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Decadal Population Traits and Fishery of Largehead Hairtail, *Trichiurus lepturus* (Linnaeus, 1758) in the East China Sea

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ABSTRACT

Largehead hairtail, *Trichiurus lepturus*, fishery status in the East China Sea was estimated using length frequencies data sets for 2001, 2004, 2009 and 2013 and catch and effort data from 2000~2012. Length frequency data for 8,350 individuals were collected using pair trawl nets. The predominant size classes in the catch comprised of 130−374 mm in 2001, 83−360 mm in 2004, 53−355 mm in 2009, and 23−389 mm in 2013. Growth parameters of asymptotic length ranged from 515.6 to 768.6 mm in 2004 and 2009, growth coefficients ranged from 0.230 to 0.685, and t_0 from -0.654 to -0.494. The rate of total mortality (Z) ranged from 0.82 to 2.73 year^{-1} in 2013 and 2001, respectively. The exploitation rate was estimated to range from 0.660−0.797 year^{-1}. Catch per unit effort estimates showed a consistent decline in catches. This study is a start to bridge the gap between data and information, allowing resource managers to determine management priorities for this economically and ecologically important species in the ECS.

INTRODUCTION

Largehead hairtail, *Trichiurus lepturus,* is an important fish resource of the East China Sea (ECS), which has been mainly exploited by fleets from the Fujian, Jiangsu, Shanghai and Zhejiang provinces. A steady increase in fishing vessels (stow net) from 1,100 to 1,200 in Zhejiang province has been registered over a decade, increasing production from 9.43 to 10.02 % (Chen *et al*., 2009). Li *et al*. (2010) reported catch composition proportions from stow net survey programs in the ECS during 2000 to be 97 percent for yellow croaker (*Pseudosciaena crocea*) and 61 percent for largehead hairtail.

Largehead hairtail is a slow growing species with a life span of up to nine years (Wu, 1985, 1991; Du *et al*., 1988). Xue and Luo (1993) suggested the annual average yield in the ECS for this species to be 42x10^4 MT, which might be obtained following proper management practices.

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Lin (1987) reported that wide fluctuation in the abundance of large yellow croaker, an important prey item for this work's target species, in addition to overfishing, caused large changes in largehead hairtail population structure during the last 20-30 years. Additionally, Xu *et al*. (1994) reported a declining trend in largehead hairtail population condition, due to excessive fishing pressure. After analyzing a time-series on largehead hairtail population abundance, Zhou *et al*. (2002) suggested an increase in productivity and a decrease in mean population age. After an ECS three-month largehead hairtail fishery closure during the summer, Yan *et al*. (2007) reported an increase in average body weight and catch, immediately following closure. Following the studies of Yan *et al*. (2007) summer closures to manage largehead hairtail at the ECS have been implemented regularly (Yan *et al*., 2010).

The increase in fishing pressure detailed above has been reported to increase fishery production from 9.43% to 10.02 % (Chen et al., 2009). This increase, however, might be short-lived, provided no investigations are conducted to evaluate the effects of fishing pressure on ECS largehead hairtail stocks. The objective of this study was to evaluate the state of current largehead hairtail population abundances and provide sound management advice for the fishery in the ECS.

MATERIALS AND METHODS

Growth, mortality, and exploitation rates for longhead hairtail were estimated from 8,350 individuals. Fish were obtained from stow-net fleets operating at the ECS during 2001, 2004, 2009, and 2013. Fish total length, mouth tip and anal opening length, and standard length were taken, together with individual weights. Population parameters were estimated using FiSAT II. Growth was estimated using the von Bertalanffy equation ($Lt = L\infty\ [1\text{-}e^{-K\ (t\text{-}to)}]$; (Sparre and Venema, 1992), with the t_0 parameter estimated as Log ($-t_0$) = -0.392-0.275 Log (L_∞) -1.038 Log (K) (Pauly, 1980). Mortality was estimated using a linearized length-converted catch curve (Sparre and Venema, 1992). The empirical equation for estimation of natural mortality for longhead hairtail was Log M = -0.0066-0.279 (Log) asymptotic length+0.6543 (Log) growth+0.4634 (Log) temperature (Pauly, 1980). Fishing mortality was estimated as F/Z and total mortality was the sum of natural and fishing mortality (Ricker, 1975). The exploitation rate was estimates as F/Z, the fraction of mortality due to fishing (Sparre and Venema, 1992). Fishing effort in the form of number of stow-net and pair trawl gears and catch in tones was used to calculate catch-per-unit-effort indices. Total catch was estimated using the equation:

$$C_t = qE_tN_t,$$

Where, C_t is catch at time *t*, E_t is the effort expended at time *t*, N_t is abundance at time *t* and *q* is catchability or the portion of the stock captured by one unit of effort.

