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Response of striped bass larvae fed brine shrimp from different sources containing different fatty acid compositions*

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ABSTRACT

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Nauplii from five sources of brine shrimp (*Artemia* sp.) were evaluated for total lipid and fatty acid compositions and subsequently fed to larvae of striped bass, *Morone saxatilis*. Chinese (CH) and a San Francisco Bay (SFBa) sources were relatively high in 20:5(*n*-3), eicosapentaenoic acid (EPA), containing 10.4 and 9.3% (of the lipid), and relatively low in 18:3(*n*-3), linolenic acid, containing 3.6 and 3.8%, respectively. Sources from Great Salt Lake (GSL), Colombia (COL), and a second San Francisco Bay source (SFBb) were lower in EPA, containing 1.2, 3.0, and 1.2% and higher in linolenic acid, containing 28.2, 24.2, and 25.2%, than the CH and SFBa sources. Docosahexaenoic acid (DHA), 22:6(*n*-3), was not found in any of the brine shrimp. Percentages of total lipids, triacylglycerols, and free fatty acids, were not significantly different among the sources. The larvae were fed nauplii from the five sources of brine shrimp as the first and only food for 12 days (experiment 1) or 17 days (experiment 2). Growth and survival were significantly higher for the larvae fed brine shrimp containing the higher levels of EPA. The slower growth and lower survival of larvae fed brine shrimp high in linolenic acid and low in EPA suggested that striped bass are not capable of elongating and desaturating linolenic acid to longer chain *n*-3 highly unsaturated fatty acids. These results indicate that striped bass larvae have a dietary requirement for EPA which is in excess of 3% of the dietary lipid or 0.5% of the dry diet, and that variation in EPA content is a major reason for the variation in nutritional quality among brine shrimp sources.

INTRODUCTION

Striped bass, *Morone saxatilis*, and hybrid striped bass (striped bass × white bass, *M. chrysops*) are important food and sport fish in North America. Ap-

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proximately 34 million striped bass and hybrids were produced in federal and state hatcheries and an undetermined number were produced in private hatcheries for recreational and aquacultural use in 1988 (Gibson, 1988). Striped bass, as many other commercially important fishes and crustaceans that are reproduced in hatcheries, must receive live foods during feeding in early life because they go through larval metamorphosis and do not assimilate dry, prepared diets effectively (Braid and Shell, 1981; Baragi and Lovell, 1986). Live brine shrimp nauplii, *Artemia* sp., are the primary food for initial feeding of striped bass and comprise 85% or more of the live foods fed to larval fish worldwide (Sorgeloos, 1980).

Growth response from feeding brine shrimp has been shown to be inconsistent among different sources, especially from different geographical areas, when fed to larvae of mud crab, *Rhithropanopeus harrisii* (Bookhout and Costlow, 1970; Seidel et al., 1982), prawn, *Palaemon serratus* (Wickens, 1972), mysid, *Mysidopsis bahia* (Johns et al., 1981), sheepshead minnow, *Cyprinodon variegatus* (Usher and Bengtson, 1981), and red sea bream, *Pagrus major* (Watanabe et al., 1980). This inconsistency appears to be due to variation in nutritional quality among brine shrimp from various sources, possibly caused by differences in fatty acid composition. Watanabe et al. (1980) found red sea bream larvae fed brine shrimp containing higher percentages of *n*-3 highly unsaturated fatty acids (HUFA) had higher growth and survival rates than those fed brine shrimp deficient in *n*-3 HUFA. Variation in *n*-3HUFA composition among brine shrimp from various sources has been reported (Watanabe et al., 1978). The objectives of this study were to determine fatty acid composition of lipids from different sources of brine shrimp nauplii and to subsequently evaluate effects of feeding brine shrimp with widely divergent fatty acid compositions on growth, survival, and fatty acid composition of striped bass larvae.

MATERIALS AND METHODS

Lipid analysis of brine shrimp nauplii

Brine shrimp cysts, presumed to be from different geographical sources, were obtained from various commercial sources (Table 1). The nauplii were hatched in 56-l conical hatching containers containing well water with salt (NaCl) added to give a specific gravity of 1.01–1.02. Water was continuously aerated. Continuous illumination was provided by fluorescent ceiling lights. After 30 h incubation at 33°C, aeration ceased and the nauplii settled to the bottom of the hatching cone and were collected.

