THE POTENTIAL FOR INCORPORATING A LARVAL INDEX OF ABUNDANCE FOR STOCK ASSESSMENT OF RED SNAPPER, *Lutjanus campechanus*

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INTRODUCTION:

Since 1982 the Southeast Area Monitoring and Assessment Program (SEAMAP) has supported collection and analysis of ichthyoplankton samples with the goal of producing a long-term database on the early life stages of fishes. Use of ichthyoplankton survey data in assessment analyses for snapper species (family Lutjanidae) has proven difficult due to the inability to distinguish the larvae of closely related species at the smallest sizes found in samples. Over 11,000 specimens of snapper larvae collected in 2094 bongo and 2159 neuston net samples from SEAMAP Summer Shrimp/Groundfish and Fall Plankton surveys, 1984-1997 were examined and identified to the lowest taxon possible using recent descriptions of snapper larvae (Drass et al. 2000). The timeframes of these two surveys coincide with the red snapper spawning season in the Gulf of Mexico. Two larval red snapper survey indices, annual mean abundance and frequency of occurrence, were calculated and compared to adult (spawning) stock size (ages 3 to 15+; Schirripa and Legault 1999) as estimated by ASAP (Age-Structured Assessment Program*;* Legault and Restrepo, 1998*)*. The larval survey indices were also compared to the abundance and occurrence of juvenile red snapper (ages 0 and 1) from SEAMAP Fall Groundfish surveys over the same time period. The resulting correlation matrix was examined for significant correlations.

SEAMAP SAMPLING GEAR, METHODS and MATERIALS:

Ichthyoplankton samples have been collected during fishery-independent, resource surveys in the Gulf of Mexico (GOM) since 1982 under the Southeast Area Monitoring and Assessment Program (SEAMAP; Rester et al. 2000). Surveys are conducted by the National Marine Fisheries Service in cooperation with the states of Florida, Alabama, Mississippi, and Louisiana. The sampling gear and methodology used during SEAMAP surveys (Rester et al. (2000) are similar to those recommended by Kramer et al. (1972), Smith and Richardson (1977) and Posgay and Marak (1980). A 61 cm bongo net fitted with 0.333 (0.335)[1] mm mesh netting is fished in an oblique tow path from a maximum depth of 200 m or to 2-5 m off the bottom at depths less than 200 m. A mechanical flowmeter is mounted off-center in the mouth of each bongo net to record the volume of water filtered. Volume filtered ranges from ~20 to 600 m^3 but is typically 30 to 40 m^3 at the shallowest stations and 300 to 400 m^3 at the deepest stations. A single or double 2x1 m pipe frame neuston net fitted with 0.947 (0.950)[1] mm mesh netting is towed at the surface with the frame half-submerged for 10 minutes. Non-standard gear used to collect

[1] Mesh size change in database does not represent an actual change in gear but only a change in the accuracy at which plankton mesh aperture size can be measured by the manufacturer.

plankton samples from smaller vessels operated by the states are coded as such in the database and are not used to calculate larval indices.

Catches of larvae from bongo nets are standardized to account for sampling effort and expressed as number of larvae under 10 m^2 of sea surface. This is accomplished by dividing the number of larvae of each taxon caught in a sample by the volume of water filtered during the tow; and than multiplying the resultant by the maximum depth of the tow in meters and the factor 10. Catches of larvae from neuston nets are standardized to account for sampling effort and expressed as number of larvae per 10 min tow.

Most but not all SEAMAP, standard plankton stations are located at 30 mile or ½ degree (~56 km) intervals in a fixed, systematic grid across the GOM (Figure 1), although, only every other N-S transect of stations is sampled during spring surveys and during fall plankton surveys in 1988-1991. Occasionally during surveys, samples are taken at non-standard locations or stations are moved to avoid navigational hazards. Samples are taken upon arrival on station regardless of time of day. At each station either a bongo and/or neuston tow are made depending on the specific survey.

Initial processing of SEAMAP plankton samples is carried out at the Sea Fisheries Institute, Plankton Sorting and Identification Center (ZSIOP), in Szczecin, Poland and the Louisiana Department of Wildlife and Fisheries. Vials of eggs and identified larvae, plankton displacement volumes, total egg counts, and counts and length measurements of identified larvae are sent to the SEAMAP Archive at the Florida Marine Research Institute in St. Petersburg, FL. There data are entered into the SEAMAP database and specimens are curated and loaned to interested scientists. Data files containing specimen identifications and lengths are sent to the NMFS Mississippi Laboratories where these data are combined with field collection data and edited according to established SEAMAP editing routines. SEAMAP survey data are currently maintained in dBase file structures but conversion to an Oracle based system is underway.

