in particular, depths fished during the survey could have had a bearing on these trends. For example, an eleven or 13-year period may not be sufficient time to reveal an accurate population trend for yellowtail snapper or red hind. Bearing in mind the trends revealed by the data, the fisheries independent data ought to be looked at in conjunction with landings data and socioeconomic information to fully determine whether a decline in fish stock has been occurring.

Given that one of the main focuses of the year's assessment is on spiny lobster, the fact that little fisheries independent data was available on the status of this species indicates that there is a need to gather more data on the status of this commercially important species. As a result, it is recommended that an agency (such as the Puerto Rico DNER, Caribbean Fisheries Management Council, SEAMAP Program, or NOAA) undertake a fishery independent data collection project tailored specifically to obtaining data on the status of *Panulirus argus* in the U.S. Caribbean. Similar methodology and data analysis to that used by the DNER and SEAMAP programs is recommended such that the lobster data obtained can be looked at in light of the reef fish data obtained over the past eleven or 13 years. In addition, it might be useful to consider undertaking a comprehensive habitat mapping assessment in conjunction with further stock assessment projects in order to better understand and explain the trends described in the data.

Literature Cited

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APPENDEX I: DESCRIPTION OF SAMPLING PROGRAM

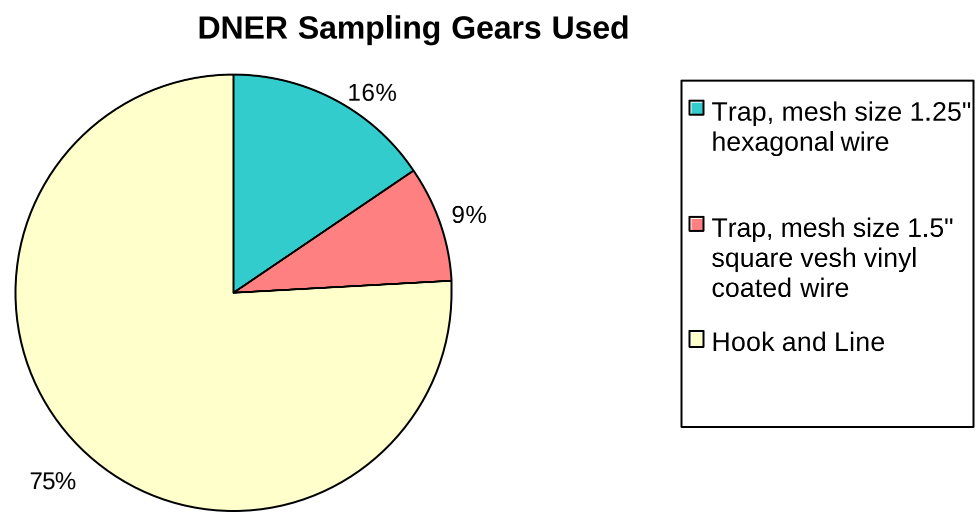

Figure 1: Percentage of indivi duals captured with each sampling gear used during the DNER survey.

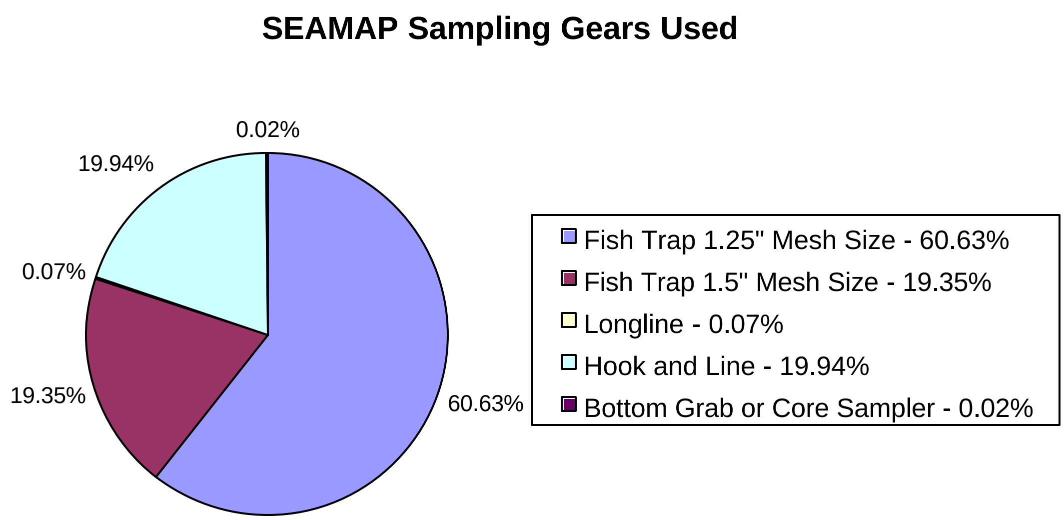

Figure 2: Percentage of individuals captured with each sampling gear employed during the SEAMAP survey.

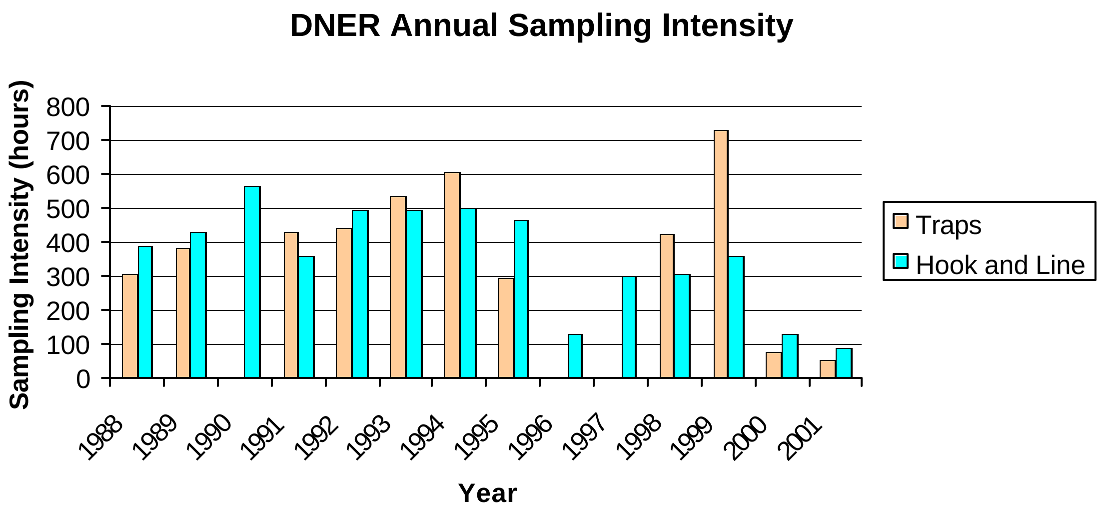

Figure 3: Sampling intensity during the DNER survey for each year and gear type.

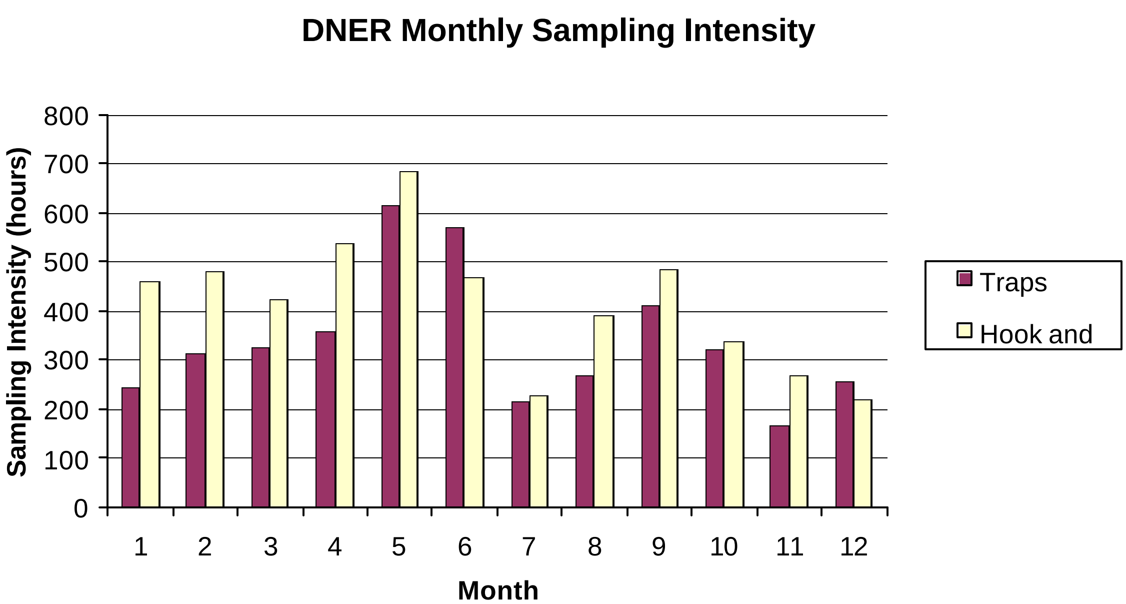

Figure 4: Sampling intensity during the DNER survey for each month and gear type.

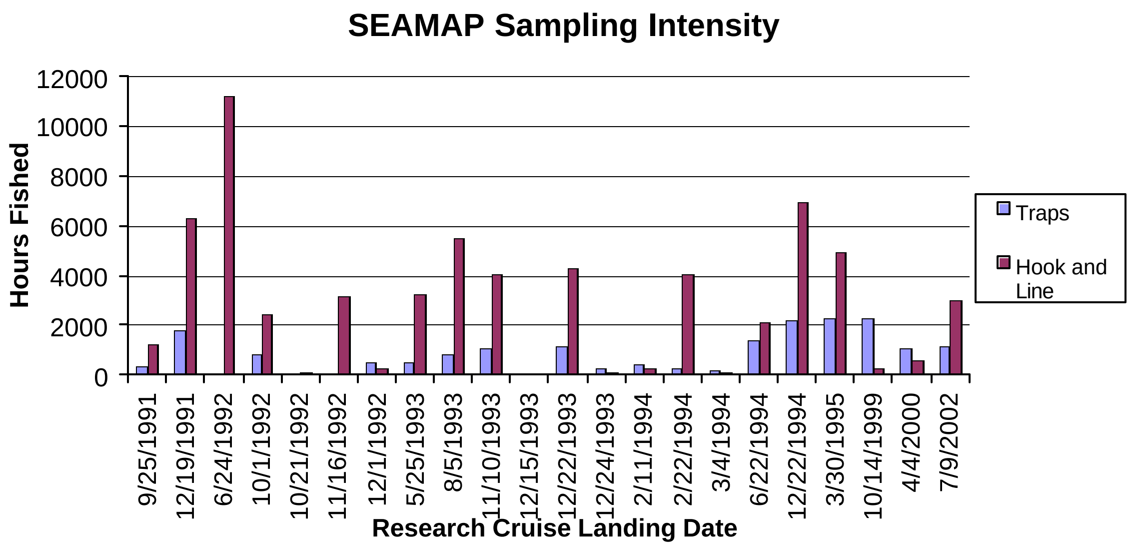

Figure 5: SEAMAP sampling intensity by the landing date of each boat on each research sampling trip in the chronological order in which they occurred, 1988 to 2002.

