Development and Distribution of the Early Life History Stages of the Mesopelagic Fish *Tactostoma macropus* (Stomiidae) in the Transitional Waters of the North Pacific

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Abstract The early life history stages of the mesopelagic fish, *Tactostoma macropus* (Stomiidae), were described from eggs to juveniles based on specimens collected in the subarctic and transitional waters of the North Pacific. The eggs are pelagic and may be distinguished from those of other species that inhabit subarctic and transitional waters of the North Pacific by the following characters: 1) egg large with a shell diameter of 1.38-1.55 mm, 2) wide perivitelline space occupying 40-47% of shell diameter, 3) smooth transparent shell, 4) lack of secondary inner membrane, 5) segmented yolk, and 6) single oil globule. Larvae are slender, ca. 4 mm notochord length (NL) in size at hatching and attain a large size; metamorphosis begins at ca. 40 mm standard length (SL) and is complete at ca. 50 mm SL. The larval pectoral fin degenerates during metamorphosis and is absent thereafter. The pigment pattern of larvae is unique, as is the sequence of formation and loss. Almost all body pigment disappears during metamorphosis.

Distribution and occurrence patterns of eggs and larvae were analyzed in relation to the temperature, salinity fields and zooplankton abundance, mainly based on specimens collected on California Cooperative Fisheries Investigations cruises (1949-1984) in the California Current region. Although samples were limited in the western North Pacific, the distributional pattern off Japan was similar to that in the eastern Pacific. Eggs and larvae occur in the warmer shallow layer (ca. 14-18°C) above the seasonal thermocline in the subarctic and transitional waters with peak abundance in the summer.

Tactostoma is a monotypic stomiid genus represented by *T. macropus*, an endemic mesopelagic species of the subarctic and transitional waters of the North Pacific, ranging from the California Current region to the Oyashio and transitional waters off northern Japan (Fisher and Pearcy, 1983). Fisher and Pearcy (1983) studied its reproduction, growth, and feeding habits off Oregon. Portions of its early life history have been described by Kawaguchi and Moser (1984), Ozawa and Aono (1986), and Matarese et al. (1989). This paper describes the entire developmental sequence of *T. macropus* from egg to juvenile. Also, we describe the areal and temporal distribution of *T. macropus* eggs and larvae in the California Current region and the eastern and western North Pacific transition zone, along with associated environmental characteristics.

Materials and Methods

Egg, larval, and juvenile specimens were obtained from the ichthyoplankton collections of the California Cooperative Oceanic Fisheries Investigations (CalCOFI), the Department of Oceanography, Oregon State University (OSU), the Ocean Research Institute, University of Tokyo (ORI), and the Iwate Prefectural Fisheries Laboratory, Kamaishi, Japan.

Annual and triennial CalCOFI surveys occupied 31,214 plankton/hydrographic stations in a >1 million km^2 area off California and Baja California during 1951-1984. *Tactostoma macropus* larvae were collected in 121 oblique plankton tows in the California Current region from 1951 to 1984. Tow depth was 0-140 m before 1969 and 0-210 m afterwards. Specimens collected on CalCOFI surveys in

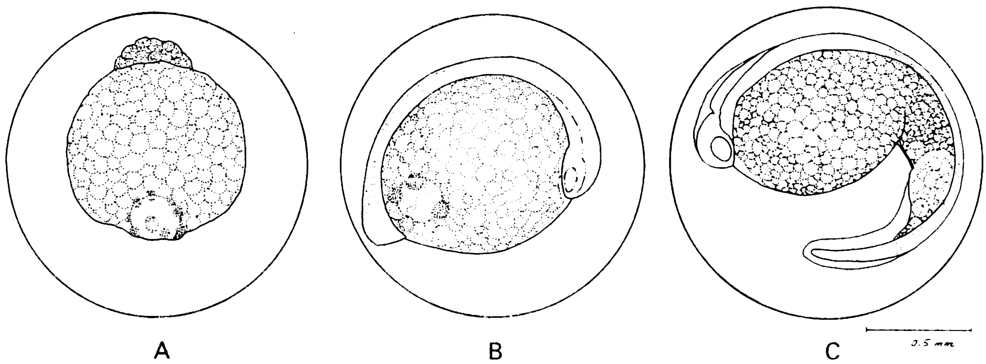

Fig. 1. Eggs of *Tactostoma macropus.* A) morula stage; B) tail-bud stage; C) free-tail stage.

1949 and 1950 were from tows taken to 70 m depth.

CalCOFI's multi-vessel NORPAC survey (August 6–September 2, 1955) occupied 195 plankton/hydrographic stations in the northeastern Pacific between 20°N and 48°N and west to 150°W. Oblique plankton tows to 140 m depth were taken at each station. Deep oblique tows to 700 m were taken at 40 stations and discrete-depth tows in the 140–280 m depth range were taken at 130 stations. Initial identifications of fish eggs and larvae from these tows were made by Dr. E. H. Ahlstrom. We reexamined these samples and results from NORPAC samples reported herein represent a combination of our identifications and of Ahlstrom's. Zooplankton displacement volumes ($ml/100\,m^3$) were determined for each station by J. R. Thrailkill.

Collection gear and methods used on CalCOFI and NORPAC surveys are described in a series of 24 data reports (e.g., Ambrose et al., 1987; Stevens et al., 1990). For CalCOFI and NORPAC samples abundance of eggs and larvae is expressed as the number under $10\,m^2$ of surface area. All eggs and larvae from CalCOFI and NORPAC surveys are deposited at the Southwest Fisheries Science Center, La Jolla, California.

OSU specimens were collected off Oregon with a 10 foot-Isaacs Kidd Midwater Trawl (IKMT) at 0–75 m depth during July and August 1966 and with a Bongo net at 0–200 m depth in July 1975.