Total lipids were extracted from approximately 2 g of intact brine shrimp nauplii by a modification of the procedure of Kates (1986). Initial extraction was in 10 ml of methanol/chloroform (2:1, by vol.) for 1.5 h. Partially extracted nauplii were collected by centrifugation (1000 rpm for 10 min) and

TABLE 1

Sources, suppliers and lot number of brine shrimp cysts

Source	Supplier	Lot no.
China (CH)	Biomarine, Inc., Hawthorne, CA	Cans 686526, 686532-686536
San Francisco Bay (SFBa)	San Francisco Bay Brands, Inc., Newark, CA	Case 65034, Lot 1106
San Francisco Bay (SFBb)	San Francisco Bay Brands, Inc., Newark, CA	Case 53404, Lot 1106
Great Salt Lake (GSL)	Biomarine, Inc., Hawthorne, CA	Cans 686032, 686043, 686047, 686049, 686050, and 686052
Colombia (COL)	Aquarium Products, Glen Burnie, MD	Lot 120

the extraction procedure was repeated two more times with methanol/chloroform (1:1, by vol.) for 1 h. Extracts were washed twice with 3 ml of 5% NaCl solution and taken to dryness with nitrogen in a water bath (27°C). The extracted lipid was stored under nitrogen and frozen (−30°C). Fatty acids and sterols were obtained by alkaline hydrolysis (0.4 ml 33% KOH in 4 ml ethanol) for 120 min at 90°C (Kates, 1986). The nonsaponifiable fraction, containing sterols, was obtained by washing the hydrolysate three times with 3 ml of hexane. The hydrolysate was then acidified (pH 1–2) with 6 *N* HCl and the saponifiable fraction, containing fatty acids, was obtained by washing three times with 3 ml of hexane. The fatty acids were converted to their methyl ester derivatives using BF_3/methanol (Morrison and Smith, 1964).

The fatty acid methyl esters were analyzed using a Hewlett-Packard 5710A chromatograph equipped with a 30-m glass capillary column coated with SP-2330 (Supelco, Inc., Bellefonte, PA) and a flame-ionization detector. The carrier gas was nitrogen at a column pressure of 0.58 kg/cm^2. Injector and detector temperatures were 300°C and the oven temperature was programmed from 140 to 210°C at 4°C/min (Weete et al., 1983). Detector response was recorded and quantitated with a HP 3380A integrator-recorder. An internal standard was added and fatty acid methyl esters were identified by comparison of their retention times with those of authentic standards (Applied Science Laboratories, Deerfield, IL; Nu-Chek Prep, Inc., Elysian, MN).

Total lipids were separated into triacylglycerols, free fatty acids, and phospholipid fractions by thin-layer chromatography. Glass plates (20×20 cm) coated with silica gel 60 (250 μm, E. Merck, Darmstadt, F.R.G.) were developed in hexane/diethyl ether/acetic acid (79:20:4, by vol.) (Weete et al., 1983). Lipids were visualized on the plates with iodine vapor and identified by comparison of *Rf* values with a standard lipid mixture containing a triacylglycerol, a free fatty acid, and a phospholipid fraction (Applied Science

Laboratories, Deerfield, IL). Silica gel containing each fraction was scraped from the plates, washed once with methanol/chloroform (2:1, by vol.) and twice with methanol/chloroform (1:1, by vol.) to obtain the lipid. The solvent was evaporated under nitrogen.

Triacylglycerol and phospholipid fractions were converted to their fatty acid methyl ester derivitives using sodium methoxide in methanol (Kates, 1986). The free fatty acid fraction was methylated using BF_3 in methanol (Morrison and Smith, 1964). Fatty acid methyl esters were analyzed as described above.

Growth experiments

Nauplii from the various sources of brine shrimp nauplii were fed as the only food to newly hatched striped bass larvae. Two feeding experiments were conducted in 112.5-l flowing-water aquaria at the Alabama Striped Bass Hatchery, Marion, AL. In experiment 1, which began 4 April, Chinese (CH), a San Francisco Bay (SFBa), and Great Salt Lake (GSL) sources of brine shrimp were fed for a 12-day period. Each source of brine shrimp was randomly assigned to three aquaria containing 3000 striped bass larvae. In experiment 2, which began 18 April, CH, Colombian (COL), and a second SFBb sources of brine shrimp were fed for a 17-day period. Each source of brine shrimp was randomly assigned to three aquaria containing 1700 five-day-old larvae.