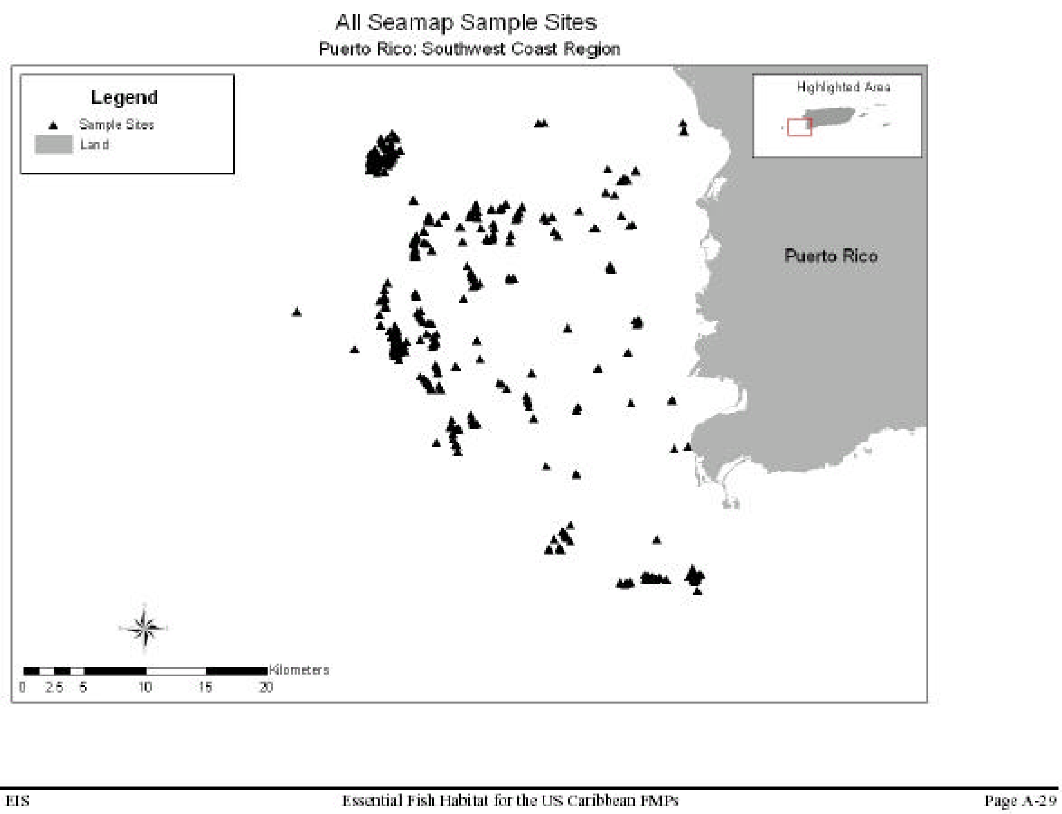

Figure 6: Survey sites off of the west coast of Puerto Rico, Rincon to Caba Rojo (Final EIS for the Essential Fish Habitat for the U.S. Caribbean FMPs 2004).

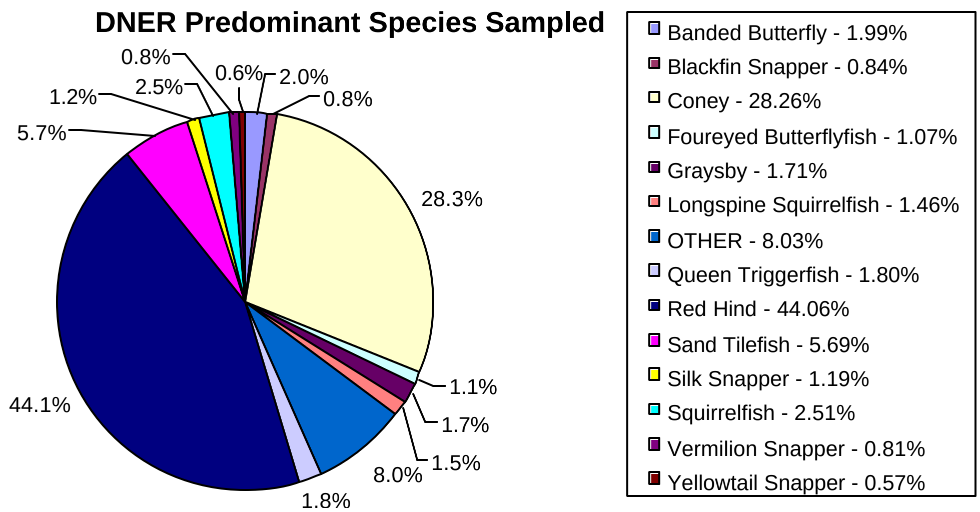

Figure 7: Predominant species sampled during the DNER survey.

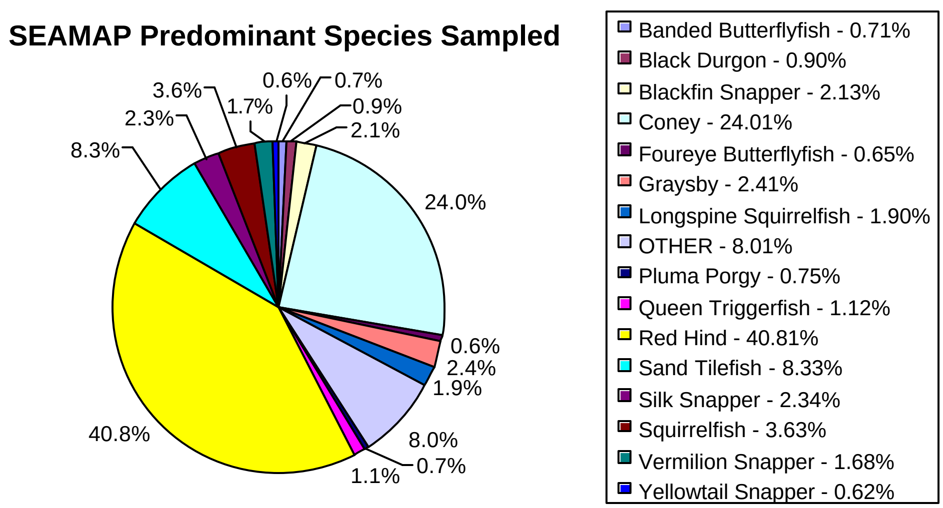

Figure 8: Predominant species sampled during the SEAMAP Survey.

APPENDEX II: SIZE AND AGE OF CATCH

Department of Natural and Environmental Resources Data

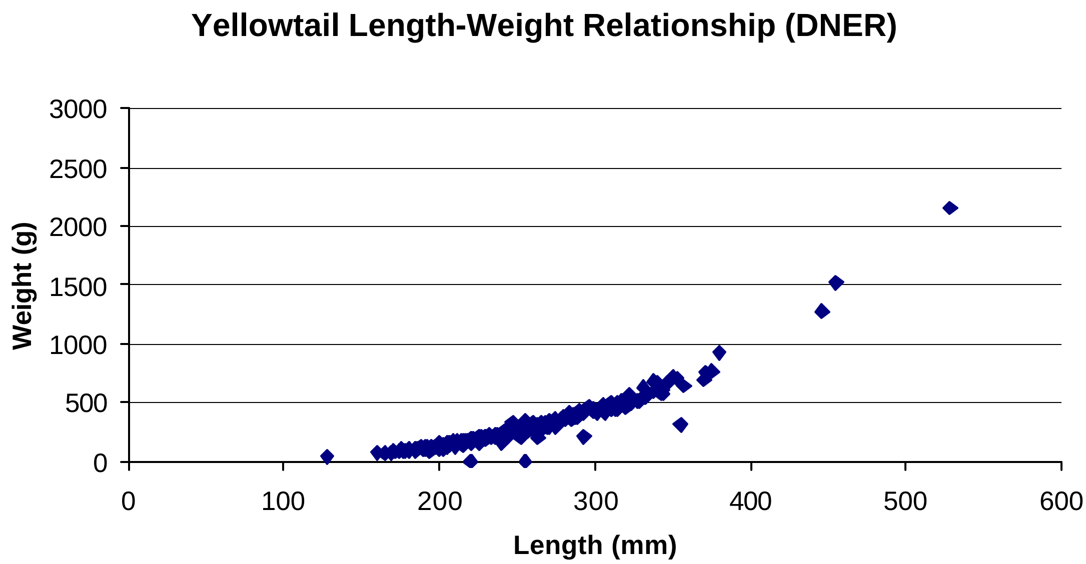

Figure 9: The length-weight relationship for yellowtail snapper surveyed by DNER (n = 244).

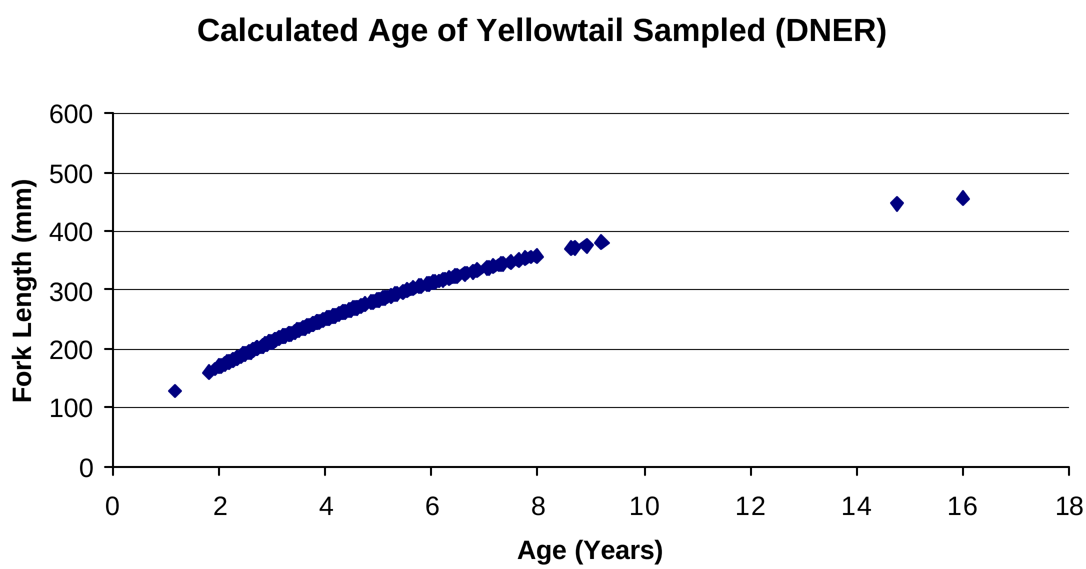

Figure 10: Calculated age of yellowtail snapper sampled by DNER using the von Bertalanffy relationship and growth parameters estimated by Manooch and Drennon (1987).