Off northern Japan a monthly fish egg and larval survey was conducted by Iwate Prefectural Fisheries Laboratory from January 1985 to December 1986 in the Oyashio-Kuroshio transitional waters bounded by 141°59′E–143°03′E and 38°56′N–40°00′N; a total of 240 surface tow samples were collected by a conical "larva" net (130 cm mouth diameter), providing good seasonal data. During the R/V Hakuho-maru cruise KH-69-4 (August 14–18, 1969), surface "larva" net tows were conducted at five stations (38°09.6′N, 152°37.7′E; 39°31.1′N, 158°41.5′E; 41°00.2′N, 165°05.0′E; 42°32.3′N, 171°16.0′E; 43°46.3′N, 179°40.1′E) along a line transecting the Kuroshio and Oyashio waters; this was helpful in depicting the distributional pattern of *T. macropus* larvae in relation to the transitional waters. Two *T. macropus* larvae collected in August 1, 1981 at Station 11 (38°34.7′N, 145°15.4′E) during the R/V Hakuho-maru cruise, were also examined for the descriptions. All of the eggs and larvae examined in the western North Pacific are deposited at ORI and the Iwate Prefectural Fisheries Laboratory.

Identification and descriptive methods used in this paper follow Sandknop et al. (1984) and Powles and Markle (1984). Before the completion of notochord flexion, body length is expressed as "notochord length" (NL), the distance from the tip of snout to the tip of notochord. After the completion of notochord flexion, body length is given as standard length (SL), the distance from the tip of snout to the posterior margin of hypural plate. Head length (HL) was measured from the tip of the snout to the posterior margin of the opercle. Predorsal length (Pre D), prepectoral length (Pre P), and preventral length (Pre V) were measured from the tip of snout to the origin of the respective fin. A series of larvae was cleared in potassium hydroxide/glycerin and stained with Alizarin Red-S and Alcian Blue to study calcification of fin rays and bones.

Description of Early Life History Stages

Egg stage

Eggs are spherical and large, 1.38–1.55 mm in diameter; ca. 95% of 57 eggs measured were within the range of 1.41–1.55 mm. Twelve eggs from off Japan ranged from 1.34 to 1.56 mm in diameter, 9 of 12 were within the range of 1.41–1.55 mm. The single oil globule is 0.30–0.40 mm in diameter. It is located opposite the embryo in the morula stage (Fig. 1A), below the tail bud at the tail-bud stage, and later at the ventral base of the tail (Fig. 1C). The yolk is segmented and 0.78–0.89 mm in diameter at hatching. The perivitelline space is wide, occupying 40–47% of the shell diameter (Fig. 1A). The shell is transparent and smooth, with no secondary inner membrane. Eggs of *Tactostoma macropus* are distinguishable from those of other sympatric species by the following combination of characters: 1) large size, 2) wide perivitelline space, 3) smooth transparent shell, 4) lack of secondary inner membrane, 5) segmented yolk, 6) single oil globule. The other sympatric stomiid species with a large egg is *Chauliodus macouni.* Its egg has a larger diameter (2.7–3.1 mm) and lacks an oil globule (Kawaguchi and Moser, 1984). NORPAC samples contained eggs of sequential developmental stages from one-cell through tail-free stages and also larvae with residual yolk just after hatching which helped confirm the identification of the egg.

Larval stage

Morphology.—The smallest larva in our collection is 4.0 mm NL and has residual yolk associated with the middle part of the gut; yolk is not detectable in 6 mm NL larvae (Fig. 2A). Transformation to the juvenile stage starts at ca. 43 mm SL and is completed at ca. 50 mm SL. Larvae of *Tactostoma macropus* have a slender cylindrical body with a well developed finfold along the dorsal and ventral body margin. Body depth (excluding the gut) is 3–4% of body length. The gut is straight and trailing from the

Table 1. Proportional changes (%) in head length (HL), prepectoral length (Pre P), predorsal length (Pre D), and preventral length (Pre V) in relation to developmental events in *Tactostoma macropus*

NL or SL (mm)	% of NL or SL				Developmental Event
	HL	Pre P	Pre D	Pre V	
4.0	7.5	—	—	—	round eye sparsely pigmented
4.9	9.7	14.2	—	—	pectoral fin bud appearing
5.2	11.5	14.4	—	—	elliptical eye pigmented
6.0	13.3	16.7	—	—	residual yolk disappearing
7.1	14.3	18.3	—	—	
8.5	15.3	17.7	—	—	
9.5	13.7	16.8	—	—	
11.5	13.0	15.7	—	—	
13.5	12.6	14.0	—	—	notochord flexion beginning
13.6	12.5	15.5	87.5	—	dorsal and anal fin anlage appearing
14.2	12.7	15.7	87.3	—	
14.8	12.2	15.5	89.2	—	
17.6	11.4	13.1	88.0	—	
20.0	12.5	14.0	86.0	—	notochord flexion finished
22.2	10.8	15.0	86.9	69.3	pelvic fin bud appearing
24.5	10.6	15.1	87.8	68.2	dorsal fin rays calcifying
25.5	10.2	12.3	85.8	67.1	anal fin rays calcifying
28.3	10.6	12.6	87.6	66.1	
29.5	10.2	13.6	85.8	66.1	
31.2	10.9	12.1	86.5	66.3	
34.2	8.8	11.4	89.0	67.5	body pigment disappearing
42.0	10.0	11.3	86.4	64.5	
43.2	9.3	11.1	86.3	62.3	
44.0	9.8	11.7	86.4	65.6	transforming stage; no body pigment
45.9	9.8	10.9	86.7	63.6	
49.5	10.0	10.7	85.3	65.0	pectoral fin degenerating

