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HOW DO TERAPONIDS UTILIZE THE REFLECTIVE SANDY BEACH?

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***ABSTRACT.* –** Occurrence patterns of the larvae and juveniles of two teraponid fishes, *Rhynchopelates oxyrhynchus* and *Terapon jarbua*, were examined in a reflective sandy beach in Tateyama Bay, Central Japan. Samplings were done at the shoreline and offshore areas of the sandy beach. A small seine net (1 mm mesh size) was used for the samplings and two sampling strategies were adopted: 1) semi-monthly daytime samplings carried out at the shoreline and the offshore areas from April 1999 to March 2001 and 2) day-night samplings carried out with tidal rhythms at the shoreline area in July and September 1999. Additionally, visual observations were also conducted in a shallow water zone (< 20 cm depth) to substantiate sampling data. The two teraponid fishes occurred mainly in the summer from July to September. Specimens of *R. oxyrhynchus* < 15 mm SL made up 76.5% of the total catch and they were at postflexion larva and juvenile developmental phases. The occurrence patterns of *R. oxyrhynchus* were not related to diel/tidal phases. Visual observations showed that only *T. jarbua* occurred in shallower zones (< 10 cm depth), where they formed small schools when they were in the juvenile and young developmental phases (10 - 30 mm SL). These results suggested that *R. oxyrhynchus* larvae/juveniles utilize the shoreline area as a nursery ground for a short period of time. On the other hand, the shoreline area would not be a suitable nursery ground for *T. jarbua* but the juveniles/young utilized the shallow water zone as a habitat.

***KEY WORDS.* –** Sandy beach, habitat utilization, *Terapon jarbua*, *Rhynchopelates oxyrhynchus*, larvae and juveniles, nursery ground.

INTRODUCTION

Four teraponid genera comprising seven species are found in Japanese waters (Senou, 2002). Among them, *Rhynchopelates oxyrhynchus* and *Terapon jarbua* are the most common species found in temperate Japanese waters and they are fished by gill nets, set nets and hand-lines in Japan (Akazaki, 1997) and other Asian countries (Chan, 1974; Miu et al., 1990; Mohsin & Ambak, 1996; Vari, 2001). These two teraponids are found from coastal shallow waters to brackish waters and the larvae/juveniles occur near sandy beaches (Senta & Kinoshita, 1985; Akazaki & Taki, 1989; Kinoshita, 1993; Yang & Senta, 1993; Gomyoh et al., 1994; Harris & Cyrus, 1996; Kohno et al., 1999; Arayama et al., 2002; Suda et al., 2002; Strydom, 2003). The juveniles of both fishes use the brackish waters as nursery grounds (Akazaki, 1997; Vari, 2001; Senou, 2002). However, no details of their occurrence patterns in sandy beaches have so far been investigated.

Sandy beaches are recognized as a nursery ground for various fishes around the world (e.g., Brown & McLachlan, 1990; Senta & Kinoshita, 1998) and various studies on fish assemblages, seasonal and diel/tidal distributions, food habits, etc., (Lasiak, 1984a, 1984b; Senta & Kinoshita, 1985; Bennett, 1989; Harris & Cyrus, 1996; Clark, 1997; Gibson et al., 1998; Kohno et al., 1999; Arayama et al., 2002; Beyst et al., 2002; Suda et al., 2002; Pessanha et al., 2003; Inoue et al., 2005) have been done. Recently, the micro-habitats of fishes in sandy beaches have been studied from the viewpoint of the relationships between fish occurrence and the physical characteristics of beaches such as water depth, beach topography and wave action (McLachlan & Hesp, 1984; Harvey, 1998; Layman, 2000; Arayama et al., 2003; Watt-Pringle & Strydom, 2003).

These studies suggested that the habitat utilization was different for different fish species and was dependent of the micro-habitats on the beach (e.g., near beach shore, offshore, bar and trough). Therefore, to understand the importance of the sandy beach as a fish nursery, it is important to understand the habitat utilization by the species concerned. In this study, we examined the seasonal and diel/tidal occurrence patterns of larvae/juveniles of two teraponids, *R. oxyrhynchus* and *T. jarbua*, to determine their habitat utilization of the sandy beach.