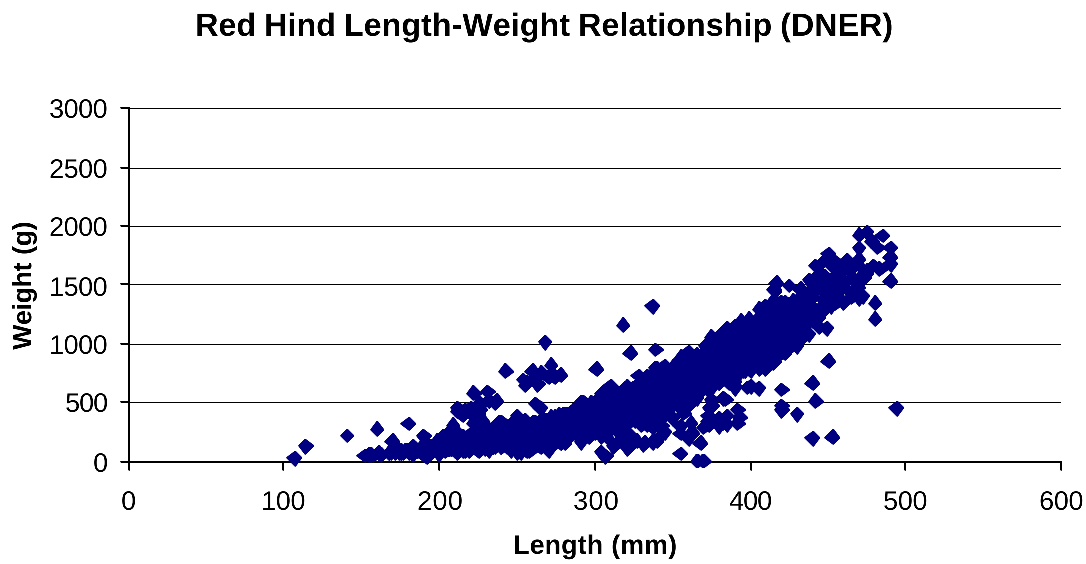

Figure 11: The length-weight relationship for red hind surveyed by DNER (n = 16,043).

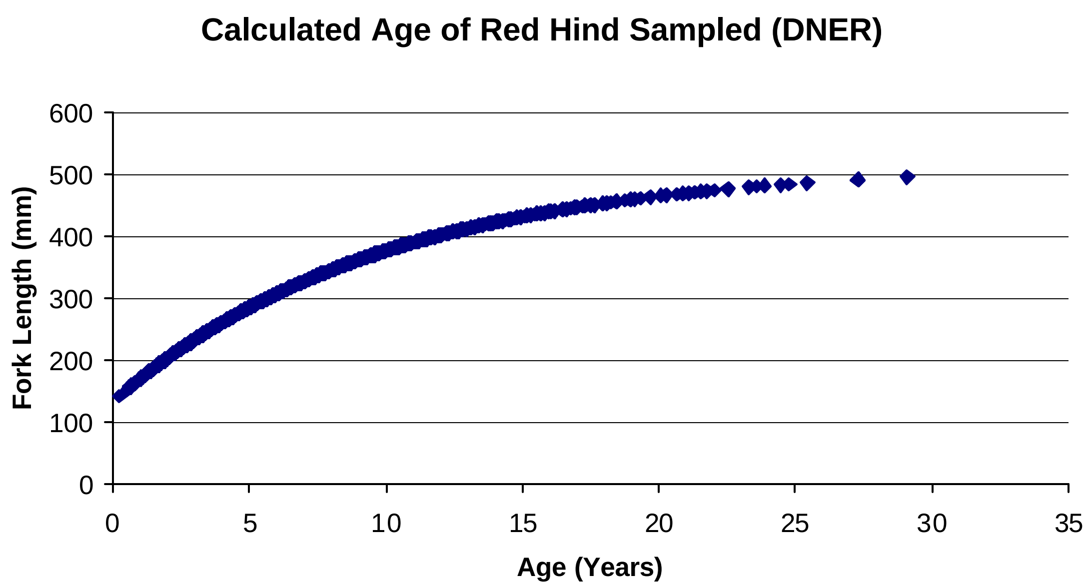

Figure 12: Calculated age of red hind sampled by DNER using the von Bertalanffy growth relationship and the estimated parameters provided by Sadovy, Figuerola and Roman (1992).

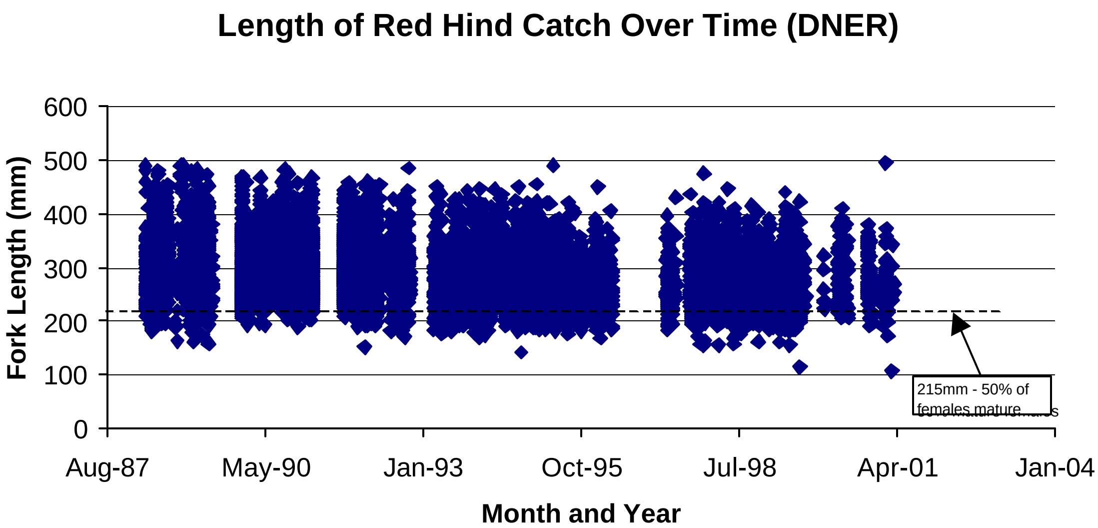

Figure 13: Length of the red hind sampled by DNER over time (n = 16,043).

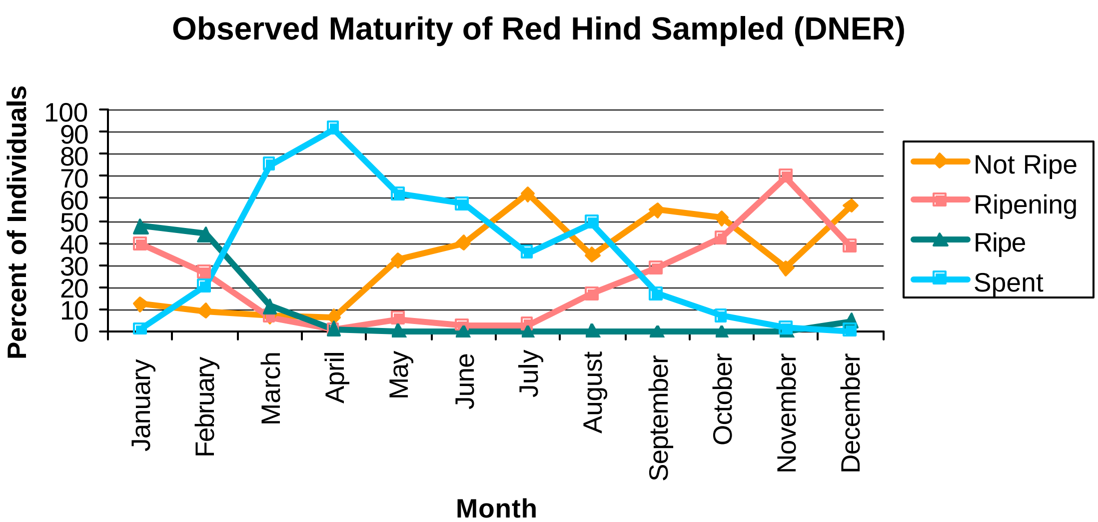

Figure 14: Gonad condition of the red hind sampled by DNER (n = 15,994).

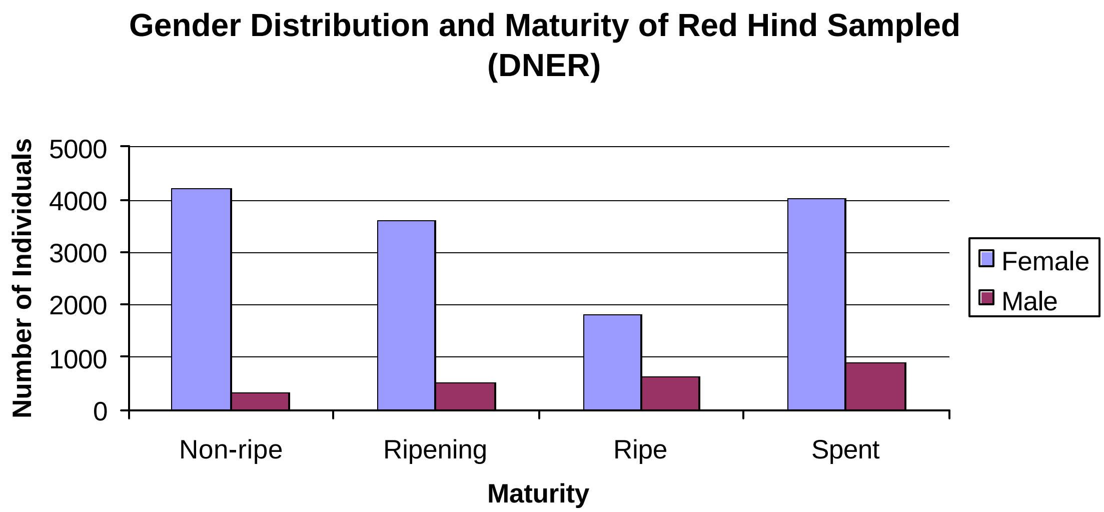

Figure 15: Red hind gender distribution and overall maturity state at the time of capture during the DNER survey.

