Review of the early life history of gray triggerfish, *Balistes capriscus*, with a summary of data from SEAMAP plankton surveys in the Gulf of Mexico: 1982, 1984-2002

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EARLY LIFE HISTORY

Ingram (2001) presented a thorough review of the literature on early life history of *Balistes capriscus* and summarized abundance and distribution data from four years of SEAMAP collections. Information thought to be germane to the application of larval triggerfish data in stock assessments is recapitulated here. Gray triggerfish are oviparous and spawn demersal, adhesive eggs in shallow, sandy excavations which are guarded by the female. Spawning occurs in late spring through summer, generally April through September in the Gulf of Mexico. Larval development was first described by Matsuura and Katsuragawa (1981). Triggerfish larvae are distinctive and can be identified at the smallest sizes found in plankton collections, i.e. ~2 mm. Lyczkowski-Shultz and Ingram (2003) described distinguishing characteristics that allow the larvae of five of the six species of triggerfishes found in the Gulf of Mexico to be identified. Only the larvae of *B. vetula* remain undescribed. Preflexion larvae are rare in plankton collections and may be demersal, while late flexion larvae and pelagic juveniles are taken primarily in neuston collections (Lyczkowski-Shultz and Ingram 2003). Their pelagic period is thought to be prolonged, and perhaps, indeterminate, lasting a few weeks to several months to as much as a year (Dooley 1972; Richards and Lindeman 1987). Young gray triggerfish are consistently associated with *Sargassum* spp. and other types of flotsam suggesting that ocean circulation may determine their dispersal and distribution patterns (Ingram 2001). Growth and mortality rates have not been determined for young gray triggerfish during their pelagic period. Size at settlement to demersal habitats was estimated to be 81 mm FL by backcalculation from the settlement mark on the first dorsal spine in trawl-caught juveniles (Ingram 2001). This estimate is similar to size at settlement of queen triggerfish (*B. vetula*) on Caribbean reefs, i.e. 49-70 mm (Robertson 1988).

SEAMAP SURVEYS, METHODS AND MATERIALS

Since 1982 the Southeast Area Monitoring and Assessment Program (SEAMAP) has supported collection and analysis of ichthyoplankton samples during fishery-independent, resource surveys in the Gulf of Mexico (GOM) with the goal of producing a long-term database on the early life stages of fishes (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 original plan for SEAMAP plankton surveys was to sample both the open (shelf edge to U.S. EEZ) and continental shelf (10 to 200 m) portions of the Gulf in their entirety at least once during each season. This ambitious goal has not been achieved because survey data relevant to fisheries-related issues must encompass the entire geographic extent of spawning which, for most species, includes either the entire open Gulf or continental shelf regions. Furthermore, once established, these surveys must be conducted on an annual basis in order to build a historical database from which population trends can be assessed. The current surveys do encompass the spawning seasons of many of the managed species in the Gulf.

Due to these constraints SEAMAP ichthyoplankton data have been collected primarily during four survey periods: spring (April and May, 1982 to present), summer (June and July, 1982 to present), late summer /early fall (typically in September, 1986 to present) and fall (October and November, 1982 to present). The spring survey covers only open U.S. GOM waters, while the summer and fall surveys encompass only continental shelf waters from south Texas to Mobile Bay; and the late summer/early fall survey from south Texas to south Florida. There have been three, winter plankton surveys in open Gulf waters during the SEAMAP time series (in 1983, 1984 and 1996). Samples used in annual estimates of larval fish abundance are collected on both state and federal cruises. Since 1982 the number of samples taken each year during SEAMAP summer and fall shrimp/bottomfish trawl surveys has typically ranged from 30 to 76 samples. In 1998 only 10 samples were collected during the summer trawl survey due to vessel breakdowns and severe weather. The summer and fall trawl survey area includes the continental shelf and coastal waters west of 88° W longitude; although in the earliest years of the time series (1982 to 1988) sampling was conducted further east off northwest Florida. Samples from late August to mid-October are taken during the SEAMAP fall plankton survey which only became a Gulfwide survey of continental shelf and coastal waters between Brownsville, Texas and south Florida in 1986. This survey has produced from 81 to 150 samples per year since 1986. In 1998 only 35 samples were collected during this timeframe due to vessel breakdowns and tropical storms. Over the years surveys and sampling have been conducted that were not part of the designated primary survey types. Data and observations from these sampling efforts are used to help define spawning times and intensity but are not used to estimate annual indices of larval fish occurrence and mean abundance.

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 60 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 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

[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.

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, 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 triggerfishes used in these analyses were re-examined by ichthyoplankton specialists at the Southeast Fisheries Science Center, Mississippi Laboratories. Identification to species level was accomplished using descriptions in Lyczkowski-Shultz and Ingram (2003).

RESULTS

General Description of Occurrence and Abundance from SEAMAP surveys in the Gulf of Mexico:

Over 5,600 triggerfish and filefish specimens collected in bongo and neuston net samples during SEAMAP surveys in 1982, and 1984-2002 were examined and identified to the lowest possible taxon. Specimens from surveys in 1983 were not available for examination.

Young *Balistes capriscus* are consistently taken in bongo and neuston samples during all SEAMAP surveys types and timeframes (Table 1). Larvae first appeared in samples from April and were present through November (Table 2). Months of highest occurrence and abundance were July, August and September when young triggerfish occurred in 8, 11 and 12 % of neuston samples, respectively. Mean abundance in neuston samples for those months was 0.18, 0.33 and 0.31 fish per 10 min, respectively. Compared to capture in neuston net samples (875 individuals) young gray triggerfish were rare in bongo nets samples with only a total of 116 individuals caught over the time series, 1982, and 1984-2002. By November per cent occurrence in neuston samples was < 2 %.

Mean abundance and occurrence of young gray triggerfish by month and survey type (including non-SEAMAP sampling effort) indicated that the SEAMAP Fall plankton survey accounts for the majority of captures (Tables 3 and 4). This survey comprises samples collected within the timeframe, 15 August to 15 October. Summed abundances of gray triggerfish during two other established long-term surveys; namely spring plankton and fall shrimp/bottomfish surveys, were an order of magnitude less than summed abundance during the fall plankton survey. Total abundance during summer shrimp/bottomfish surveys was 5 times that of the abundance in fall plankton surveys. The explanation for this difference is that sampling during spring surveys takes place primarily in open Gulf waters, i.e. outside gray triggerfish spawning grounds. Sampling during summer and fall shrimp/ bottomfish surveys apparently misses peak spawning production.

Size frequency distributions (catch curves) of young gray triggerfish captured during the three, long-term SEAMAP surveys in shelf waters are shown in Figures 1 and 2. Overall range in body length (BL) of individuals was 1.3-27.0 mm BL, i.e. standard length in postflexion larvae and juveniles (mean = 5.3, median = 2.9) in bongo net samples; and 1.9-79.5 mm BL (mean = 16.5, median = 14.6) in neuston net samples. Overall the neuston net captured larger individuals than did the bongo net. Over 98 % of individuals in bongo net samples measured ≤ 25 mm BL, while individuals accounting for the same cumulative percentage taken in neuston net samples were ≤ 45 mm BL (Tables 5 & 6). Both standard length (SL) and total length (TL) were measured on a sample (N=33) of gray triggerfish caught in plankton samples. The equations for converting these measurements are: $TL= 1.2103SL + 1.9443$ ($R^2= 0.9961$); and $SL= 0.8231TL – 1.5243$ ($R^2= 0.9961$).

The SEAMAP Fall Plankton survey yielded the majority of observations on young gray triggerfish in the Gulf (Table 4). Maps showing distribution and relative abundance of gray triggerfish in bongo and neuston samples from the SEAMAP August 1984 plankton survey and SEAMAP Fall Plankton surveys, 1986 to 2002 are presented in Figures 3-20. Although specimens were captured at stations over the entire east-west extent of the survey area most occurrences were observed at stations west of the Mississippi River on the mid and outer continental shelf between the 50 and 100 m isobaths. Triggerfish consistently occurred off the south Texas coast at depths between 10 and 50 m. There were fewer occurrences east of the Mississippi River especially off central and southwest Florida. Highest station abundances were generally observed off Texas and western Louisiana.

Larval Index:

We recommend that the gray triggerfish index of 'larval' abundance be based on neuston net samples from the SEAMAP Fall Plankton survey (Table 7). The time series for this index begins with the 1986 season when the fall plankton survey became Gulfwide, and subsequently, it has been conducted each year from mid August to mid October. Too few samples were taken during the 1998 field season on which to base an estimate of larval abundance due to tropical storms and hurricanes that severely curtailed field work that year. It is evident from a comparison of mean annual abundances, coefficients of variation of mean abundance (CV), and annual per cent occurrence between both gear types that gray triggerfish are taken more consistently in neuston than in bongo samples (Tables 8 & 9). CV's over the time series for neuston net catches are lower and relatively more stable than for bongo net catches. Triggerfish occurred less frequently and in lower numbers during the summer and fall shrimp/bottomfish surveys than during the fall plankton survey. Another consideration is geographic coverage relative to the range of the gray triggerfish stock in the Gulf. The fall plankton survey is the only established SEAMAP survey that samples the entire spawning grounds of this species in the U.S. Gulf of Mexico.

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Table 1: Table 1: Surveys where young gray triggerfish were caught in plankton samples. SP=SEAMAP Spring survey; SG=SEAMAP Summer Shrimp/Bottomfish survey; FG=Fall Shrimp/Bottomfish survey; FP=SEAMAP Fall Plankton survey; SQ=Squid/Butterfish survey; AF=Alabama Fall SEAMAP survey; AS=Alabama Summer SEAMAP; * donotes sampling outside established SEAMAP surveys

CRUISE	VESSEL	Survey Type	No of Samples NEUSTON	No of Samples BONGO	Cruise Begin Date	Cruise End Date
126	04	SP	128	127	4/15/1982	5/25/1982
127	04	SG	60	66	6/2/1982	7/13/1982
143	04	SP	88	141	4/21/1984	5/16/1984
145	04	SG	59	60	6/8/1984	7/22/1984
146	04	FP	161	156	8/2/1984	8/27/1984
153	04	SG	36	38	6/11/1985	7/15/1985
154	04	SQ	46	47	7/30/1985	8/26/1985
852	17	SQ	20	20	8/2/1985	8/13/1985
854	17	SQ	5	5	8/22/1985	8/24/1985
854	35	FP	10	24	9/16/1985	10/4/1985
159	04	SP	69	69	4/22/1986	5/21/1986
161	04	FP	48	48	9/4/1986	9/12/1986
862	36	FP	29	29	9/6/1986	9/13/1986
864	17	FP	9	9	9/8/1986	9/10/1986
865	28	FP	56	55	9/13/1986	9/22/1986
862	23	AF	10	6	9/22/1986	9/18/1986
864	35	FG	23	24	10/27/1986	10/30/1986
875	36	FP	35	35	9/1/1987	9/8/1987
169	04	FP	91	91	9/12/1987	9/27/1987
882	35	SG	12	12	7/11/1988	7/14/1988
886	28	*	16	16	7/29/1988	8/19/1988
882	36	FP	36	36	8/26/1988	9/2/1988
176	04	FP	80	39	9/7/1988	9/28/1988
177	04	FG	39	38	10/20/1988	11/21/1988
892	49	SP	121	61	4/26/1989	5/19/1989
892	28	*	30	0	6/24/1989	6/28/1989
183	04	FP	75	37	9/13/1989	9/29/1989
901	36	SP	4	21	5/24/1990	5/30/1990
904	28	SP	129	64	5/30/1990	6/30/1990
190	04	FP	100	52	9/2/1990	9/28/1990

Table 1 cont.

195	04	SG	37	37	6/18/1991	7/13/1991
912	36	FP	22	23	8/21/1991	8/25/1991
914	28	FP	95	49	9/6/1991	9/26/1991
914	35	FP	7	7	9/30/1991	10/4/1991
197	04	FG	40	40	10/14/1991	11/18/1991
200	04	SG	40	41	6/13/1992	7/13/1992
925	28	FP	72	73	8/30/1992	9/20/1992
204	04	SP	120	64	5/19/1993	6/15/1993
205	04	SG	40	41	6/20/1993	7/21/1993
936	28	FP	72	72	9/10/1993	9/29/1993
207	04	FP	10	10	10/5/1993	10/6/1993
208	04	FG	36	30	10/15/1993	11/14/1993
941	36	SP	5	5	5/20/1994	5/22/1994
210	04	SG	42	41	6/16/1994	7/17/1994
946	28	FP	88	88	9/11/1994	9/29/1994
214	04	FG	48	48	10/14/1994	11/20/1994
216	04	SP	264	127	4/19/1995	6/7/1995
217	04	SG	21	20	6/23/1995	7/14/1995
955	28	FP	88	87	9/9/1995	9/26/1995
952	26	FP	24	25	9/24/1995	9/28/1995
219	04	FG	21	21	10/16/1995	11/16/1995
221	04	SG	22	22	6/14/1996	7/16/1996
965	28	FP	92	92	9/5/1996	9/25/1996
962	26	FP	19	19	9/11/1996	9/14/1996
224	04	FG	43	43	10/11/1996	11/21/1996
225	04	SP	186	95	4/17/1997	6/9/1997
226	04	SG	47	47	6/13/1997	7/16/1997
975	28	FP	93	93	9/7/1997	9/27/1997
229	04	FG	20	18	10/10/1997	11/19/1997
981	63	FP	25	27	9/7/1998	9/24/1998
234	04	SP	179	88	4/23/1999	5/31/1999
235	04	SG	35	35	6/15/1999	7/20/1999
992	63	FP	116	117	9/3/1999	9/29/1999
993	17	FP	9	9	9/9/1999	9/10/1999
237	04	FG	45	43	10/16/1999	11/20/1999
002	63	SP	166	85	4/20/2000	5/26/2000
240	04	SG	45	45	6/13/2000	7/19/2000
242	04	FP	104	111	9/7/2000	10/1/2000
001	26	FP	13	14	9/26/2000	9/29/2000

Table 1 cont.