MATERIALS AND METHODS

***Study site.* –** The study site (34°59'N 139°51'E) is located at the sandy beach of Tateyama Bay, Central Japan (Fig. 1). The sandy beach is approximately 4 km long. There is a small river inlet near the beach, but a jetty prevents river water from flowing into the beach. Sea conditions are usually very calm and waves of 20 - 50 cm break at points about 5 m from the shoreline. Main beach substratum is sand and there is a small sandbar formed 50 - 70 m offshore from the shoreline. The beach is defined as a reflective type, as based on Short & Wright (1983). According to Arayama et al. (2003), water temperature and salinity in the study site ranges from 12.0 - 28.0°C and from 13.5 - 36.5‰, respectively.

***Study methods.* –** Samplings were conducted at two areas, one being at the shoreline and the other at 70 - 100 m offshore and beyond a sandbar (Fig. 1). Water depth at the sampling sites was approximately 70 - 100 cm. Samplings were conducted using a small seine net (wing net: 4 m wide and 1 m deep, 2 mm mesh; central purse bag: 4.5 m long, 1 mm mesh). The seine net was hauled parallel to the shoreline for a distance of 50 m and two seine-hauls were made for each sampling. Two sampling schemes were carried out: 1) semi-monthly daytime samplings carried out in both the areas at around low tide from April 1999 to March 2001 on new and full moon phases (to study the seasonal occurrences of the teraponids) and 2) day-night samplings carried out at the shoreline area in July and September 1999 at new moon phases (to study occurrence patterns of the teraponids in different diel and tidal rhythms such as low, flood, high and ebb tides). Results of the latter scheme were analyzed for *Rhynchopelates oxyrhynchus* only, as an insufficient number of *Terapon jarbua* were collected to carry out any useful analysis.

During the semi-monthly daytime samplings, 5 minute visual observations were conducted in the shallow water zone (< 20 cm depth) (Fig. 1) and the numbers of teraponid schools and individuals in each school were counted. However, the visual observations were not carried out in early July and early August 1999 and early October 2000 due to bad weather.

Samples were fixed in a 10% formaldehyde-seawater solution immediately after collection at the site and preserved in 70% ethanol after sorting in the laboratory. Fish identification followed Okiyama (1988) and Nakabo (2002). The determination of developmental phases followed Kendall et al. (1984). Standard length (SL) in mm was measured from the snout tip to the posterior edge of the hypural plate.

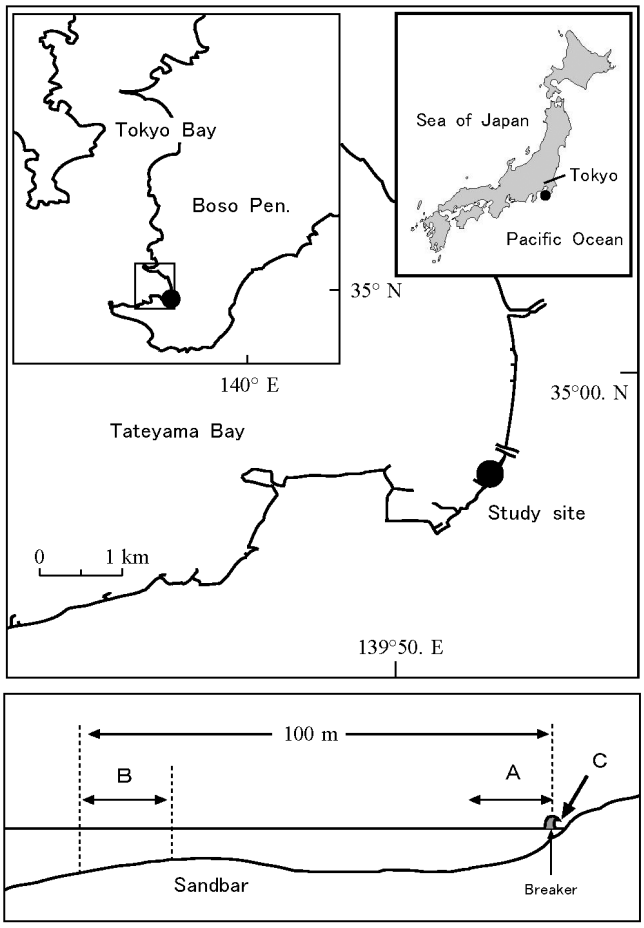

Fig. 1. Map detailing location of sampling site (above) and cross-sectional diagram of sampling site at the sandy beach (below) at Tateyama Bay, Central Japan. A = shoreline area; B = offshore area; C = shallow water zone.