RESULTS

Most fish were in the range from 180 to 240 mm for the entire dataset. For fish sampled during 2001, length peaked between 150 and 260 mm, for 2004, length peaked between 170 and 210 mm, for 2009, peak length was from 180 to 220, and for 2010, that peak was from 190 to 270 mm. The trends indicate slow growth and catches of pre-recruit individual, below legal harvestable size for this species. Unregulated gear usage, in addition, could have caused limited representation of small and large largehead hairtail individuals.

Population cohorts also indicate that lower and upper size classes were consistently targeted (Fig. 1), explaining the low numbers for such size classes. The VBGF estimated maximum length (asymptotic length) for this work ranged from 515.6 to 768.6 mm, the growth coefficients from 0.230 to 0.685, and the fishing mortality from 0.599 to

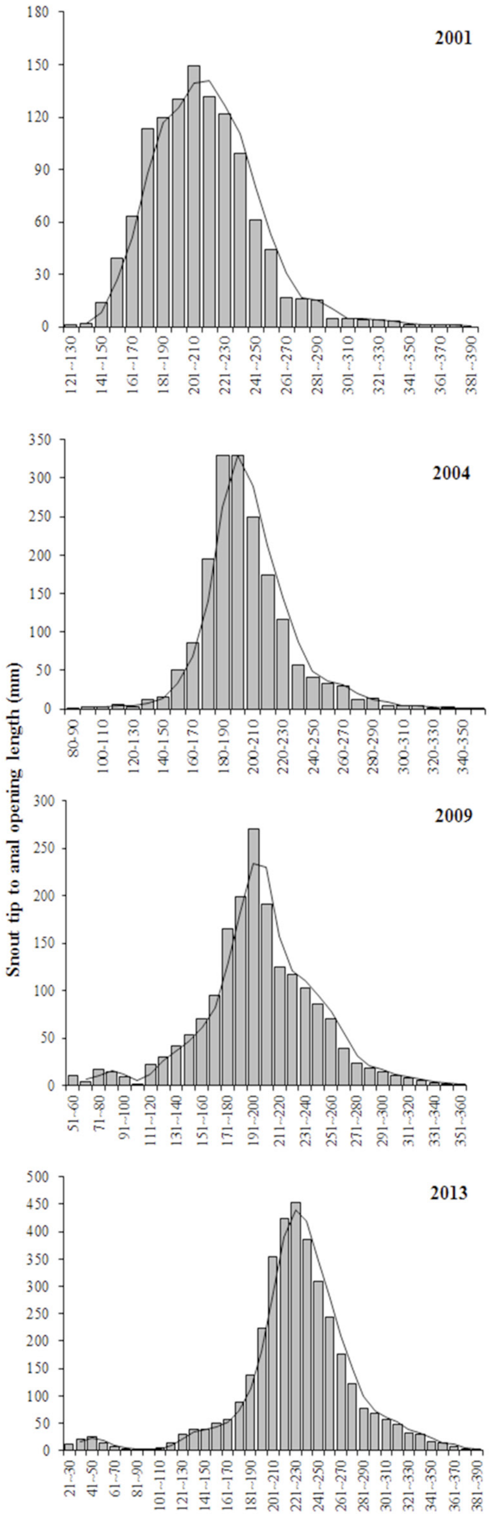

Fig. 1. Length cohorts of various largehead hairtail (*T. lepturus*) size groups from 2001-2013 catches indicating higher size groups from 2013 collections in the ECS fishing area (horizontal lines indicate target fish group).

Table I.- Summary of the population parameters estimated for Largehead hairtail (*T. lepturus*) in the EC Sea fishing area (length used here is from snout tip to anus opening in mm).

