# Population dynamics of *Stolephorus dubiosus* in Bay Hap and Cua Lon estuaries, Mekong Delta, Vietnam

[1]Dinh D. Tran, [1]Vang T. Nguyen, [2]Quang M. Dinh

[1] Department of Fisheries Management and Economics, College of Aquaculture and Fisheries, Can Tho University, Can Tho, Vietnam; [2] Department of Biology, School of Education, Can Tho University, Can Tho, Vietnam. Corresponding author: Q. M. Dinh, dmquang@ctu.edu.vn

**Abstract**. This study provided information on population dynamics of *Stolephorus dubiosus*, a commercial fish in the Mekong Delta, Vietnam. Data analysis results of 19,356 individuals collected bimonthly from August 2017 to June 2019 (14,113 individuals in Bay Hap (BH) and 8,243 individuals in Cua Lon (CL)) showed that $L_\infty$ of these two populations was 8.4 cm, the $K$ value in BH (0.88 $yr^{-1}$) was higher than that in CL (0.59 $yr^{-1}$). Likewise, the $t_0$ values were −0.39 $yr^{-1}$ in CL and −0.26 $yr^{-1}$ in BH. The fishing (2.40 $yr^{-1}$), natural (1.85 $yr^{-1}$) and total mortalities (3.63 $yr^{-1}$) in BH were also higher than those in CL which were 1.85 $yr^{-1}$, 0.38 $yr^{-1}$ and 2.23 $yr^{-1}$ respectively, leading to the lower in the longevity of the former population ($t_{max}$=3.41 yr) compared to the later one ($t_{max}$=5.08 yr). Its growth performance was 1.79 in BH and 1.62 in CL. Both these two populations had two recruitment peaks, but the recruitment time of the CL population (mid of May and late August) was one month later compared to BH population (mid of April and late July). Albeit the exploitation rate of the BH population ($E$=0.34) was higher than that of the CL population ($E$=0.17), they had not been subjected to overfishing as these exploitation rates were lower than $E_{0.5}$ (0.358 in BH and 0.354 in CL). The length at first capture was 3.9 cm in BH and 3.8 cm in CL. The fisherman should avoid catching *S. dubiosus* during the recruitment period for sustainable fishery management.
**Key Words**: exploitation rate, mortality, growth, recruitment, coastal areas.

**Introduction**. Fishery management is strongly related to the exploitation rate estimated from the yield-per-recruit analysis (Al-Husaini et al 2002). The growth parameters and mortality rates are also related to fish population biology assessment (Amezcua et al 2006). The variations of fish growth rate between locations are also related to the growth performance that was calculated from growth and asymptotic length relationship (Pauly & Munro 1984). However, the knowledge of fish population dynamics, especially anchovy species in the Mekong Delta, where fish species diversifies (Tran et al 2013), is little known.

Thai anchovy *Stolephorus dubiosus* is one of 20 species of the genus *Stolephorus* (Engraulidae) in the world (Froese & Pauly 2019) and six in Vietnam (Le & Vo 2013). This species distributes widely from Eastern Indian Ocean (northern part of Bay of Bengal) to Western Pacific (the Gulf of Thailand, the Java Sea to at least Kalimantan) (Froese & Pauly 2019) and along the coastal and marine regions in Vietnam from northern to southern (Le & Vo 2013; Tran et al 2013). This anchovy lives even in the riverine area in the Mekong Delta, Vietnam (Nguyen 2005; Tran et al 2013; Nguyen & Pham 2017; Tong et al 2019; Tran & Hong 2019). This species is a commercial fish and has been used as a mains source for fish sauce and dried fish production, but there is no information on the population dynamics of this species, especially in the Mekong Delta, where the CPUE of this species decrease (Van 2016). Therefore, this study aims to gather knowledge on the biological parameters of the fish populations to improve its stock and fishery management.

## Material and Method

***Study site, fish collection and analysis***. This study was conducted along with Bay Hap (BH) and Cua Lon (CL) riverine system from estuary to midstream in Ca Mau Province, Vietnam, from August 2017 to June 2019. In the dry season (December–May), no rain but on the wet season (June-November), heavy rain with roughly 400 mm of precipitation per month. The mean annual temperature in these regions is ~29°C.

Fish specimens were collected every two months using the push net (6.0 m in mouth width, 1.2 m in mouth height, and 1.8 cm in mesh size) at 12 sampling sites in BH and CL. Samples were collected during the spring tide from Cha La (1, 08°55'59.7"N, 105°05'52.4"E) to Dam Cung (2, 08°51'29.5"N, 104°01'25.3"E), Rach Cheo (3, 08°47'58.5"N, 104°53'54.7"E), Bay Hap (4, 08°47'28"N, 104°52'20.9"E), right bank of Bay Hap (5, 08°46'47.5"N, 104°50'35.1"E) and left bank of Bay Hap (6, 08°45'31.7"N, 104°50'44.6"E) in BH. Likewise, fish specimens were also caught from Sa Pho (7, 08°44'37"N, 105°58'19,2"E) to Nhung Mien (8, 08°41'37.8"N, 104°55'28"E), Ong Trang 1 (9, 08°41'36.8"N, 104°51'23.6"E), Ong Trang 2 (10, 08°45'45.9"N, 104°50'53.2"E), right bank of Ong Trang (11, 08°43'44.4"N, 104°49'12.3"E) and left bank of Ong Trang (12, 08°42'39.6"N, 104°49'24.4"E) in CL. The fish specimens were measured standard length (SL) to the nearest 0.1 cm. The environmental factors, including temperature, pH, salinity, water depth, water clarity, and flow rate, were also recorded simultaneously with the fish collection. These values were then used to examine the relationship between them and population biological parameters of two fish populations in BH and CL.

***Data analysis***. The differences in temperature, pH, salinity, water depth, water clarity, and flow rate between two ecological regions (BH and CL) and the seasons (dry and wet) were confirmed by t-test, and months were performed by one-way ANOVA. The interaction of ecological variables influenced the changes in temperature, pH, salinity, water depth, water clarity, and the flow rate was also confirmed by two-way ANOVA. All tests were set in a meaningful value of 5%, and the SPSS v.21 was used to perform these tests.

Data on length frequency of this species was analyzed by using FiSAT II software to estimate its population parameters (Gayanilo et al 2005). Both growth parameter ($K$) and asymptotic length ($L_\infty$) were estimated from The ELEFAN I (Pauly & David 1981; Pauly 1982, 1987). The total mortality rate ($Z$) was quantified by using the length-converted capture curve (Beverton & Holt 1957; Ricker 1975). The theoretical age parameter ($t_0$) was calculated from the equation $\log_{10}(-t_0) = -0.3922 - 0.2752 \log_{10} L_\infty - 1.038 \log_{10} K$ (Pauly 1979). The equation $\mathrm{Log}M = -0.0066 - 0.279\mathrm{Log}L_\infty + 0.6543\mathrm{Log}K + 0.463\mathrm{Log}T$ ($T$ is the mean annual water temperature (°C) in the studied site) was applied to estimate the natural mortality rate ($M$) (Pauly 1980). Thereafter, the fishing mortality ($F$) was calculated as $F = Z - M$, and the exploitation rate ($E$) was determined from equation $E = F/Z$ (Ricker 1975).