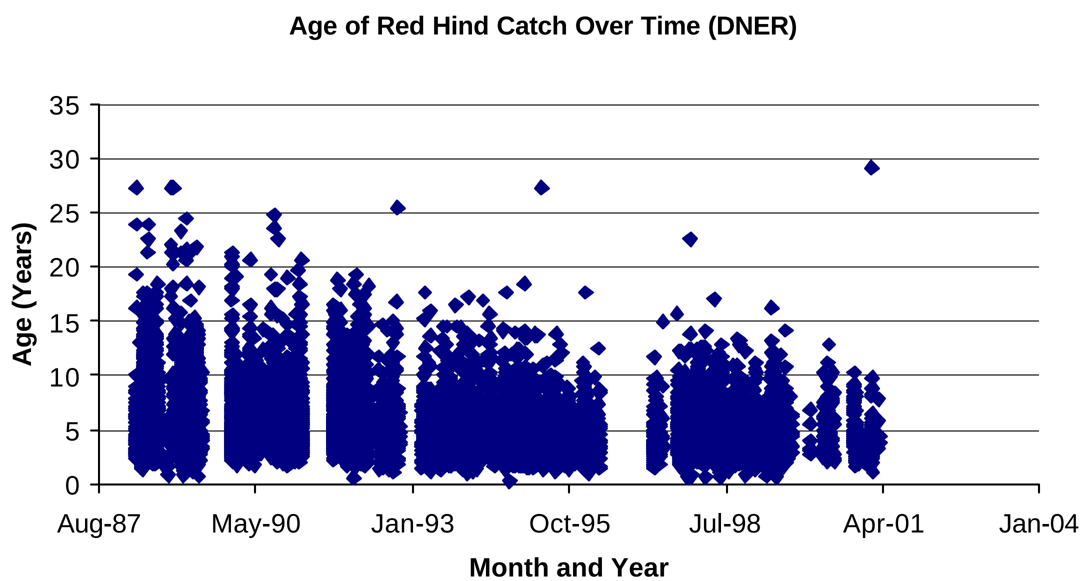

Figure 16: Calculated Age of the red hind catch during the DNER surve y over time (n = 16,043).

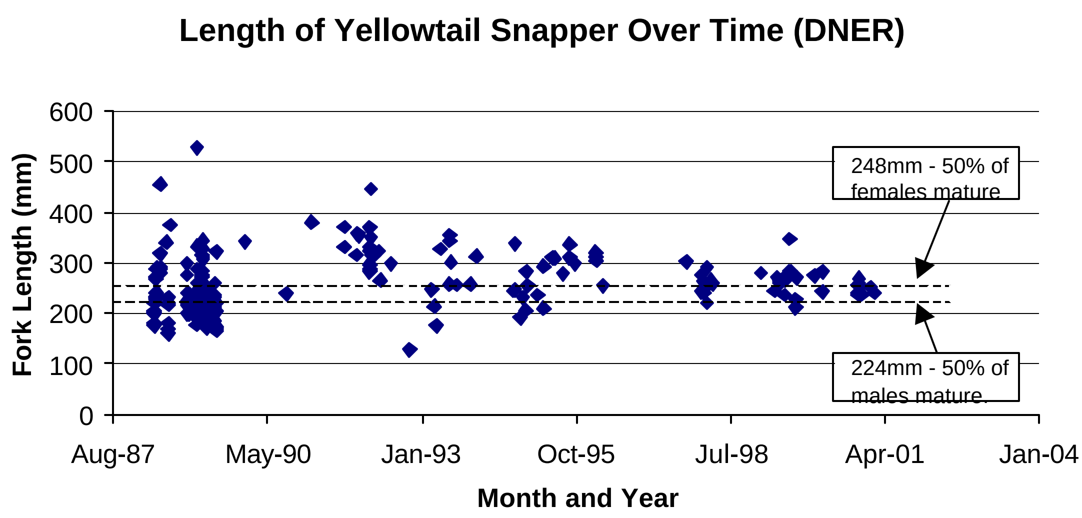

Figure 17: Length of yellowtail snapper sampled by DNER over time (n = 244).

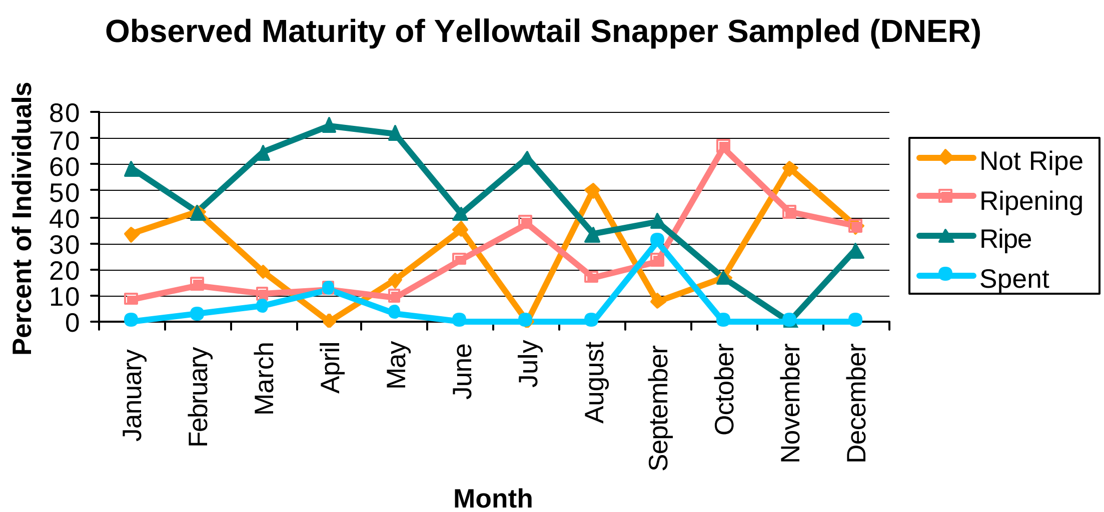

Figure 18: Gonad condition of the yellowtail snapper sampled by DNER (n = 235).

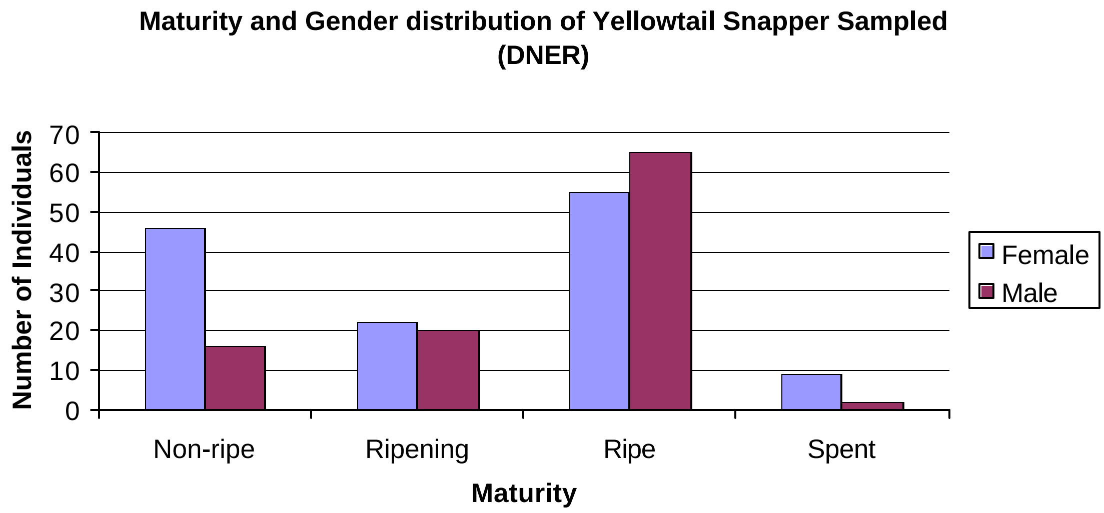

Figure 19: Yellowtail snapper gender distribution and overall maturity state at the time of capture during the DNER survey.

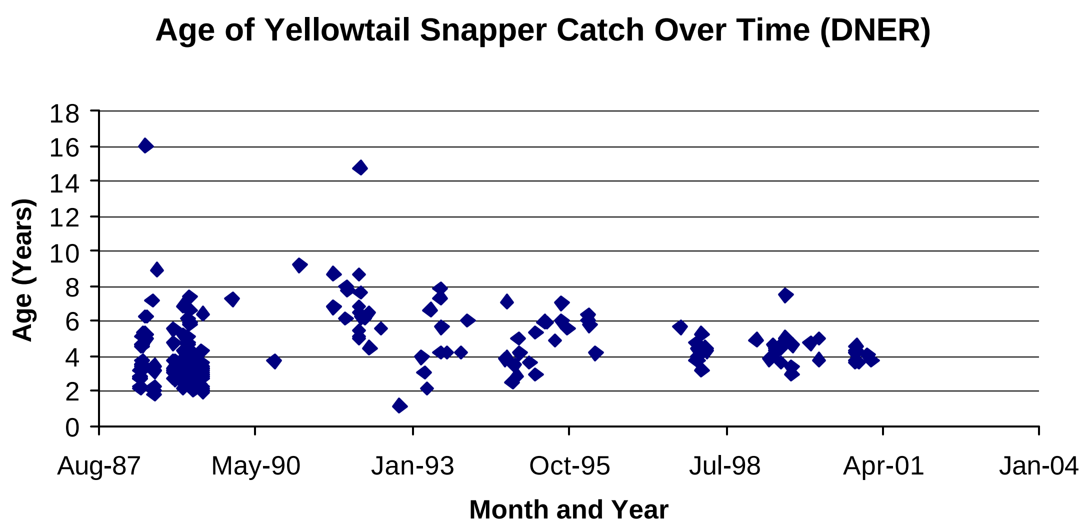

Figure 20: Calculated age of yellowtail snapper sampled by DNER over time (n = 244).

<u>Southeast Area Monitoring Program Data</u>

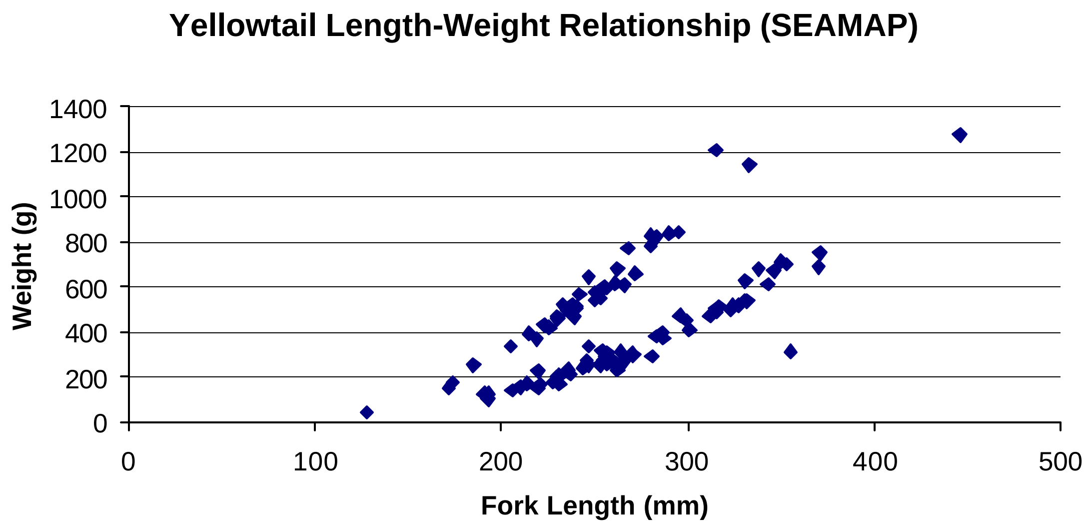

Figure 21: The length-weight relationship for yellowtail snapper surveyed by SEAMAP (n = 95).

