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Caribbean Yellowtail snapper yield per recruit

by

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Background

Dennis (1991) presented yield per recruit (YPR) information for yellow tail snapper in Puerto Rico. Yield per recruit calculations were made assuming constant recruitment, constant fishing mortality over the fishable life span, knife edge recruitment (i.e., selectivity was constant over age), isometric von Bertalanffy growth, non varying natural mortality (over age), and total mortality was expressed by a negative exponential curve (see Dennis 1991, pp 127-128). Required as input into the YPR calculations is information on the growth rate parameter (k), asymptotic size (L-infinity), and length (age) at first capture. Dennis used two years of length data from the Puerto Rico commercial fishery between 1984 and 1985 to derive length based growth information and values for length at first capture.

In his analyses, Dennis (1991) calculated growth parameters for two years of length data (1984 and 1985 combined) of catch length samples from the Puerto Rico commercial fisheries. The ELEFAN method was used to estimate values for the growth rate parameter, K and asymptotic size (L infinity). In addition, Dennis re-estimated K and L-infinity from the Manooch and Drennon back-calculated size at annulus data for only ages 1-16. as he considered the back-calculated size at age estimates for the older age 17 as an outlier. Manooch and Drennon's samples were from the US Virgin Islands commercial fisheries and were taken in the middle 1980's. For Dennis's analyses, the estimate of natural mortality, M, was obtained using the Pauly (1980) relationship between L infinity, K, and mean annual water temperature. Dennis calculated two values of M: one from the length based growth estimates and one value of M using the age-based growth estimates. Dennis then derived estimates of total mortality (Z) using four separate methods (length – converted catch curve, age-length key catch curve, Beverton and Holt's equation, and Hoening et al's equation). Estimates of total mortality, Z, were determined as F = Z - M. For both sets of growth parameters (i.e., length derived or otolith-derived) Dennis provided values of total mortality, Z for each method used and for the two years of length composition data providing a range of estimates of total mortality for the two years ranging from 0.56 - 1.18. Estimates of total mortality from the otolith-length-key catch curve were 1.26 and 1.14 for the 1984 and 1985 data respectively. In addition, values of length at first capture, l_c, were calculated for each year (1984, 1985) for each method of aging (i.e., length based or age based). Values for 1984 were 23.53 and 23.58 cm FL (length and otolith based respectively). Values for 1985 were 25.37 and 25.20 cm FL (length and otolith based respectively) (see Table 2)

Two yield per recruit contours graphics were presented by Dennis (1991) corresponding to YPR results utilizing the two separate inputs of growth parameter estimates (i.e., length derived or otolith derived k and L-infinity). Dennis's objective was to show the hypothetical change in yield given changes in fishing mortality (F) and size at first capture for the two differing sets of growth information. Although Dennis calculated a single value of M using Pauly's equation for each growth model, the YPR calculations were made using a range of M values. The range of M values was obtained, by varying the value of M plus or minus 20% of the empirical values of 0.321 (otolith derived) and 0.437 (length derived) using a plus or minus two step increase/decrease.

Dennis (1991) presented two YPR contour graphics to illustrate the effects of changes in yield given F and l_c given each set of growth input information (Table 3). Empirical estimates of l_c ranged from about 23.3 to 25.2 cm FL for the two years, 1984 and 1985 with relative l_c varying from about 0.43 to 0.44 (length based methods) and 0.44 to 0.46 (age based) of asymptotic size. In 1985, a minimum size regulation of 8 inches TL (about 15 cm inch FL using Muller et al's 2003 TL to FL relation). The minimum size regulation of 8 inches TL, set in 1985, was increased by one inch annually until a minimum size of 12 inches TL (about 23 cm Fl –assuming Muller et al's 2003 TL:FL relation) was reached in 1989. The 1985 and 1985 estimated fishery lc of 23.5 and 25.2 cm FL were both above minimum size of entry of 15 cm FL, 8 inches TL (for 1984) and 17 cm FL, 9 inches TL (for 1985). Dennis also noted that the trap fishery in Puerto Rico would be most affected as the sizes encountered were somewhat smaller on average than those encountered by the hook and line fishery. However, given the estimated values of l_c estimated for the fishery, little impact from the regulation would be expected for either gear used to harvest yellowtail snapper at that time (hook and line and pots).

From the YPR results in Table 3 it can be seen that values of l_c ranged from about 13.3 cm FL to 29.4 cm FL for the length derived growth input parameters and from about 20.9 cm FL to 27.2 cm FL for the age derived growth model data. YPR was higher for the length derived method and Dennis's noted this was a direct result of the higher M/K ratio for the length-derived parameters. For the two years of data explored here, 1984 and 1985 and given the two empirical estimates of M (0.32 (age derived) and 0.44 length derived)) it was found that the relative annual rate of exploitation E, was above 0.5 (above 50%) for the two years examined, 1984 and 1985. In general, values of l_c decreased with decreasing M, suggesting that if M were lower than estimated by through the empirical methods that fishing would have to be increased to achieve the sample yield.

