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Forum Paper

Assessing the feasibility of bio-logging research in adult temperate bass, *Lateolabrax latus*, in subtropical-temperate coastal waters of southwestern Japan

Seiji Arakaki[1], Yuuki Kawabata[2] and Mutsunori Tokeshi[1]

[1]AMBL, Kyushu University, Amakusa 863-2507, Japan
[2]Graduate School of Fisheries and Environmental Science, Nagasaki University, Nagasaki 852-8521, Japan
Corresponding author : S. Arakaki, e-mail: arakaki@ambl-ku.jp

Abstract

Dummy tagging was conducted to evaluate the feasibility of bio-logging research on the sea bass *Lateolabrax latus*. Different attachment methods resulted in successful recaptures of tagged fishes, leading to 26% recapture rate in 1.5 years. Surgical implantation seemed to inflict less damages to the fish than external attachment. Our estimation of fish abundance suggested that the local population of *L. latus* was not large enough to be able to endure relatively high fishing pressures in the long term. Combination of conventional methods and bio-logging approaches is considered necessary for an accurate evaluation of the current status of the species.

Keywords: biotelemetry, remote sensing, recapture, population assessment

Temperate sea basses of the genus *Lateolabrax* are common coastal fishes that constitute important elements of commercial and recreational fisheries in East Asia including Japan, Korea and China. The blackfin sea bass, *Lateolabrax latus*, is considered to have a relatively limited distribution, mainly occurring on rocky shores of southern Japan and the East China Sea (Hatooka 2013). Despite its importance as a fisheries target (including recreational fishing) and as a major predator in coastal ecosystems, there is an apparent paucity of ecological information on this species, especially concerning its adult stage. The lack of ecological research is due mainly to the difficulties of specimen collection and of direct observation on exposed rocky shores where adults are known to occur; see a recent report on their seasonal occurrence and foraging ecology (Arakaki *et al*. 2014).

While direct observation in the field is essential for ecological studies, highly-mobile, medium-sized animals in complex shallow-water habitats give researchers a substantial challenge. Remote assessment/sensing techniques, frequently described as “bio-logging” and “bio-telemetry”, are one of the powerful and useful approaches to complement conventional methods for studying various ecological aspects including the patterns of migration and habitat utilisation (Cooke *et al*. 2004; Ropert-Coudert & Wilson 2005; Cooke 2008). While useful, bio-logging inevitably has negative effects on subject organisms and the effect of tag/logger attachment varies with procedures and species (Bridger & Booth 2003). In many previous studies, assessment of tagging methods was done prior to conducting field-based research in order to minimise negative effects on target species (e.g. Mellas & Haynes

1985; Mitamura *et al*. 2006; Makiguchi & Ueda 2009). There are different advantages and disadvantages depending on the type of equipment employed (Ropert-Coudert & Wilson 2005). In the case of storage tags, they can often record multiple data (e.g. animal moving and physiological environments) simultaneously and continuously without observer limitations. However, tagged animals need to be re-collected to retrieve the logged information. In such a case it is necessary to assess the effects of device attachment and the possibilities of recapture, which have been unknown for *L. latus*. Capture-recapture methods with tagging are a primary means for estimating the abundance and survival of animal populations (Pine *et al*. 2003). Despite methodological difficulties and uncertainties, assessing population size is a necessary and worthwhile task for conservation and management of wildlife, especially those organisms that are heavily consumed or endangered. The present study has been undertaken to examine the feasibility of bio-logging in *L. latus* and to evaluate its population size based on recapture information.

On the north-west coast of Amakusa-Shimoshima Island, south-western Japan (Fig. 1), fish individuals were collected during daylight hours (including twilight) between April 2000 and March 2007 and between April 2011 and March 2015 by line fishing from the shore using artificial lure baits. All fishes were brought back to the laboratory and their body sizes were measured: total body length (TL) and fork length (FL) to the nearest 0.5 cm, and wet weight (W) to the nearest 10 g. Additionally, local fisheries data including the number of individuals and the total weight of monthly catch between April 2012 and March 2015 were obtained from the Reihoku branch of the Amakusa Fishermen's Cooperative. Fisheries data mainly consisted of catch by netting (i.e. gill and fixed nets).