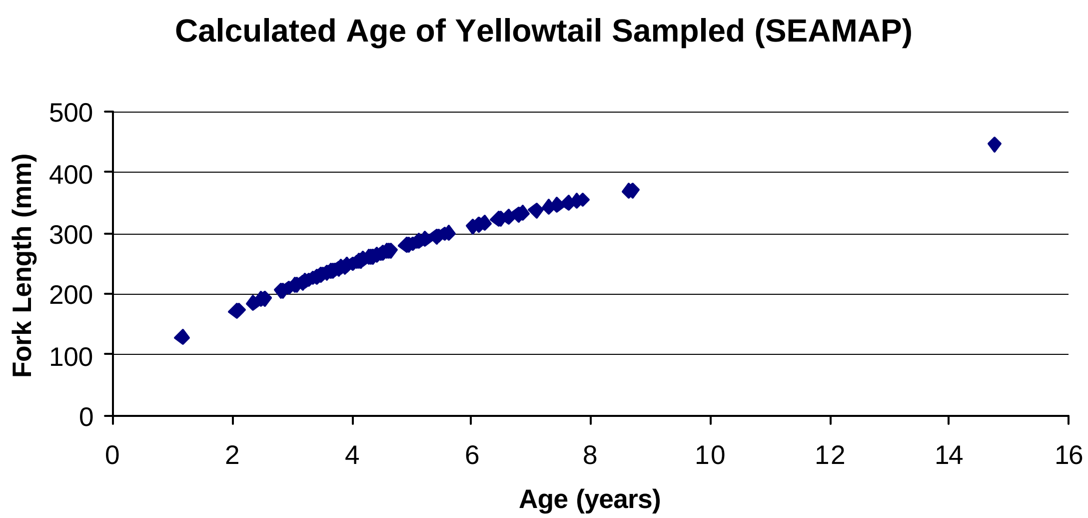

Figure 22: Calculated age of yellowtail sampled using SEAMAP data, the von Bertalanffy relationship and growth parameters estimated by Manooch and Drennon (1987).

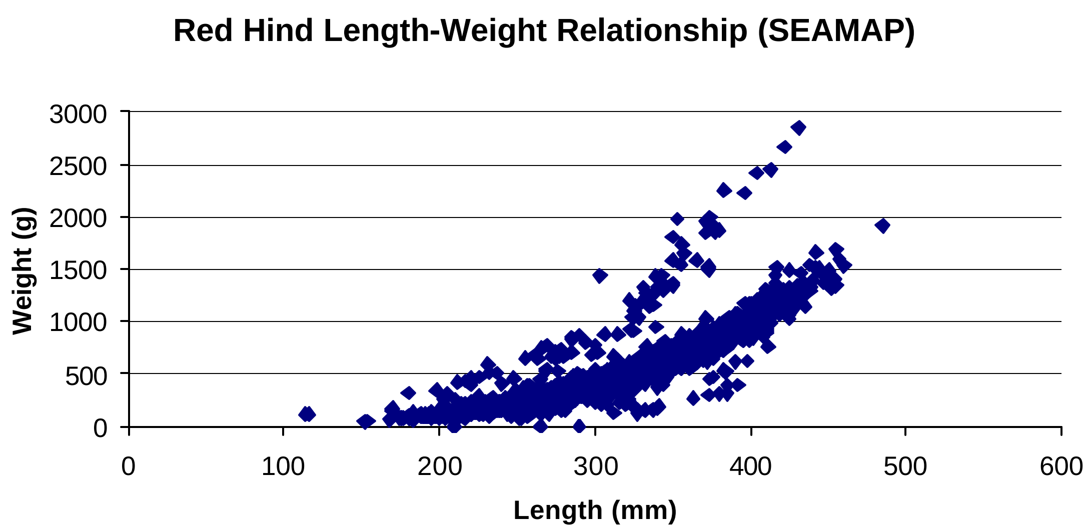

Figure 23: The length-weight relationship for red hind surveyed by SEAMAP (n = 7,353).

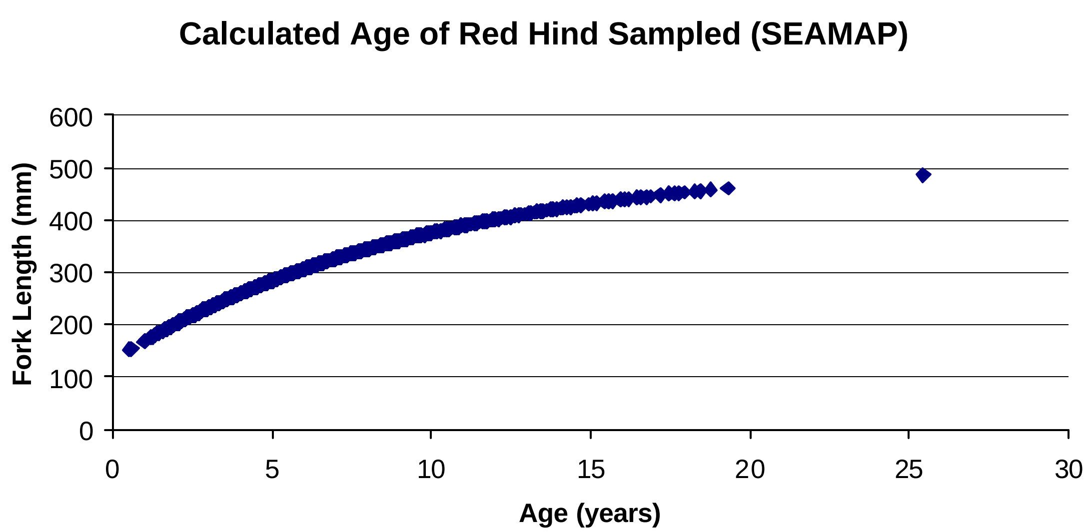

Figure 24: Calculated age of red hind sampled using SEAMAP data, the von Bertalanffy growth relationship and the estimated parameters provided by Sadovy, Figuerola and Roman (1992).

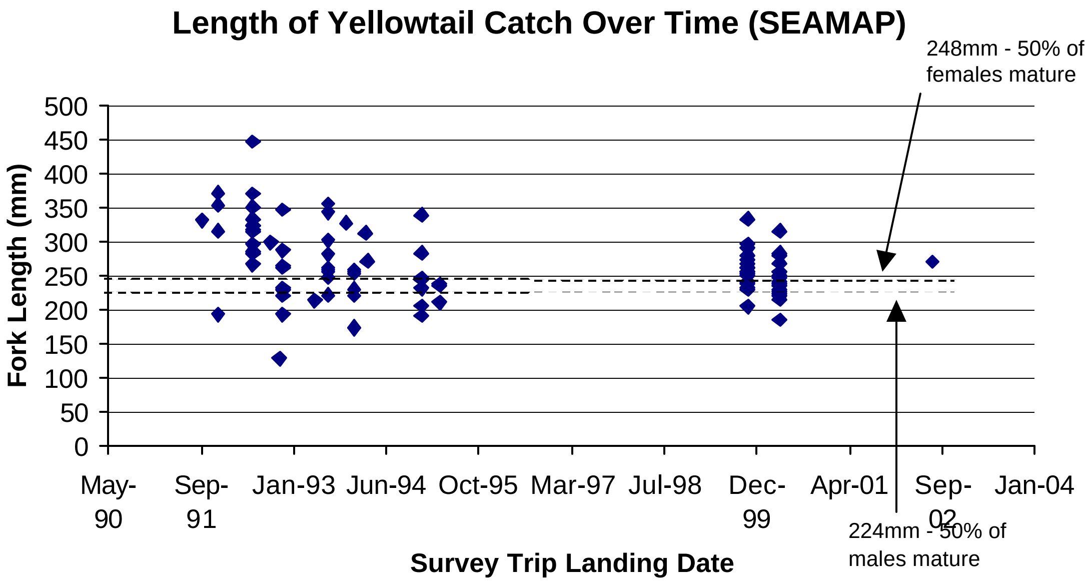

Figure 25: Length of the yellowtail snapper sampled by the DNER ove r time (n = 95).

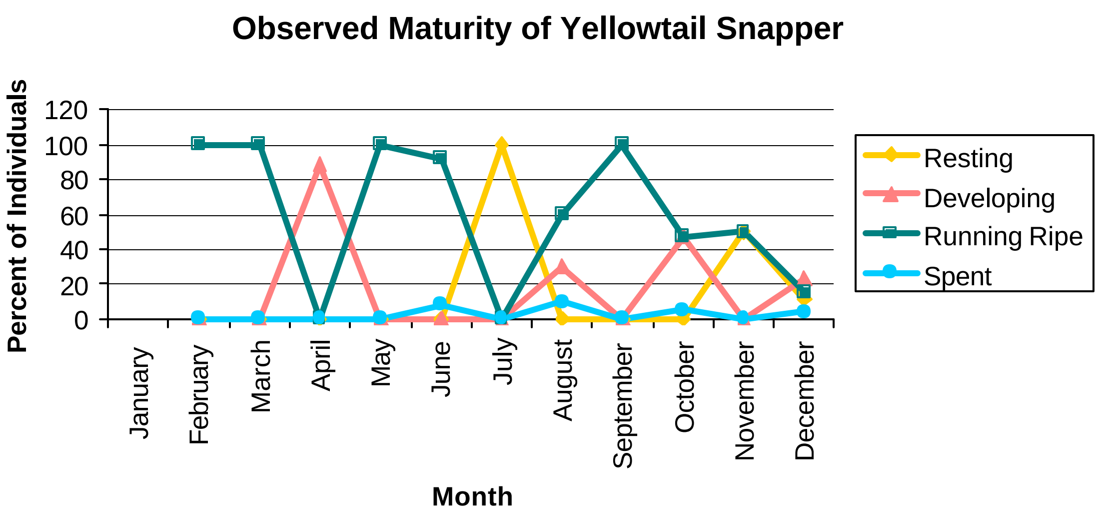

Figure 26: Observed gonad condition of the yellowtail sampled during the SEAMAP survey (n = 95).