246	04	SG	28	29	6/12/2001	7/24/2001
013	17	SG	12	11	7/3/2001	7/10/2001
015	63	FP	131	127	8/31/2001	9/26/2001
022	63	SP	160	90	4/18/2002	5/28/2002
250	04	SG	51	50	6/12/2002	7/16/2002
021	35	SG	7	7	7/9/2002	7/12/2002
025	63	FP	86	88	8/30/2002	9/20/2002
022	23	AF	9	0	9/17/2002	9/17/2002
023	17	FP	6	6	10/10/2002	10/11/2002
252	04	FG	46	44	10/13/2002	11/15/2002
024	17	FG	2	2	10/19/2002	10/19/2002

Table 2: Summary of young gray triggerfish catches by month based on all surveys in the Gulf of Mexico; 1982, 1984-2002. CV=coefficient of variation of mean abundance.

A. Bongo samples

Month	No. Samples	No. Occurrences	No. Larvae	% Occurrence	Mean Abundance	Std	SE	Lower 95%CI	Upper 95%CI	Minimum Abundance	Maximum Abundance	Summed Abundance	CV
1	72	0											
2	35	0											
3	170	0											
4	581	2	2	0.34	0.02	0.284	0.012	-0.006	0.040	0	5.12	9.68	70.76
5	1277	5	5	0.39	0.03	0.412	0.012	0.003	0.048	0	7.20	32.92	44.71
6	630	8	9	1.27	0.07	0.667	0.027	0.021	0.125	0	9.51	45.86	36.50
7	550	15	23	2.73	0.22	1.491	0.064	0.091	0.340	0	20.43	118.54	29.50
8	329	4	14	1.22	0.29	3.836	0.211	-0.131	0.702	0	67.80	93.94	74.07
9	1615	47	62	2.91	0.17	1.127	0.028	0.111	0.221	0	20.25	268.83	16.85
10	648	1	1	0.15	0.01	0.135	0.005	-0.005	0.016	0	3.43	3.43	100.00
11	472	0											
12	221	0											

B. Neuston samples

Month	No. Samples	No. Occurrences	No. Larvae	% Occurrence	Mean Abundance	Std	SE	Lower 95%CI	Upper 95%CI	Minimum Abundance	Maximum Abundance	Summed Abundance	CV
1	76	0											
2	33	0											
3	37	0											
4	863	2	2	0.23	0.00	0.060	0.002	-0.001	0.007	0	1.46	2.46	71.91
5	1958	13	20	0.66	0.01	0.146	0.003	0.004	0.017	0	4.00	19.94	32.39
6	724	27	40	3.73	0.06	0.359	0.013	0.032	0.084	0	4.00	41.88	23.09
7	515	43	85	8.35	0.18	0.781	0.034	0.114	0.249	0	10.17	93.33	18.99
8	331	35	109	10.57	0.33	1.397	0.077	0.175	0.477	0	12.58	108.04	23.53
9	1878	226	587	12.03	0.31	1.545	0.036	0.244	0.384	0	31.00	589.42	11.36
10	635	15	26	2.36	0.04	0.357	0.014	0.013	0.069	0	6.00	25.93	34.69
11	403	6	6	1.49	0.02	0.123	0.006	0.003	0.027	0	1.04	6.08	40.58
12	166	0											

Table 3: Summary of young gray triggerfish catches in bongo net samples by month and survey type based on all surveys in the Gulf of Mexico; 1982, 1984-2002. CV=coefficient of variation of mean abundance. * donotes sampling outside established SEAMAP surveys

Month	Survey Type	No. Samples	No. Occurrences	No. Larvae	% Occurrence	Mean Abundance	Std	SE	Lower 95%CI	Upper 95%CI	Minimum Abundance	Maximum Abundance	Summed Abundance	CV
1	*	72	0											
2	*	35	0											
3	*	122	0											
6	*	34	0											
7	*	3	0											
8	*	13	0											
11	*	31	0											
12	*	210	0											
3	SP	48	0											
4	SP	581	2	2	0.34	0.02	0.284	0.012	-0.006	0.040	0	5.12	9.68	70.76
5	SP	1261	5	5	0.40	0.03	0.415	0.012	0.003	0.049	0	7.20	32.92	44.71
6	SP	147	0											
6	AS	2	0											
6	SG	447	8	9	1.79	0.10	0.790	0.037	0.029	0.176	0	9.51	45.86	36.42
7	SG	544	15	23	2.76	0.22	1.499	0.064	0.092	0.344	0	20.43	118.54	29.50
5	SQ	16	0											
7	SQ	3	0											
8	SQ	69	2	3	2.90	0.29	1.758	0.212	-0.137	0.708	0	13.16	19.68	74.20
9	AF	6	0											
8	FP	247	2	11	0.81	0.30	4.332	0.276	-0.242	0.843	0	67.80	74.25	91.68
9	FP	1609	47	62	2.92	0.17	1.129	0.028	0.112	0.222	0	20.25	268.83	16.85
10	FP	269	0											
10	FG	379	1	1	0.26	0.01	0.176	0.009	-0.009	0.027	0	3.43	3.43	100.00
11	FG	441	0											
12	FG	11	0											

Table 4: Summary of young gray triggerfish catches in neuston net samples by month and survey type based on all surveys in the Gulf of Mexico; 1982, 1984-2002. CV=coefficient of variation of mean abundance. * donotes sampling outside established SEAMAP surveys

Month	Survey Type	No. Samples	No. Occurrences	No. Larvae	% Occurrence	Mean Abundance	Std	SE	Lower 95%CI	Upper 95%CI	Minimum Abundance	Maximum Abundance	Summed Abundance	CV
1	*	76	0											
2	*	33	0											
4	*	5	0											
5	*	84	0											
6	*	64	2	2	3.13	0.03	0.175	0.022	-0.013	0.075	0	1.00	2.00	70.15
7	*	3	1	1	33.33	0.33	0.577	0.333	-1.101	1.768	0	1.00	1.00	100.00
8	*	13	0											
11	*	31	0											
12	*	158	0											
3	SP	37	0											
4	SP	858	2	2	0.23	0.00	0.060	0.002	-0.001	0.007	0	1.46	2.46	71.91
5	SP	1860	13	20	0.70	0.01	0.150	0.003	0.004	0.018	0	4.00	19.94	32.38
6	SP	249	16	27	6.43	0.12	0.552	0.035	0.047	0.185	0	4.00	28.91	30.11
6	AS	4	0											
6	SG	407	9	11	2.21	0.03	0.190	0.009	0.008	0.045	0	2.00	10.97	34.93
7	SG	509	42	84	8.25	0.18	0.784	0.035	0.113	0.250	0	10.17	92.33	19.17
5	SQ	14	0											
7	SQ	3	0											
8	SQ	68	11	48	16.18	0.69	2.192	0.266	0.161	1.222	0	12.58	47.05	38.42
9	AF	125	3	5	2.40	0.04	0.293	0.026	-0.012	0.091	0	3.00	4.93	66.50
10	AF	18	0											
8	FP	250	24	61	9.60	0.24	1.116	0.071	0.105	0.383	0	11.00	60.99	28.93
9	FP	1753	223	582	12.72	0.33	1.596	0.038	0.259	0.408	0	31.00	584.48	11.43
10	FP	258	4	8	1.55	0.03	0.328	0.020	-0.009	0.071	0	5.00	7.93	66.41
10	FG	359	11	18	3.06	0.05	0.385	0.020	0.010	0.090	0	6.00	18.01	40.53
11	FG	372	6	6	1.61	0.02	0.128	0.007	0.003	0.029	0	1.04	6.08	40.56
12	FG	8	0											

Figure 1: Overall size frequency distribution of young gray triggerfish (2 mm size classes) captured in bongo net samples during SEAMAP surveys; 1982, 1984-2002. FG=Fall Shrimp/Bottomfish survey; SG= Summer Shrimp/Bottomfish survey; FP=Fall Plankton survey.

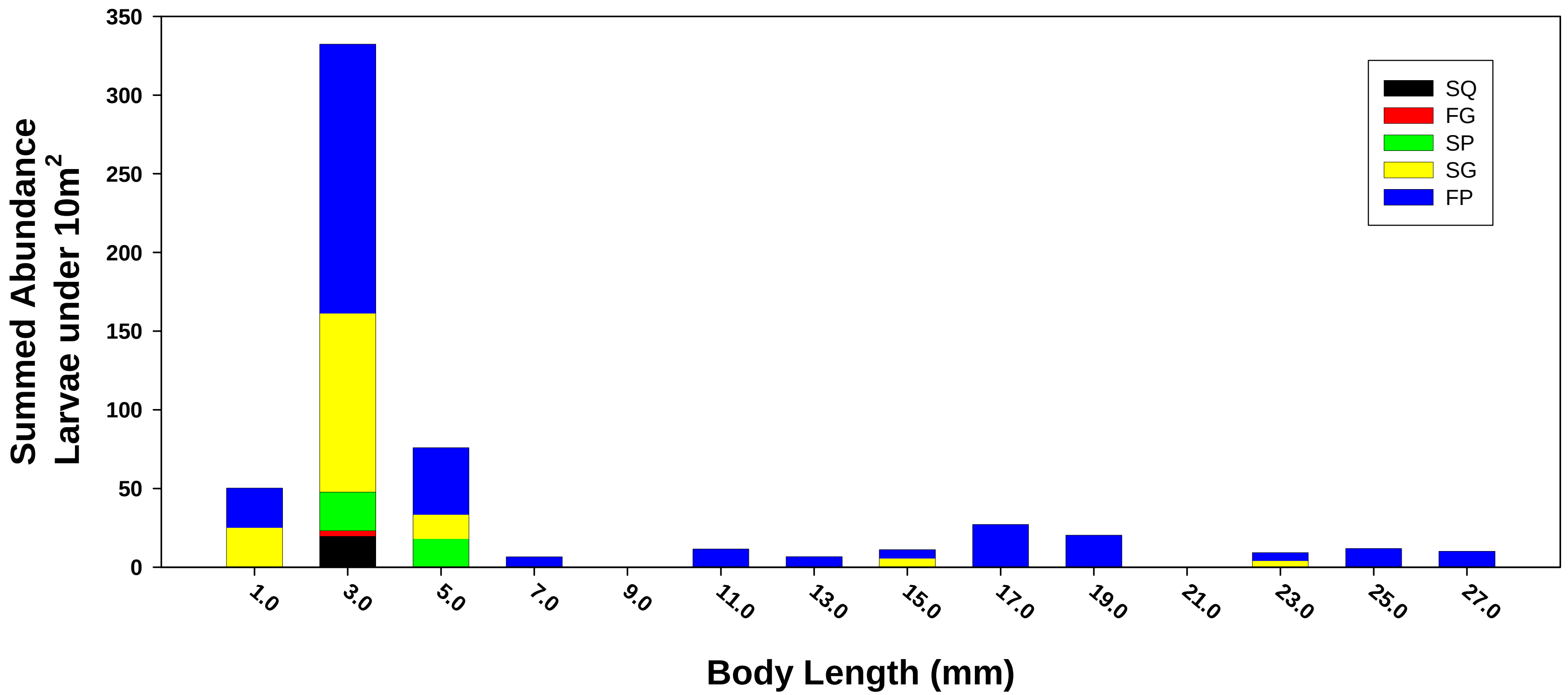

Figure 2: Overall size frequency distribution of young gray triggerfish (2 mm size classes) captured in neuston net samples during SEAMAP surveys: 1982, 1984-2002. FG=Fall Shrimp/Bottomfish survey; SG= Summer Shrimp/Bottomfish survey; FP=Fall Plankton survey.

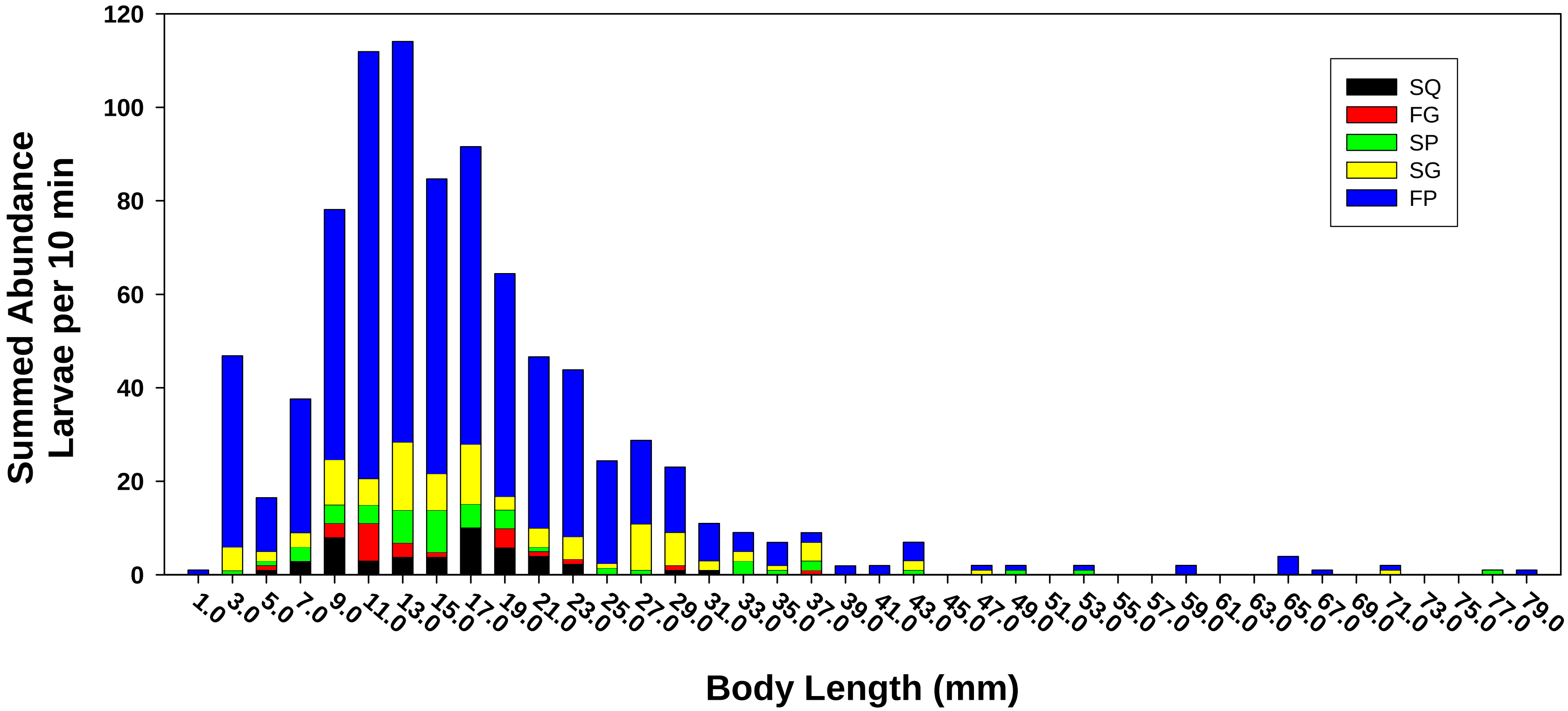

Table 5: Per cent cumulative frequency of young gray triggerfish in 2 mm size classes caught in bongo net samples during SEAMAP surveys; 1982, 1984-2002.