L. latus was collected all through the year with seasonal fluctuations (Fig. 2). Catch by line fishing occurred in both autumn (October - December) and spring (March to May), while catch by fisheries nets occurred mainly in autumn-winter (October - January). Catch in summer was very rare. According to the line fishing results, mean TL of collected

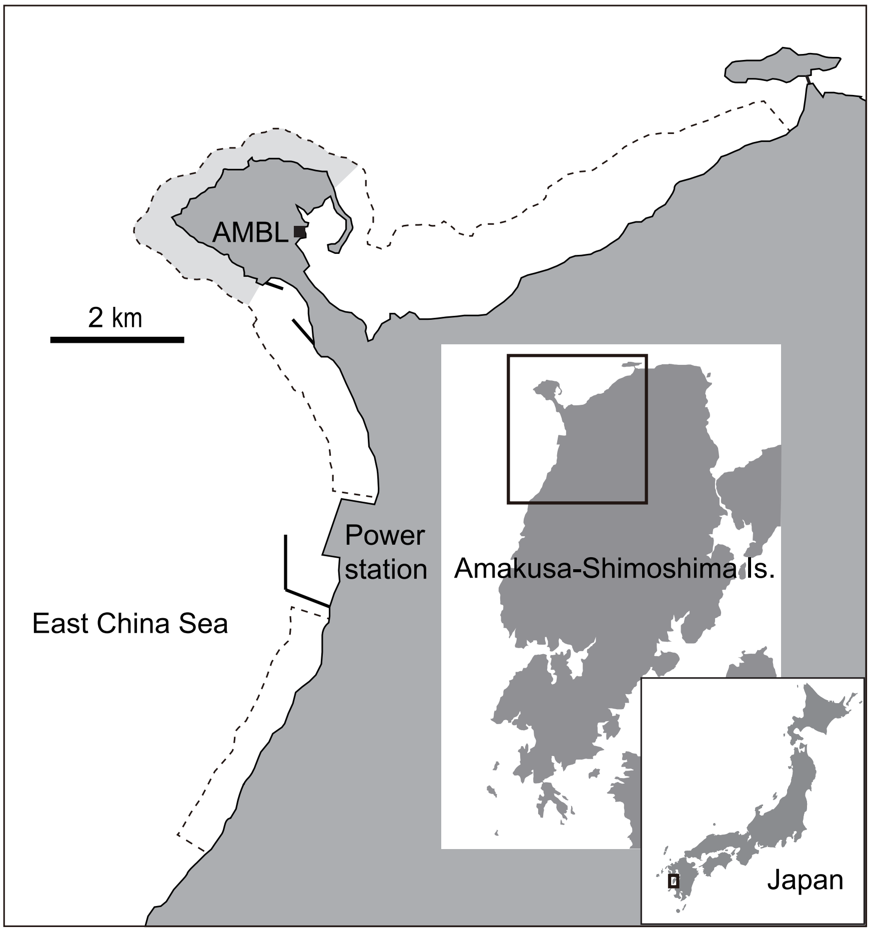


Fig. 1 Study site: north-western coastal area of the Amakusa-Shimoshima Island, south-western Japan. The potential areal extent of collection by fisheries, shallow waters of < 10 m depth at low tide time, is enclosed by dotted line. Shaded area within the enclosed area represents the collection area by line-fishing.

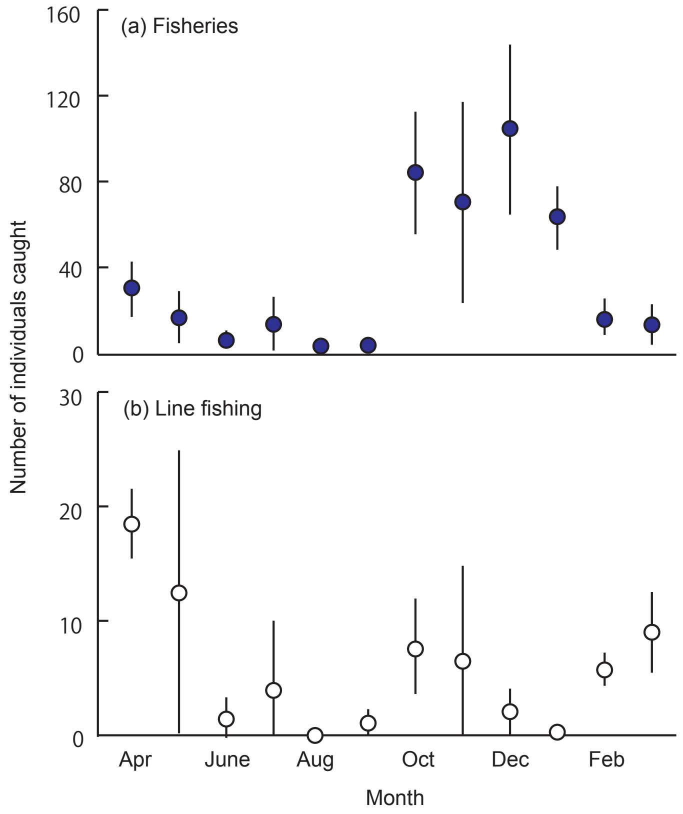


Fig. 2 Variation in monthly catch (mean ± 1SD). Values were averaged over the whole study period for (a) fisheries data (filled circles): April 2012 - March 2015, and for (b) line fishing data (open circles): April 2011 - March 2015.