RESULTS

***Seasonal occurrences.* –** Eighty-one *Rhynchopelates oxyrhynchus* individuals were collected by the semi-monthly samplings of which 72 (88.9%) were collected from the shoreline and nine (11.1%) were collected from the offshore. The difference in numbers between the two sites was statistically significant (Wilcoxon signed-ranks test, $P < 0.01$). At the shoreline, *R. oxyrhynchus* occurred constantly from early July to late September 1999 and from early July to early October 2000 (Fig. 2), with a peak in early September in both

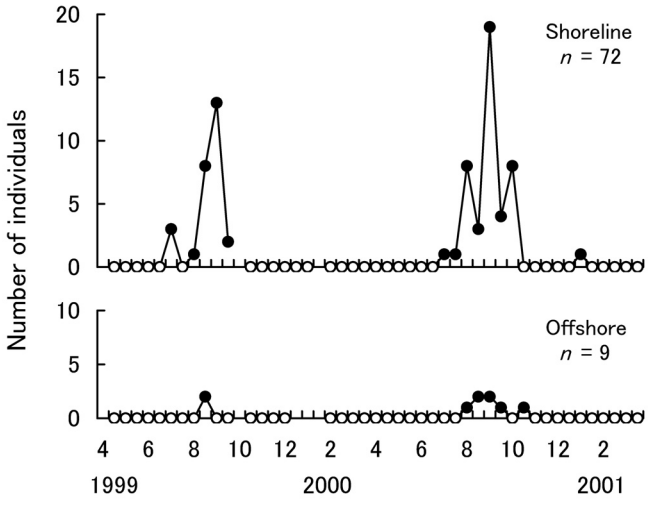

Fig. 2. Seasonal changes of the number of individuals of *Rhynchopelates oxyrhynchus* collected at the shoreline and the offshore areas in the sandy beach of Tateyama Bay, Central Japan from April 1999 to March 2001. open dots = no specimens collected; *n* = number of individuals collected.

Table 1. The numbers of teraponid schools of *Rhynchopelates oxyrhynchus* and *Terapon jarbua* observed by visual observations in the shallow water zone at the sandy beach of Tateyama Bay, Central Japan.

Year	Month	Period	*Rhynchopelates oxyrhynchus*	*Terapon jarbua*
1999	Jul	early	-	-
		late	0	0
	Aug	early	-	-
		late	0	0
	Sep	early	0	1
		late	0	2
2000	Jul	early	0	0
		late	0	0
	Aug	early	0	0
		late	0	0
	Sep	early	0	3
		late	0	1
	Oct	early	-	-
		late	0	0

0 = no individuals observed; - = no observations carried out.

years. Also, at the offshore site, specimens were only collected in the summer (August in 1999 and from August to October in 2000).

Individual sizes ranged from 7.0 - 46.2 mm SL (mean ± SD = 13.8 ± 8.6 mm) at the shoreline and from 8.5 - 30.0 mm SL (15.3 ± 6.9 mm) at the offshore site, respectively (Fig. 3). No significant difference was detected in the fish sizes between the sites (Student's t-test, $P > 0.05$). Specimens smaller than 15 mm SL made up 76.5% (62 out of 81 individuals) of the total catch and they were at postflexion larva and juvenile developmental phases.

The semi-monthly changes of *R. oxyrhynchus* fish-size frequencies indicated that the fish grew in the study sites, although the growth was not obvious in the early sampling periods (Fig. 4).

Three *Terapon jarbua* individuals were collected from the shoreline and none was collected from the offshore site. Two specimens were collected in early July and early August 1999, both being 10.0 mm SL juveniles and one 55.0 mm SL young was collected in late November 2000.