The probability of capturing for each of the sizes and the seasonal recruitment pattern were estimated using the length-converted catch. The length at first capture ($L_c$) was computed by plotting the cumulative probability of capture against the class mid-length (Pauly 1987). The current status of the fish stock was estimated from the yield-per-recruit model of Beverton & Holt (1957) (Sparre & Venema 1992). The knife-edge selection was performed to evaluate the maximum yield exploitation rate ($E_{max}$), the fishing rate with a minimal increase of 10% of $Y'/R$ ($E_{0.1}$) and the fishing rate with stock reduction of 50% ($E_{0.5}$) (Beverton & Holt 1966). The combined analysis of $E$ and isopleth ratio ($L_c/L_\infty$) was used to determine the fishing status rely on the method of Pauly & Soriano (1986). The growth performance was determined from the equation $\Phi' = \mathrm{Log}K + 2\mathrm{Log}L_\infty$ (Pauly & Munro 1984). The longevity ($t_{max}$) of *S. dubiosus* was calculated as $t_{max} = \frac{3}{K}$ (Taylor 1958; Pauly 1980).

**Results**

***Environmental factors***. The temperature in BH (29.60±0.25 SE°C, n=72) was not significant different from that in CL (29.36±0.26 SE°C, n=72, t-test, t=0.91, df=142, *P*>0.05). In BH, pH (8.05±0.05, n=72) water flow rate (20.53±5.96 SE, n=72) and water clarity (19.89±1.35 SE, n=72) were similar to those in CL which were 8.04±0.05 SE (n=72), 27.52±13.26 SE (n=72), 22.48±1.43 SE (n=72), respectively (df=142, *P*>0,05 for all cases). By contrast, in BH, the salinity (25.89±0.47 SE, n=72) and water depth (2.53±0.18 m, n=72) were significantly higher than those in CL which were 23.31±0.74 (n=72) and 1.13±0.12 (n=72), respectively (df=142, *P*<0.05 for all cases). The change of the salinity in BH and CL was regulated by dry and wet seasons (two-way ANOVA, F=5.54, *P*<0.05). Whereas, the variations of temperature, pH, water flow rate, water clarity, and water depth between BH and CL were not regulated by seasonal changes (*P*>0.05 for all cases).

The variations of salinity, pH, temperature, water flow rate, water clarity, and depth are presented in Table 1. Accordingly, the salinity reached a high point during the dry season, especially in the late dry season of April 2018 and April 2019. In contrast, pH, temperature, and water clarity showed a reverse trend, with high values record in months of the wet season. The water flow rate reached the highest value in October 2017 (231.14±61.70 SE) as compared to other months, where the water depth showed a similar trend amongst the 12 allocations of time.

***Population parameters***. The length-frequency analysis of 19,356 individuals (14,113 individuals in BH and 8,243 individuals in CL, Table 2) showed that >80% of the fish was caught between 2.0-5.0 cm at TL (11,894 individuals in BH and 6,644 individuals in CL, Figure 1) and very few fish were caught at TL <1-2 cm and >5 cm. Most *S. dubiosus* found during the wet season, both in BH and CL regions, were as shown in Figure 2. There were four to five cohorts of *S. dubiosus* BH and CL populations, respectively, i.e., the growth curves represented by blue lines (Figure 1). As the slight slope in the larger cohort compared to the smaller cohort, the small fish grew faster than the bigger one. The analysis of growth increment data obtained from ELEFAN procedure showed that the von Bertalanffy growth curve of *S. dubiosus* was $L_t = 8.4\left(1 - e^{-0.88(t+0.26)}\right)$ for BH and $L_t = 8.4\left(1 - e^{-0.59(t+0.39)}\right)$ for CL (Figure 3).

The total, natural, and fishing mortalities of *S. dubiosus* were 3.63, 2.40, and 1.85 in BH and 2.23, 1.85, and 0.36 in BH, respectively, based on the length-converted catch curve analysis (Figure 4). Although both BH and CL population, they had two recruitment peaks, the recruitment time of the CL population (mid of May and late August) was a month later as compared to BH one (mid of April and late July, Figure 5). This fish was firstly caught ($L_c$ or $L_{50}$) at 3.9 cm (TL) in BH and 3.8 cm in CL (Figure 6).

The exploitation rates of *S. dubiosus* in BH (*E*=0.34) was double in CL (*E*=0.17), but these two populations had not subjected to overfishing as these values were lower than that of the biomass reduction of 50% ($E_{50}$). The yield-per-recruit and biomass-per-recruit analysis of *S. dubiosus* showed the optimum yield ($E_{0.1}$ was 0.556 in BH and 0.500 in CL). This yield at the stock reduces 50% ($E_{0.5}$was 0.358 in BH and 354 in CL) and at the maximum sustainable yield ($E_{max}$ was 0.637 in BH and 0.622 in CL, Figure 7). The yield isopleths of this fish was 0.46 in BH and 0.45 in CL. Its growth performance ($\Phi'$) was 1.79 in BH and 1.62 in CL, and the longevity was 3.41 yr in BH and 5.08 yr in CL.

Table 1

The variations of environmental factors between sampling times based on one-way ANOVA