The larvae were obtained from adult striped bass collected from the Coosa River, AL, and induced to spawn by injection with human chorionic gonadotropin (Stevens, 1966). Incubation of eggs and hatching of larvae were as described by Bonn et al. (1976). Five to six days post-hatch, when the fish began to seek food, they were transferred from the hatching tanks to the rearing aquaria. Well water ($19 \pm 1°C$) was supplied to the aquaria at a rate of 13.5 l/min. Aeration was provided to all aquaria. Ceiling fluorescent lights provided continuous illumination. Walls of the aquaria were covered in black plastic to minimize visual disturbances (Hale and Carlson, 1972) and to reduce the amount of light entering the aquaria. Aquaria were treated every 8 h with furacin (Hess and Clark, Inc., Ashland, OH) to prevent fungal infestation and uneaten brine shrimp were siphoned from aquaria every 8 h.

The larvae were fed every 3 h. Brine shrimp nauplii, hatched as described previously, were added at a density of 10–20 nauplii per ml aquarium water. Nauplii density was determined by counting three 1-ml samples taken 10 min after adding nauplii to the aquarium.

Growth rate and feeding activity of the fish were measured at 3- to 4-day intervals. Twenty-five fish were randomly collected at each sampling from each aquarium and were examined individually under a dissecting microscope for the presence of food in the transparent digestive tract and for morphological anomalies. Forty to 50 larvae were randomly collected and preserved in 10% formalin for subsequent measurement of standard length with

dial calipers (Rogers and Westin, 1981). Survival rate was determined by adding the number of larvae taken at each sampling period to the number of fish surviving at the conclusion of the experiment. Striped bass larvae were collected at 1 day old and at the conclusion of the feeding trials, flash-frozen with liquid CO_2 and stored under nitrogen at $-30°C$ for lipid analysis. Larvae used for analysis were not fed 12 h prior to sampling.

Pesticide analysis

A pesticide scan was made on all sources of brine shrimp cysts to assure that pesticides would not influence growth responses of the fish. Analysis was performed by the Alabama Pesticide Laboratory, Auburn, AL, using the methods described in McMahon and Sawyer (1986). Quantitative analyses for benzene hexachloride (BHC), heptachlor, aldrin, dieldrin, dichlorodiphenyldichloroethane (DDD), endrin, heptachlorepoxide, dichlorodiphenyltrichloroethane (DT), and dichlorodiphenyldichloroethylene (DDE) were determined.

Statistical methods

Analysis of variance (ANOVA) was computed for fatty acid percentages of the brine shrimp and the striped bass larvae and for length, survival, and food consumption of the larvae using the SAS ANOVA procedure (Statistical Analysis Systems, 1985) to determine if there were differences among means. Survival, food consumption and fatty acid percentages were transformed to arc sin values for analysis (Zar, 1984). Duncan's multiple range test was used to compare individual means. Untransformed data are reported to facilitate comparison with results from other related studies.

RESULTS

Lipid composition of brine shrimp

There were major differences in fatty acid composition among the various sources of brine shrimp (Table 2). Most notable were the proportions of 16:1(*n*-7) (palmitoleic acid) and the *n*-3 fatty acids, 18:3(*n*-3) (linolenic acid) and 20:5(*n*-3) (eicosapentaenoic acid or EPA). The CH and SFBa brine shrimp were similar, both having high percentages of palmitoleic acid and EPA, and a relatively low percentage of linolenic acid. This is in contrast to the GSL, COL, and SFBb sources of brine shrimp which contained relatively low percentages of palmitoleic acid and EPA, but a high percentage of linolenic acid. Percentage of total *n*-3 fatty acids was approximately twice as high for the GSL, COL, and SFBb, which were high in linolenic acid but low EPA, as compared with the CH and SFBa sources. No detectable 22:6(*n*-3) (docosahexaenoic acid or DHA) was found in any of the sources.