All specimens of snapper larvae used in these analyses were re-examined by ichthyoplankton specialists at the Southeast Fisheries Science Center, Mississippi Laboratories. A strict identification protocol was followed to assure the accuracy and consistency of red snapper identifications over the time series. Larval specimens were identified as red snapper only if 4 or more dorsal fin spines were present and those spines were smooth.

Correlation between adult spawning stock size; abundance and occurrence of juvenile red snapper (ages 0 and 1); and annual mean abundance and frequency of occurrence of red snapper larvae were estimated by using the correlation procedure of SAS (SAS Institute Inc., 1990).

RESULTS:

The larvae of 12 taxa of snappers were identified from among the 11,033 specimens of snapper larvae collected in SEAMAP samples over the time period 1984 - 1997. Although larvae of 7 taxa were identifiable to the species level, over 50% of snapper larvae in samples (most ≤ 3.0 mm in length) could only be identified to the family level. Larvae identified as red snapper, *Lutjanus campechanus*, accounted for 5 and 13 % of all snapper larvae taken in bongo and neuston samples, respectively. Eighty-nine per cent of larvae identified as red snapper were > 3.5 mm in length. Precision of annual estimates of larval mean abundance and occurrence increased after the initiation of an annual Gulfwide Fall Plankton survey in 1986 with CV's generally in the range of 20 to 40 % for both types of sampling gear (Table 1 and 2). Examination of the correlation matrix (Table 3) indicated a number of significant correlations between larval indices and estimates of adult stock size, all of which were based on neuston net catches. The highest correlation found, $r = 0.813$ ($p = 0.0004$) and $r^2 = 0.661$, was between adult abundance and larval frequency of occurrence in neuston samples from the Summer Shrimp/Groundfish and Fall Plankton surveys combined (Figure 2). None of the indices based on bongo net catches were significantly correlated with adult abundance.

DISCUSSION:

Larval survey indices in the form of mean abundance and/or frequency of occurrence generated from annual SEAMAP surveys in the Gulf of Mexico are currently being used as 'tuning variables' in stock assessments for two highly valued FMP species in the southeastern U.S., Atlantic bluefin tuna, *Thunnus thynnus* (Scott et al. 1993) and Gulf king mackerel, *Scomberomorus cavalla* (Gledhill and Lyczkowski-Shultz 2000). The highly significant correlation between larval red snapper occurrence in SEAMAP neuston samples and estimates of adult red snapper stock size provides a potential tuning variable for assessment of the red snapper stock in the Gulf of Mexico.

An updated listing of the SEAMAP annual red snapper larval indices for the period, 1982 to 2002, is provided in Appendix 1. These values are based on all samples taken during the two SEAMAP surveys. The potential effect of spatial allocation of sampling effort on index values over the time series is being investigated. A modeling approach may be used to improve the precision of the final larval red snapper index used for stock assessment.

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Scientists at the Sea Fisheries Institute, Plankton Sorting and Identification Center in Szczecin, Poland sorted and initially identified snapper larvae from all SEAMAP samples. Subsequently, Denice Drass, Pam Bond and Glenn Zapfe of the Mississippi Laboratories re-examined and re-identified larvae as necessary. Rosanne Brasher and Connie Cowan also of the Mississippi Laboratories built and verified the ichthyoplankton database. Kim Williams provided us with specimens and data from the SEAMAP Archive at the Florida Marine Research Institute. Numerous NMFS and State scientists over the years collected samples and the associated data.

Figure 1: SEAMAP Survey area of coastal and shelf waters of the U.S. Gulf of Mexico.