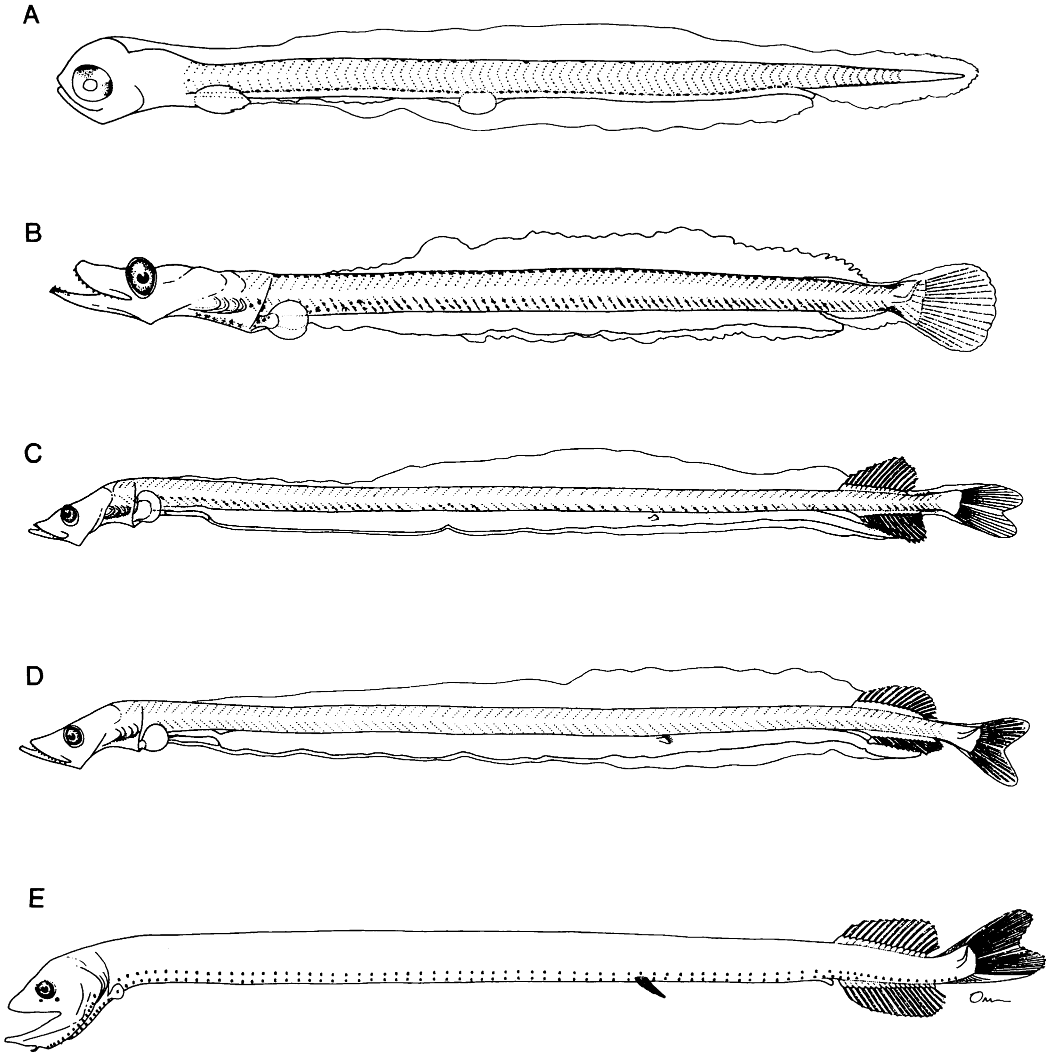

Fig. 2. Larvae of *Tactostoma macropus.* A) 4.9 mm NL preflexion larva with residual yolk at middle part of gut and linearly arranged ventral melanophore series; B) 13.5 mm NL flexion-stage larva with developed dorsal myomere and ventral myoseptum melanophore series; C) 34.2 mm SL postflexion larva that has lost the dorsal melanophore series (from Kawaguchi and Moser, 1984); D) 44.0 mm SL postflexion larva without body melanophores; E) 49.4 mm SL transforming stage with photophores forming.

body. Initially, the head is small, 7.5–11.5% of the body length (Fig. 2A; Table 1). As development progresses to initial notochord flexion (ca. 13–14 mm NL), the head becomes depressed and elongate, and the lower jaw protrudes forward beyond the upper jaw (Fig. 2B). Subsequently, the head becomes less flat and relatively smaller in specimens larger than 15 mm NL. Relative head length does not change appreciably in larvae larger than 22 mm SL (Table 1).

The eye is round just after hatching, becomes vertically elliptical and often directed forward beyond ca. 5.5 mm NL, then becomes round again just before transformation (Fig. 2A–D). Eye diameter is ca. 50% of HL just after hatching and becomes relatively smaller with development; eye width is ca. 16–20% of HL in specimens larger than 10 mm NL.