Percentages of saturated and diene fatty acids were similar for the various

TABLE 2

Percentages of selected fatty acids in the total lipids extracted from various sources of brine shrimp nauplii[1]

Fatty acid[3]	Brine shrimp source[2]				
	CH	SFBa	GSL	COL	SFBb
			(wt.%)		
16:1(*n*-7)	19.83±0.25[a]	20.52±0.29[a]	3.34±0.23[c]	5.61±1.20[b]	5.40±0.34[b]
18:3(*n*-3)	3.64±0.21[c]	3.76±0.16[c]	28.19±0.77[a]	24.24±1.89[b]	25.20±0.67[b]
20:5(*n*-3)	10.41±0.35[a]	9.32±0.23[b]	1.19±0.39[d]	2.99±0.60[c]	1.21±0.23[d]
Other fatty acids[4]	66.12	66.40	67.28	67.16	68.19
% Sat.	21.67	22.54	22.13	21.26	19.80
% Monoene	50.83	51.76	33.60	34.90	34.71
% Diene	5.77	5.67	9.16	10.75	12.12
% Polyene	16.32	15.60	31.41	28.45	29.96
% Total (*n*-3)	14.35	13.44	29.68	27.50	26.79

[1]Values in each row with the same superscript are not significantly different ($P>0.05$). Values are means ± s.e. for four replications.

[2]Sources of brine shrimp were Chinese (CH), San Francisco Bay (SFBa, SFBb), Great Salt Lake (GSL), and Colombian (COL).

[3]The number preceding the colon indicates the number of carbon atoms; the number following the colon indicates the number of double bonds; the position of the double bond nearest the terminal end is given by the designation '*n* (total number of carbon atoms) minus the number of carbon atoms from the end of the chain'.

[4]Other fatty acids measured were 12:0, 14:0, 14:1(*n*-5), 15:0, 16:0, 16:1(*n*-7), 16:1(*n*-9), 17:0, 18:0, *cis*-18:1(*n*-9), *tr*-18:1(*n*-9), 18:1(*n*-7), 18:2(*n*-6), 20:0, 20:1(*n*-9), 20:2(*n*-6), 20:3(*n*-3), 20:4(*n*-6), 22:0, 22:1(*n*-9), 22:2(*n*-6), 22:3(*n*-3) and 22:4(*n*-6). No detectable 22:6(*n*-3) was found in any source of brine shrimp.

sources of brine shrimp, but percentages of monoenes and polyenes showed variation. Monoenes varied because of the high percentage of palmitoleic acid present in SFBa and CH sources. Polyenes varied because of the high percentage of linolenic acid found in GSL, COL, and SFBb sources. Brine shrimp with a large percentage of EPA had a greater percentage of monoene and a lower percentage of polyenes than those with large percentages of linolenic acid.

There were no statistical differences ($P>0.05$) among brine shrimp in total lipids, triacylglycerols or free fatty acids (Table 3). The GSL and COL brine shrimp had lower percentages of phospholipid than the other sources ($P<0.05$).

Pesticide analysis of brine shrimp

Pesticide analysis of brine shrimp cysts showed that SFBa had 0.02 mg/kg BHC, 0.01 mg/kg DDD, and 0.015 mg/kg DDT. The CH cysts had 0.01 mg/kg of BHC and DDT. Cysts from the other sources had no detectable pesticide

TABLE 3

Total lipids, triacylglycerols (TG), free fatty acids (FFA), and phospholipids (PL) in various sources of brine shrimp[1]

Source[2]	Total lipid	TG	FFA	PL
	(% dry wt.)		(% of lipid)	
CH	15.0 ± 1.0^a	64.2 ± 2.0^a	8.6 ± 1.6^a	27.2 ± 2.9^a
SFBa	20.5 ± 1.2^a	60.0 ± 3.0^a	13.7 ± 1.5^a	26.3 ± 1.0^a
GSL	16.2 ± 3.1^a	68.2 ± 4.7^a	12.2 ± 0.9^a	19.6 ± 0.8^b
COL	18.2 ± 3.6^a	74.0 ± 8.0^a	10.8 ± 2.4^a	15.2 ± 3.0^b
SFBb	20.1 ± 0.7^a	62.0 ± 3.6^a	12.9 ± 2.9^a	25.1 ± 1.8^a

[1]Means represent four replications. Values with the same superscript are not significantly different ($P > 0.05$).
[2]Sources of brine shrimp are Chinese (CH), San Francisco Bay (SFBa and SFBb), Great Salt Lake (GSL), and Colombian (COL).

residues. These relatively low concentrations have been found in brine shrimp cysts which produced satisfactory growth in larval prawn, *P. serratus*, and should not affect larval fish growth (Wickens, 1972).