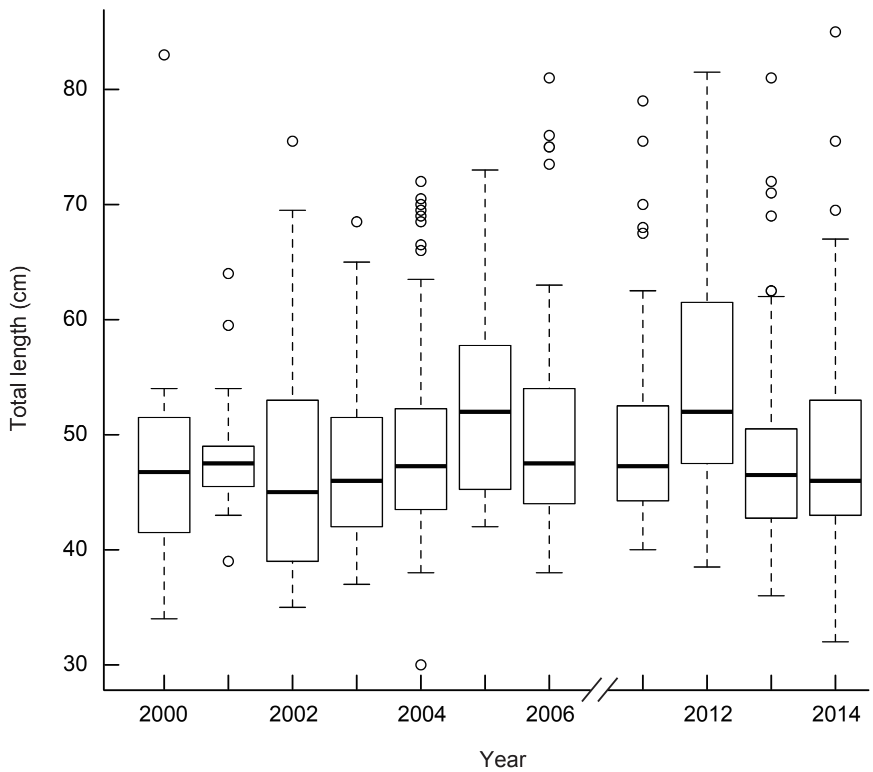
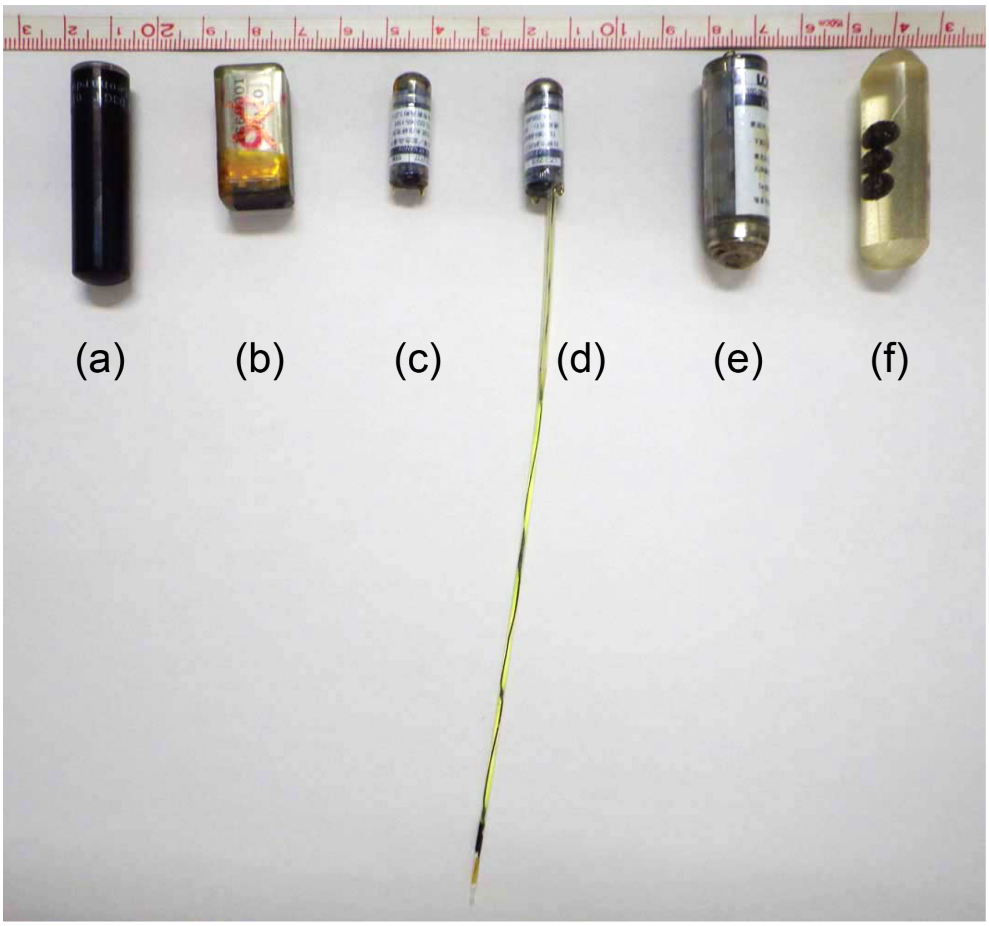