Pectoral fin buds are appearing in a 4.2 mm NL larva (Fig. 2A). No calcification occurs in the

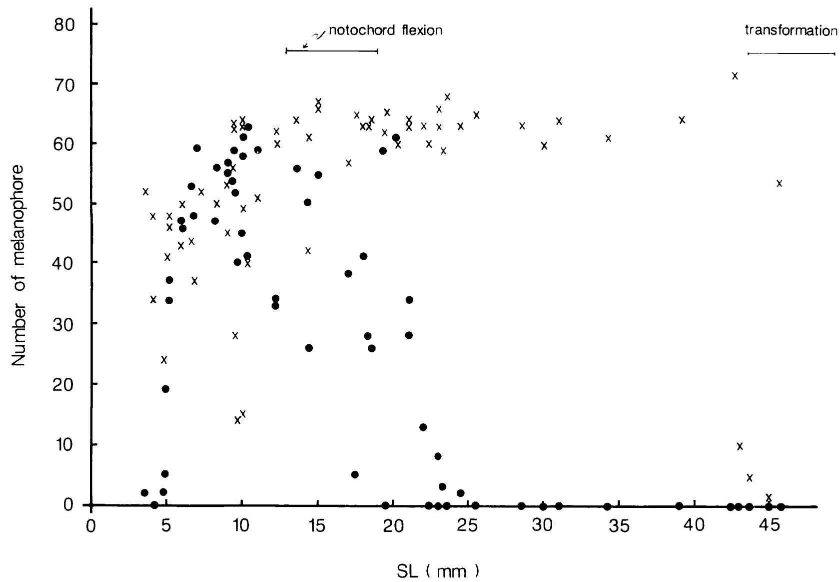

Fig. 3. Numbers of melanophore pairs in the dorsal series (dorsal myomere melanophores indicated by dots) and in ventral melanophore series (hypaxial myoseptum melanophores indicated by ×'s) during the larval development of *Tactostoma macropus*.

pectoral fin during the larval period and the fin is lost during transformation. Dorsal and anal fin pterygiophores begin to develop simultaneously in larvae of ca. 13–14 mm during early notochord flexion. The dorsal fin origin is slightly forward of the anal fin origin. Predorsal length is 85–89% of SL and shows no marked change throughout development (Table 1). Dorsal fin rays begin to calcify at ca. 24 mm SL, slightly earlier than the anal rays. Counts of calcified rays are: D 14, A 10 at 24.5 mm SL; D 14, A 15 at 28.3 mm SL; D 15, A 19 at 46.2 mm SL. The adult complements of D 14–16 and A 19–22 are attained just before the completion of transformation. Pelvic fin anlagen are present in a 26.5 mm SL larva and ray development begins at ca. 30 mm SL. Transforming specimens of 44.4 mm and 46.2 mm SL have 6 cartilaginous pelvic fin rays, but the rays and pterygiophores do not calcify during the larval period.

Notochord flexion begins at about 13 mm NL and is completed at a maximum length of 20 mm SL. Principal caudal rays begin to calcify in 18 mm larvae and a 25 mm larva has the adult complement of 10 superior and 9 inferior rays. Cartilaginous hypural elements are present in a 13.5 mm larva and the adult complements of superior (hypurals 4–6) and inferior (parhypural, hypurals 1–3) elements are present at ca. 20 mm SL. These elements are beginning to calcify in a 25 mm larva and all are calcified in a 33 mm SL larva.

Pigmentation.—A 4.0 mm NL larva has faintly pigmented eyes; larvae larger than 4.5 mm NL have fully pigmented eyes. Series of supracaudal and infracaudal melanophores are the first to develop on the body, appearing at about 4 mm NL and remaining to ca. 30 mm SL (Fig. 2A–C). Paired melanophore series, continuous with the densely pigmented supra- and infracaudal series, develop along the dorsal and ventral body margins. Melanophores in the dorsal series (dorsal myomere melanophores) are positioned above the myomeres. Melanophores in the ventral series are also positioned on the myomeres in early larvae less than ca. 10 mm NL, but later are located along the myosepta (hypaxial myoseptum melanophores; Fig. 2A, B). The ventral series appears slightly earlier and is completed earlier than the dorsal series: a 4.1 mm larva lacks ventral and dorsal body margin series, a 4.8 mm larva has ca. 20 pairs of ventral melanophores with only 2 dorsal pairs near the nape, and a 5.1 mm specimen has 46 ventral and 37 dorsal pairs (Fig. 3). The maximum number of dorsal pairs, 50–60, is attained at 7–9 mm NL, and thereafter the number gradually decreases. Larvae larger than 25 mm SL have no dorsal body margin melanophores (Figs. 2C, 3). Ventral mela-

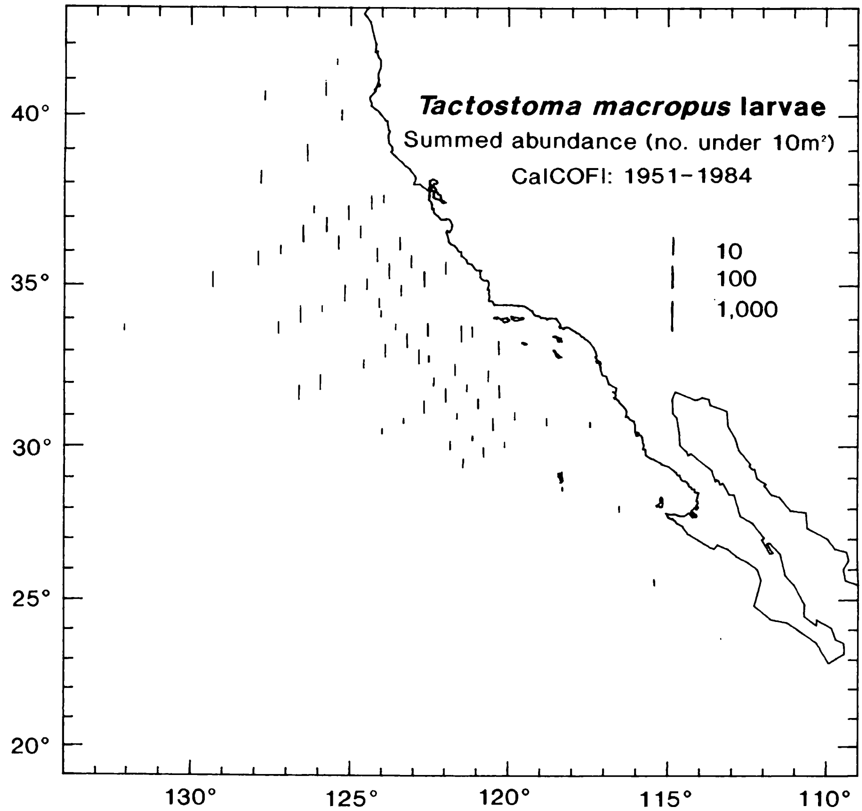

Fig. 4. Summed abundance (no. under $10\,m^2$ of surface area) of *Tactostoma macropus* larvae collected on CalCOFI surveys during 1951–1984.