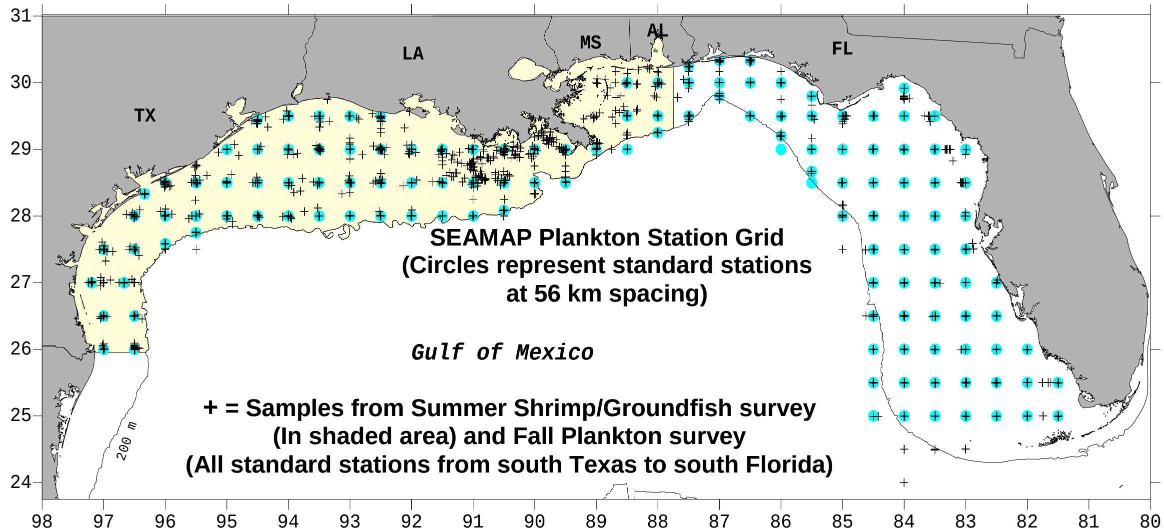

Figure 2: Red snapper larvae (Summer Shrimp/Groundfish and Fall Plankton surveys combined) frequency of occurrence (per cent of stations where larvae were captured ±SE) and mean abundance (number per 10 min tow ±SE) from SEAMAP neuston samples; and estimated adult stock size (ages 3 through 15+).