Fig. 3 Annual variation in total length of collected *L. latus* (data collated for April - March). The approximate 95% confidence range is indicated by the vertical line, the 25 - 75% range by box height, and the median by the thick horizontal line in each box. Open circles are outliers.

individuals varied significantly among years (Fig. 3, Kruskal Wallis test, $P < 0.05$). There was, however, neither an increasing nor a decreasing trend with time (Spearman rank correlation, $P > 0.05$).

Dummy tags which simulate the cylindrical shape and size of bio-logging devices (Fig. 4) were attached to individuals of *L. latus* collected between October 2013 to October 2014. Specimens collected by line fishing were immediately brought back to the laboratory and kept in 0.8 ton tank with running seawater before the tagging treatment and release. The dummy tag was attached to 23 individuals (total size ranging 36 - 69 cm TL), using two common methods (external and internal, see below). For pros and cons of these methods and their effects on fish, see Mellas & Haynes (1985), Bridger & Booth (2003), Mitamura *et al*. (2006), Makiguchi & Ueda (2009). The tag was small enough for fish individuals (< 2% of total weight), except for the smallest (2.7%; TL 36 cm; W 470 g). External attachment was employed in 20 individuals and internal implantation in 3. For the former, two small holes (approximately 2 mm in diameter) were drilled into their dorsal musculature below the first dorsal fin. The logger (diameter ca. 13.5 mm, length ca. 55-60 mm, and weight ca. 13-14 g) was attached using two plastic cables that passed through the holes and was set on the left side of the body. In internal implantation, two dummy tags (diameter ca. 13 mm, length ca. 25 mm, and weight ca. 5 g for each) were surgically implanted into the abdominal cavity of fish. An incision of ca. 15 mm in length was made in the abdomen of the fish and the logger inserted. The wound was closed with a surgical needle and suture. The surgically implanted specimens were also marked with the spaghetti tag below the second dorsal fin. Fish individuals

Fig. 4 Examples of bio-logging devices (a-e) and the dummy tag used in the present study (f). (a), three-axis accelerometer/water temperature/depth data logger (ORI400-D3GT, Little Leonard); (b), three-axis gyroscope/accelerometer data logger (LP-BLKU02, Biologging Solutions Inc.); (c), water temperature/depth/illuminometer data logger (LAT2900, Lotek); (d), logger (c) with sensor cable; (e), water temperature/depth data logger (LAT1800, Lotek); (f), dummy tag.