Estimated population parameters	2001	2004	2009	2013
Number of individuals (n)	1161	1778	1819	3592
Mean length from snout tip to anus opening and weight in parenthesis	210 (155)	200 (128)	198 (129)	226 (193)
Asymptotic length (L_∞)	537.6	515.6	642.6	768.6
Growth rate (K)	0.685	0.270	0.450	0.230
Fishing mortality (F)	2.227	0.764	1.307	0.599
Natural mortality (M)	0.503	0.276	0.363	0.221
Total mortality (Z) ($CL_{imits95\%}$ of Z)	2.730	1.040	1.670	0.820
Length at fish does not grow (t_0)	-0.494	-0.654	-0.530	-0.586
Goodness of fit (R_n)	0.888	0.614	0.846	0.596
Fishing limits (F_{limit})	1.485	0.509	0.871	0.399
Optimum fishing (F_{opt}).	1.114	0.382	0.654	0.300
Exploitation ratio (U)	0.745	0.426	0.616	0.865
Exploitation rate (E)	0.797	0.660	0.759	0.700
Bottom water temperature	17.76	17.69	17.62	17.48

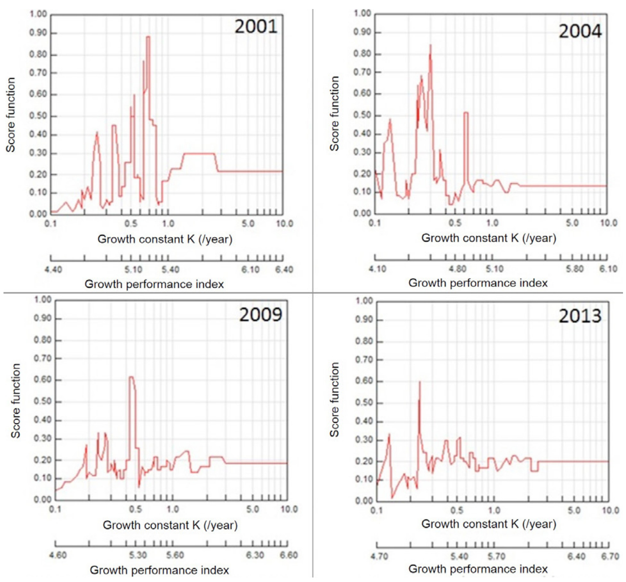

Fig. 2. Largehead hairtail (*T. lepturus*) growth performance index during 2001, 2004, 2009, and 2013 in the ECS fishing area.

2.227 in 2013 and 2001, respectively. The exploitation rate and goodness of fit are summarized in (Table I). From the VBGF growth equation, largehead hairtail population growth ranged from 0.230 to 0.685 (Table I); whereas, growth performance was between 4−6 (Fig. 2). The total mortality (Z) was estimated separately for the entire data and for individual years.

The highest mortality was found in 2001 (2.73 per year) and the lowest in 2013 when Z score reached at 0.82 year^{1} (Figs. 3, 4). A comparison between growth and mortality (Fig. 5) demonstrates large uncertainties in

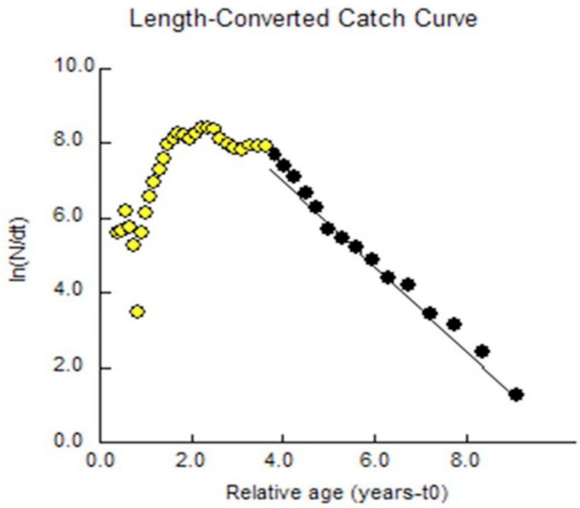

Fig. 3. Length-converted catch curve for largehead hairtail (*T. lepturus*) in the ECS (pooled data for 2001, 2004, 2009, and 2013; L∞ =484mm, K=0.22/year).