| *Environmental factors* | | *Aug 17* | *Oct 17* | *Dec 17* | *Feb 18* | *Apr 18* | *Jun 18* | *Aug 18* | *Oct 18* | *Dec 18* | *Feb 19* | *Apr 19* | *Jun 19* | *Total* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *n* | | *12* | *12* | *12* | *12* | *12* | *12* | *12* | *12* | *12* | *12* | *12* | *12* | *144* |
| Salinity (F=16.21, *P*<0.001) | Mean | $26.92^{d,e}$ | $16.92^{a}$ | $21.08^{a,b,c}$ | $27.58^{e}$ | $28.50^{e}$ | $28.00^{e}$ | $22.00^{b,c,d}$ | $17.25^{a,b}$ | $26.67^{d,e}$ | $25.83^{c,d,e}$ | $28.83^{e}$ | $25.67^{c,d,e}$ | 24.60 |
| | SE | 1.60 | 2.04 | 0.92 | 0.53 | 0.53 | 0.54 | 1.68 | 0.63 | 0.89 | 0.68 | 0.58 | 0.33 | 0.45 |
| pH (F=29.82, *P*<0.001) | Mean | $7.97^{c,d}$ | $7.54^{a}$ | $7.62^{a,b}$ | $7.95^{c,d}$ | $7.94^{b,c,d}$ | $7.70^{a,b,c}$ | $8.13^{d}$ | $8.00^{c,d}$ | $7.99^{c,d}$ | $8.22^{d}$ | $8.65^{e}$ | $8.83^{e}$ | 8.05 |
| | SE | 0.05 | 0.03 | 0.04 | 0.03 | 0.05 | 0.07 | 0.06 | 0.19 | 0.04 | 0.04 | 0.03 | 0.03 | 0.04 |
| Temperature (F=11.00, *P*<0.001) | Mean | $29.62^{b,c,d}$ | $30.40^{c,d,e}$ | $28.68^{a,b,c}$ | $26.73^{a}$ | $28.38^{a,b,c}$ | $28.88^{a,b,c}$ | $29.32^{b,c,d}$ | $28.08^{a,b}$ | 30.00 | $30.13^{b,c,d}$ | $31.46^{d,e}$ | $32.57^{e}$ | 29.52 |
| | SE | 0.25 | 0.66 | 0.27 | 0.21 | 0.27 | 0.53 | 0.46 | 0.77 | 0.26 | 0.41 | 0.70 | 0.40 | 0.18 |
| Water flow rate (F=13.34, *P*<0.001) | Mean | $2.73^{a}$ | $231.14^{b}$ | $19.17^{a}$ | $24.3^{a}$ | $0.67^{a}$ | $0.57^{a}$ | $2.38^{a}$ | $1.81^{a}$ | $1.08^{a}$ | $2.86^{a}$ | $1.40^{a}$ | $0.22^{a}$ | 24.03 |
| | SE | 1.36 | 61.70 | 4.83 | 7.04 | 0.20 | 0.13 | 0.59 | 0.49 | 0.51 | 0.60 | 0.46 | 0.14 | 7.25 |
| Water clarity (F=2.77, *P*<0.05) | Mean | $25.21^{a,b}$ | $18.05^{a,b}$ | $19.63^{a,b}$ | $12.38^{a}$ | $19.00^{a,b}$ | $17.79^{a}$ | $17.08^{a}$ | $20.00^{a,b}$ | $24.04^{a,b}$ | $22.81^{a,b}$ | $24.94^{a,b}$ | $33.33^{b}$ | 21.19 |
| | SE | 3.02 | 2.87 | 4.65 | 2.88 | 2.88 | 2.35 | 2.06 | 1.85 | 2.67 | 4.68 | 4.26 | 2.72 | 0.99 |
| Water depth (F=0.34, *P*>0.05) | Mean | $2.03^{a}$ | $1.50^{a}$ | $2.09^{a}$ | $1.60^{a}$ | $1.91^{a}$ | $1.86^{a}$ | $1.43^{a}$ | $1.55^{a}$ | $1.87^{a}$ | $2.23^{a}$ | $1.92^{a}$ | $1.97^{a}$ | 1.83 |
| | SE | 0.52 | 0.32 | 0.44 | 0.31 | 0.43 | 0.35 | 0.30 | 0.35 | 0.53 | 0.50 | 0.47 | 0.61 | 0.12 |

Different letters (a, b, c, d, and e) in each environmental factor showed a significant difference between sampling time.

Table 2

The number of *Stolephorus dubiosus* collected from the study site

| Fish size | Aug-17 | | Oct-17 | | Dec-17 | | Feb-18 | | Apr-18 | | Jun-18 | | Aug-18 | | Oct-18 | | Dec-18 | | Feb-19 | | Apr-19 | | Jun-19 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *(TL, cm)* | *BH* | *CL* | *BH* | *CL* | *BH* | *CL* | *BH* | *CL* | *BH* | *CL* | *BH* | *CL* | *BH* | *CL* | *BH* | *CL* | *BH* | *CL* | *BH* | *CL* | *BH* | *CL* | *BH* | *CL* |
| 0-1 | | | | | | 1 | 2 | | | 1 | 1 | | | | | 3 | 48 | | | 2 | | | | |
| 1-2 | 6 | 7 | 62 | 1 | 38 | 136 | 332 | 3 | 111 | 23 | 28 | 30 | | | 15 | 30 | 341 | 230 | 6 | 21 | 19 | 30 | 28 | 12 |
| 2-3 | 74 | 109 | 137 | 5 | 742 | 190 | 913 | 11 | 96 | 125 | 177 | 217 | 63 | 10 | 93 | 3 | 1419 | 393 | 64 | 46 | 130 | 522 | 117 | 12 |
| 3-4 | 502 | 987 | 45 | 56 | 869 | 58 | 1538 | 42 | 109 | 156 | 202 | 277 | 134 | 90 | 95 | 6 | 494 | 307 | 104 | 197 | 97 | 208 | 244 | 439 |
| 4-5 | 199 | 453 | 229 | 541 | 252 | 34 | 516 | 70 | 94 | 85 | 258 | 247 | 823 | 150 | 141 | 41 | 224 | 44 | 173 | 210 | 170 | 181 | 157 | 122 |
| 5-6 | 10 | 105 | 66 | 100 | 352 | 36 | 135 | 30 | 36 | 33 | 80 | 104 | 102 | 79 | 122 | 88 | 40 | 23 | 52 | 43 | 159 | 198 | 18 | 33 |
| 6-7 | 1 | 25 | 1 | 15 | 44 | 14 | 19 | 1 | 4 | 7 | 6 | 26 | | 20 | 102 | 23 | 19 | 18 | | 2 | 4 | 38 | 3 | 5 |
| 7-8 | | | 2 | | | | 2 | | | | | | | | | | 3 | | | | | 3 | | |
| Total | 792 | 1,686 | 542 | 718 | 2,297 | 469 | 3,457 | 157 | 450 | 430 | 752 | 901 | 1,122 | 349 | 568 | 194 | 2,588 | 1,015 | 399 | 521 | 579 | 1,180 | 567 | 623 |

BH: Bay Hap river, CL: Cua Lon river.