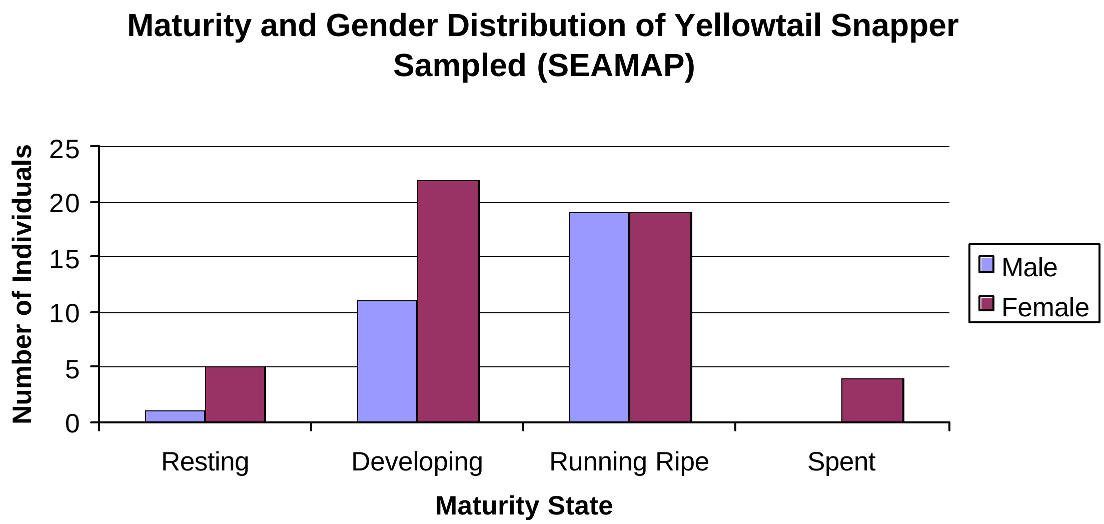

Figure 27: Maturity and gender distribution of yellowtail snapper captured during the SEAMAP survey.

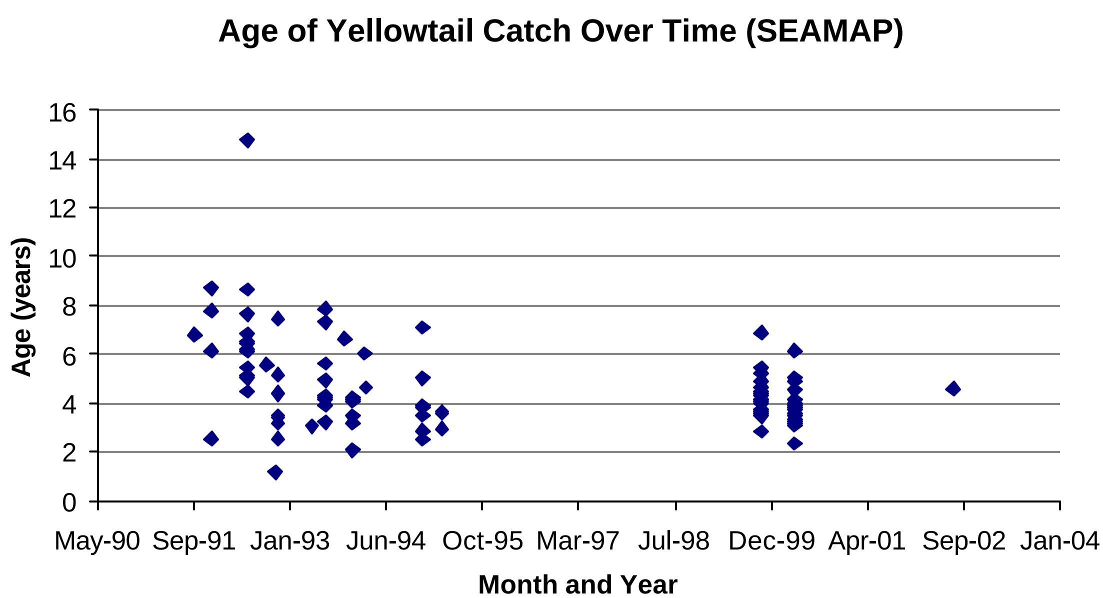

Figure 28: Calculated age of yellowtail snapper caught during the SEAMAP survey over time (n = 95).

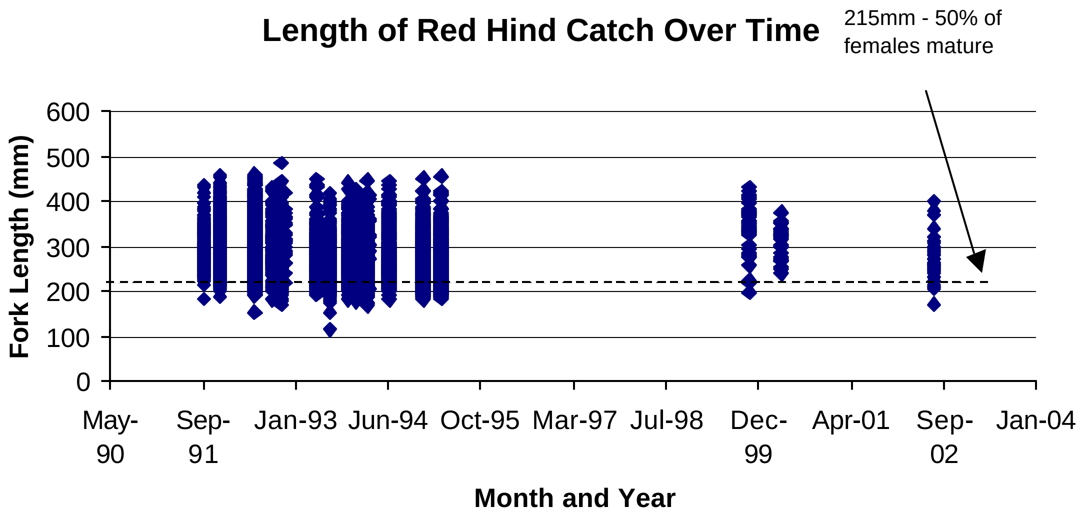

Figure 29: Length of the red hind sampled during the SEAMAP survey over time (n = 7,353).

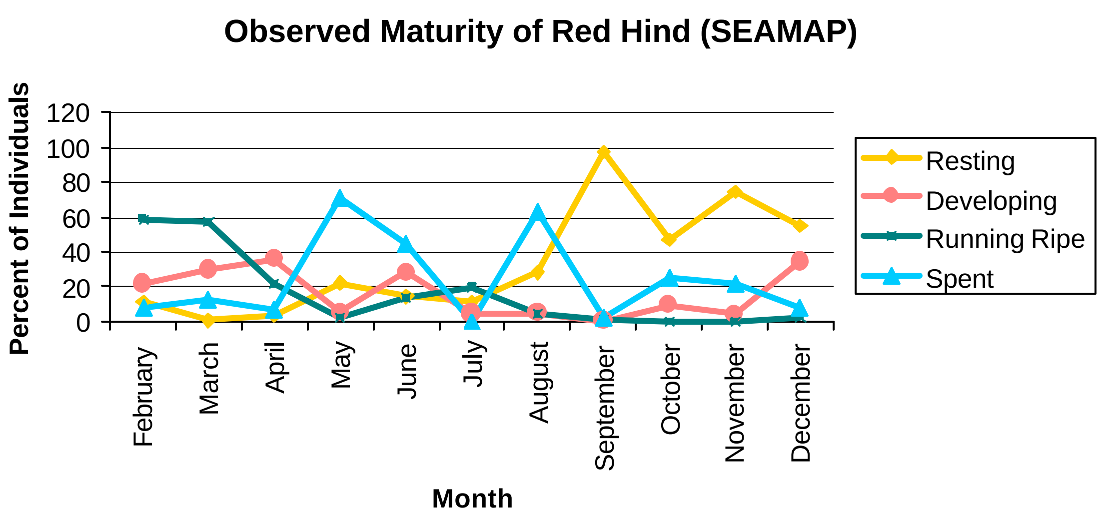

Figure 30: Observed gonad condition of red hind during the SEAMAP survey (n = 7353).

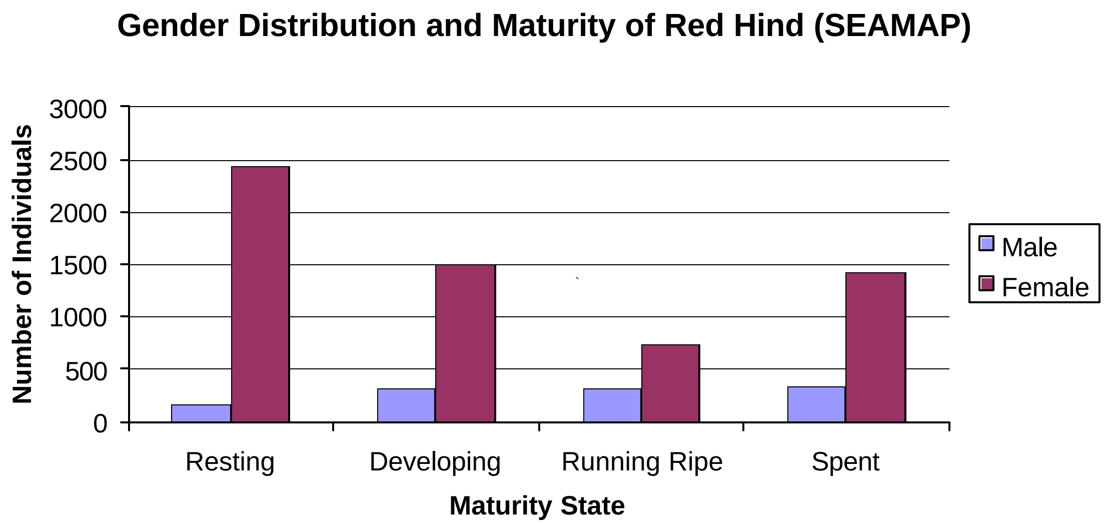

Figure 31: Maturity and gender distribution of red hind captured during the SEAMAP survey.