Size Class (BL mm)	Number of Larvae	Adjusted Total Number of Larvae	Adjusted Number of Larvae under 10m^2	% Cumulative Frequency
1.0	12	12	50.21	8.76
3.0	70	70	332.22	66.72
5.0	14	14	75.99	79.98
7.0	2	2	6.63	81.13
9.0	0	0	0.00	81.13
11.0	2	2	11.60	83.16
13.0	1	1	6.78	84.34
15.0	2	2	11.10	86.27
17.0	4	4	27.12	91.01
19.0	3	3	20.34	94.55
21.0	0	0	0.00	94.55
23.0	2	2	9.25	96.17
25.0	2	2	11.84	98.23
27.0	2	2	10.13	100.00

Table 6: Per cent cumulative frequency of young gray triggerfish in 2 mm size classes caught in neuston net samples during SEAMAP surveys; 1982, 1984-2002.

Size Class (BL mm)	Number of Larvae	Adjusted Total Number of Larvae	Adjusted Number of Larvae/10min Tow	% Cumulative Frequency
1.0	1	1.00	1.00	0.11
3.0	46	46.00	46.84	5.45
5.0	16	16.70	16.47	7.33
7.0	40	41.05	37.60	11.62
9.0	78	79.40	78.13	20.53
11.0	110	112.77	111.92	33.29
13.0	111	112.03	114.08	46.29
15.0	81	82.05	84.68	55.95
17.0	90	91.50	91.61	66.39
19.0	62	62.00	64.39	73.73
21.0	45	45.00	46.62	79.05
23.0	42	42.50	43.83	84.04
25.0	24	24.00	24.40	86.82
27.0	27	27.00	28.77	90.10
29.0	21	21.00	23.02	92.73
31.0	11	11.00	11.00	93.98
33.0	7	7.00	9.03	95.01
35.0	7	7.00	6.95	95.80
37.0	9	9.00	8.99	96.83
39.0	2	2.00	1.91	97.05
41.0	2	2.00	1.97	97.27
43.0	6	6.00	6.99	98.07
45.0	0	0.00	0.00	98.07
47.0	2	2.00	2.00	98.30
49.0	2	2.00	2.00	98.52
51.0	0	0.00	0.00	98.52
53.0	2	2.00	2.00	98.75
55.0	0	0.00	0.00	98.75
57.0	0	0.00	0.00	98.75
59.0	2	2.00	2.01	98.98
61.0	0	0.00	0.00	98.98
63.0	0	0.00	0.00	98.98
65.0	4	4.00	3.93	99.43
67.0	1	1.00	1.00	99.54
69.0	0	0.00	0.00	99.54
71.0	2	2.00	2.00	99.77
73.0	0	0.00	0.00	99.77
75.0	0	0.00	0.00	99.77
77.0	1	1.00	1.00	99.89
79.0	1	1.00	1.00	100.00

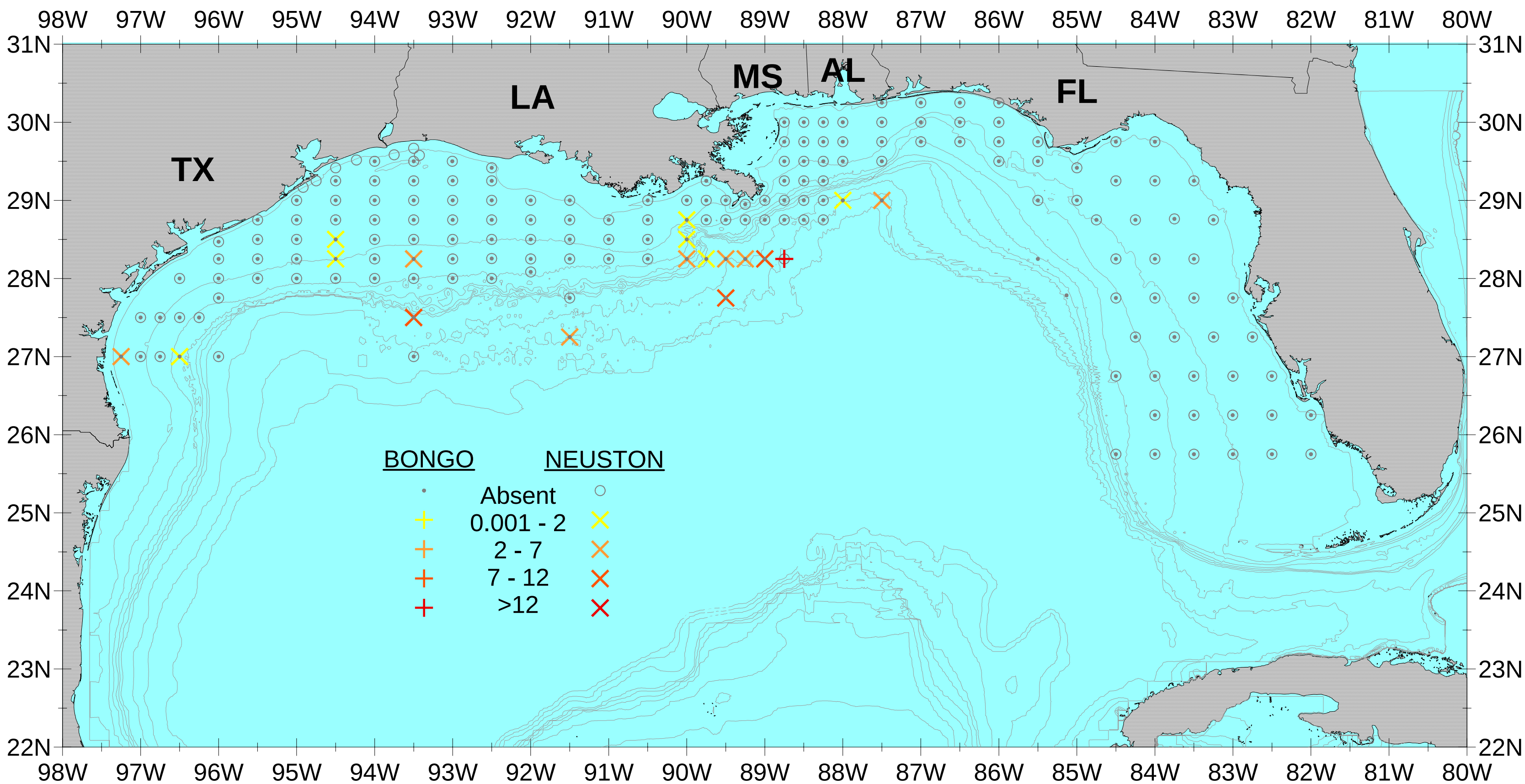

Figure 3. Occurrence and abundance of gray triggerfish, *Balistes capriscus*, during the August 1984 SEAMAP plankton survey, Oregon II cruise 146. Abundance in bongo net samples = Larvae / 10 m^2. Abundance in neuston net samples = Larvae / 10 min.

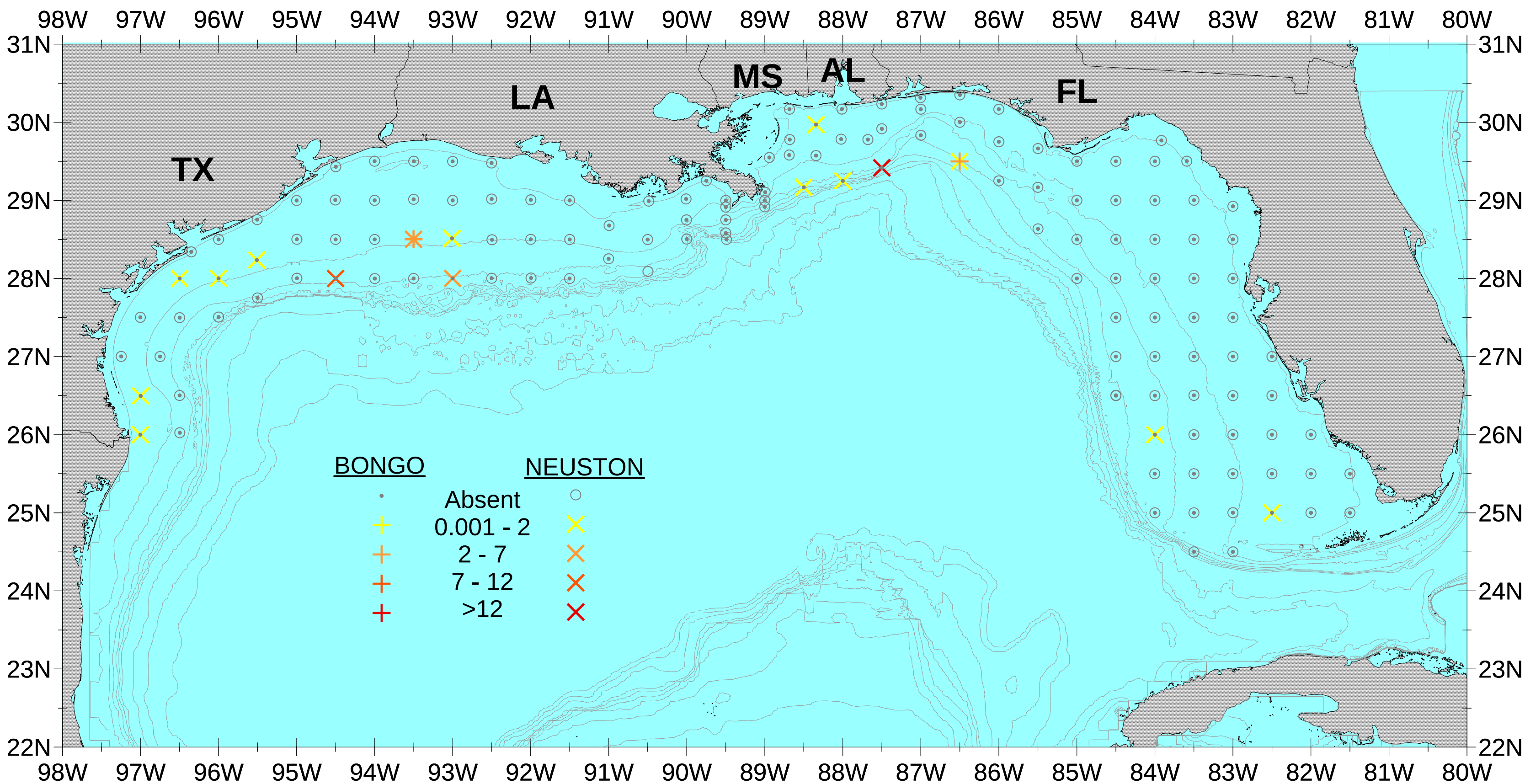

Figure 4. Occurrence and abundance of gray triggerfish, *Balistes capriscus*, at SEAMAP stations during the fall plankton survey in 1986. Abundance in bongo net samples = Larvae / 10 m^2. Abundance in neuston net samples = Larvae / 10 min.

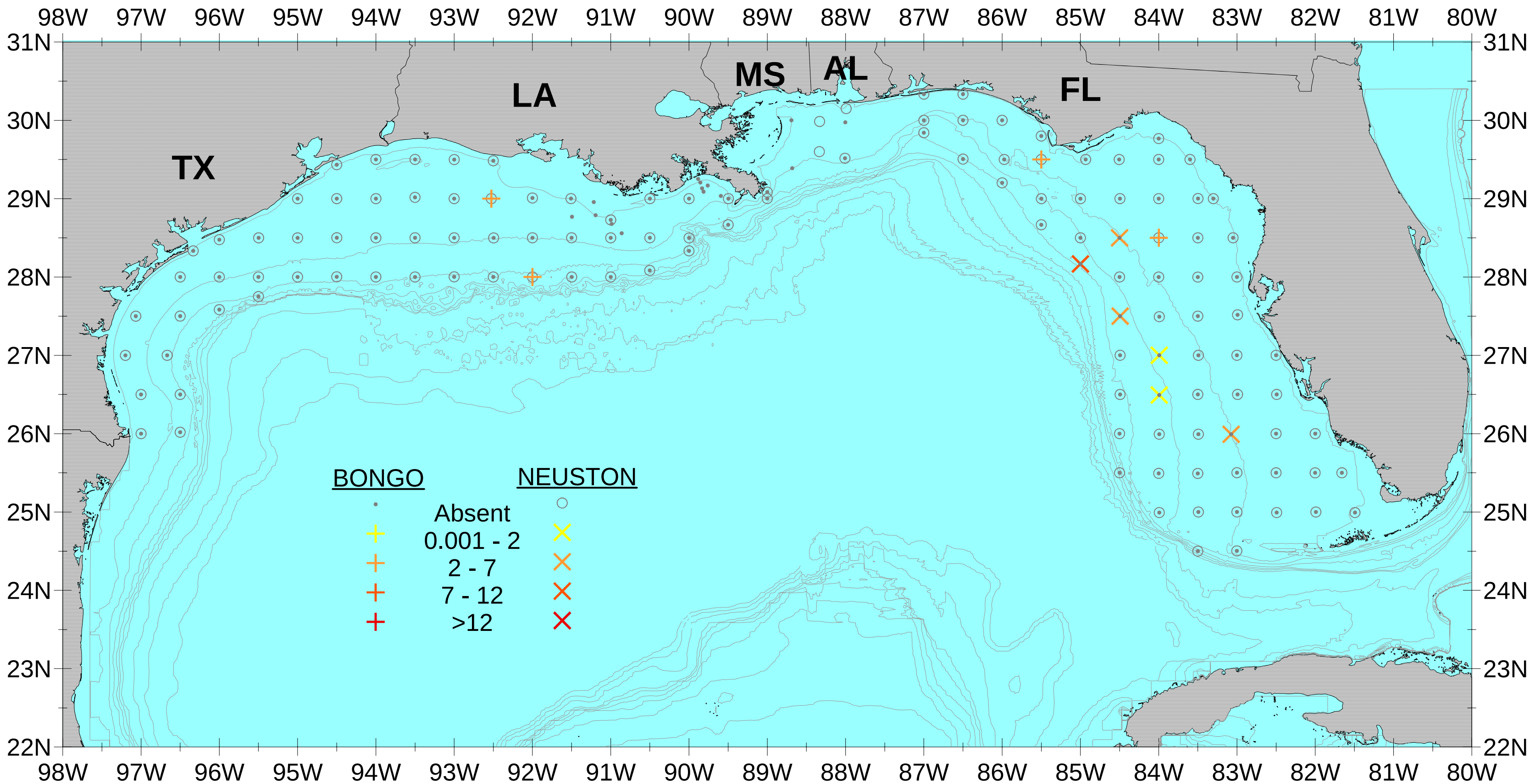

Figure 5. Occurrence and abundance of gray triggerfish, *Balistes capriscus*, at SEAMAP stations during the fall plankton survey in 1987. Abundance in bongo net samples = Larvae / 10 m^2. Abundance in neuston net samples = Larvae / 10 min.