Fish growth and survival

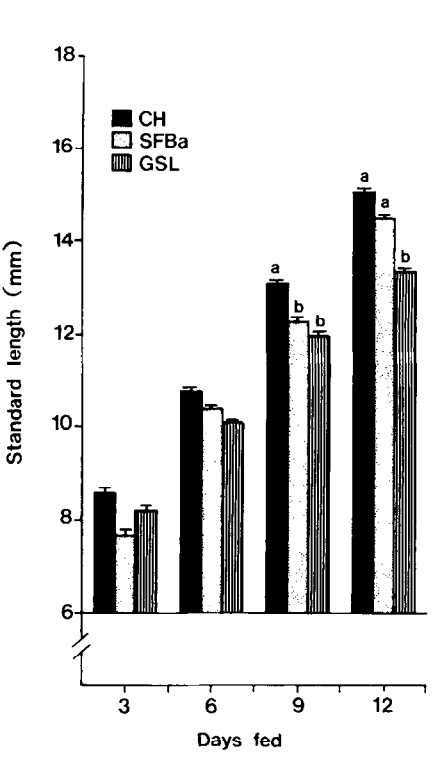
In experiment 1, after 9 days feeding, larvae fed CH brine shrimp showed significantly ($P < 0.05$) greater growth than larvae fed the SFBa and GSL, but after 12 days feeding there was no significant difference in size between the CH and SFBa groups, while the GSL group was markedly smaller (Fig. 1). In experiment 2, there was no difference in growth among the CH, SFBb, and COL brine shrimp after 12 days feeding, but after 17 days the CH group were much larger than the SFBb and COL groups ($P < 0.05$) (Fig. 2).

In experiment 1, survival of striped bass fed GSL was slightly lower than that of larvae fed CH or SFBa; however, this difference was not significant at $P < 0.05$ (Table 4). In experiment 2, survival of striped bass fed the COL and SFBb brine shrimp had much lower survival rates than those fed the CH brine shrimp ($P < 0.05$). Gross examination of the fish with a dissecting microscope revealed no differences among the groups in appearance externally or of internal organs.

Food consumption rate of the larvae, based on the percentage of fish with brine shrimp nauplii in their digestive tracts 10 min after feeding, indicated that striped bass larvae consumed all of the sources of brine shrimp nauplii equally well (Table 4). No significant ($P > 0.05$) difference was found among treatment groups in either experiment.

Lipid composition of fish

Fatty acid composition of lipids from the fish fed the different sources of brine shrimp in experiment 2 was similar to that of the lipids of the brine



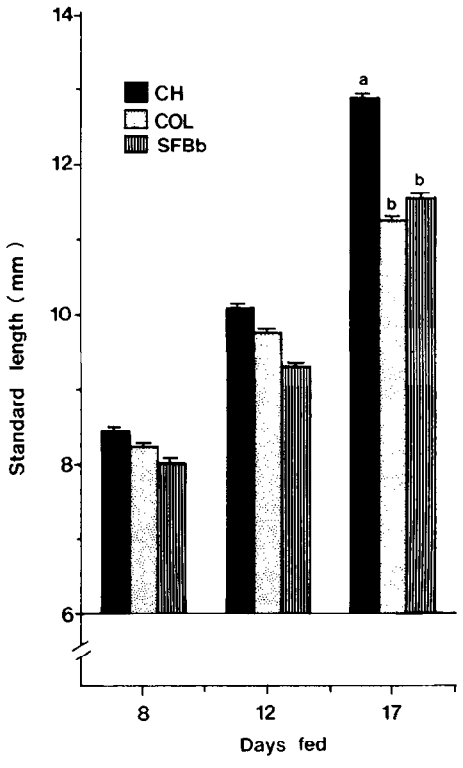


Fig. 1 (left). Standard lengths (mm) of striped bass larvae fed different sources of brine shrimp in experiment 1. Data are means ± s.e. of three replications. Bars with different letters represent significantly different mean lengths ($P<0.05$).