Current YPR of Caribbean yellowtail snapper

Samples of size composition from the Puerto Rico commercial catches were used to address recent YPR for yellowtail snapper in recent years. Samples of size were available for 1983-2003 and preliminary summaries of the data were given by Cummings (2004, SEDAR8-AW-Doc-7).

The intent of this analysis was to address current YPR for yellowtail snapper in relation to current size composition observed in the commercial fishery. In addition, an objective was to derive estimates of YPR that incorporated variable selectivity at age (size) and natural mortality at size (age) into the calculations. Recruitment was assumed constant.

Dennis (1991) provided useful calculations of YPR given two differing scenarios for growth parameter input which is a requirement in YPR calculations. Dennis used otolith derived estimates of K and L-infinity (asymptotic size) in addition to deriving values of K and L-infinity from length based methods of ELEFAN. Parrack and Cummings (2003) evaluated the use of length frequency analysis methods for ageing a fish like the yellowtail snapper which exhibits rapid growth during the early years and relatively high variability in length within an age group. Simulation results from that study suggested that length frequency analyses methods were accurate in separation of modal groups for about the first quarter of the distribution of ages commonly observed in the catch if the variation in length at age was reasonably low (CV~0.05), or about 4 ages including the first age of recruitment (about age 2).

For the initial YPR demonstration runs input growth parameters were K=0.17 and L-infinity = 60 cm FL. It should be pointed out that the values of K and L-infinity for the Mannoch and Drennon (1987) entry in Table 5 of Cummings (SEDAR8 Doc-04) are typographical errors. The re-estimated values of Manooch and Drennon's estimates for K and L-infinity from Dennis's calculations were 54.48 cm FL and 0.104 (per year) respectively. For the demonstration here the growth parameters from Manooch and Drennon was used. Other values for the growth parameter (K) and asymptotic size (L infinity) can be input and the change in YPR results for those values as desired.

As noted by Dennis (1991) a minimum size regulation of 8 inches TL was implemented in federal waters in 1985, increasing by one inch to 12 inches TL (22.7 cm FL) in 1989. Preliminary information presented on recent size composition of yellowtail snapper from the commercial fisheries of Puerto Rico and the US Virgin Islands was given by Cummings (2004, SEDAR8-AW-Doc-07) and Sladek-Nowlis (2004, SEDAR8-DW-Doc-10). To this point, the preliminary analyses of the size composition data for Puerto Rico, have been restricted to evaluating the size composition data for completeness and comprehensiveness across fisheries (gears), spatially (by island and intra island region – e.g., Puerto Rico) and temporally. Average size information was presented for each year in the time series and by fishery. The primary gear harvesting yellowtail snapper has been lines (rod and reels) followed by pots and traps with some harvesting also occurring by the minor gears in these regions (nets, seines, dive).

Cummings (2004, Figures 1a-1d, SEDAR8-AW-Doc-07) provided information on the unadjusted size composition for yellowtail harvested in Puerto Rico from 1983-2003. Figure 1a of Cummings' report reflects very similar results as shown by Dennis (1981) for the two major harvest gears for the 1984 and 1985 years of harvest. Figure 1d of that report can be used to crudely evaluate recent l_c for these two fisheries that harvest yellowtail snapper. Since 1999, the unadjusted size sample data suggests that l_c has consistently been above the minimum size of 12 inches TL (or about 23 cm FL) in Puerto Rico and actually has been well above the minimum size of 12 regulation for many years. It is recommended that additional analyses be continued to estimate l_c for each strata of interest (year-region-fishery) in this fishery. Cummings noted that in some years the average size harvested in the south and west regions was somewhat smaller than other regions so these intra island differences should be examined more closely. Dennis (1991) noted concerns regarding the sizes harvested by the minor gears in Puerto Rico, in particular from seines which mainly are used within the commonwealth jurisdiction.

Data were not available in this dataset to explore this concern. It is also noted that the recent average annual size of yellowtail snapper harvested is above the estimated size of 50% maturation reported by Figuerola (1997)

Cummings (2004, Figures 1-8, SEDAR8-AW-Doc-08) provided information on the unadjusted size composition for yellowtail harvested in US Virgin Islands from 1983-2003. In that report, Cummings summarized sample sizes by island and by major fishery and noted concerns of using the size composition data for particular strata (year-island-fishery cells) to evaluate trends in size in the fishery. In particular, very little information is available for St. Thomas/St. John to evaluate current trends with size and to determine length at first capture for any fishery. The tabled data in that report (see Tables 1 (annual-island) and 2 (annual-island-gear) shows that from 1988-1991 little sampling occurred and again again after 1997. Current information seems sufficient for St. Croix to allow an estimate of length at first capture to the trap/pot fishery however, information for the hook and line fishery could be considered inadequate. It is recommended that once the missing biostatistical sample data has been computerized (see SEDAR8 DW report) that the size composition data be evaluated for trends and to estimate l_c for individual fisheries.