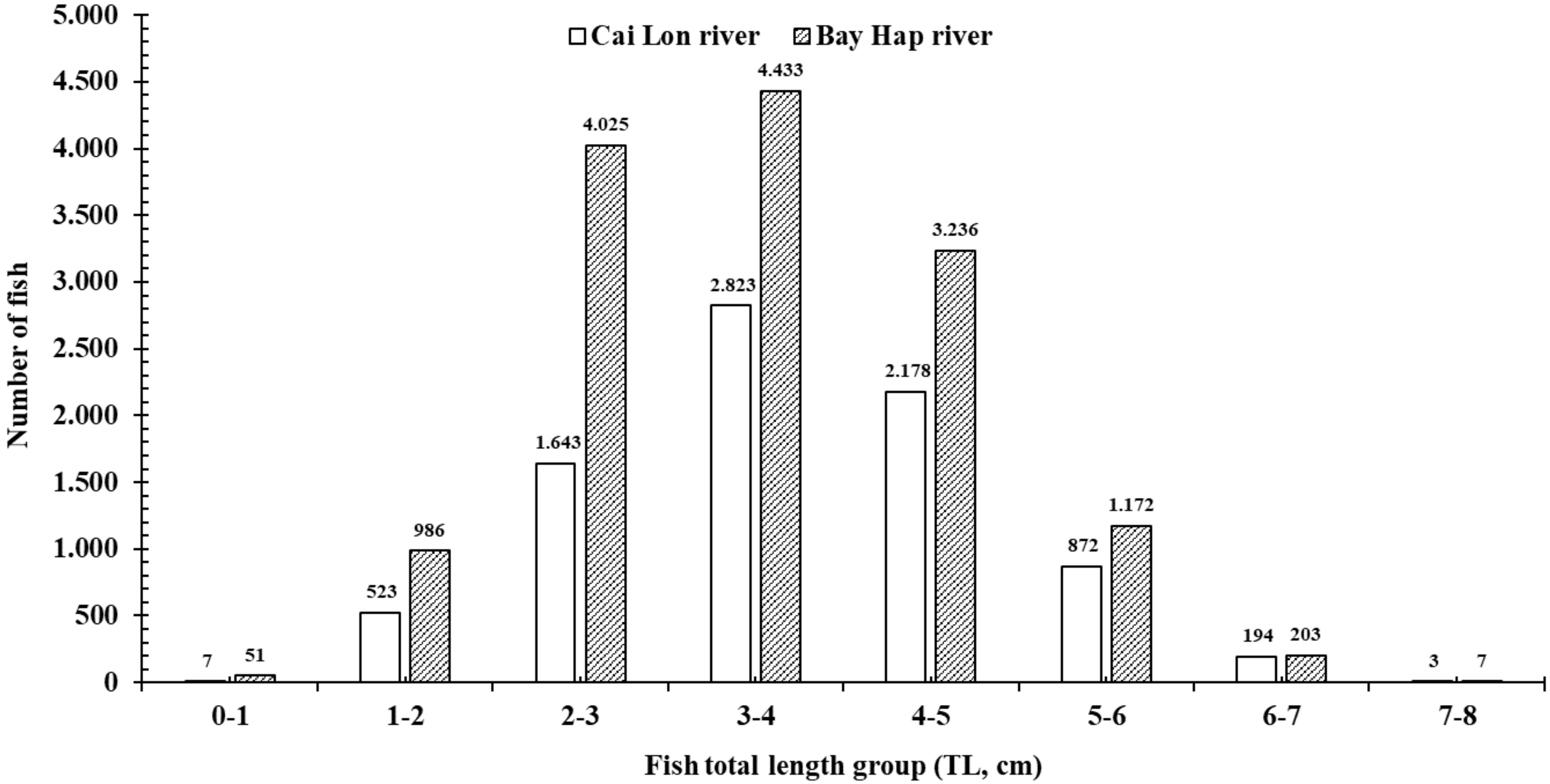


Figure 1. Number of *Stolephorus dubiosus* caught at two ecological regions according to fish size.

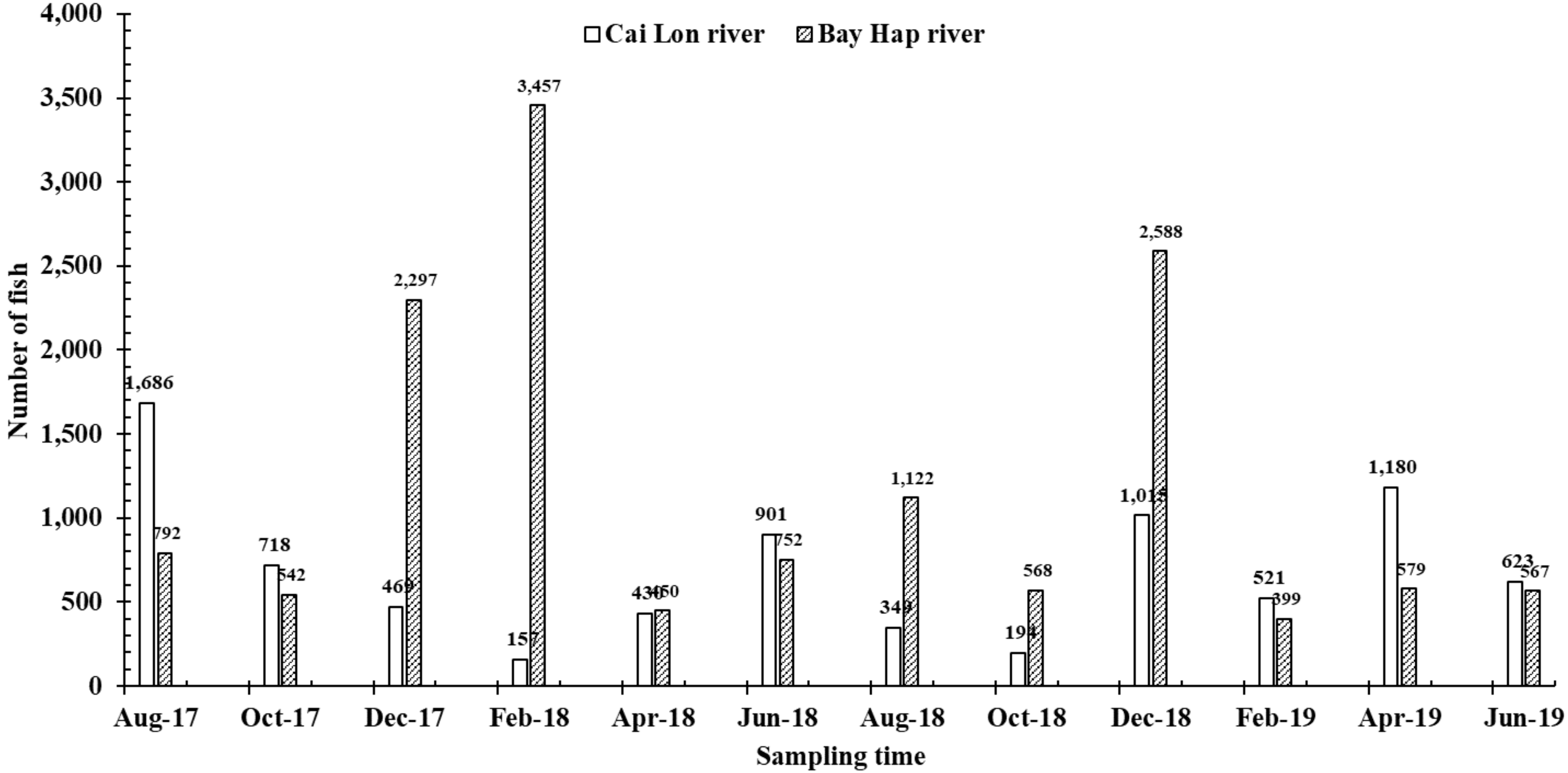


Figure 2. Number of *Stolephorus dubiosus* caught at two ecological regions according to sampling times.