Diel and tidal distributions. **–** *Rhynchopelates oxyrhynchus* was collected most abundantly during the day-night samplings during ebb tides and in the day (16 individuals: three in July and 13 in September 1999), followed by the high tide samplings at night time (14 individuals: two in July and 12 in September 1999). However, no obvious relationships were recognized between the occurrence patterns and diel/tide cycles (Fig. 5).

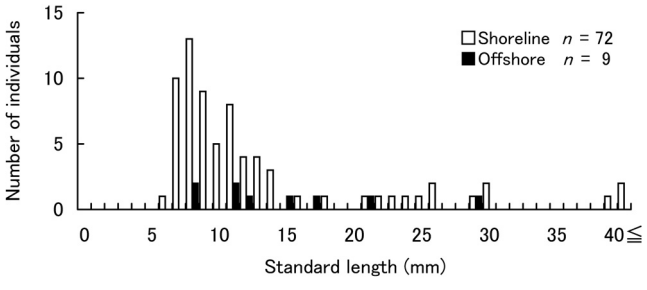

Fig. 3. Standard length (SL) frequencies of *Rhynchopelates oxyrhynchus* collected from the sandy beach of Tateyama Bay, Central Japan from April 1999 to March 2001. *n* = number of individuals collected.

The modal fish size was 8 mm SL in July 1999 and the modal class size was the 8 - 9 mm SL class in September 1999, respectively (Fig. 6). Whereas no obvious fish size differences was detected between diel/tidal modes.

Visual observations. **–** The schools identified by visual observations were solely those of *T. jarbua* occurring in September 1999 and 2000 (Table 1). The school sizes were between five to 20 individuals and they were found in the shallow water (< 10 cm depth) near the shoreline. The individuals were in the juvenile and young developmental phase (10 - 30 mm SL), the latter having characteristic body stripes.

DISCUSSION

Differences were revealed in habitat utilization between the two species when the larval/juvenile occurrence patterns between the two teraponid species in a reflective sandy beach were compared.

Rhynchopelates oxyrhynchus occurred more often (88.9% of all individuals collected) at the shoreline than in the offshore site and individuals smaller than 15 mm SL and postflexion larva and juvenile made up 76.5% of the total catch. Based on previous studies, the fish size of *R. oxyrhynchus* occurring in brackish waters were reported to be 8.3 - 44.2 mm SL (Kanou et al., 2000) and 9.0 - 48.1 mm SL (Fujita et al., 2002). Whereas those occurring on sandy beaches were reported to be 8.0 - 14.5 mm SL (Kinoshita, 1993), 11.8 - 15.2 mm SL (Yang & Senta, 1993), 8.1 - 9.6 mm SL (Gomyoh et al., 1994), 5.5 - 13.0 mm SL (Harris & Cyrus, 1996), 8.4 - 10.2 mm SL (Arayama et al., 2002) and 9.20 - 12.25 mm SL (Suda et al.,