YPR demonstration runs were made for this workshop using the values for growth rate K and L-infinity discussed previously (K=0.17 per year and L-infinity = 60 cm FL), allowing variable selectivity with age, assuming length at recruitment occurred at 8 inches FL and unit rerecruitment equaled 12 inches TL. The three constant M runs assumed M=0.4, M=0.5, and M=0.6. One run was made assuming varying M at age with M following a power function assuming that M at 2 inches = 1.2 per year and M at 18 inches = 0.6 per year.

Muller et al. (2003) applied a rate of 0.15 per year for the instantaneous rate of M calculated using Hoenig's method and assuming F=0.1 for populations off south Florida. Using Pauly's (1980) method, Carrillo de Albornoz (1999) estimated M to be 0.4 for yellowtail snapper off Cuba. Dennis (1992) derived M for yellowtail snapper off Puerto Rico applying the Pauly method to age and length frequency derived growth estimates to be 0.32 and 0.44 respectively. Dennis's age derived growth estimates were calculated by re-fitting the von Bertalanffy curve to the mean BCL's of Manooch and Drennon (1987) excluding the age 17 observation. Dennis's two estimates of M were calculated assuming two different treatments of Mannoch and Drennon's data. Thompson and Munro (1974) calculated an M value of 0.6 for yellowtail snapper off Jamaica. The range of M values from these analyses were 0.15 - 0.6. Thus for the YPR demonstrations here 4 fixed values were used (0.3, 0.4, 0.5, and 0.6) and one run with variable M at age. Summary YPR results are presented in Table 4.

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Table 1. von Bertalanffy growth and natural mortality parameter values presented by Dennis (1991). Data for age derived estimates are from the US Virgin Islands while the length data used in the length derived analyses were from 1984 and 1985 Puerto Rico commercial catch samples.

	Age Derived estimates	Length derived estimates (ELEFAN)
L infinity	54.48 FL	53.42
K	0.1041	0.166
Tzero	-1.83	not estimated in model
M	0.321	0.437

Table 2. Values of total mortality, Z (Rows 3-6), and estimates of length at first capture (t_c) (bottom row) presented by Dennis (1991) for yellowtail snapper sampled in 1984 and 1985 from Puerto Rico commercial catches.

	1984	1984	1985	1985
	Length – derived	Otolith derived	Length derived	Otolith derived
Length-converted catch curve estimated Z	1.148	0.727	1.051	0.608
Beverton & Holt estimated Z	0.978	0.641	0.824	0.542
Hoening estimated Z	0.962	0.628	0.865	0.566
Age-length key catch curve estimated Z	1.26	1.26	1.14	1.14
L_C (estimated from ELEFAN per Gulland 1983)	23.53	23.58	25.37	25.20

Table 3a. Optimal size at first capture (lc) in cm (FL) to maximize YPR as a function of exploitation rate (E) and M, assuming constant recruitment, non-varying selectivity and M over age**. Estimates derived for the Length-derived growth equation parameters presented by Dennis (1991, Table 3).**

		Exploitation Rate						
M	%	0.2	0.3	0.4	0.5	0.6	0.7	0.8
0.524	+20	13.36	16.03	18.70	21.37	21.37	24.04	24.04
0.481	+10	14.42	17.63	18.70	21.37	21.37	24.04	24.04
0.437	0	16.03	18.70	21.37	21.37	24.04	24.04	26.71
0.393	+10	16.03	18.70	21.37	24.04	24.04	26.71	26.71
0.350	-20	16.03	18.70	21.37	24.04	26.71	26.71	29.38

Table 3b. Optimal size at first capture (lc) in cm (FL) to maximize YPR as a function of exploitation rate (E) and M, assuming constant recruitment, non-varying selectivity and M over age. **Estimates derived for the Age-derived growth equations parameters presented by Dennis (1991, Table 3).**

		Exploitation Rate						
M	%	0.2	0.3	0.4	0.5	0.6	0.7	0.8
0.524	+20	10.9	16.34	16.34	19.07	19.07	21.79	21.79
0.481	+10	13.62	16.34	19.07	19.07	21.79	21.79	24.52
0.437	0	13.62	16.34	19.07	21.79	21.79	24.52	24.52
0.393	+10	16.34	19.04	19.07	21.79	24.52	24.52	27.24
0.350	-20	16.34	19.04	21.79	23.15	24.52	27.24	27.24

Table 4. YPR statistics for four fixed values of natural Mortality rate (M) for yellowtail snapper using the Dennis (1991) age derived estimates of growth rate (K) and asymptotic size (L-infinity) and one length variable M run. Weight – length equation parameters from Manooch and Drennon (1987). Current federal minimum size = 12 inches (TL) (9 inches FL) since 1989.

	Natural Mortality Value					
	0.3	0.4	0.5	0.6	0.7	Variable M [1]
Criticial age (years)	4.6	3.5	2.6	2.1	1.8	3.7
Critical age (months)	55	39	31	25	21	44
Critical size (length inches FL)	14 (35.6 cm)	13 (33 cm)	11 (27.9 cm)	10 (25.4 cm)	9 (22.3 cm)	14 (35.6 cm)

Variable M power curve: Values input to determine curve were M=1.2 per year (2 inches) and M=0.6 per year (18 inches).