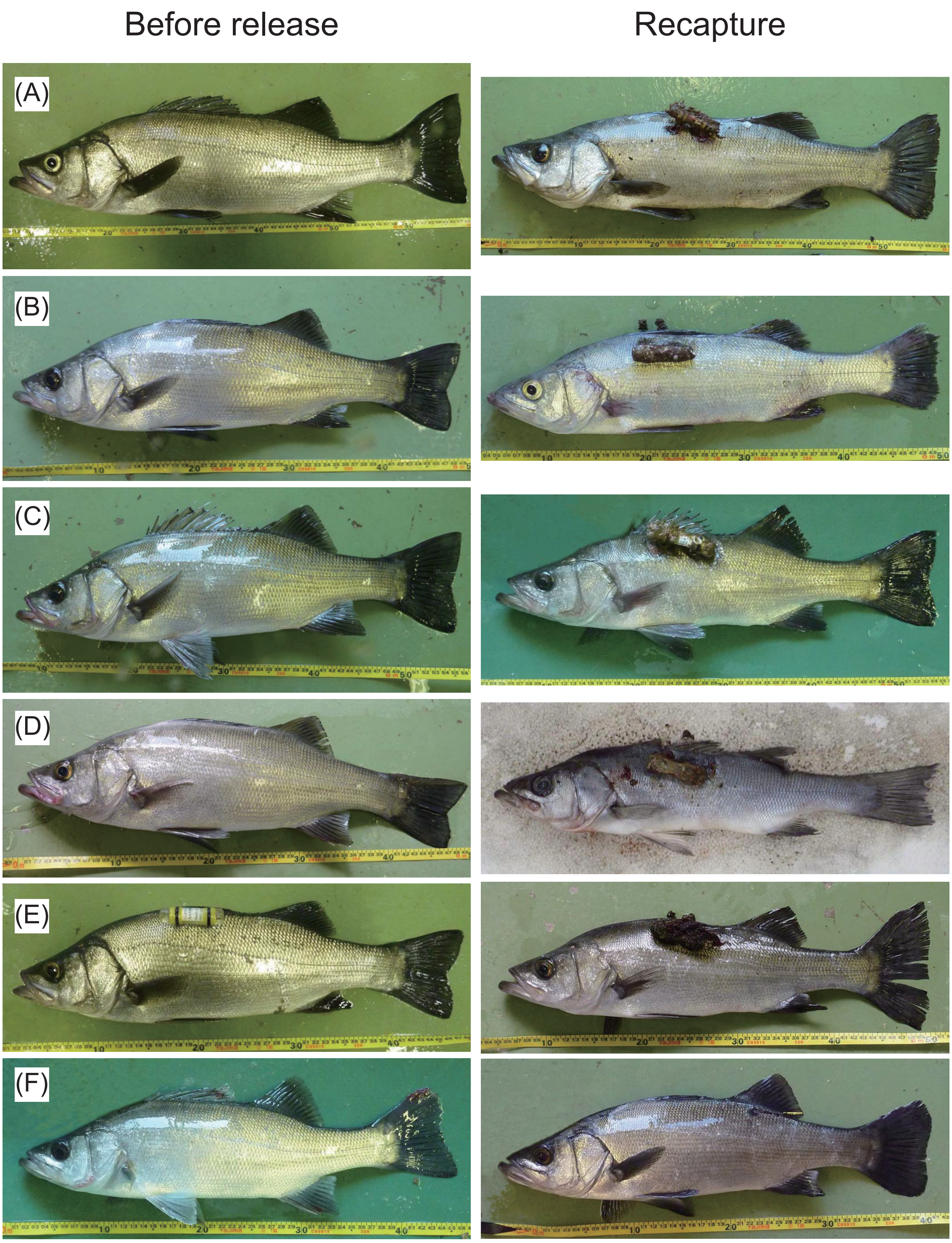


Fig. 5 Recaptured *Lateolabrax latus* individuals before tagging (left) and at the time of recapture (right). Panel labels correspond with Table 1. All photographs were taken under live conditions, except for the recaptured individual D as frozen sample.

Table 1. Measurements of recaptured fish individuals. Size refers to fork length (FL) and wet weight (W).

Fish	Tag type	Size before release		Change in size		Recapture		
		FL (cm)	W (g)	(cm)	(g)	distance moved (km)	time after release (days)	method
A	external	59.5	1990	0	-390	0.3	179	line fishing
B	external	45.5	1020	0.5	-260	6.0	321	set net
C	external	48.5	1240	1.0	-70	1.8	352	gill net
D	external	47.5	1180	-0.5	-550	1.8	368	gill net
E	external	44.5	950	0.5	-140	5.1	387	set net
F	internal	44.0	850	1.5	50	1.6	156	line fishing

were anesthetized under 2-phenoxiethanol solution during both attachment procedures. After attachment operation, tagged individuals were placed back in the stock aquarium for recovery and released at the same point of collection within a couple of days. There were no observable effects of tagging on all specimens. Information of recaptured individuals was obtained from both line fishing collection and fisheries.