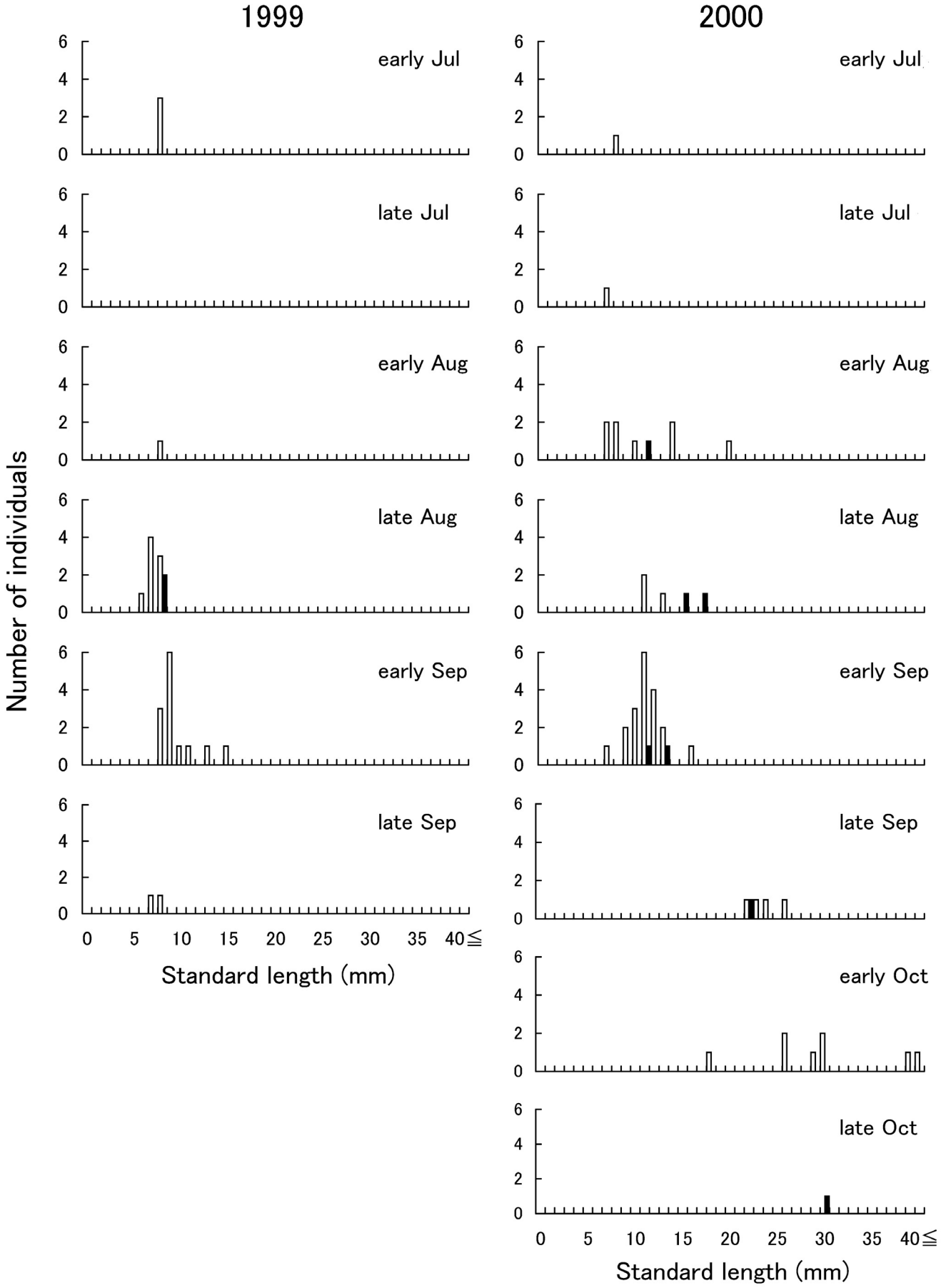

Fig. 4. Semi-monthly changes of standard length (SL) frequencies in *Rhynchopelates oxyrhynchus* collected from the sandy beach of Tateyama Bay, Central Japan from 1999 and 2000. white bars = shoreline area; black bars = offshore area.

2002). These results would indicate that the shoreline area of the reflective sandy beach is utilized as a transient nursery ground by *R. oxyrhynchus* larvae/juveniles before they move to brackish waters, such as estuaries and river mouths.

On the other hand, *Terapon jarbua* is also known to be an estuarine-dependent species and large numbers of juveniles larger than 10 mm SL appear in brackish waters (Miu et al., 1990; Harrison & Whitfield, 1995; Kanou et al., 2000; Fujita et al., 2002; Tzeng et al., 2002). In sandy beaches, *T. jarbua* smaller than 15 mm SL are known to occur (Kinoshita, 1993; Yang & Senta, 1993; Gomyoh et al., 1994; Harris & Cyrus, 1996; Kohno et al., 1999; Arayama et al., 2002; Suda et al., 2002; Strydom, 2003), but in smaller numbers compared to brackish waters. This observation is supported by our study where only three specimens were collected from the shoreline.