Fig. 2 (right). Standard lengths (mm) of striped bass larvae fed different sources of brine shrimp in experiment 2. Data are means ± s.e. of three replications. Bars with different letters represent significantly different mean lengths ($P<0.05$).

shrimp fed except that the fed larvae contained small amounts of DHA (Table 5). The DHA content of 1-day-old larvae, which had not begun to feed, was 8.97% of the lipid, but decreased to less than 1% after 17 days because of the lack of DHA in the brine shrimp. Percentage of EPA in striped bass before they began feeding was 5% and increased ($P<0.05$) in larvae fed CH brine shrimp (high in EPA) but decreased ($P<0.05$) in larvae fed SFBb and COL brine shrimp (low in EPA). The 1-day-old striped bass contained 5.65% linolenic acid and the fish fed the CH brine shrimp (low in linolenic acid) contained about the same level; however, larvae fed SFBb and COL brine shrimp (high in linolenic acid) increased their concentration of linolenic acid markedly.

TABLE 4

Percentage survival and percentage of the fish consuming brine shrimp nauplii for striped bass larvae fed different sources of brine shrimp[1,2]

Source	Survival (%)	Fish consuming brine shrimp (%)
Experiment 1		
CH	44.5 ± 3.7^{a}	95.7 ± 1.2^{a}
SFBa	41.7 ± 4.0^{a}	99.0 ± 0.6^{a}
GSL	33.1 ± 5.2^{a}	95.7 ± 1.2^{a}
Experiment 2		
CH	41.0 ± 3.4^{a}	96.9 ± 1.3^{a}
COL	7.8 ± 0.1^{b}	90.4 ± 3.0^{a}
SFBb	7.8 ± 0.3^{b}	93.2 ± 2.4^{a}

[1]Sources of brine shrimp used in experiment 1 are Chinese, San Francisco Bay a, and Great Salt Lake. Sources used in experiment 2 are Chinese, Colombian, and San Francisco Bay b.
[2]Values are means ±s.e. for three replications. Means within a column for the same year with the same superscript are not significantly different ($P > 0.05$).

TABLE 5

Percentages of selected fatty acids in total lipids from striped bass before feeding (1 day old) and after feeding brine shrimp from three sources for 17 days[1]

Fatty acid[3]	Before feeding	Brine shrimp source[2]		
		CH	COL	SFBb
		(wt.%)		
16:1(*n*-7)	21.35 ± 0.24^{a}	15.13 ± 1.14^{b}	4.87 ± 0.85^{c}	4.48 ± 0.21^{c}
18:3(*n*-3)	5.65 ± 0.17^{b}	4.26 ± 0.14^{c}	20.31 ± 0.61^{a}	20.98 ± 0.28^{a}
20:5(*n*-3)	5.00 ± 0.21^{b}	11.86 ± 0.58^{a}	4.31 ± 0.48^{bc}	3.13 ± 0.66^{c}
22:6(*n*-3)	8.97 ± 0.35^{a}	0.44 ± 0.04^{b}	0.72 ± 0.11^{b}	0.83 ± 0.08^{b}
Other fatty acids[4]	59.03	68.28	69.79	70.58
% Sat.	14.08	23.92	25.31	22.13
% Monoene	50.18	44.05	34.47	32.34
% Diene	6.01	6.01	9.81	11.39
% Polyene	24.99	20.37	27.62	28.77
% Total (*n*-3)	21.82	17.48	25.70	25.70

[1]Values in each row with the same superscript are not significantly different ($P > 0.05$). Values are means of two replicate groups.
[2]See Table 1.
[3]The number preceding the colon indicates the number of carbon atoms; the number following the colon indicates the number of double bonds; the position of the double bond nearest the terminal end is given by the designation *n* (total number of carbon atoms) minus the number of carbon atoms from the end of the chain.
[4]Other fatty acids measured were 12:0, 14:0, 14:1(*n*-5), 15:0, 16:0, 16:1(*n*-6), 17:0, 18:0, *cis*-18:1(*n*-9), *tr*-18:1(*n*-9), 18:1(*n*-7), 18:2(*n*-6), 20:0, 20:1(*n*-9), 20:2(*n*-6), 20:3(*n*-3), 20:4(*n*-6), 22:0, 22:1(*n*-9), 22:2(*n*-6), 22:3(*n*-3), 22:4(*n*-6) and 22:5(*n*-3).