nophores are arranged linearly along the ventral body margin in early larvae less than 10 mm NL (Fig. 2A). At ca. 10 mm NL, melanophores are rearranged to form oblique lines along the hypaxial myosepta, one to three (usually two) melanophores at each myoseptum. The number of the ventral pigment series is variable, especially in larvae ca. 10 mm NL, when rearrangement of the ventral pigments begins. The maximum number, 60–70, of paired hypaxial series is reached at ca. 18 mm NL and maintained until ca. 40–42 mm SL when they decrease abruptly and then disappear just before transformation (Fig. 3).

During late notochord flexion, pigmentation develops on the lower jaw symphysis, isthmus, pectoral fin base, cleithral region, the base of caudal fin rays, and on the free terminal section of the gut. This pigmentation is present in most specimens until just before transformation, and some remains during metamorphosis.

Metamorphosis (transformation).—The accumulation of numerous metamorphosing specimens permitted a detailed study of the striking changes that occur during transformation to the juvenile stage. Transformation starts at ca. 40–42 mm SL when hypaxial myoseptum melanophores begin to disappear (Fig. 3). Most specimens >44 mm SL have no lateral body pigment (Fig. 2D), but pigment sometimes remains on the isthmus and on the bases of the caudal and pectoral fin rays. The photophores appear at 47–49 mm SL (Fig. 2E). Development of the primary photophores precedes that of the smaller secondary photophores that are widely scattered on the adult body surface. Pigmentation of the entire body surface begins at ca. 50 mm SL and is completed at 55 mm SL, when all of the juvenile features are attained. The pectoral fin is degenerating in a 50 mm SL specimen and is lost during metamorphosis.

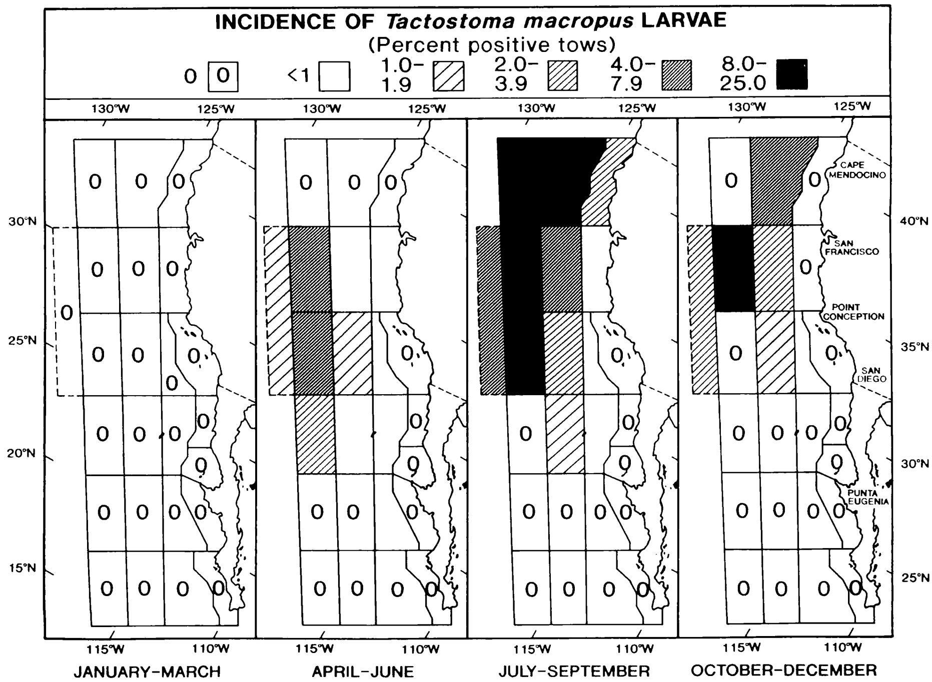

Fig. 5. Average seasonal occurrence (percent positive tows) of *Tactostoma macropus* larvae in 24 CalCOFI regions during 1951–1984.

Distribution

Areal, seasonal and interannual distribution

A total of 809 larvae were collected in 31,214 plankton tows from CalCOFI surveys off California and Baja California from 1951 to 1984. Larvae occurred in the California Current region and were absent near the coastal waters (Figs. 4, 5). Occurrences diminished abruptly south of California, although larvae were taken as far south as Station 130.60 (25°23.0′N, 115°13.1′W). Larval occurrence and abundance were strongly seasonal (Figs. 5, 6A). Larvae appeared in April and increased steadily in both occurrence and abundance. They peaked in July, again in September and then declined abruptly in October. They were absent from November to March. Occurrences earlier than July were restricted to the area south of 36°30′N, while occurrences north of 40°N were restricted to July–October. Annual mean abundance fluctuated erratically and no interannual trends were apparent (Fig. 6B).

On the NORPAC Expedition, a total of 345 *T. macropus* eggs occurred at 36 stations in the region bounded by 35°–48°N, 124°–150°W with highest relative abundance at ca. 40°–45°N and 127°–137°W (Fig. 7). A total of 408 larvae occurred at 21 stations and their distribution and relative abundance were similar to the eggs (Fig. 7).