In total, six (5 external and 1 internal) out of 23 tagged individuals were recaptured during 1.5 years (Fig. 5, Table 1). Two individuals were caught by each of three collection methods: line fishing, gill nets, and fixed nets. Periods to recapture ranged from 156 days to 387 days. In terms of body length, individuals tagged by the external method did not grow much compared with surgically implanted ones. All tagged individuals tended to lose weight with individual

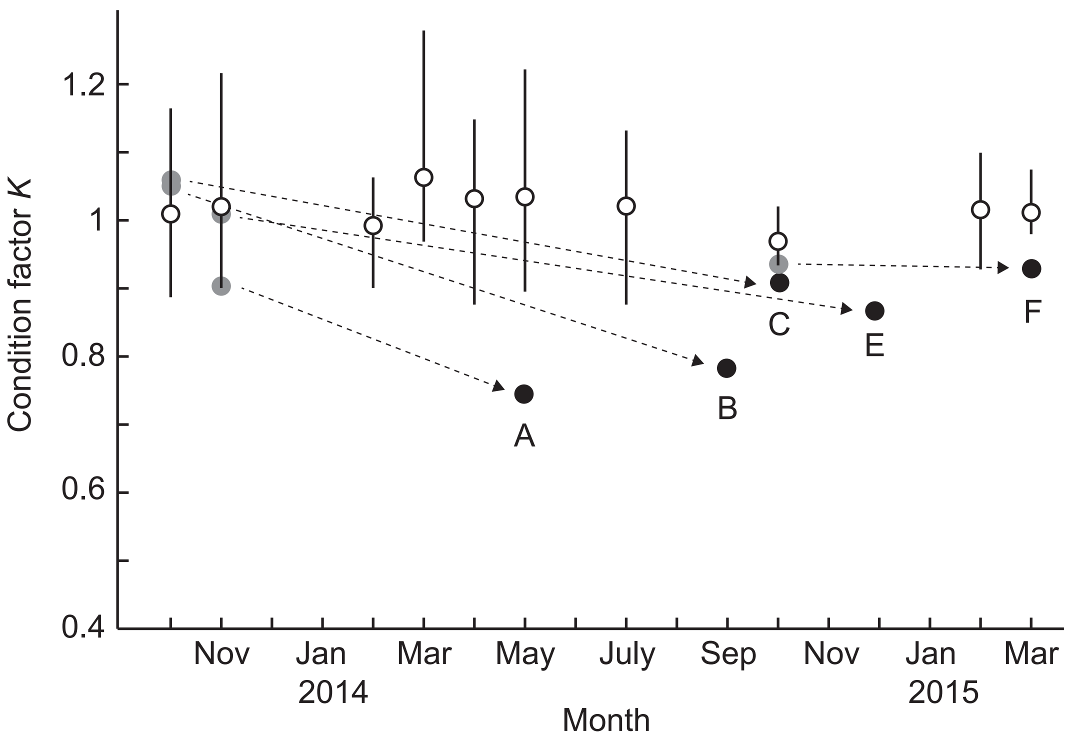


Fig. 6 Fulton's condition factor (*K*). Open circles and vertical lines denote mean and range (max-min), respectively, for individuals collected by line fishing. The values from tagged individuals were shown as filled circles: grey (at the time of release), black (at the time of recapture). Dotted arrows indicate the same individuals. Alphabet labels correspond with Table 1.

variations. Inflammation was observed in the body part where the external tag was attached. In the case of the surgically treated individuals, there was no obvious damage in the part of suturing and the implanted tag seemed to remain in the abdominal cavity. In all tagged individuals, the tail fin (especially its lower tip) was slightly damaged; recovery from damage of the upper tip of the fin was also observed in individual F (Fig. 5). In the case of individual B, relatively heavy damages were observed on all fins and body surfaces, probably due to capture by fixed net and storage in a tank for a few days. Individual D had deteriorated appearance because the specimen was kept for weeks in the freezer before a photograph was taken. Externally attached tags, including both the dummy and the spaghetti tags, were covered by sessile organisms (algae, barnacles, etc.).

To compare fish conditions between natural and tagged individuals, Fulton's condition factor (K) was calculated,

$$K = 100 \text{ x } W \text{ x } TL^{-3}$$

where W is the whole body weight (g) and TL is the total length (cm). For the natural individuals, data from the line fishing collection was applied for the calculation. Individual D was excluded from this analysis due to being a non-fresh specimen (i.e. frozen and dry). Values of the condition factor were smaller in recaptured individuals compared with those of natural individuals caught on same/similar occasions (Fig. 6). Except for the surgically implanted individuals, all recaptured individuals had a lower condition factor after recapture in comparison to before release.