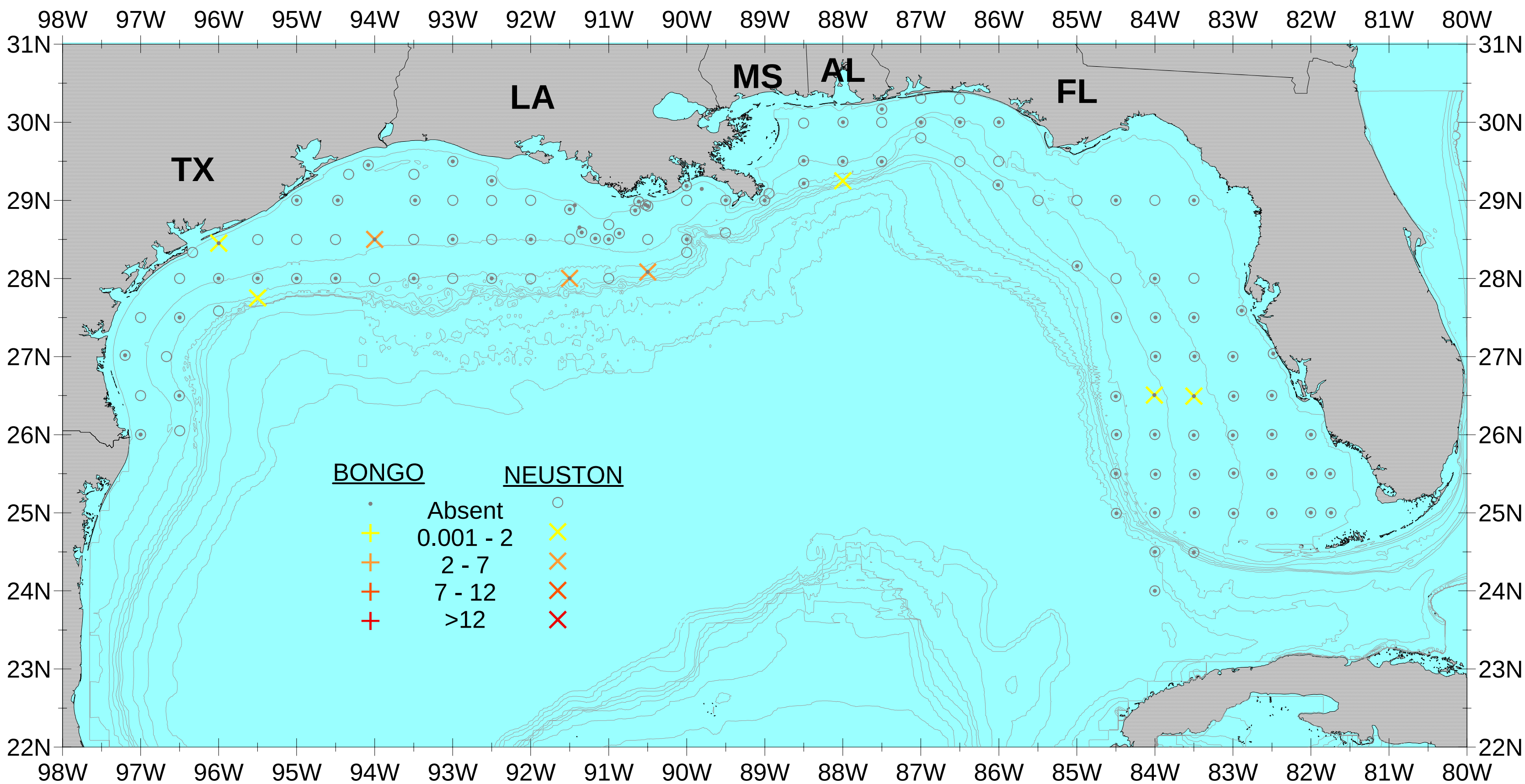

Figure 6. Occurrence and abundance of gray triggerfish, *Balistes capriscus*, at SEAMAP stations during the fall plankton survey in 1988. Abundance in bongo net samples = Larvae / 10 m^2. Abundance in neuston net samples = Larvae / 10 min.

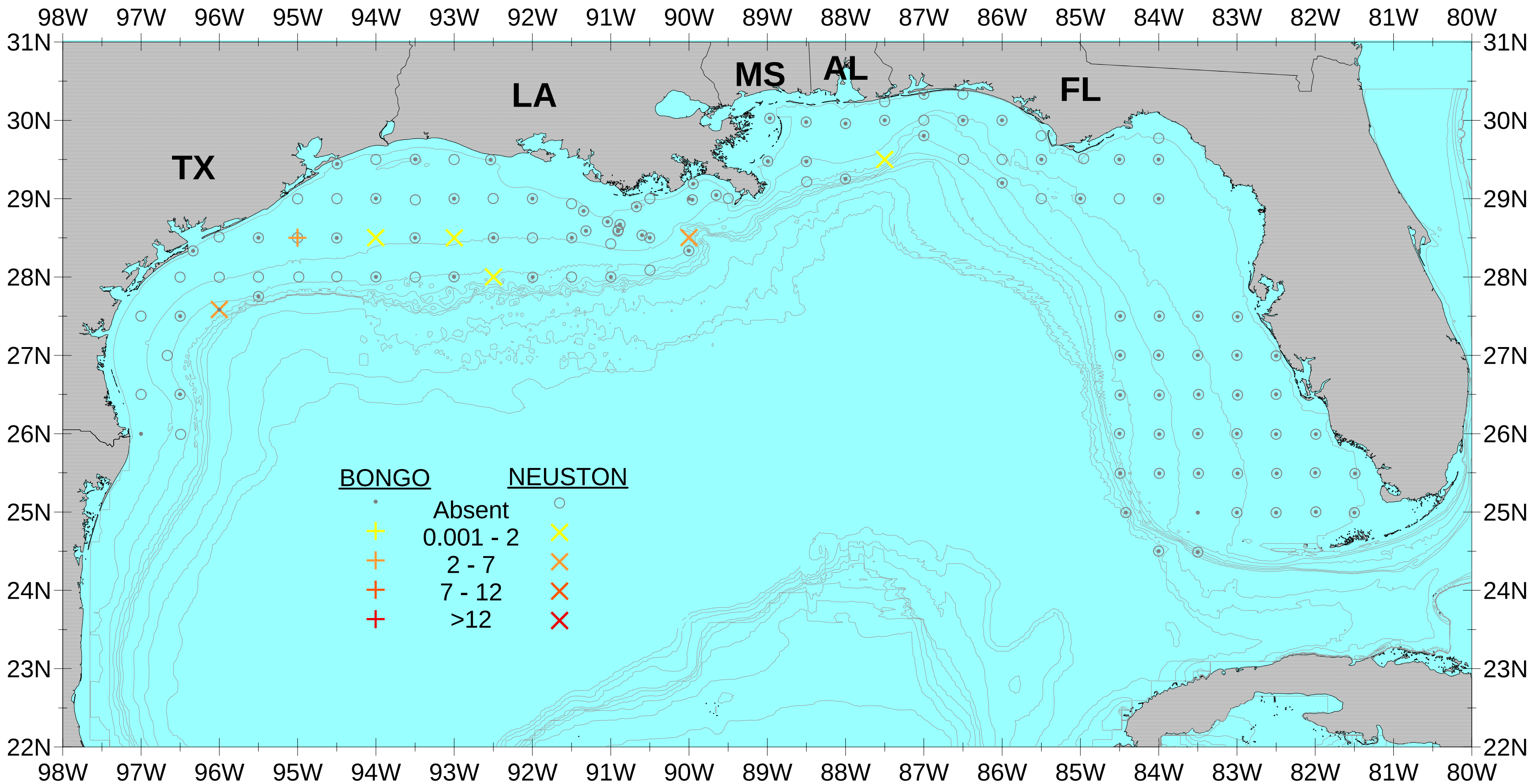

Figure 7. Occurrence and abundance of gray triggerfish, *Balistes capriscus*, at SEAMAP stations during the fall plankton survey in 1989. Abundance in bongo net samples = Larvae / 10 m^2. Abundance in neuston net samples = Larvae / 10 min.

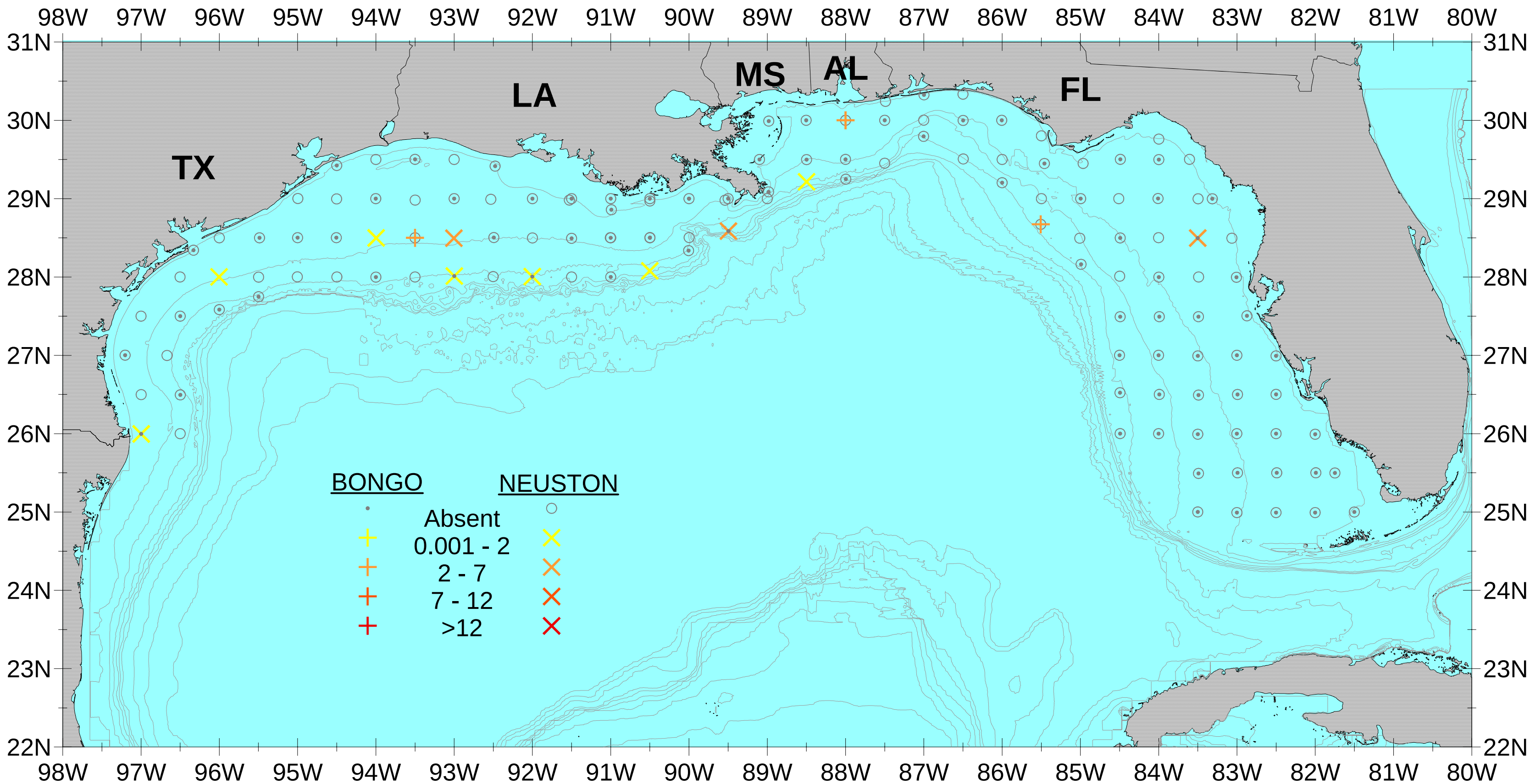

Figure 8. Occurrence and abundance of gray triggerfish, *Balistes capriscus*, at SEAMAP stations during the fall plankton survey in 1990. Abundance in bongo net samples = Larvae / 10 m^2. Abundance in neuston net samples = Larvae / 10 min.