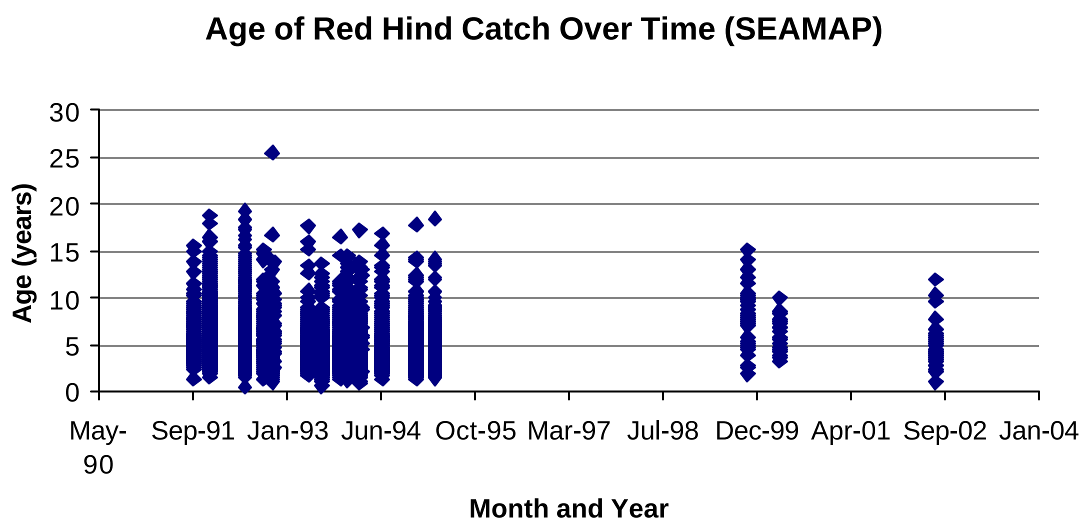

Figure 32: Calculated age of the red hind caught during the SEAMAP survey over time (n = 7,353).

<u>APPENDEX III: CATCH RATES</u>

<u>Department of Natural and Environmental Resources Data</u>

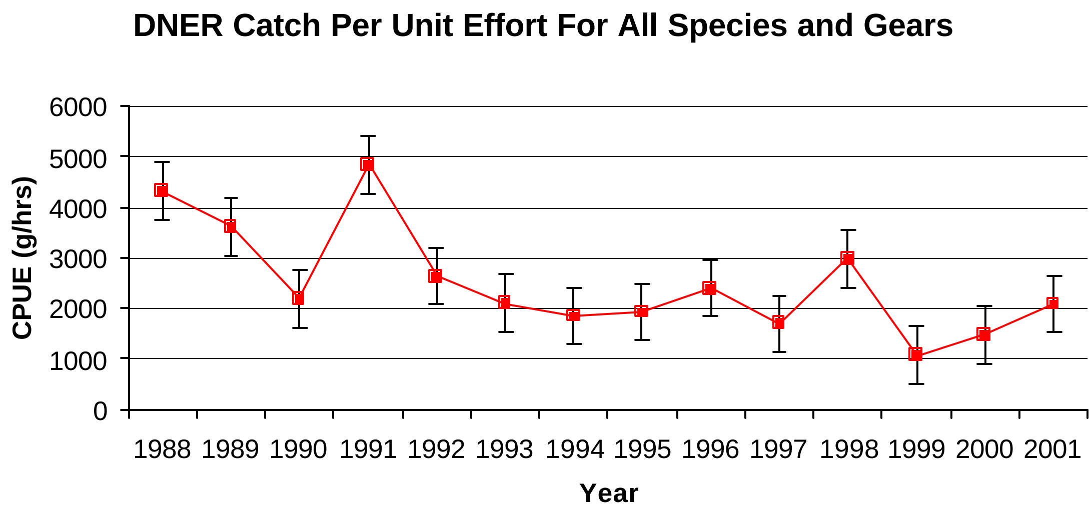

Figure 33: Catch per unit effort for all gear types and species combined. [1]

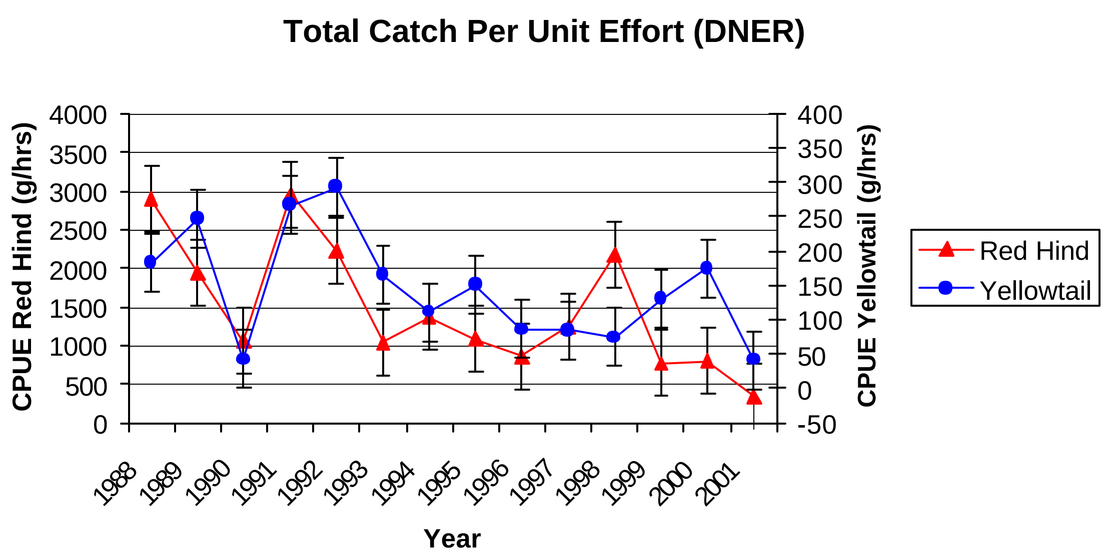

Figure 34: Total catch per unit effort for all gear types.

[1] Note: Error bars represent a 95% confidence interval calculated for CPUE values.

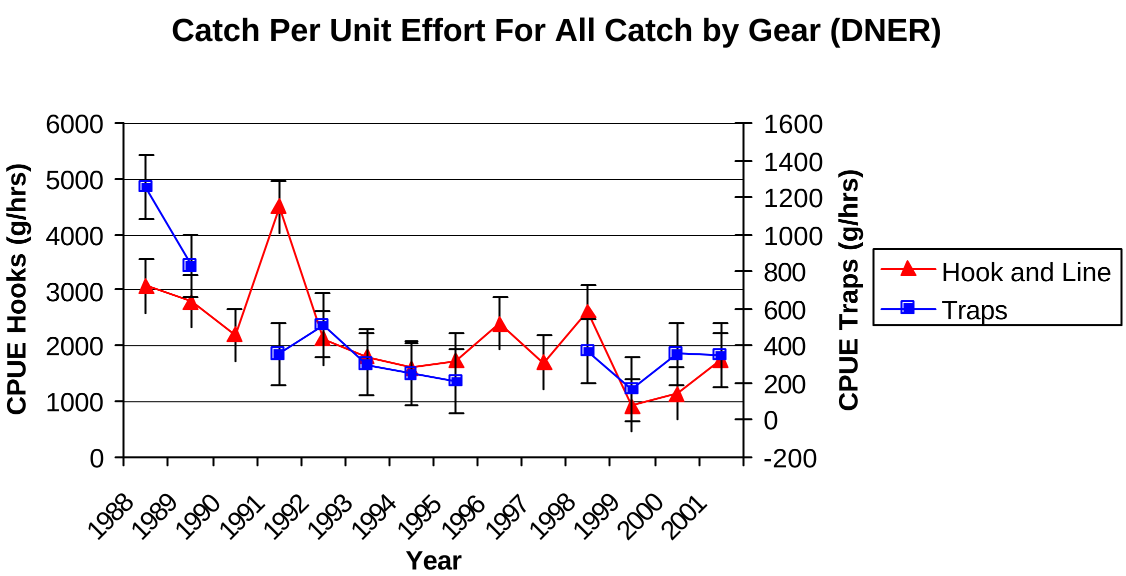

Figure 35: Catch per unit effort for all species by gear type.

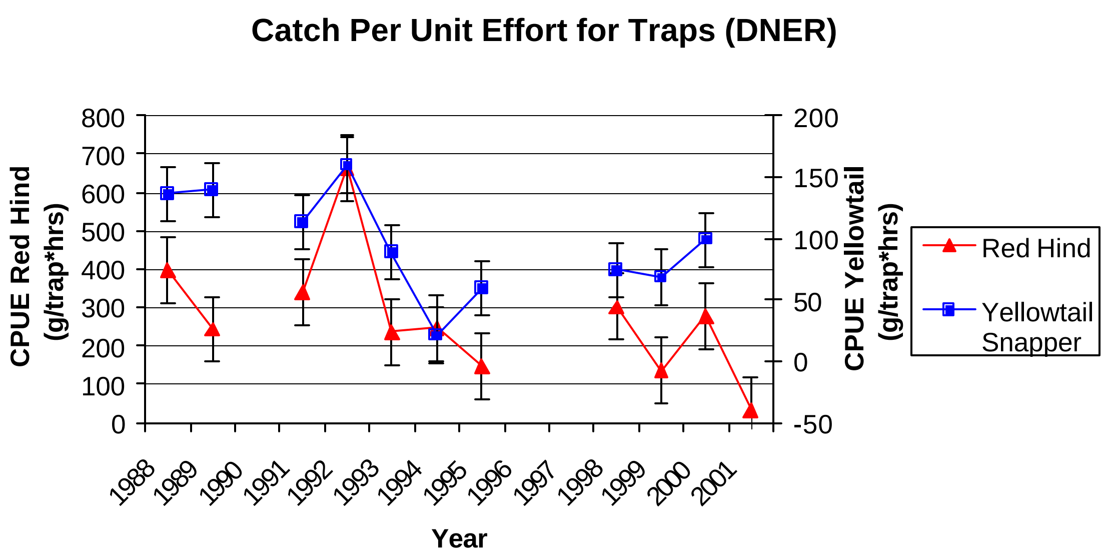

Figure 36: Catch per unit effort for yellowtail snapper and red hind using traps.

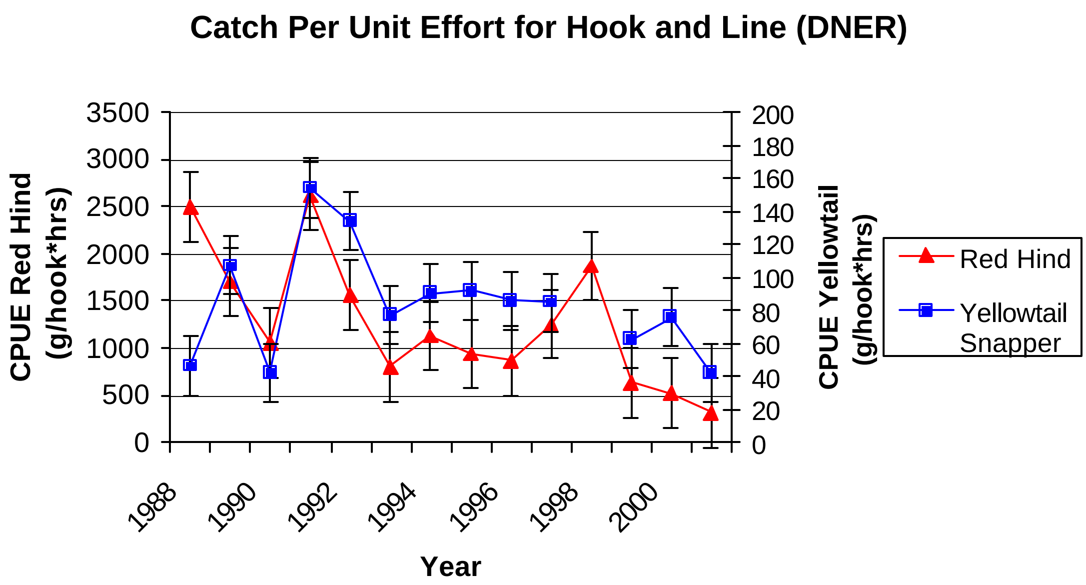

Figure 37: Catch per unit effort for yellowtail snapper and red hind using hook and line.