No *T. macropus* eggs occurred in the 130 discrete depth tows (140–280 m) taken on NORPAC and only a single larva was captured in those tows (Sta. 14; 44°15′N, 140°31′W). Larvae ranging from 14 to 47 mm SL and juveniles from 47 to 57.5 mm SL were collected by surface IKMT tows off Oregon. In the early CalCOFI surveys in 1949 and 1950, when net tows were made to a depth of 70 m, *T. macropus* larvae were taken at 68 stations in the California Current region from 31°54.5′N to 46°15.0′N.

Examination of the 240 samples collected monthly in surface tows off Iwate Prefecture, northern Japan from January 1985 to December 1986 showed that eggs occurred only in August at 2 stations (39°15′N, 142°50′E; 39°32′N, 143°35′E). In the surface tow samples collected in August 14–18, 1969 at 5 stations along the line transecting the Kuroshio and Oyashio waters, 75 larvae (14.3–40.0 mm SL) occurred only at one station (39°31.1′N, 158°41.5′E) in the transitional area. All egg and larval specimens from the western North Pacific were collected in late summer

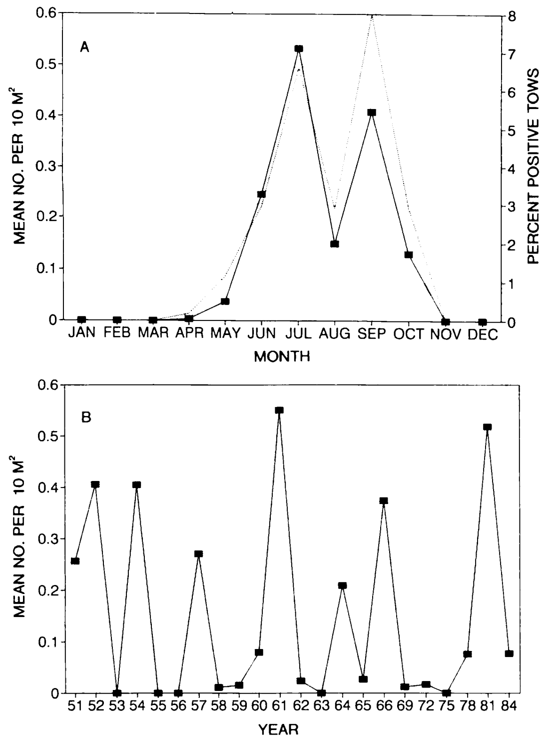

Fig. 6. Seasonal and interannual trends in occurrence and abundance of *Tactostoma macropus* larvae from CalCOFI surveys during 1951–1984. A) monthly abundance (no. per $10\,m^2$ surface area, solid squares) and monthly occurrence (percent positive tows, dotted line); B) interannual abundance (no. per $10\,m^2$ surface area). Values represent means derived from data pooled from CalCOFI regions *5*, *6*, *9*, and *10* (see Moser et al., 1993, for location of CalCOFI regions).

from the shallow layer of the transitional waters between the Oyashio and Kuroshio waters, showing a strong similarity to distributional patterns observed off Oregon and northern California in the eastern North Pacific.

Environmental characteristics

Our data and those of other investigators (see Discussion) indicate that *T. macropus* eggs and larvae are distributed in the warm surface waters above the seasonal thermocline, especially in the upper 5-m layer. Data from the NORPAC Expedition in August 1955 suggest that eggs and larvae were vertically distributed above the seasonal thermocline defined by 14°C (Fig. 8), and horizontally distributed in waters of 14–20°C and salinities >32.4‰. Samples with highest relative abundance of eggs and larvae were characterized by temperatures of 15–18°C and salinities of 32.4–33.4‰ at 10 m depth (Fig. 9A, B). The eastern boundary coincides with the low salinity front of the Columbia River plume (Fig. 9B). Northern and inshore waters had relatively higher zooplankton volumes than more southern and offshore waters (Fig. 9C). These zones are separated by the 10 and $20\,ml/100\,m^3$ contours; highest relative abundance of eggs and larvae generally was associated with the above-mentioned boundary area of zooplankton volumes around the $10–30\,ml/100\,m^3$ range (Figs. 7, 9C). Off Japan, eggs and larvae of *T. macropus* were collected in the surface layer of 17–18°C above the seasonal thermocline, defined by the 15°C isotherm at about 50 m depth.

Discussion

Tactostoma macropus is one of the most common stomiid species in the subarctic-transitional region of the North Pacific. Juveniles and adults are abundant between ca. 40° and 50°N with reduced abundance north of 50°N in the Gulf of Alaska, Bering Sea, and Kurile-Kamchatka region (Fisher and Pearcy, 1983). A recent summary of midwater trawl catches throughout the North Pacific showed that *T. macropus* was widespread in the eastern portion of the range, extending south into the California Current and north into the Gulf of Alaska (Willis et al., 1988). The distribution narrows in the western basin of the North Pacific, where most trawl catches were made in the southern region of the subarctic domain and in the transitional domain (Willis et al., 1988).