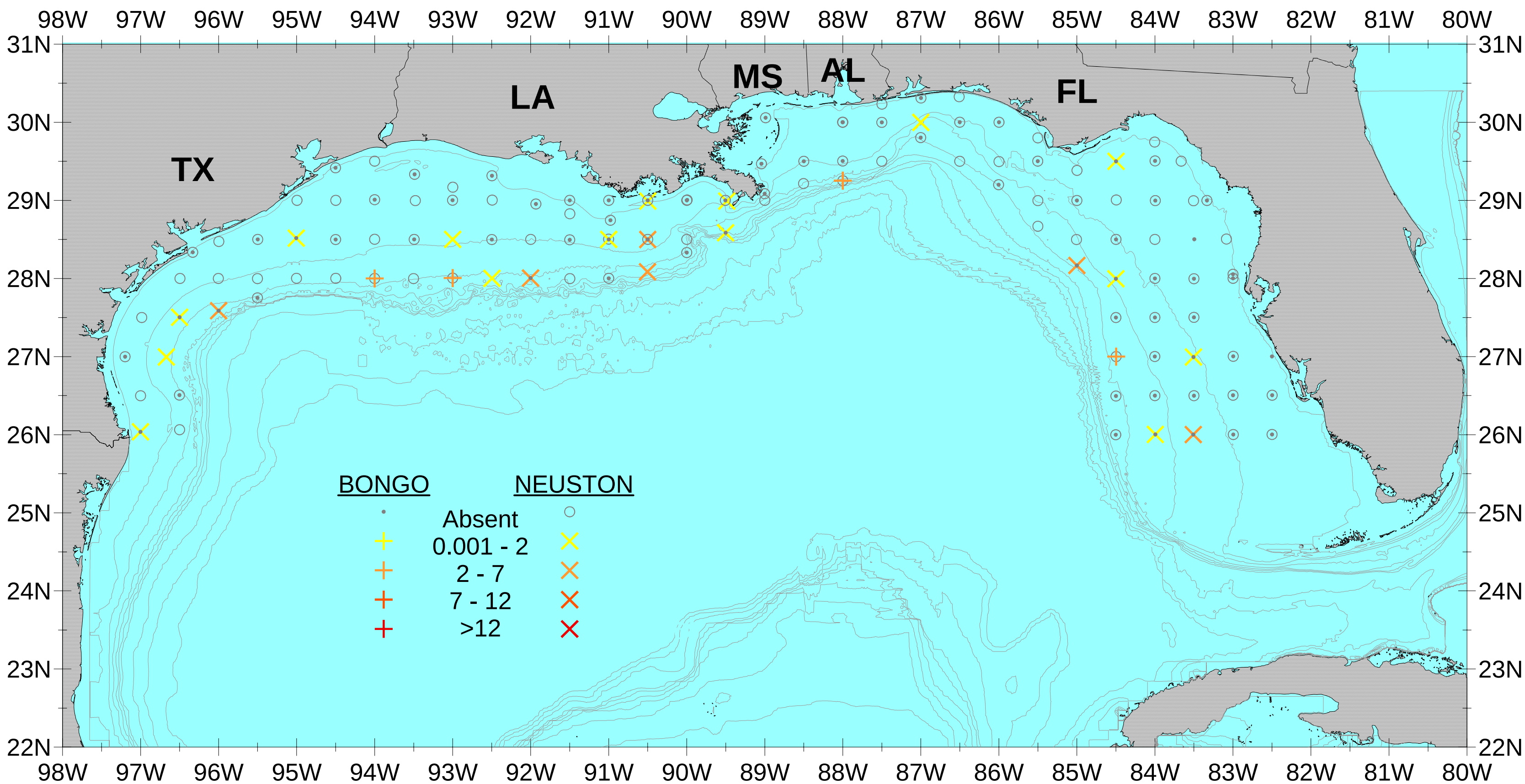

Figure 9. Occurrence and abundance of gray triggerfish, *Balistes capriscus*, at SEAMAP stations during the fall plankton survey in 1991. Abundance in bongo net samples = Larvae / 10 m^2. Abundance in neuston net samples = Larvae / 10 min.

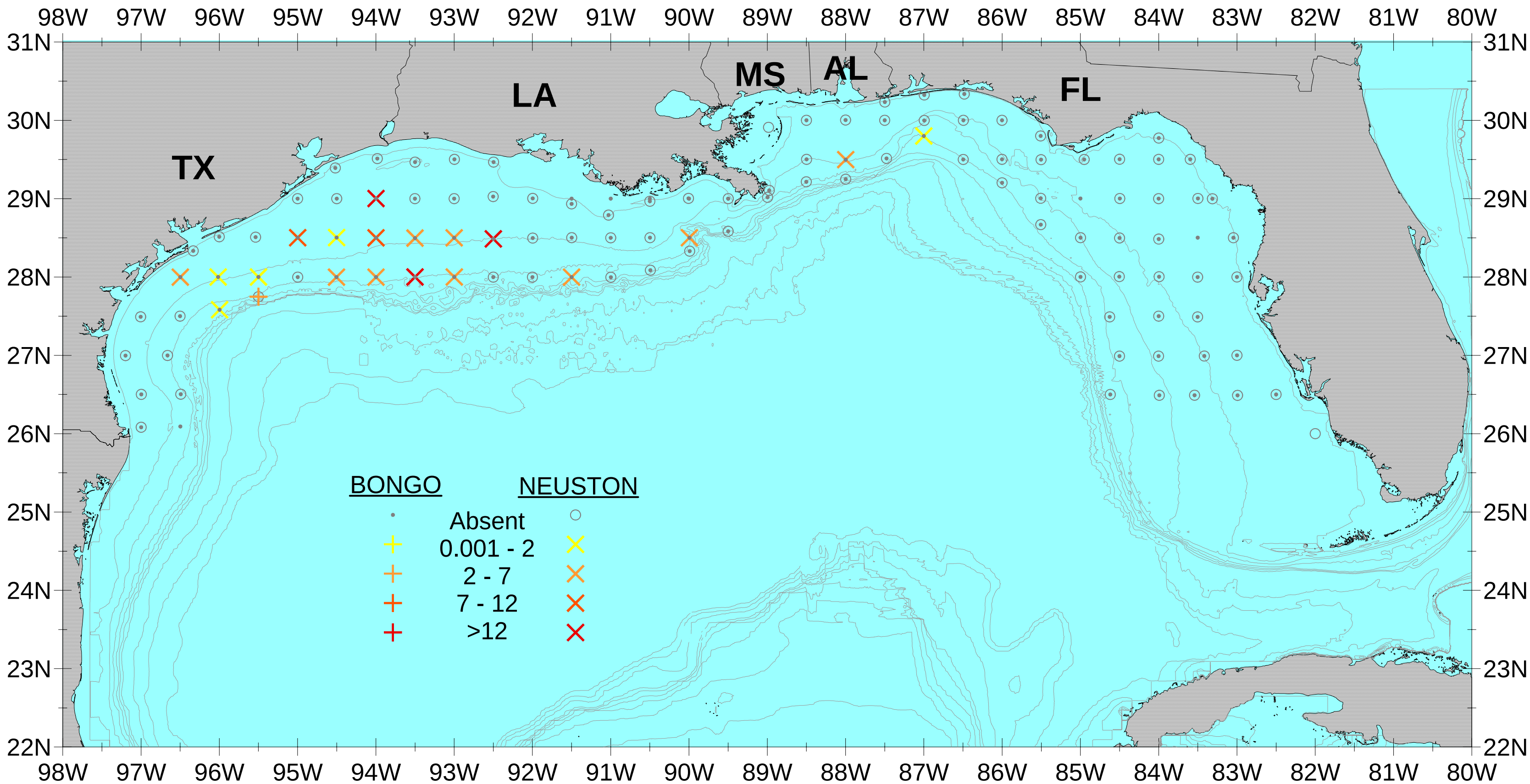

Figure 10. Occurrence and abundance of gray triggerfish, *Balistes capriscus*, at SEAMAP stations during the fall plankton survey in 1992. Abundance in bongo net samples = Larvae / 10 m^2. Abundance in neuston net samples = Larvae / 10 min.

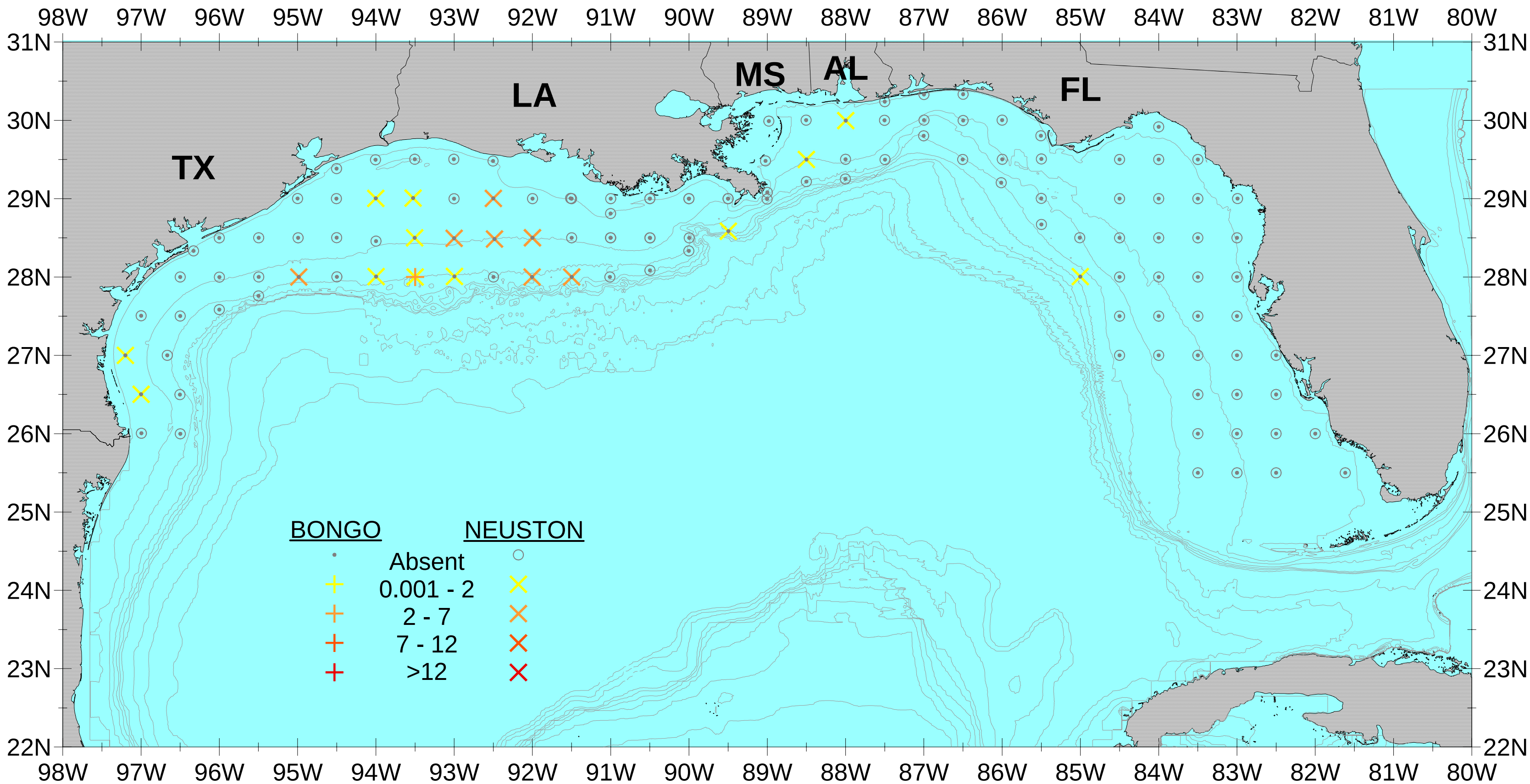

Figure 11. Occurrence and abundance of gray triggerfish, *Balistes capriscus*, at SEAMAP stations during the fall plankton survey in 1993. Abundance in bongo net samples = Larvae / 10 m^2. Abundance in neuston net samples = Larvae / 10 min.

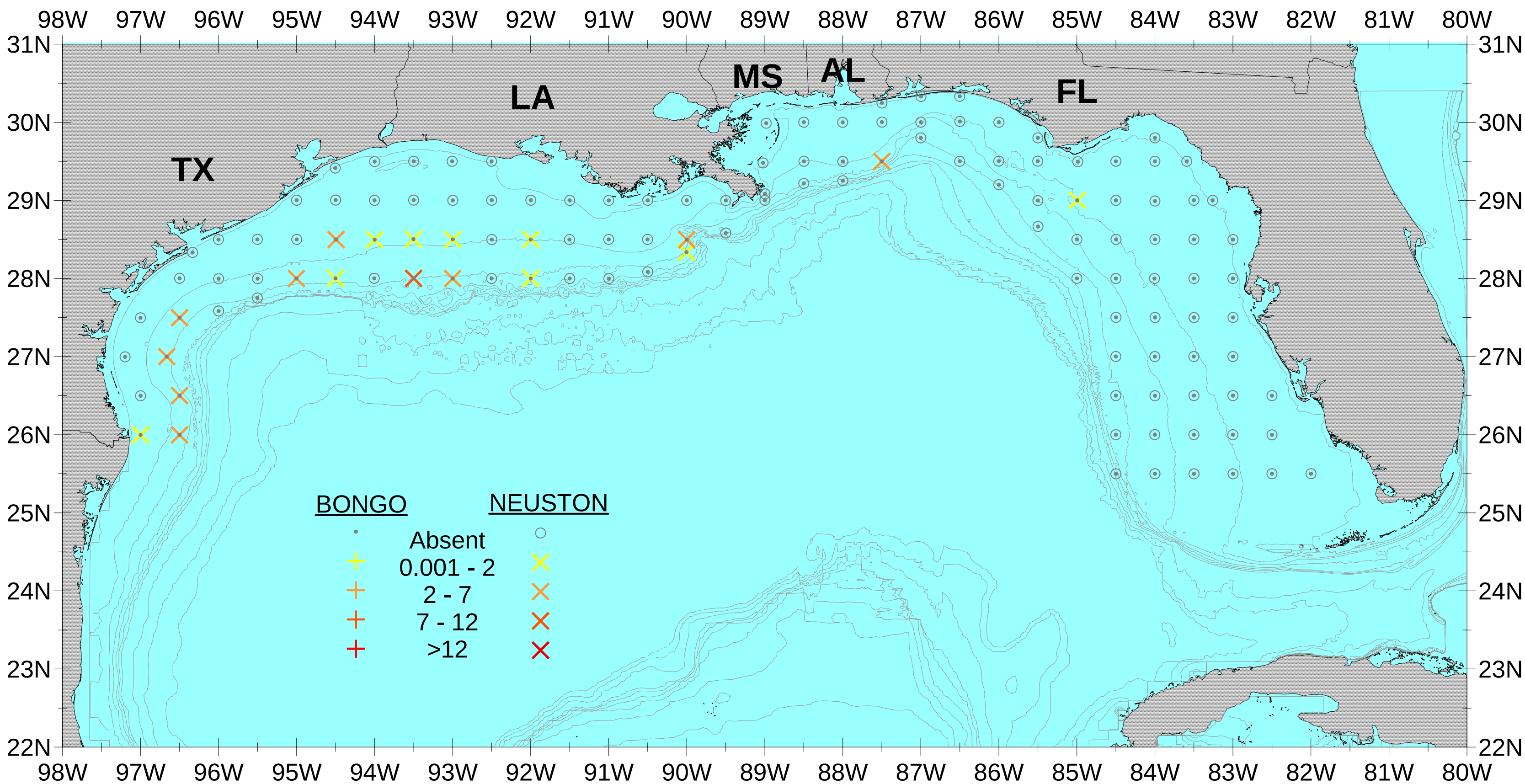

Figure 12. Occurrence and abundance of gray triggerfish, *Balistes capriscus*, at SEAMAP stations during the fall plankton survey in 1994. Abundance in bongo net samples = Larvae / 10 m^2. Abundance in neuston net samples = Larvae / 10 min.