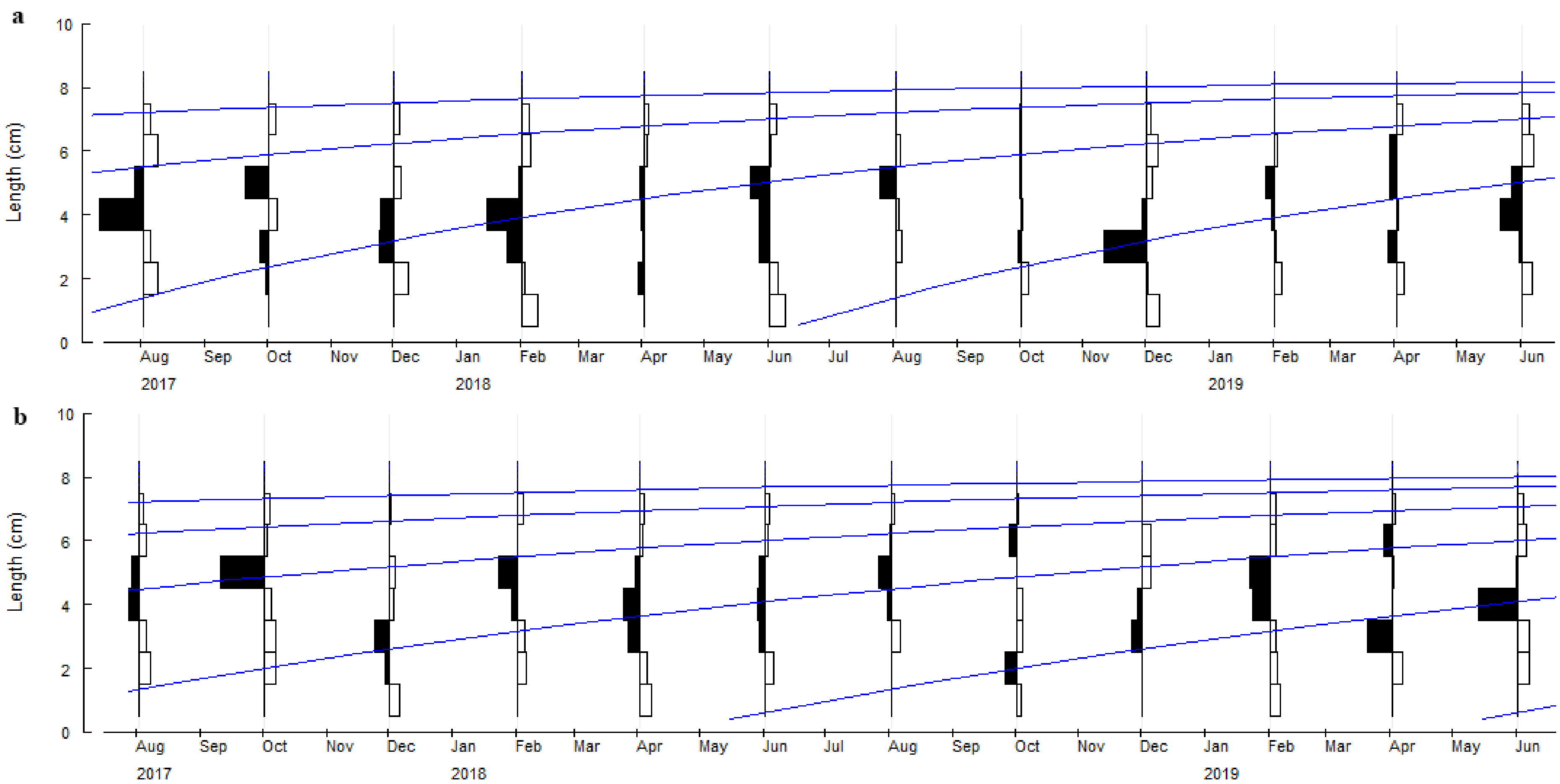


Figure 3. Length-frequency distribution of *Stolephorus dubiosus* in Bay Hap river (a, n = 14,113) and in Cua Lon river (b, n = 8,243). The curves represent the fish length increase over time.

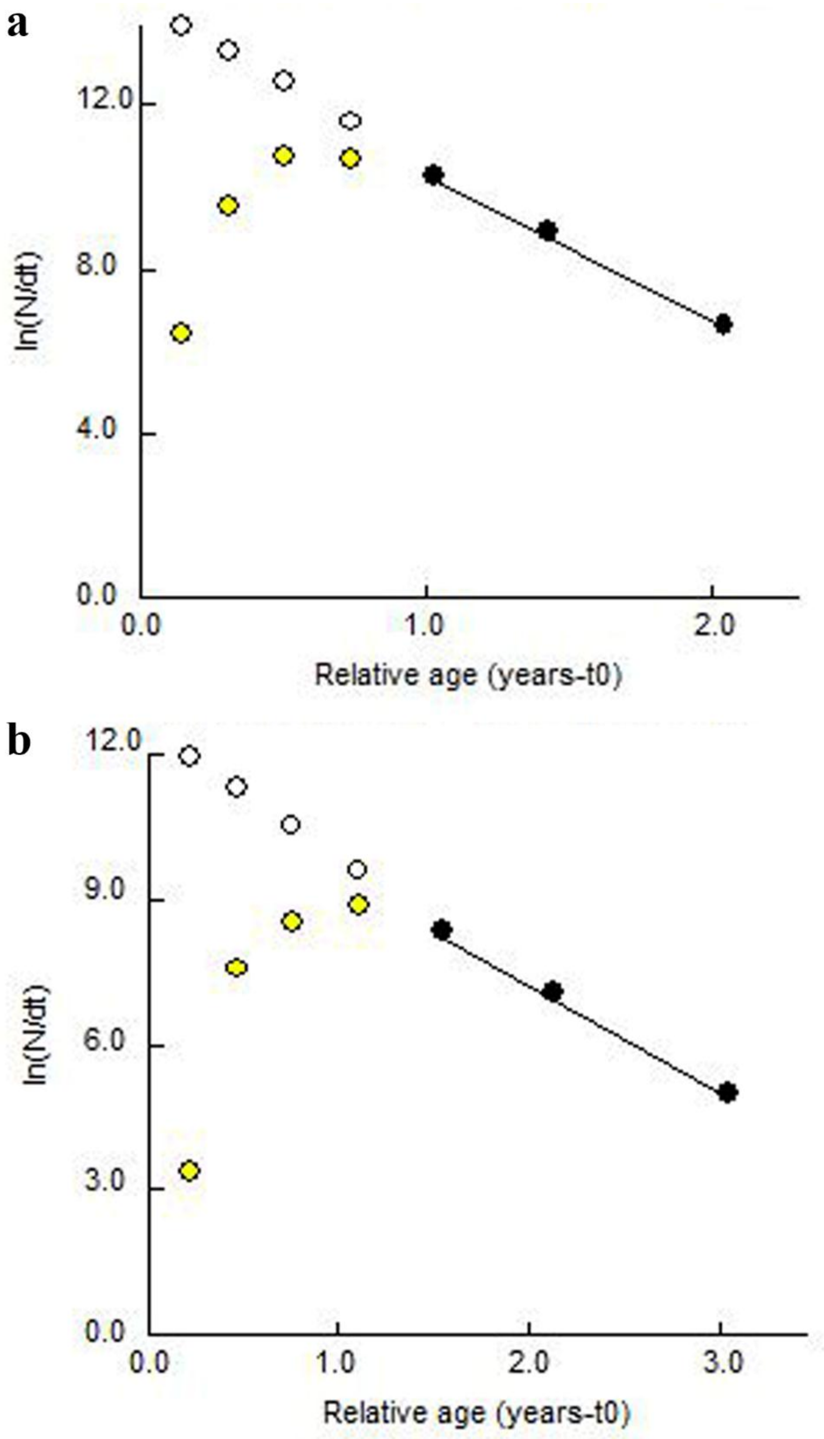


Figure 4. The the probability of capture of *Stolephorus dubiosus* in BH (a, $Z$=3.63 yr$^{-1}$, $M$=2.40 $^{yr-1}$ at $T$=29.4 $^{oC}$, $F$=1.23 yr$^{-1}$ and $E$=0.34) and CL (b, $Z$=2.23 yr$^{-1}$, $M$=1.85 $^{yr-1}$ at $T$=29.7 $^{oC}$, $F$=0.38 yr$^{-1}$ and $E$=0.17)