The population size (N) of *L. latus* in the study area was estimated using cumulative capture values, assuming a simple closed system for ease of calculation.

$$N_t = n_t R_{t\text{-}1} / r_t$$

where n_t is the cumulative number of collected individuals in month t. $R_{t\text{-}1}$ is the cumulative number of tagged individuals in month t-1 and r_t the cumulative number of recaptured individuals in month t. Calculation was conducted (i) separately for line fishing and fisheries data, and (ii) in combination. The extent of collection area covered by each method was also estimated on the map using imaging software (Image J 1.46), within shallow waters (< 10 m at low tide time) where the species is known to be concentrated (Fig. 1). Fisheries grounds under the control of the local fisherman's cooperative were taken as the potential

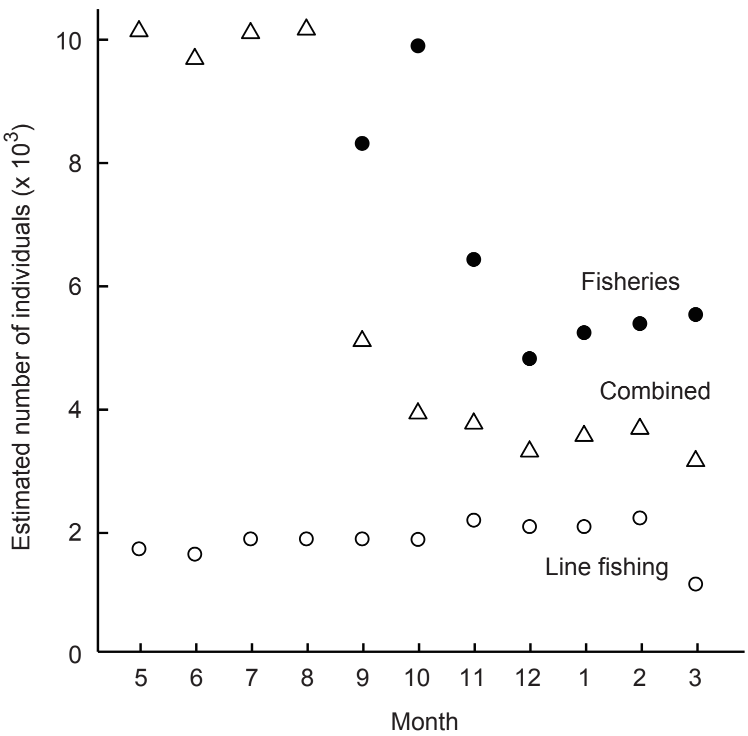


Fig. 7 Estimated number of *L. latus* individuals in the local population. The values were separately calculated for fisheries data (filled circles), line fishing (open circles), and combined data (triangles) by month.

Table 2. Local population estimation of *L. latus*. Values based on the most recent (March 2015) data.

Data base	Population estimation	
	number of individuals	density (number km^{-2})
line fishing	1150	441
fisheries	5513	439
combined	3140	250

collection area, excluding the area around the power station. In the case of line fishing, all sites visited for collection were included in the estimated range. Thus, the potential collection areas for fisheries and line fishing were estimated as 12.6 km^2 and 2.6 km^2, respectively (the former included all of the latter).

Estimated population size appeared to reach a more or less stable level with an increasing cumulative number of recaptured individuals (Fig. 7). Estimated numbers incorporating all recaptures were 5513, 1150, and 3140 based on the fisheries data, the line fishing data, and combined data, respectively (Table 2). When standardized as density based on coverage areas, these yielded similar values: 439 individuals km^{-2} (fisheries netting), 441 (line-fishing) and 250 (combined).

In the present study, a high recapture rate was attained (ca. 26%) with all individuals passing 150 days (> 320 days in four out of six individuals) since release, which gives support to the applicability of bio-logging techniques to this species. This suggests that irrespective of tagging methods tagged fish can survive in nature long enough to allow bio-logging observations. The observed recapture rate is higher than the values previously reported for various fishes, including 1.8% for *L. latus* during 1985 - 2012 (JGFA 2015). The difference was probably due to variation in tag retention time. The external tag in the present study was difficult to be removed from fish body compared with the spaghetti and dart tags that simply hooked in muscle tissue.