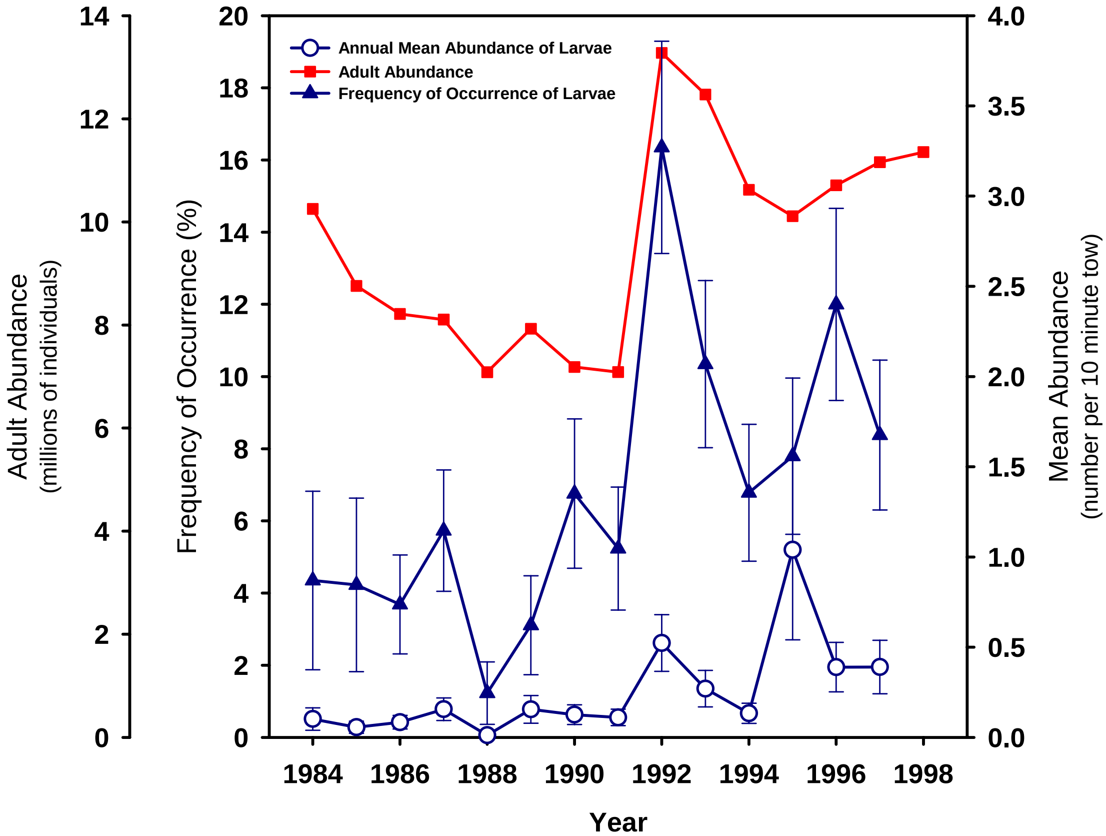

Table 1: Annual estimates of mean abundance (no. per 10 mins) and frequency of occurrence of red snapper larvae collected in neuston net samples from SEAMAP Summer Shrimp/Groundfish and Fall Plankton surveys combined, 1984-1997. CV=100xSE/mean.

Year	Number of Samples	MEAN Abundance	SE	CV(%)	Occurrence (%)	SE	CV(%)
1984	69	0.10	0.062	61.54	4.35	0.025	56.88
1985	71	0.06	0.034	60.50	4.23	0.024	56.90
1986	190	0.08	0.038	44.60	3.68	0.014	37.19
1987	192	0.16	0.063	40.31	5.73	0.017	29.35
1988	163	0.01	0.008	70.51	1.23	0.009	70.49
1989	161	0.16	0.077	49.33	3.11	0.014	44.16
1990	148	0.13	0.054	42.92	6.76	0.021	30.64
1991	172	0.11	0.046	41.83	5.23	0.017	32.54
1992	159	0.52	0.157	30.05	16.35	0.029	17.99
1993	174	0.27	0.101	37.47	10.34	0.023	22.38
1994	177	0.13	0.056	41.72	6.78	0.019	27.95
1995	154	1.04	0.498	47.93	7.79	0.022	27.81
1996	150	0.39	0.137	35.24	12.00	0.027	22.18
1997	179	0.39	0.148	37.94	8.38	0.021	24.78

Table 2: Annual estimates of mean abundance (no. per 10 sq. m) and frequency of occurrence of red snapper larvae collected in bongo net samples from SEAMAP Summer Shrimp/Groundfish and Fall Plankton surveys combined, 1984-1997. CV=100xSE/mean.

Year	Number of Samples	MEAN Abundance	SE	CV(%)	Occurrence (%)	SE	CV(%)
1984	70	0.34	0.141	41.39	8.57	0.034	39.32
1985	91	0.49	0.196	40.42	8.79	0.030	33.95
1986	213	0.43	0.118	27.26	7.98	0.019	23.32
1987	215	0.54	0.199	36.91	6.98	0.017	24.96
1988	125	0.34	0.142	42.23	5.60	0.021	36.87
1989	123	0.56	0.188	33.66	8.13	0.025	30.43
1990	128	0.37	0.136	36.42	6.25	0.021	34.37
1991	129	0.48	0.141	29.38	10.08	0.027	26.40
1992	167	0.80	0.265	33.15	10.18	0.023	23.06
1993	175	0.39	0.136	34.61	6.29	0.018	29.27
1994	176	0.60	0.273	45.73	6.25	0.018	29.28
1995	153	0.91	0.276	30.44	12.42	0.027	21.54
1996	150	1.50	0.553	36.96	11.33	0.026	22.91
1997	179	1.10	0.275	25.02	15.08	0.027	17.78

Figure 3: Correlation matrix of mean abundance and/or frequency of occurrence of red snapper larvae, adult spawning stock (ages 3 to 15+) size, and frequency of occurrence and/or abundance of juveniles (ages 0 and 1). BN = Bongo net samples; NN = Neuston net samples; SG = SUMMER Shrimp/ Groundfish surveys; FP = FALL Plankton Surveys; F = Frequency of occurrence; M = Mean abundance.