DISCUSSION

These results show that there are marked differences in *n*-3 HUFA concentration among brine shrimp nauplii from different sources and that this significantly influences growth and survival rates of striped bass larvae. The variation in fatty acid composition among the brine shrimp nauplii is apparently caused by variation in food, primarily algae, consumed by the adult female (Persoone and Sorgeloos, 1980). Type of algae in the aquatic environment is influenced by various abiotic and biotic factors, such as nutrients, salinity, and water temperature. Thus, specific algae species, having characteristic fatty acid compositions, will dominate each brine shrimp habitat (Persoone and Sorgeloos, 1980). Algae, and subsequently brine shrimp cysts, from an inland saline lake, such as the Great Salt Lake, usually have a high percentage of linolenic acid and a low percentage of EPA, while algae and brine shrimp cysts from a marine environment often have a high concentration of EPA and a lower concentration of linolenic acid (Watanabe et al., 1978; Claus et al., 1979). Seasonal variation in the *n*-3 HUFA content in algae from a single location sometimes occurs in temperate climates because of changing algae communities (Jeffries, 1970).

Growth and survival of the striped bass larvae appeared to be influenced by the EPA content of the brine shrimp fed. The CH and SFBa brine shrimp, which contained higher concentrations of EPA, provided better growth and survival than GSL, COL, and SFBb sources, which had less EPA. The highest survival rates in this study were satisfactory; the hatchery average in the United States for striped bass from first feeding through advanced larval development is approximately 20% (Hodson, 1987). Although the CH and SFBa were markedly higher in EPA, they contained less total *n*-3 fatty acids than GSL, COL, and SFBb. This indicates that EPA, not total *n*-3 fatty acids, is important for growth and survival in striped bass larvae.

In fish, EPA is selectively incorporated into the phospholipid fraction of the lipid pool (Lee et al., 1967). Cook and Spence (1987) found that in glioma cells, only EPA was esterified to form phospholipids while all other fatty acids were esterified to form triacylglycerols. There is probably a critical level of EPA in the lipid pool for normal growth and development of striped bass larvae. Data from this study (Table 5) would indicate that about 11% EPA is found in lipids of normally functioning striped bass larvae and below 5% is found in larvae with reduced growth and survival rate.

This study indicates that striped bass larvae, like other species such as turbot, *Scophthalmus maximum* (Owen et al., 1975; Leger et al., 1979), are not able to elongate and desaturate linolenic acid into EPA. The reduced rate of growth and survival of the fish fed brine shrimp with a high percentage of linolenic acid and a low percentage of EPA would indicate that the fish were not synthesizing EPA. Also, the COL and SFBb sources of brine shrimp con-

tained large percentages of linolenic acid, however, the striped bass fed these brine shrimp did not increase in EPA as did the fish fed the CH brine shrimp which was high in EPA. Some species of fish, such as rainbow trout, *Oncorhynchus mykiss* (Owen et al., 1975), and kelp bass, *Paralabrax clathratus* (Kayama et al., 1983), can convert linolenic acid to the longer-chain *n*-3 fatty acids, EPA and DHA. Martin et al. (1984) reported that striped bass could elongate and desaturate linolenic acid into DHA; however, in their study percentage of DHA decreased in the lipid of larvae fed brine shrimp nauplii without DHA.

The present study indicates that when brine shrimp nauplii are the only food fed to striped bass larvae for an extended period, approximately 12 days or longer, the nauplii should contain above 3% EPA on a lipid basis or 0.5% EPA on a dry matter basis. Brine shrimp nauplii with a lower percentage of EPA may be suitable for short-term larval feeding because residual EPA from the oil globule or yolk sac may temporarily serve the needs of the larvae. The results also indicate that source identification is not always an indication of the fatty acid composition of the brine shrimp. Two lots of brine shrimp cysts, identified as San Francisco Bay, had divergent fatty acid compositions and promoted different growth and survival rates in striped bass larvae.

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