Results of CalCOFI ichthyoplankton surveys reported herein show that incidence and abundance of eggs and larvae of *T. macropus* are relatively high in the subarctic-transitional region of the eastern North Pacific. These surveys also show that spawning begins in the spring off California and progresses northward, with a summer peak off Oregon and Washington and offshore transitional waters. Annual mean abundance fluctuated erratically in the CalCOFI time series and interannual trends were not apparent. Whether this represents a pattern of annual flux in reproduction or survival off California or is a result of sampling bias cannot be determined

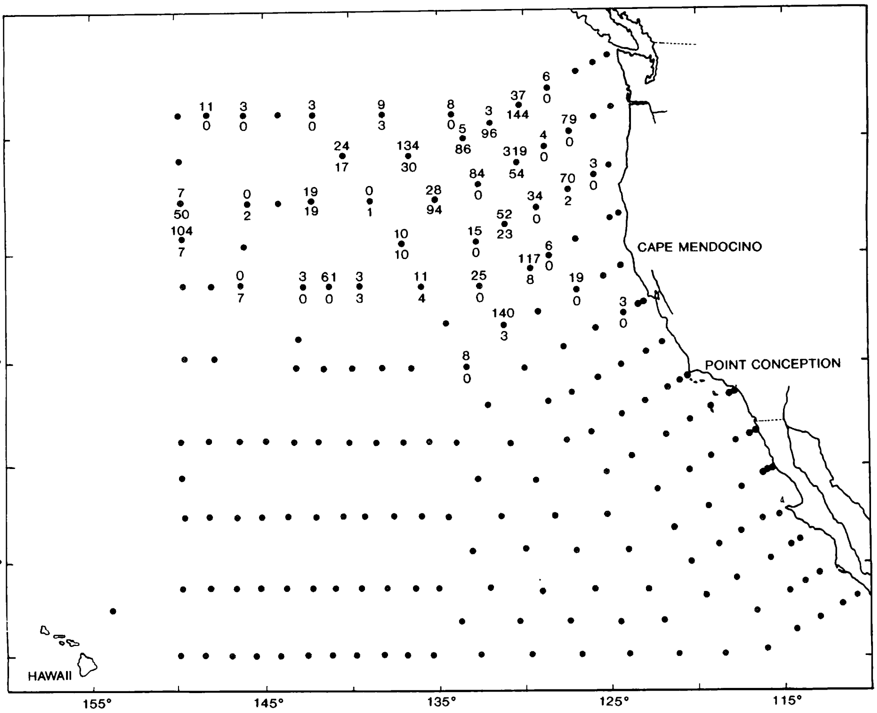

Fig. 7. Numbers (per $10\,m^2$ surface area) of eggs and larvae of *Tactostoma macropus* taken in oblique plankton tows to 140 m depth during the NORPAC Expedition, August 6–September 2, 1955. Numbers of eggs are indicated above each station dot and numbers of larvae below each dot. The dots without numbers indicate a negative station for both eggs and larvae.

at this time.

The more coastal surveys made by Oregon State University and the Northwest and Alaska Fisheries Science Center showed maximum egg and larval abundance in July–August with high relative abundance seaward of the continental shelf and slope (Fisher and Pearcy, 1983; Kendall and Clark, 1982). Fisher and Pearcy (1983) indicated that the principal spawning area is 150 to 300 km off the Oregon coast and is characterized by lower chlorophyll concentrations and higher temperatures than inshore waters during the summer. Our results also support this view and further suggest that eggs and larvae of *T. macropus* develop in waters warmer than 12–14°C above the seasonal thermocline and that spawning is centered in the transitional area between the northern or inshore waters characterized by high zooplankton biomass and the southern offshore waters with relatively low zooplankton biomass.

In a plankton survey in August 1980 from Cape Flattery, Washington to Cape Mendocino, Califor-

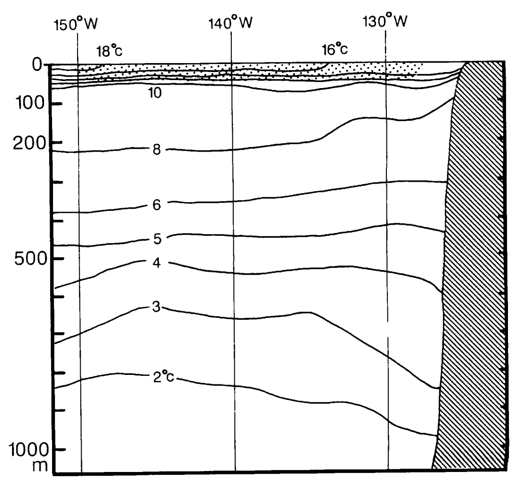

Fig. 8. Temperature section along 44°N from 123°W to 150°W during the NORPAC Expedition. Principal zone of distribution of eggs and larvae of *Tactostoma macropus* is indicated by shading.