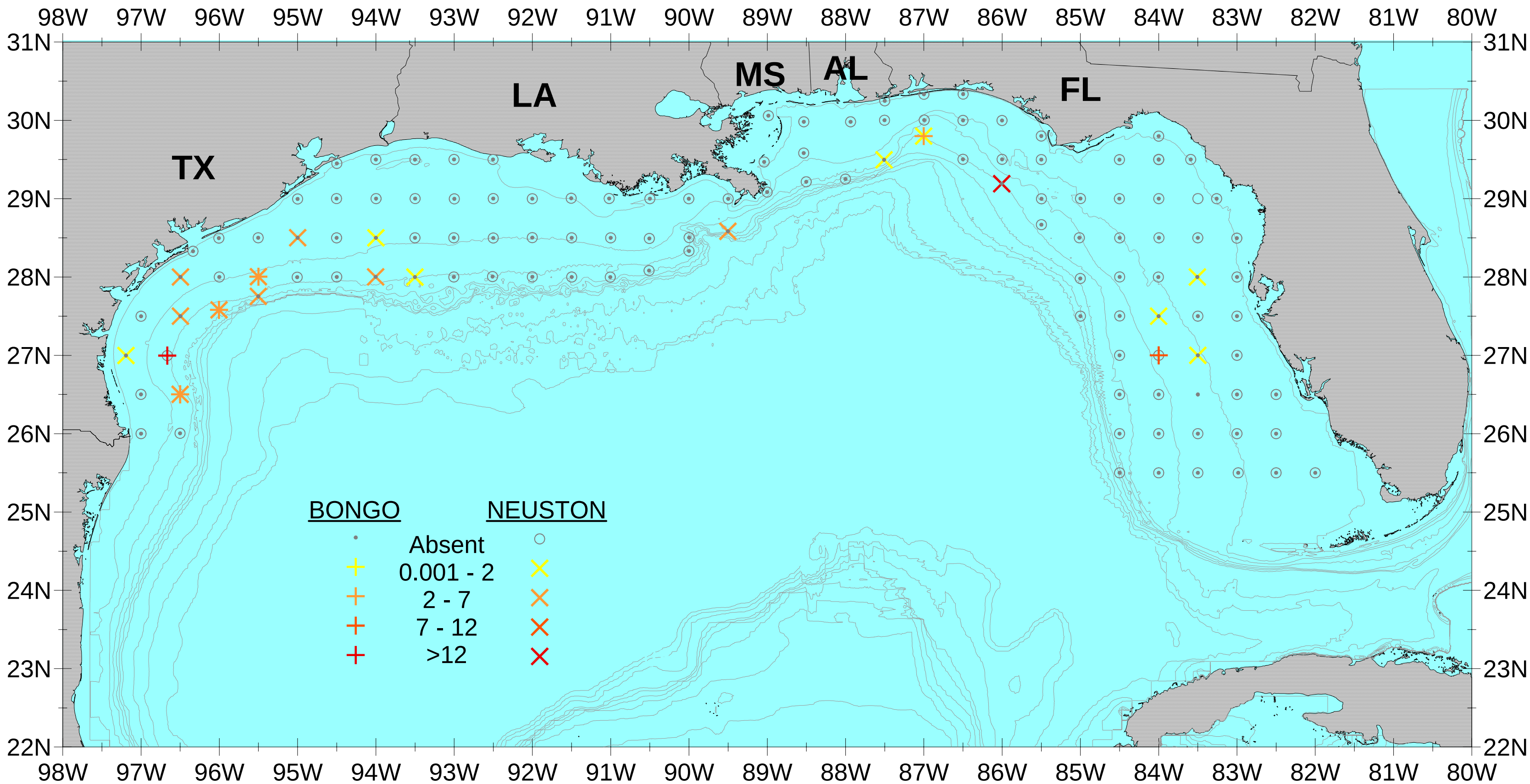

Figure 13. Occurrence and abundance of gray triggerfish, *Balistes capriscus*, at SEAMAP stations during the fall plankton survey in 1995. Abundance in bongo net samples = Larvae / 10 m^2. Abundance in neuston net samples = Larvae / 10 min.

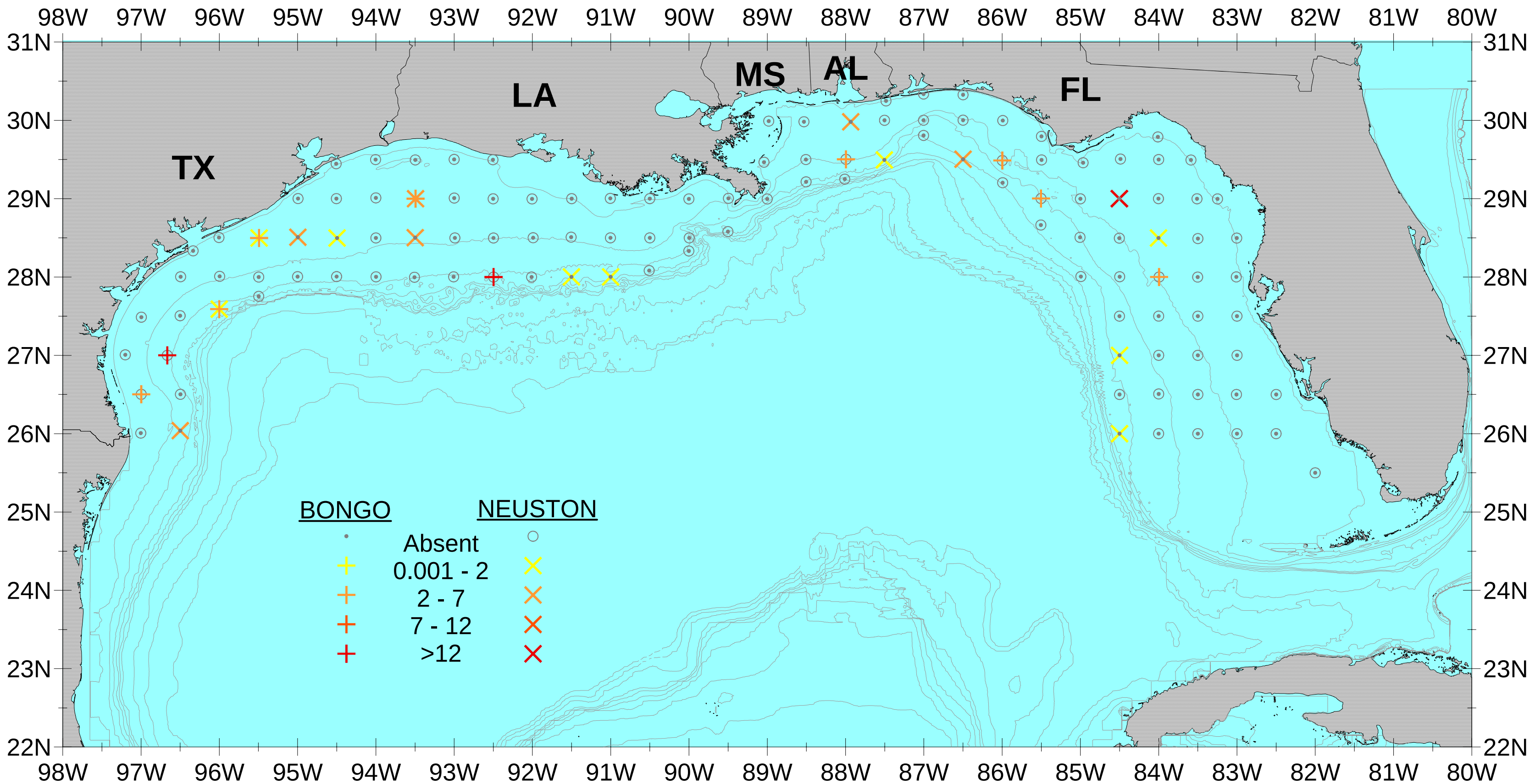

Figure 14. Occurrence and abundance of gray triggerfish, *Balistes capriscus*, at SEAMAP stations during the fall plankton survey in 1996. Abundance in bongo net samples = Larvae / 10 m^2. Abundance in neuston net samples = Larvae / 10 min.

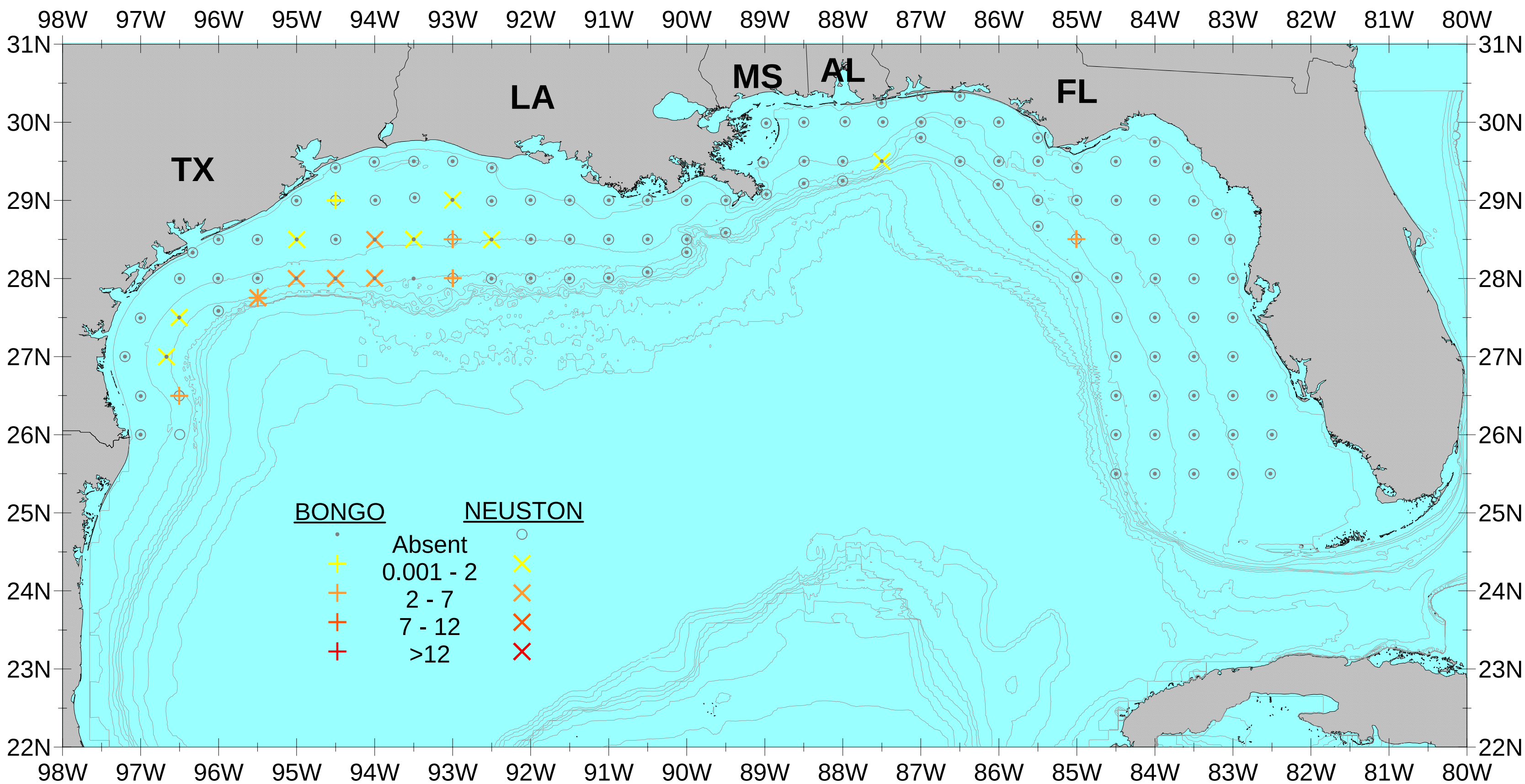

Figure 15. Occurrence and abundance of gray triggerfish, *Balistes capriscus*, at SEAMAP stations during the fall plankton survey in 1997. Abundance in bongo net samples = Larvae / 10 m^2. Abundance in neuston net samples = Larvae / 10 min.