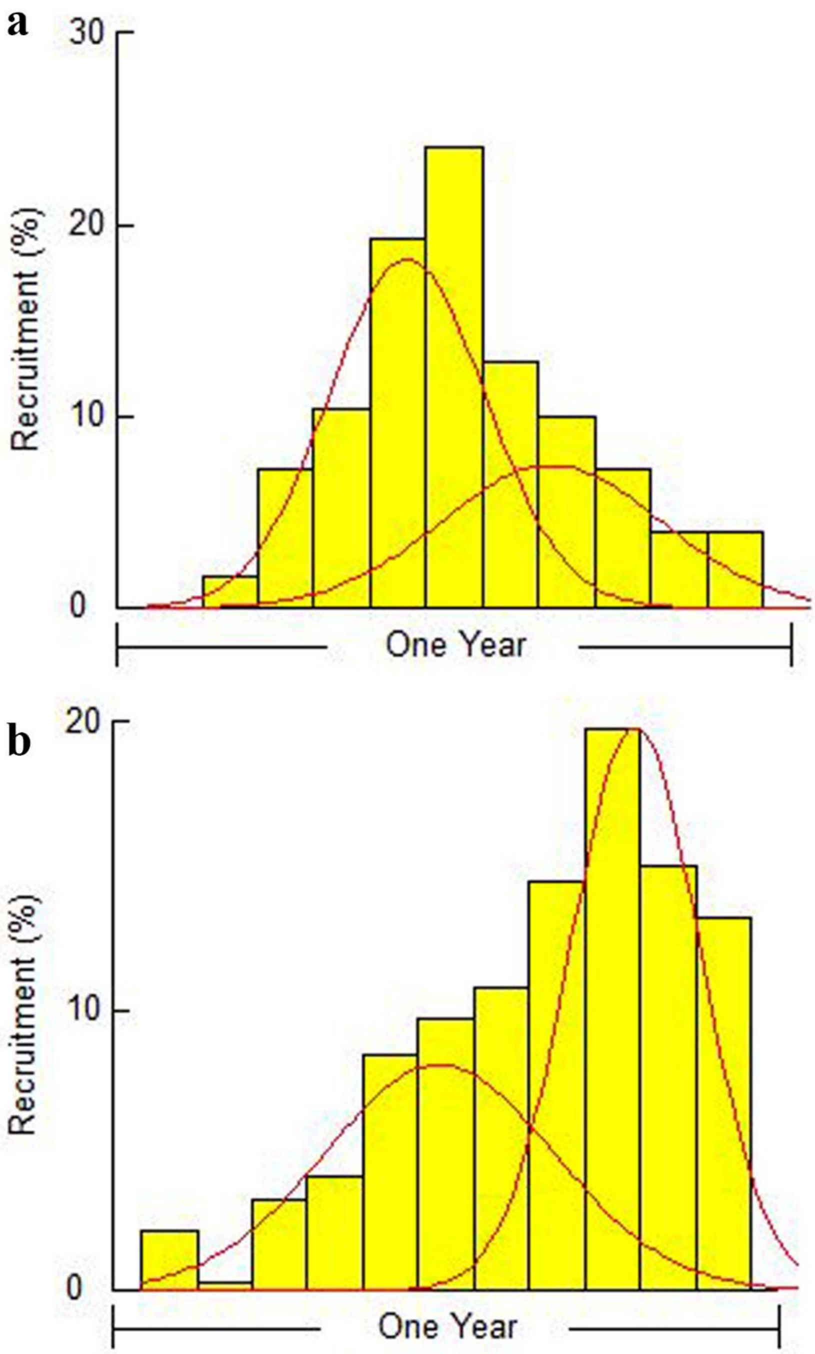


Figure 5. The recruitment pattern of *Stolephorus dubiosus* with two peaks in BH (a, main peak in mid of May and another in late August) and in CL (b, main peak in late September and another in mid of June).