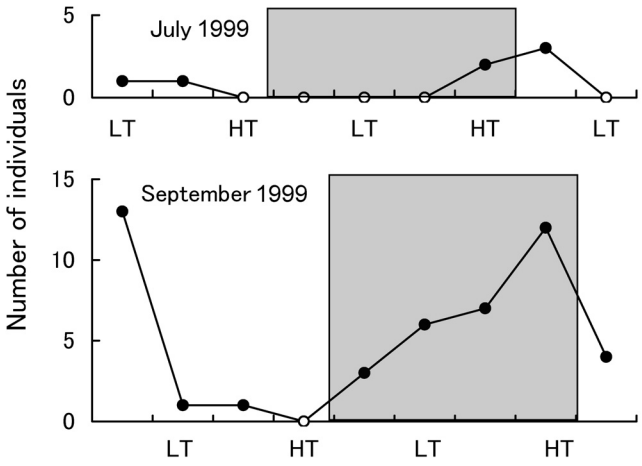

Fig. 5. Diel changes of the number of individuals of *Rhynchopelates oxyrhynchus* collected at the shoreline area of the sandy beach of Tateyama Bay, Central Japan in July and September 1999. shaded areas = night time; open dots = no specimens collected; HT = high tide; LT = low tides.

However, schools of juvenile/young *T. jarbua* composing of 5 - 20 individuals (10 - 30 mm SL) were recorded in shallow water (< 10 cm depth) in September from visual observations. Whitfield (1979) also reported the occurence of *T. jarbua* in shallow waters in South African estuaries. These results suggest that the shoreline and offshore areas of a reflective sandy beach is not as important as a nursery ground for *T. jarbua*, although the shallow waters of a sandy beach provide a habitat for the juveniles/young of this species.

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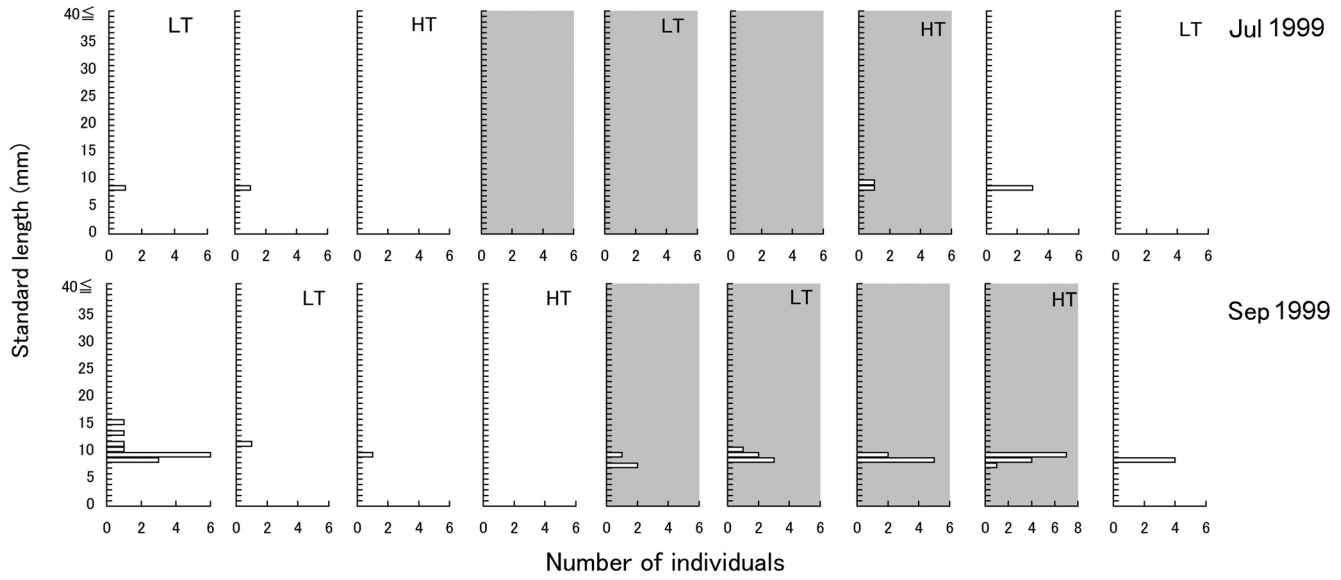

Fig. 6. Diel changes of standard length distributions of *Rhynchopelates oxyrhynchus* collected at the shoreline area of the sandy beach of Tateyama Bay, Central Japan. shaded graphs = night time collection; HT = high tide; LT = low tide.

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