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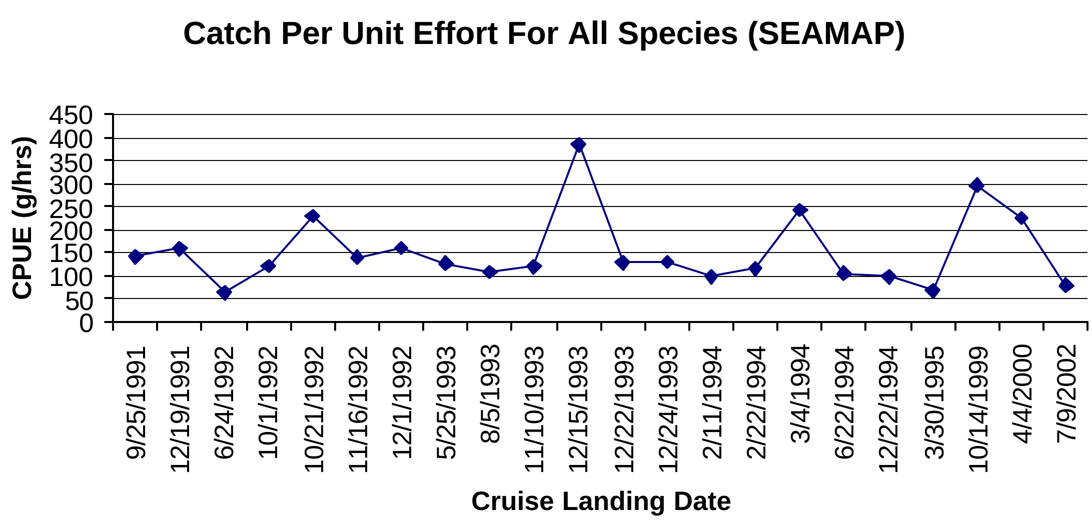

Figure 38: Catch per unit effort for all gear types and species combined.

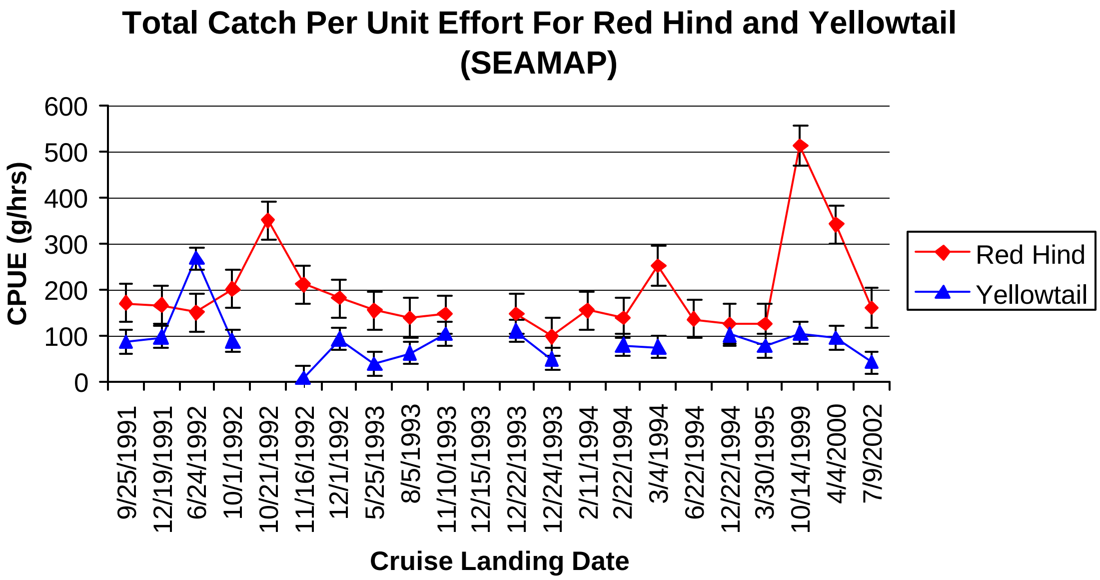

Figure 39: Combined catch per unit effort for red hind and yellowtail for both predominant gear types.

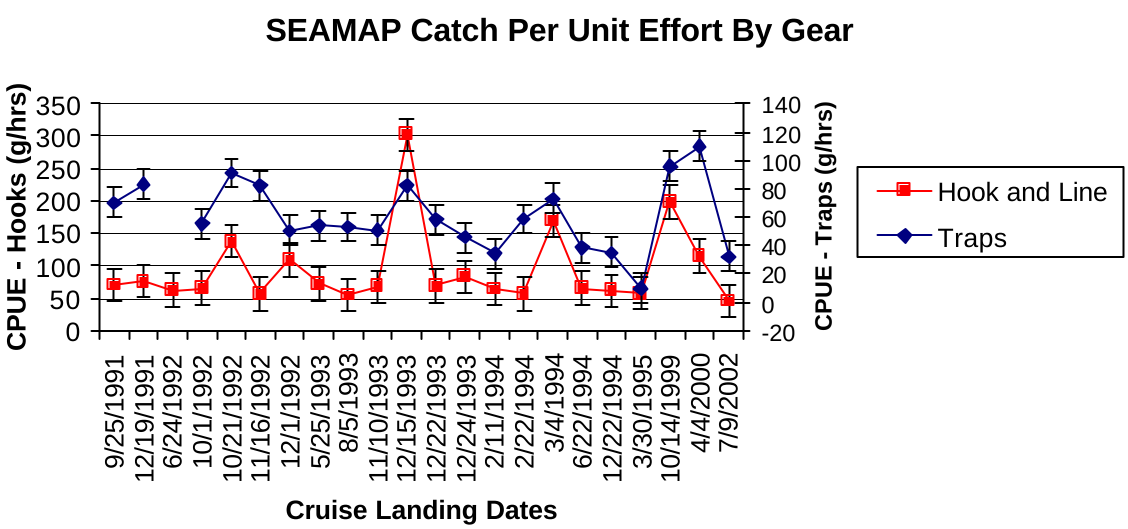

Figure 40: Catch per unit effort attained for each gear.

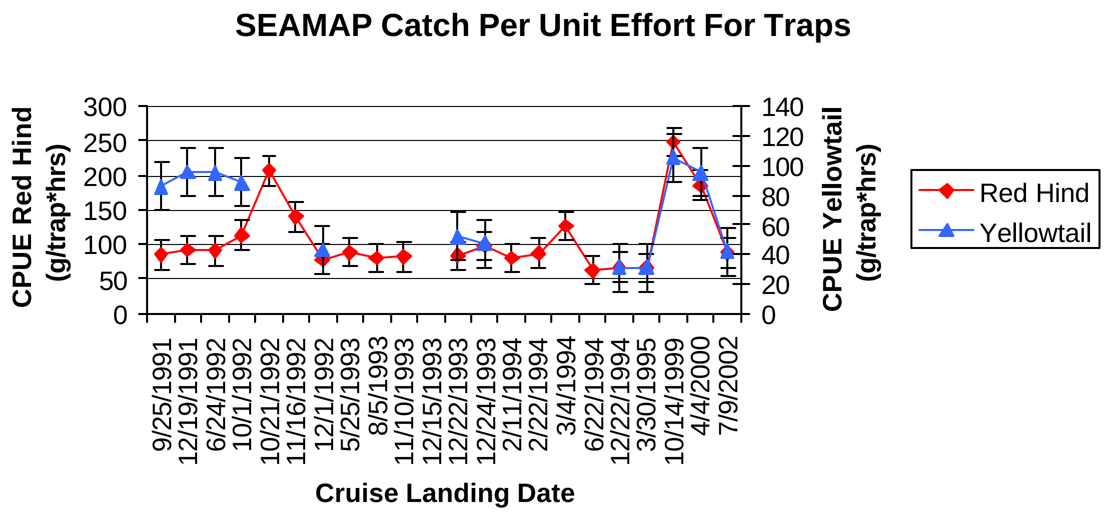

Figure 41: Catch per unit effort for red hind and yellowtail snapper using fish traps.

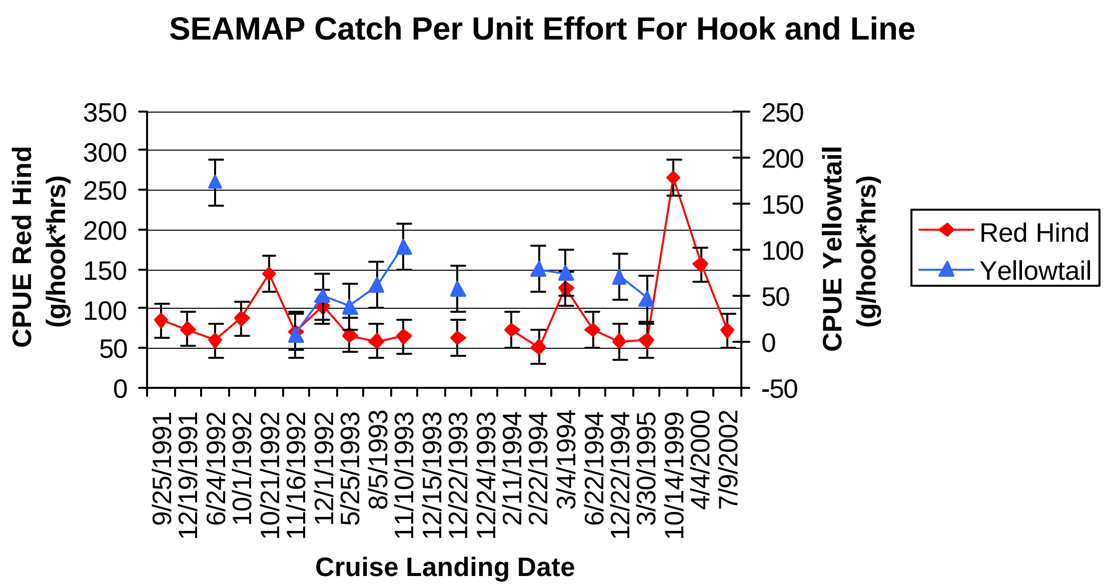

Figure 42: Catch per unit effort for yellowtail and red hind using hook and line.