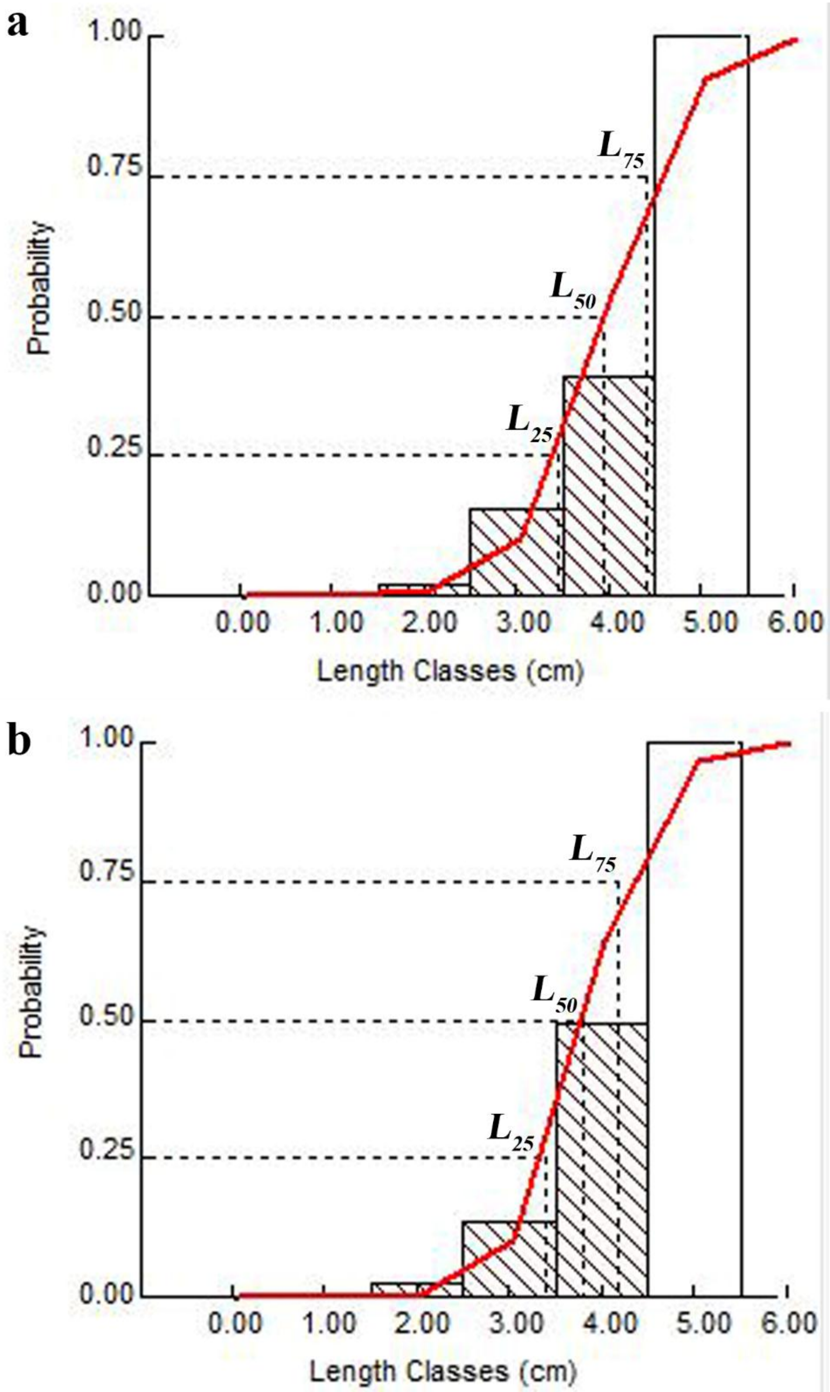


Figure 6. The probability of *Stolephorus dubiosus* capture in BH (a, $L_{25}$ = 3.5, $L_{50}$ = 3.9 and $L_{75}$ = 4.4 cm) and CL (b, $L_{25}$ = 3.4, $L_{50}$ = 3.8 and $L_{75}$ = 4.2 cm) that was estimated from the logistic transform curve, e.g., red line.

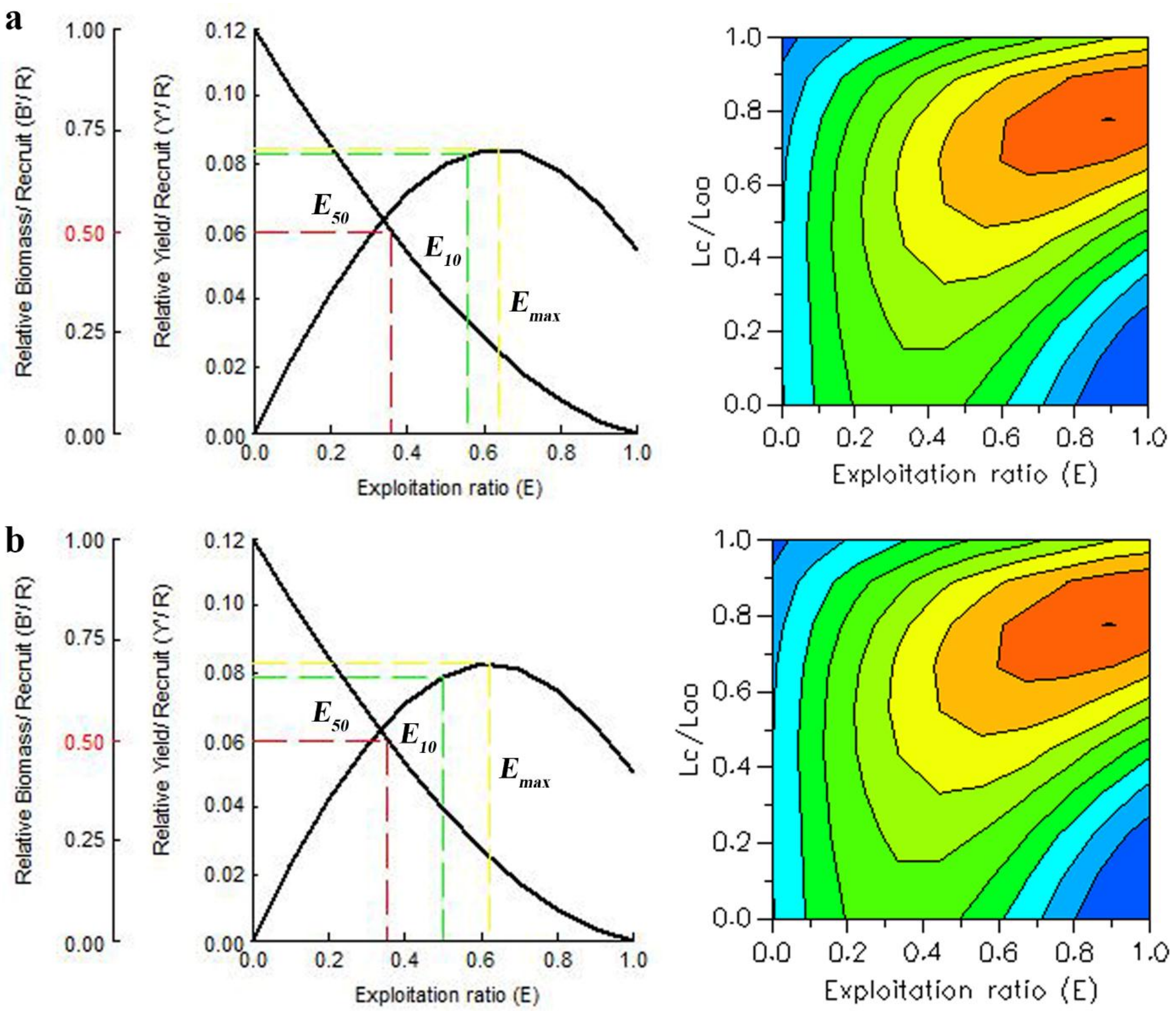


Figure 7. The exploitation rate of *Stolephorus dubiosus* in BH (a, $E_{10}$=0.556, $E_{50}$=0.358 and $E_{max}$=0.637) and CL (b, $E_{10}$=0.500, $E_{50}$=0.354 and $E_{max}$=0.622.

**Discussion**. The higher values of pH, salinity, and water depth in BH compared to CL could lead to a higher number of fish individuals collected in BH comparing to CL. Most of the fish was caught in February in BH and August in CL suggesting that it is the recruitment time of *S. dubiosus* population. The environmental conditions in BH may be more suitable for *S. dubiosus* than of the CL as *K* was higher (0.88) in BH as compared to CL (0.59), which relates to the difference in the number of cohorts in these two populations.

Moreau et al (1986) reported that growth performance index ($\Phi'$) is the best growth index when compared to another growth index $\omega = K \times L_\infty$. This is due to its small variation degree when they do compare growth parameters between different tilapia populations. Moreau et al (1986) also indicate that $\Phi'$ is usually similar within the related taxa and have narrow normal distributions. Dinh et al (2015) indicated that the difference in growth performance between some fishes resulted from the variation of growth parameter (*K*) and asymptotic length ($L_\infty$). Hence, the $\Phi'$ of *S. dubiosus* in BH was slightly higher than CL since the K in BH was higher than that of CL. It suggests that environmental factors lead to the assumption of the variation of growth parameters. The $\Phi'$ of *S. dubiosus* was lower than that of other fish species living in the Mekong Delta such as *Pseudapocryptes elongatus* (Tran et al 2007), *Parapocryptes serperaster* (Dinh et al 2015), *Butis butis* (Dinh 2018a), *Trypauchen vagina* (Dinh 2018b) and *Stimatogobius pleurostigma* (Dinh & Nguyen 2018); and two anchovy species in the subfamily Engraulinae including *Encrasicholina heteroloba* in Sofala Bank, Central Mozambique

(Ingles & Pauly 1984) and *E. punctifer* in Manila bay, Philippines (De Paula e Silva 1992) (Table 3). The difference in $\Phi'$ in *S. dubiosus* and other fish species living in and out of the Mekong Delta indicated it is species-specific.