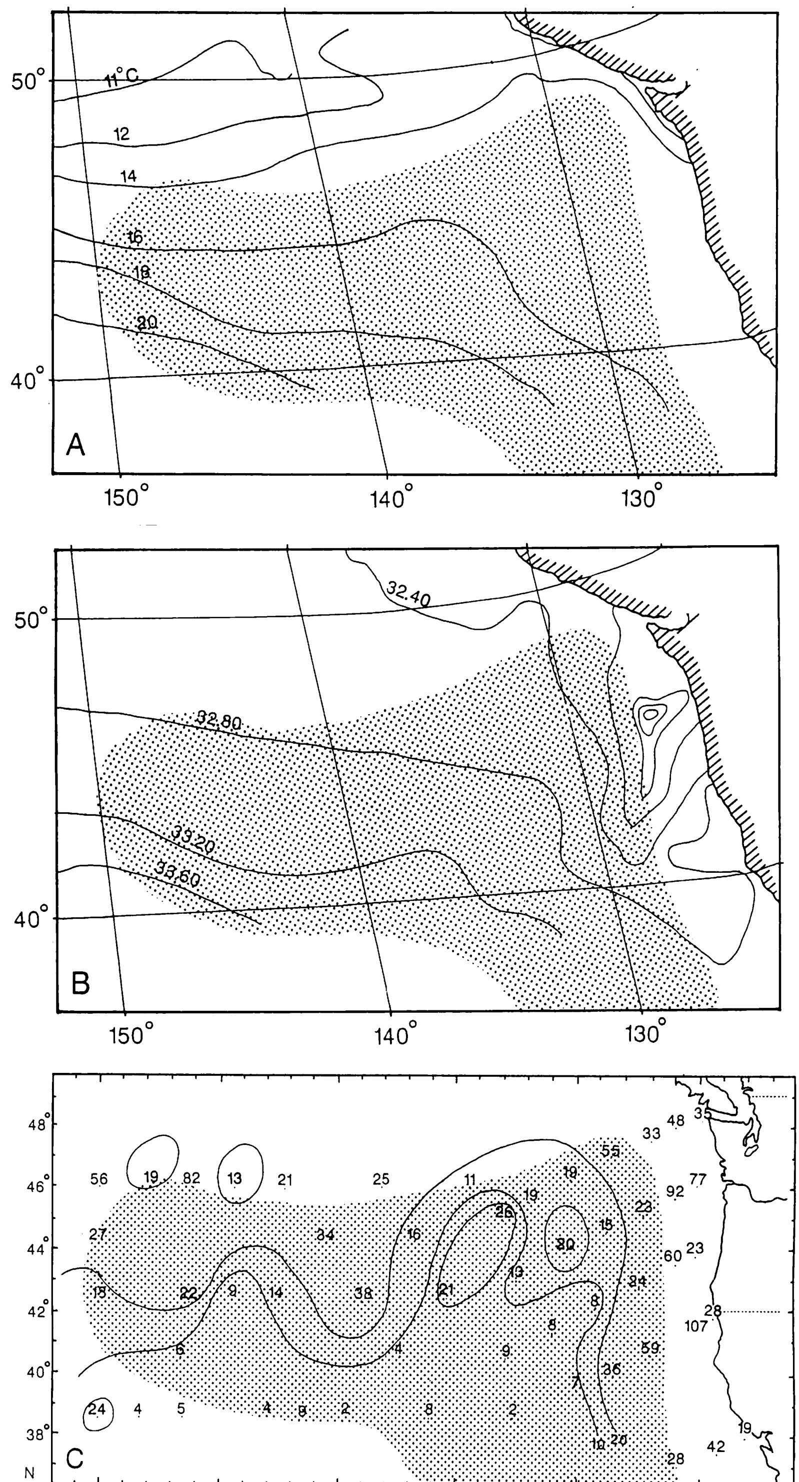
11°C
12
14
16
18
20
50°
40°
A
150°
140°
130°
32.40
32.80
33.20
33.60
B
C
48°
46°
44°
42°
40°
38°
N
W
145°
135°
125°

Fig. 9

nia, *T. macropus* eggs occurred in 30.8% of the neuston tows and in 25.3% of the Bongo tows; larvae were absent from the neuston samples and occurred in 4.4% of the Bongo tows (Kendall and Clark, 1982). In our western Pacific samples both eggs and larvae were collected by surface tows at night.

Our results and those of other studies on juveniles and adults suggest the following life history scenario for *T. macropus.* First-spawning females are ca. 300 mm SL and do not undertake diel vertical migration, staying at ca. 400–600 m depths (Fisher and Pearcy, 1983; Willis and Pearcy, 1982). Eggs are spawned at depth and rise to the upper 50 m, above the summer thermocline, where they hatch. Larvae are also distributed above the summer thermocline where both primary and secondary production are high. Comparing our results on the distribution of larvae with the vertical distribution pattern of the main prey organisms (Pearcy et al., 1977; Willis and Pearcy, 1982; Fisher and Pearcy, 1983), it appears that *T. macropus* spends the larval period in the most productive upper 0–60 m layer, feeding mainly on copepods, which were commonly found in the intestines of larvae in the present study. Occurrence of both juveniles and metamorphosing larvae in the subsurface layer indicates that metamorphosis takes place above the thermocline. Metamorphosing larvae have prey organisms, mainly copepods, in their intestines and apparently feed continuously during this process. Juveniles start vertical migration and shift to vertically migrating euphausiid prey. Specimens larger than ca. 250 mm are reported to stop diel vertical migration and stay below 400 m depth where they fed on vertically migrating myctophids (Fisher and Pearcy, 1983).

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Fig. 9. Contours of environmental characteristics in the principal spawning areas (shaded) of *Tactostoma macropus* off Washington, Oregon, and northern California based on data from the NORPAC Expedition (August 6–September 2, 1955). A) Temperature (°C) at 10 m depth; B) salinity (‰) at 10 m depth; C) zooplankton displacement volume (m*l* per 100 m^3).

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ハダカホテイエソの初期生活史と分布・出現様式

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北太平洋の亜寒帯域と移行域に分布するハダカホテイエソ *Tactostoma macropus* の初期生活史を卵から稚魚までの連続標本に基づき記載した．卵は浮遊性で，同所的に分布する他種の卵とは，1) 卵径が 1.38–1.55 mm であること，2) 囲卵腔の最大幅が卵径の 40–47% を占めること，3) 卵膜が滑らかであること，4) 卵膜が一層であること，5) 卵黄に亀裂があること，6) 油球は 1 個であることにより区別可能である．

仔魚は，孵化直後約 4 mm NL であるが発育して約 40 mm SL となり，変態して稚魚となる．変態過程で胸鰭とほとんどすべての体色素が一時消失する．

カリフォルニア海流域での CalCOFI (1949–1984) 及び日本沖のデータに基づき，卵・仔魚の分布と出現様式が似ていることが明らかとなった．卵と仔魚は，亜寒帯域から移行域の水温 14–18°C の季節温度躍層より浅い表層に出現し，夏に出現のピークをもつ．

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