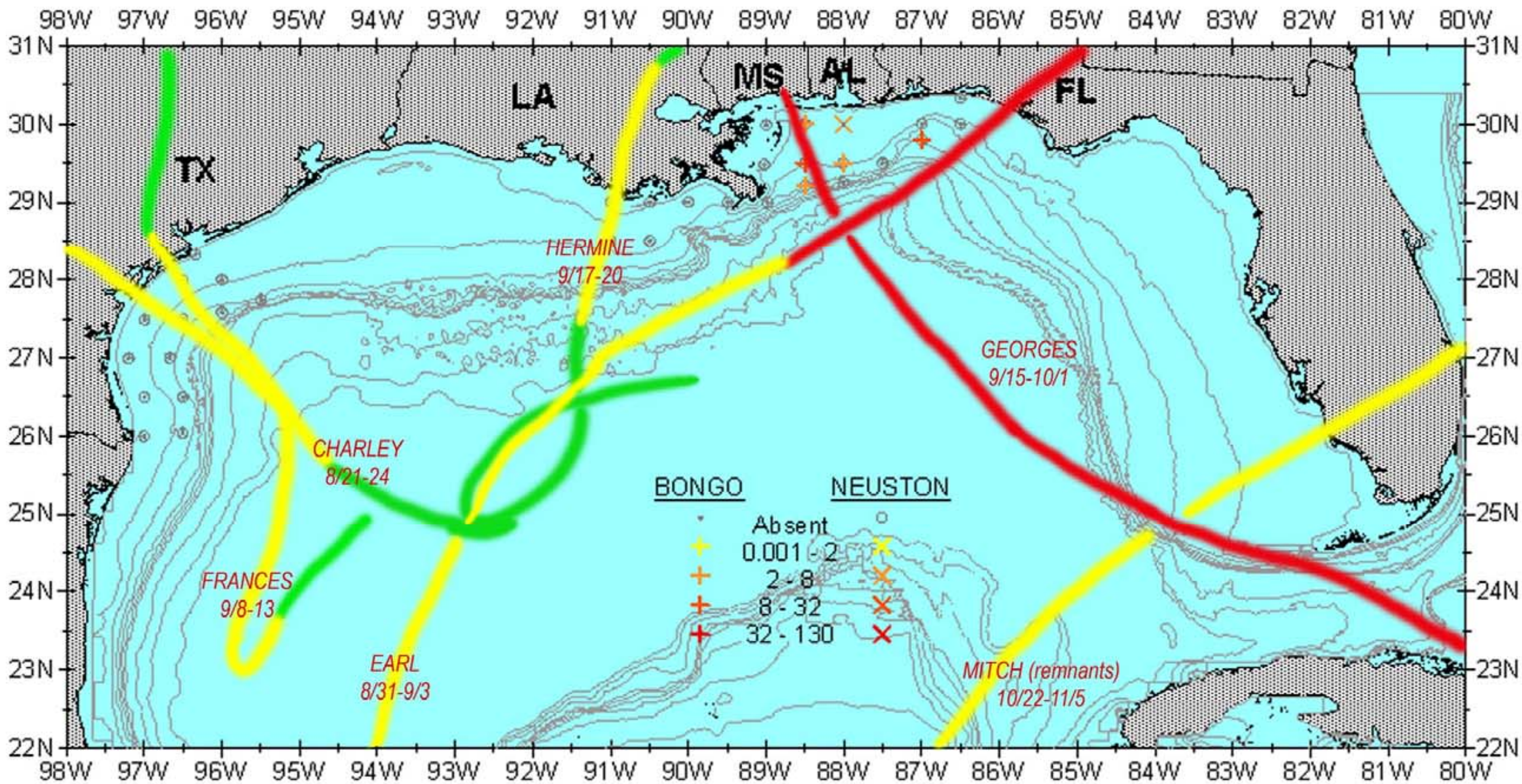

Figure 16. Occurrence and abundance of gray triggerfish, *Balistes capriscus*, at SEAMAP stations during the fall plankton survey in 1998. Abundance in bongo net samples = Larvae / 10 m^2. Abundance in neuston net samples = Larvae / 10 min. Green line = Tropical Depression; Yellow line = Tropical Storm; Red line = Hurricane.

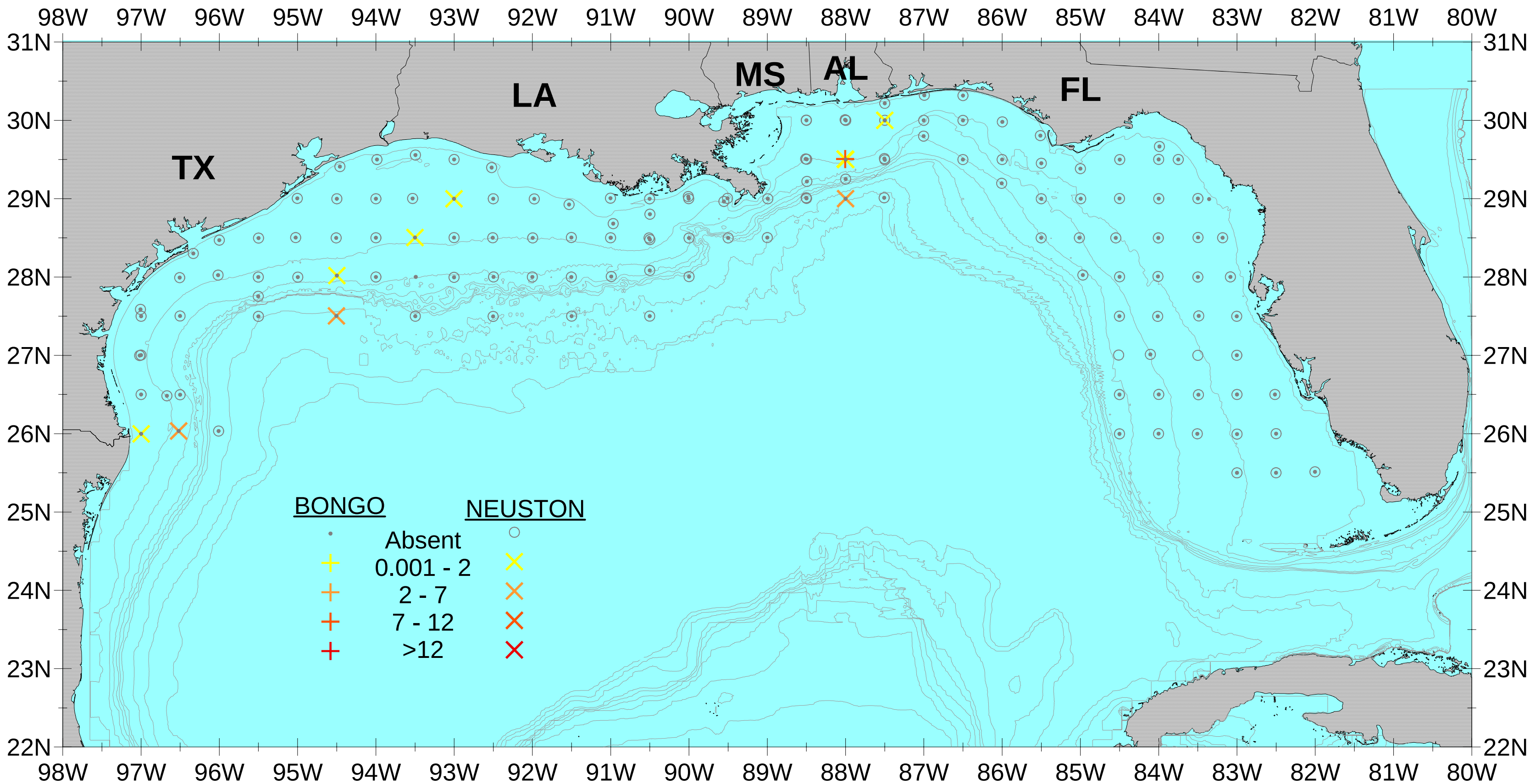

Figure 17. Occurrence and abundance of gray triggerfish, *Balistes capriscus*, at SEAMAP stations during the fall plankton survey in 1999. Abundance in bongo net samples = Larvae / 10 m^2. Abundance in neuston net samples = Larvae / 10 min.

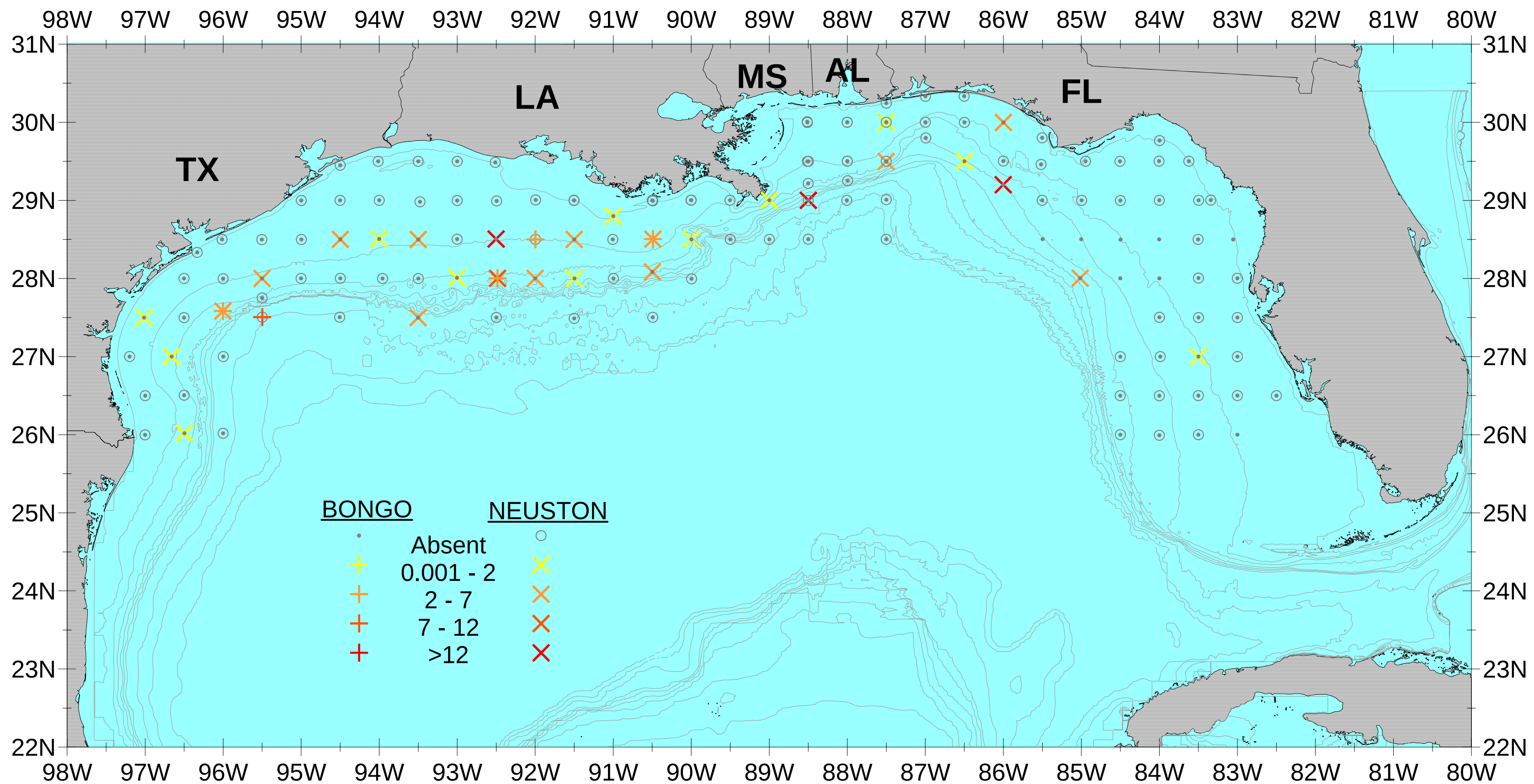

Figure 18. Occurrence and abundance of gray triggerfish, *Balistes capriscus*, at SEAMAP stations during the fall plankton survey in 2000. Abundance in bongo net samples = Larvae / 10 m^2. Abundance in neuston net samples = Larvae / 10 min.

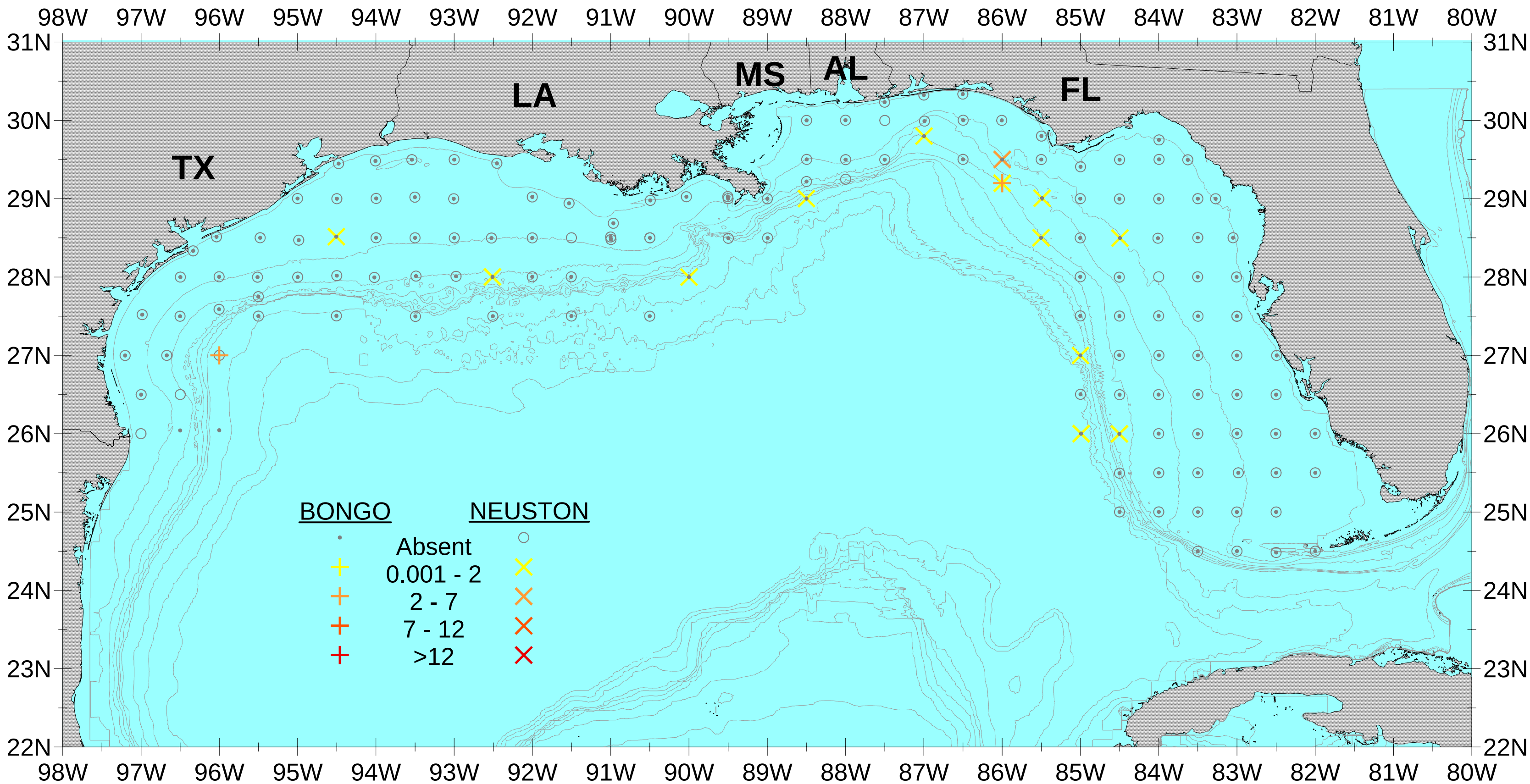

Figure 19. Occurrence and abundance of gray triggerfish, *Balistes capriscus*, at SEAMAP stations during the fall plankton survey in 2001. Abundance in bongo net samples = Larvae / 10 m^2. Abundance in neuston net samples = Larvae / 10 min.