Although $L_\infty$ and $L_c$ of *S. dubiosus* were significantly shorter than those of other fish species, the isopleths parameter ($L_c/L_\infty$) was similar to some of the fish species, yet it is higher than the species presented in Table 3. For example, $L_\infty$ and $L_c$ of *S. dubiosus* in BH were roughly 1/3 of *P. elongatus* (Tran et al 2007) and *P. serperaster* (Dinh et al 2015); but for the isopleths parameter, it was higher than these two species. It suggests a fraction of $L_c/L_\infty$ should be used when comparing to $L_\infty$ and $L_c$ instead of making the individual comparison.

The anchovy *S. dubiosus* could spawn many times during its life cycle due to the high value of longevity. This fish has more potential for the practice of artificial spawning, which has a higher $t_{max}$, compared to other fish species living in the Mekong Delta. For example, *P. elongatus* (Tran et al 2007), *P. serperaster* (Dinh et al 2015), *B. butis* (Dinh 2018a), *T. vagina* (Dinh 2018b), and *S. pleurostigma* (Dinh & Nguyen 2018). The longevity of *S. dubiosus* found to be higher in comparison to other species. It led to the growth performance which was lower than that of *P. elongatus* (Tran et al 2007), *P. serperaster* (Dinh et al 2015), *B. butis* (Dinh 2018a), *T. vagina* (Dinh 2018b), and *S. pleurostigma* (Dinh & Nguyen 2018) (Table 3).

Table 3

Population parameters of various fish species

| *Species* | $L_\infty$ | *K* | $t_{max}$ | *Z* | *F* | *M* | $L_c$ | $L_c/L_\infty$ | *E* | $\Phi'$ | *Place* | *Sources* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Encrasicholina heteroloba* | 11.4 | 0.95 | - | - | - | - | - | - | - | 2.09 | 1 | Ingles & Pauly (1984) |
| *Encrasicholina punctifer* | 12.0 | 2.00 | - | - | - | - | - | - | - | 2.46 | 2 | De Paula e Silva (1992) |
| *Pseudapocryptes elongatus* | 26.0 | 0.65 | 4.35 | 2.91 | 1.47 | 1.44 | 11.75 | 0.45 | 0.51 | 2.64 | 3 | Tran et al (2007) |
| *Parapocryptes serperaster* | 25.5 | 0.74 | 4.05 | 3.07 | 1.57 | 1.51 | 14.6 | 0.57 | 0.49 | 2.67 | 3 | Dinh et al (2015) |
| *Butis butis* | 24.0 | 0.61 | 4.92 | 3.40 | 1.98 | 1.42 | 10.5 | 0.44 | 0.58 | 2.55 | 3 | Dinh (2018a) |
| *Trypauchen vagina* | 24.2 | 0.56 | 5.56 | 2.73 | 1.29 | 1.44 | 13.8 | 0.57 | 0.53 | 2.50 | 3 | Dinh (2018b) |
| *Stigmatogobius pleurostigma* | 8.6 | 0.83 | 3.61 | 3.48 | 2.31 | 1.17 | 3.8 | 0.44 | 0.34 | 1.79 | 3 | Dinh & Nguyen (2018) |
| *Stolephorus dubiosus* | 8.4 | 0.88 | 3.41 | 3.63 | 2.40 | 1.85 | 3.9 | 0.46 | 0.34 | 1.79 | 3 | Present study in Bay Hap River |
| *Stolephorus dubiosus* | 8.4 | 0.59 | 5.08 | 2.23 | 1.85 | 0.38 | 3.8 | 0.45 | 0.17 | 1.62 | 3 | Present study in Cua Lon River |

1: Sofala Bank, Central Mozambique; 2: Manila bay, Philippines; 3: The Mekong Delta, Vietnam.

Both *S. dubiosus* populations in BH and CL had two recruitment peaks, but the time of recruitment of CL appeared later whence compared to BH, and the main peaks were also different, as it has been caused by the environmental factors between BH and CL. The two peaks of the contributed cohort were also found in *P. elongatus* (Tran et al 2007), *P. serperaster* (Dinh et al 2015), *B. butis* (Dinh 2018a), *T. vagina* (Dinh 2018b), and *S. pleurostigma* (Dinh & Nguyen 2018), but at different times.

The fish stock of *S. dubiosus* had not been subjected to overfishing in both BH and CL regions, in the present study, as the exploitation rate was lower than that of $E_{50}$. Moreover, the combination of the yield of isopleths ($L_c/L_\infty$) and exploitation rate (*E*) analysis showed that this species had not been overfished. Since the yield of isopleths ($L_c/L_\infty$) (0.46 in BH and 0.45 in CL) and *E* (0.34 in BH and 0.17 in CL) failed into eumetric fishing developing fishery (quadrant B) described by Pauly & Soriano (1986). This assumption was supported by a long length at first capture of this anchovy. Likewise, the population of *P. elongatus* (Tran et al 2007), *P. serperaster* (Dinh et al 2015), and *S.*

*pleurostigma* (Dinh & Nguyen 2018) have not been subjected to excessive fishing. In contrast, the population of *B. butis* (Dinh 2018a) and *T. vagina* (Dinh 2018b) were overexploited. For sustainable fishery management, although *S. dubiosus* populations had not been overfished, the recommendation is to increase the mesh size of the fishing gears to avoid degradation of undersized fish during the recruitment period.

**Conclusions**. *S. dubiosus* was found with a high K value in the population recruitment studies, and they could be a potential species for future aquaculture due to high growth constant. The original stock had not been subjected to overexploitation in the studied regions; however, the mesh size of the push-nets should be increased, and fishing should be avoided during the recruitment period for future sustainable fishery management.

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Authors:
Dinh Dac Tran, Can Tho University, College of Aquaculture and Fisheries, Department of Fisheries Management and Economics, Vietnam, 900000 Can Tho, Can Tho city, 3/2 street, e-mail: tddinh@ctu.edu.vn
Vang Thi Nguyen, Can Tho University, College of Aquaculture and Fisheries, Department of Fisheries Management and Economics, Vietnam, 900000 Can Tho, Can Tho city, 3/2 street, e-mail: ntvang@ctu.edu.vn
Quang Minh Dinh, Can Tho University, School of Education, Department of Bioloy, Vietnam, 900000 Can Tho, Can Tho city, 3/2 street, e-mail: dmquang@ctu.edu.vn

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