While different attachment methods could be employed for long-term bio-logging observations, surgical implantation may be best for maintaining better fish conditions. The fact that all externally tagged individuals had a reduced body weight is a clear indication of the negative effects of tagging, such as increased drag, loss of balance and abrasion through friction between the skin and the logger (see Mellas & Haynes 1985; Bridger & Booth 2003; Mitamura *et al*. 2006; Makiguchi & Ueda 2009). Nevertheless, it is important to minimize such negative impacts and maximize the quality of information obtained through a bio-logging approach. In the present study, the dummy tag imitated the maximum size of

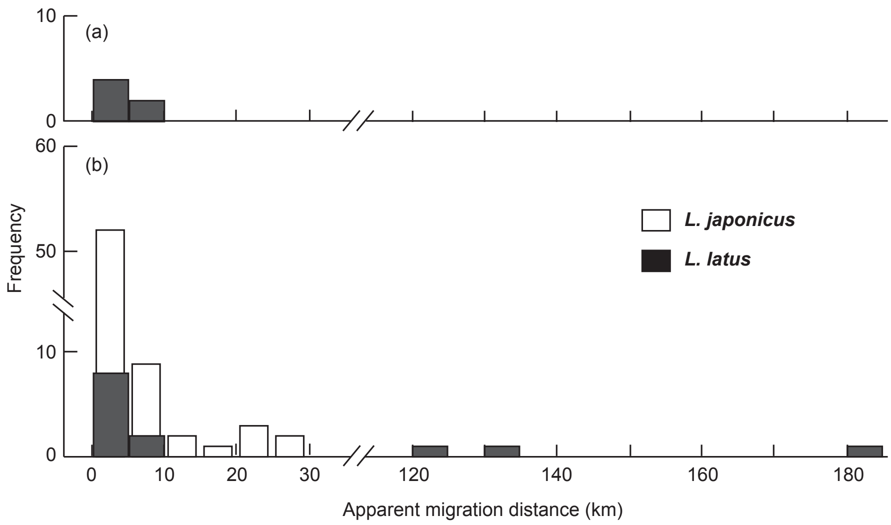


Fig. 8 Frequency distribution of movement distances in *L. latus* (filled bars), data from (a) the present study, (b) the JGFA, including data for *L. japonicus* (open bars).

candidate tags (cf. Fig. 4). Therefore, the observed negative influences of dummy tag were considered as maximal. External attachment still has considerable advantages such as in measuring fish locomotion by a speed sensor or accelerometer, measuring the physical characteristics of surrounding environments, and in increasing the detectability of tagged individuals by fishermen, while surgical implantation seemed to be advantageous in terms of fish conditions.

The estimated local population size of *L. latus* was considered modest, with the density of ca. 450 individuals km^{-2}. Given the fact that over 450 individuals were captured by commercial fisheries in a year and a further unknown number is being caught by recreational fishers, the species is clearly exposed to a high fishing pressure, roughly estimated to be a minimum of 10% of the local population. This necessitates a continuous observation in order to assess its population trends.

In relation to the population size assessment, migration ability is also worth noting. In this study, apparent migration distance was measured on a map as the minimum distance between the release and the catch point using imaging software (Image J 1.46). Most of the tagged individuals of *L. latus* were recaptured within 2 km and long distance dispersion (> 6 km) has not been observed (Fig. 8a). A similar pattern was also recognized in the JGFA data: 10 individuals out of 14 were recaptured within 5 km (Fig. 8b). Interestingly, other 4 individuals moved over 55 km with a maximum of 180 km. A congener *L. japonicus* also had a tendency of short-distance migration (< 5 km, 52/69 individuals). In contrast to *L. latus*, *L. japonicus* showed middle-distance movements (≤ 30 km, 17/69 individuals) but never a long-distance migration (> 30 km). In both species, some individuals seemed to migrate or disperse relatively longer distances, the tendency being more conspicuous in *L. latus* than in *L. japonicus*. There was no significant correlation between the apparent distance and time of day for recapture (Spearman rank correlation, $P > 0.05$). All these results suggest that most individuals of *Lateolabrax* spp. tend to utilize a particular area with only a limited range of migration. Thus, *L. latus* individuals seemed to have high site fidelity and a local population may consist of limited members with few exchanges among different local populations.

Though based on limited data, our result apparently point to severe negative influences of human activities on the local *L. latus* population. As a species with high commercial and recreational value and of ecological importance in coastal ecosystems, further research on its current status is urgently needed in order to implement appropriate measures for its conservation and management.

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Forum papers are intended for stimulating discussion and research. Though limited in scale, this forum paper hopefully contributes towards further development in bio-logging research.