Pearson's *r* *p*-value	**BN SG M**	**BN SG F**	**BN FP M**	**BN FP F**	**BN SGFP M**	**BN SGFP F**	**NN SG M**	**NN SG F**	**NN FP M**	**NN FP F**	**NN SGFP M**	**NN SGFP F**	**Adult Abundance**	**Age 0 and 1 Abundance**
BN SG F	**0.8764 <.0001**													
BN FP M	0.3876 0.1906	0.0761 0.8047												
BN FP F	0.1171 0.7032	-0.1066 0.7289	**0.8339 0.0004**											
BN SGFP M	**0.8302 0.0002**	**0.6056 0.0217**	**0.7930 0.0012**	0.5379 0.0580										
BN SGFP F	0.4504 0.1061	0.3893 0.1689	**0.6614 0.0138**	**0.7458 0.0034**	**0.7491 0.0020**									
NN SG M	**0.5946 0.0249**	**0.5839 0.0283**	0.1694 0.5800	0.2104 0.4902	0.4637 0.0949	0.3825 0.1771								
NN SG F	0.5162 0.0588	0.4817 0.0811	0.0227 0.9413	-0.0409 0.8945	0.3117 0.2780	0.1002 0.7333	**0.8921 <.0001**							
NN FP M	0.1028 0.7381	-0.1100 0.7206	**0.6911 0.0089**	**0.6581 0.0145**	0.5315 0.0616	**0.5955 0.0318**	0.0766 0.8036	-0.1002 0.7447						
NN FP F	**0.5530 0.0500**	0.3055 0.3101	0.4889 0.0900	0.4687 0.1062	**0.5949 0.0320**	0.4289 0.1437	**0.6794 0.0106**	0.4972 0.0838	**0.5870 0.0349**					
NN SGFP M	0.1887 0.5182	-0.0283 0.9236	**0.6864 0.0096**	**0.6574 0.0146**	**0.5883 0.0269**	**0.6290 0.0160**	0.2068 0.4782	0.0254 0.9314	**0.9919 <.0001**	**0.6493 0.0163**				
NN SGFP F	**0.6057 0.0217**	0.3805 0.1795	0.3581 0.2296	0.3100 0.3027	**0.5910 0.0260**	0.3872 0.1714	**0.7906 0.0008**	**0.6849 0.0069**	0.4583 0.1152	**0.9510 <.0001**	**0.5593 0.0376**			
Adult Abundance	0.4473 0.1088	0.3344 0.2426	0.2716 0.3695	0.2164 0.4777	0.4471 0.1090	0.3575 0.2095	**0.7332 0.0028**	**0.6299 0.0158**	0.4493 0.1235	**0.8038 0.0009**	0.5027 0.0669	**0.8128 0.0004**		
Age 0 and 1 Abundance	-0.1100 0.7081	-0.3627 0.2025	0.2907 0.3353	0.4234 0.1494	0.1277 0.6636	0.2052 0.4816	-0.3932 0.1643	**-0.5395 0.0465**	0.1555 0.6120	-0.1024 0.7393	0.1442 0.6228	-0.1643 0.5745	-0.3483 0.2223	
Age 0 and 1 Freq of Occurrence	0.0662 0.8222	-0.2172 0.4558	**0.6634 0.0134**	**0.6635 0.0134**	0.4280 0.1268	0.4358 0.1193	-0.1101 0.7079	-0.2972 0.3021	0.3812 0.1988	0.1604 0.6006	0.3813 0.1786	0.0727 0.8050	-0.0831 0.7777	**0.7662 0.0014**

Appendix 1. SEAMAP larval red snapper index: annual per cent frequency of occurrence in neuston samples from Summer Shrimp/Groundfish and Fall Plankton surveys combined, 1982-2002. N = number of neuston samples; No. Spec. = number of larvae caught; Occ = number of occurrences; CV = coefficient of variation of the mean.

YEAR	N	No. Spec.	Occ	% Freq. of Occurrence	SE	CV (%)
1982	73	1	1	1.37	0.0137	100.00
1983	57	7	2	3.51	0.0246	70.08
1984	69	7	3	4.35	0.0247	56.88
1985	71	3	3	4.23	0.0240	56.90
1986	191	15	7	3.66	0.0136	37.19
1987	192	31	11	5.73	0.0168	29.35
1988	163	2	2	1.23	0.0086	70.49
1989	166	25	5	3.01	0.0133	44.18
1990	148	19	10	6.76	0.0207	30.64
1991	172	19	9	5.23	0.0170	32.54
1992	159	85	26	16.35	0.0294	17.99
1993	174	47	18	10.34	0.0232	22.38
1994	177	24	12	6.78	0.0189	27.95
1995	154	160	12	7.79	0.0217	27.81
1996	150	60	18	12.00	0.0266	22.18
1997	179	70	15	8.38	0.0208	24.78
1998	43	5	3	6.98	0.0393	56.34
1999	186	92	24	12.90	0.0246	19.10
2000	176	124	17	9.66	0.0223	23.12
2001	178	63	12	6.74	0.0188	27.96
2002	148	95	24	16.22	0.0304	18.75