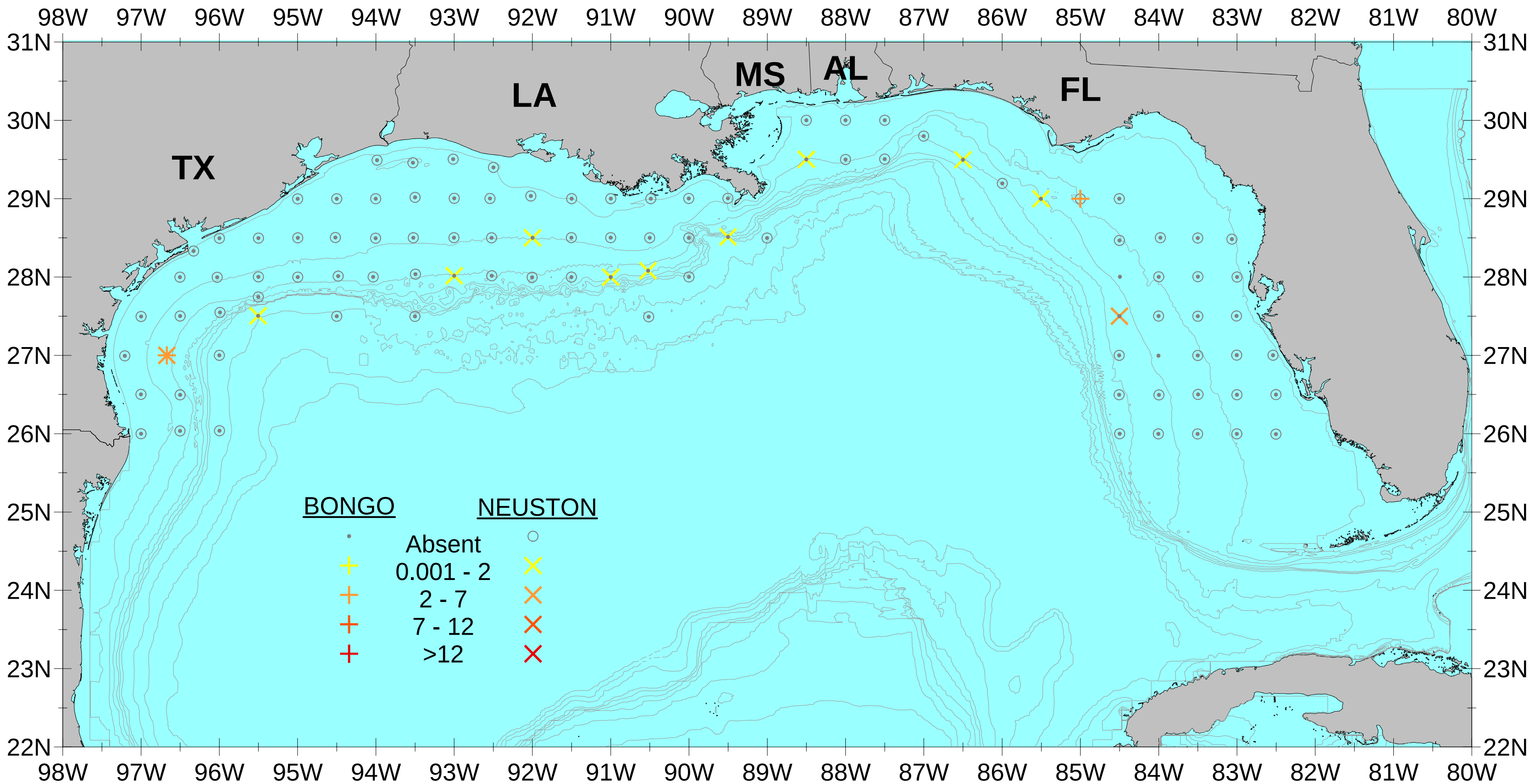

Figure 20. Occurrence and abundance of gray triggerfish, *Balistes capriscus*, at SEAMAP stations during the fall plankton survey in 2002. Abundance in bongo net samples = Larvae / 10 m^2. Abundance in neuston net samples = Larvae / 10 min.

Table 7: Summary of cruises and sampling effort during SEAMAP Fall Plankton surveys, 1986-1999 and 2000-2002.

CRUISE	VESSEL	Survey Type	No. NEUSTON Samples	No. BONGO Samples	Cruise Begin Date	Cruise End Date
161	04	FP	48	48	9/4/1986	9/12/1986
862	36	FP	29	29	9/6/1986	9/13/1986
864	17	FP	9	9	9/8/1986	9/10/1986
865	28	FP	56	55	9/13/1986	9/22/1986
875	36	FP	35	35	9/1/1987	9/8/1987
169	04	FP	91	91	9/12/1987	9/27/1987
873	17	FP	4	4	9/15/1987	9/17/1987
874	35	FP	0	11	9/29/1987	10/1/1987
882	36	FP	36	36	8/26/1988	9/2/1988
176	04	FP	80	39	9/7/1988	9/28/1988
882	17	FP	4	3	10/1/1988	9/30/1988
884	35	FP	7	10	10/3/1988	10/12/1988
183	04	FP	75	37	9/13/1989	9/29/1989
892	17	FP	5	5	9/17/1989	9/19/1989
894	35	FP	11	11	10/2/1989	10/5/1989
892	36	FP	34	35	10/4/1989	10/11/1989
190	04	FP	100	52	9/2/1990	9/28/1990
902	17	FP	2	2	9/16/1990	9/16/1990
904	35	FP	6	7	10/1/1990	10/4/1990
902	36	FP	30	30	10/13/1990	10/18/1990
912	36	FP	22	23	8/21/1991	8/25/1991
914	28	FP	95	49	9/6/1991	9/26/1991
912	17	FP	2	2	9/23/1991	9/23/1991
914	35	FP	7	7	9/30/1991	10/4/1991
925	28	FP	72	73	8/30/1992	9/20/1992
201	04	FP	25	27	9/24/1992	9/27/1992
923	35	FP	0	5	9/28/1992	10/1/1992
923	17	FP	1	0	9/29/1992	9/29/1992
922	26	FP	13	12	10/12/1992	10/19/1992
936	28	FP	72	72	9/10/1993	9/29/1993
934	17	FP	2	2	9/20/1993	9/21/1993
933	35	FP	7	7	10/4/1993	10/7/1993
207	04	FP	10	10	10/5/1993	10/6/1993
932	26	FP	36	36	10/11/1993	10/18/1993

Table 7 cont.

943	17	FP	2	2	9/10/1994	9/11/1994
946	28	FP	88	88	9/11/1994	9/29/1994
943	35	FP	7	7	9/26/1994	9/29/1994
942	36	FP	29	29	9/28/1994	10/8/1994
955	28	FP	88	87	9/9/1995	9/26/1995
952	17	FP	5	5	9/16/1995	9/18/1995
952	26	FP	24	25	9/24/1995	9/28/1995
953	35	FP	7	7	9/25/1995	9/29/1995
965	28	FP	92	92	9/5/1996	9/25/1996
962	26	FP	19	19	9/11/1996	9/14/1996
962	17	FP	2	2	9/22/1996	9/23/1996
962	35	FP	7	7	9/30/1996	10/3/1996
975	28	FP	93	93	9/7/1997	9/27/1997
972	17	FP	4	4	9/20/1997	9/22/1997
972	26	FP	19	19	10/2/1997	10/6/1997
972	35	FP	7	7	10/4/1997	10/7/1997
992	63	FP	116	117	9/3/1999	9/29/1999
993	17	FP	9	9	9/9/1999	9/10/1999
991	26	FP	12	10	9/25/1999	9/29/1999
994	17	FP	5	6	10/12/1999	10/14/1999
242	04	FP	104	111	9/7/2000	10/1/2000
001	26	FP	13	14	9/26/2000	9/29/2000
002	35	FP	3	3	10/11/2000	10/13/2000
002	17	FP	11	11	10/13/2000	10/15/2000
015	63	FP	131	127	8/31/2001	9/26/2001
012	35	FP	4	3	10/8/2001	10/21/2001
011	26	FP	12	12	10/11/2001	10/14/2001
025	63	FP	86	88	8/30/2002	9/20/2002
022	35	FP	7	7	9/16/2002	9/19/2002
023	17	FP	6	6	10/10/2002	10/11/2002

Table 8: Annual per cent occurrence and mean abundance of young gray triggerfish caught in bongo net samples during SEAMAP Fall Plankton surveys, 1986-1997 and 1999-2002.

Year	No. Samples	No. Occurrences	No. Larvae	% Occurrence	Std	SE	Lower 95%CI	Upper 95%CI	Mean Abundance	Std	SE	Lower 95%CI	Upper 95%CI	Abundance Min	Abundance Max	Summed Abundance	CV
1986	141	2	2	1.42	0.119	0.010	0.000	3.394	0.08	0.636	0.054	0.000	0.181	0	6.02	10.61	71.11
1987	141	4	4	2.84	0.167	0.014	0.063	5.611	0.12	0.736	0.062	0.000	0.244	0	5.43	17.20	50.82
1988	88	0															
1989	88	1	1	1.14	0.107	0.011	0.000	3.395	0.04	0.363	0.039	0.000	0.116	0	3.41	3.41	100.00
1990	91	3	3	3.30	0.180	0.019	0.000	7.036	0.12	0.696	0.073	0.000	0.266	0	5.40	10.98	60.51
1991	81	4	4	4.94	0.218	0.024	0.118	9.759	0.27	1.213	0.135	0.005	0.541	0	6.46	22.12	49.37
1992	117	1	1	0.85	0.092	0.009	0.000	2.548	0.04	0.431	0.040	0.000	0.119	0	4.67	4.67	100.00
1993	127	1	1	0.79	0.089	0.008	0.000	2.346	0.04	0.476	0.042	0.000	0.126	0	5.37	5.37	100.00
1994	126	0															
1995	124	6	12	4.84	0.215	0.019	1.009	8.669	0.42	2.224	0.200	0.020	0.811	0	20.25	51.55	48.04
1996	120	10	15	8.33	0.278	0.025	3.317	13.350	0.55	2.255	0.206	0.140	0.956	0	16.64	65.76	37.57
1997	123	6	9	4.88	0.216	0.020	1.017	8.739	0.20	0.949	0.086	0.031	0.369	0	5.70	24.59	42.81
1999	142	1	2	0.70	0.084	0.007	0.000	2.096	0.06	0.761	0.064	0.000	0.190	0	9.07	9.07	100.00
2000	139	5	5	3.60	0.187	0.016	0.463	6.732	0.21	1.136	0.096	0.015	0.396	0	9.22	28.62	46.79
2001	141	2	2	1.42	0.119	0.010	0.000	3.394	0.08	0.713	0.060	0.000	0.203	0	6.92	11.86	71.45
2002	101	2	2	1.98	0.140	0.014	0.000	4.744	0.09	0.680	0.068	0.000	0.228	0	5.75	9.49	71.96

Table 9: Annual per cent occurrence and mean abundance of young gray triggerfish caught in neuston net samples during SEAMAP Fall Plankton surveys, 1986-1997 and 1999-2002. The dataset recommended as the basis for the larval index.

Year	No. Samples	No. Occurrences	No. Larvae	% Occurrence	Std	SE	Lower 95%CI	Upper 95%CI	Mean Abundance	Std	SE	Lower 95%CI	Upper 95%CI	Abundance Min	Abundance Max	Summed Abundance	CV
1986	142	16	39	11.27	0.317	0.027	6.003	16.532	0.28	1.442	0.121	0.046	0.524	0	14.44	40.43	42.49
1987	130	6	20	4.62	0.211	0.018	0.960	8.270	0.15	0.833	0.073	0.007	0.297	0	7.00	19.76	48.10
1988	127	8	15	6.30	0.244	0.022	2.016	10.582	0.12	0.572	0.051	0.018	0.219	0	5.00	15.00	42.98
1989	125	6	8	4.80	0.215	0.019	1.000	8.600	0.06	0.304	0.027	0.010	0.118	0	2.00	8.00	42.54
1990	138	10	16	7.25	0.260	0.022	2.866	11.626	0.11	0.525	0.045	0.026	0.203	0	5.00	15.76	39.13
1991	126	21	31	16.67	0.374	0.033	10.070	23.264	0.25	0.678	0.060	0.126	0.365	0	5.00	30.95	24.58
1992	111	19	114	17.12	0.378	0.036	10.000	24.234	1.02	3.715	0.353	0.325	1.722	0	31.00	113.62	34.45
1993	127	19	32	14.96	0.358	0.032	8.672	21.249	0.25	0.716	0.063	0.124	0.375	0	4.00	31.73	25.42
1994	126	19	49	15.08	0.359	0.032	8.745	21.414	0.34	1.168	0.104	0.132	0.544	0	10.63	42.63	30.75
1995	124	18	45	14.52	0.354	0.032	8.229	20.803	0.36	1.428	0.128	0.109	0.617	0	14.00	44.98	35.34
1996	120	16	35	13.33	0.341	0.031	7.163	19.504	0.29	1.219	0.111	0.072	0.512	0	12.00	35.05	38.10
1997	123	12	26	9.76	0.298	0.027	4.438	15.074	0.21	0.778	0.070	0.071	0.349	0	5.00	25.82	33.43
1999	142	10	14	7.04	0.257	0.022	2.783	11.302	0.10	0.390	0.033	0.032	0.162	0	2.77	13.79	33.67
2000	131	28	113	21.37	0.412	0.036	14.261	28.487	0.93	3.365	0.294	0.350	1.513	0	27.00	121.99	31.58
2001	146	13	21	8.90	0.286	0.024	4.229	13.579	0.15	0.648	0.054	0.040	0.252	0	6.61	21.36	36.65
2002	99	11	17	11.11	0.316	0.032	4.811	17.411	0.17	0.566	0.057	0.053	0.279	0	3.87	16.46	34.20