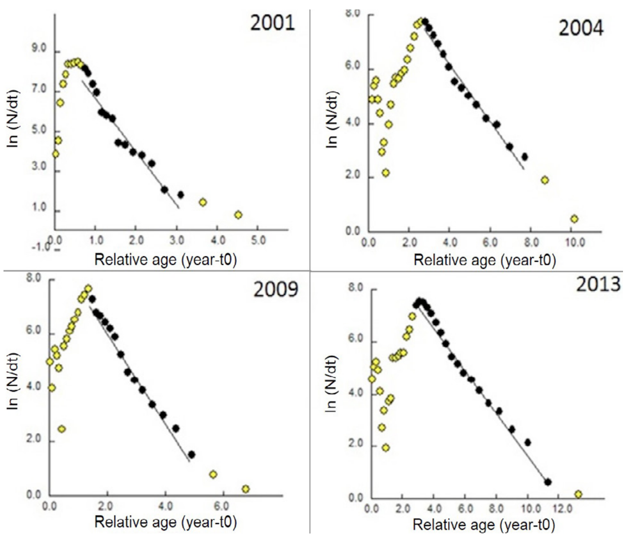

Fig. 4. Length converted catch curve for largehead hairtail (*T. lepturus*) sampled during the ECS surveys for 2001, 2004, 2009, and 2013).

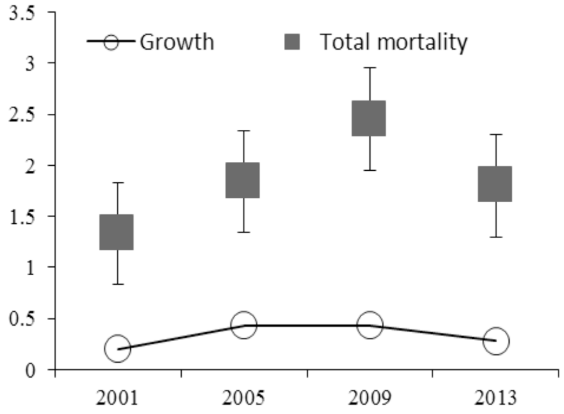

Fig. 5. Estimates of growth versus total mortality for the largehead hairtail (*T. lepturus*) fishery.

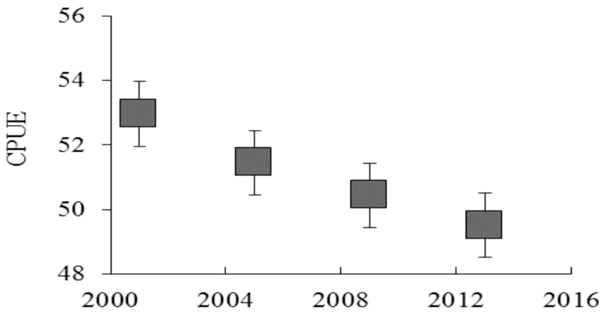

Fig. 6. Catch-per-unit-effort from all fishing gears targeting largehead hairtail (*T. lepturus*) in the ECS fishing area.

theses population parameters. Over the period of a decade, data of fishing vessels and biomass (tones) were used to estimate catch per unit effort for largehead hairtail (Fig. 6). The catch per unit effort for largehead hairtail fishery in ECS area was reduced from 53 in 2001 and 49 in 2013, which indicates that this population might have been over-fished beyond recovery.

DISCUSSION

Despite lack of basic biological and environment data on largehead hairtail, this paper demonstrates key population characteristics for the ECS. The VBGF parameters for the study population are largely different from previous studies by Fofandi (2012). The estimated exploitation rate of 0.8 year^{-1} was higher than the optimum exploitation rate recommended by Gulland (1971), leading support that the population of largehead hairtail in the ECS is overfished. The target length for the ECS largehead hairtail fishery (180–260 mm) caused pressure on the younger individuals for this fishery, keeping recruitment rates down, with the consequent low population levels at all size classes. It is generally accepted that natural mortality is very high during the larval stages and decreases as the age of fish approaching a steady rate (Jennings *et al*., 2001). The rate of natural mortality increases exponentially when the fish nears maximum age. A decline in CPUE, as observed in this study, suggests a fishery has overextended its resources. A decline in CPUE may also be a function of data uncertainties from data collections, such as personnel, time, and space from where data is gathered. Despite of these factors, a decline in CPUE should trigger an immediate management action, such as recommendations for a reduction in exploitation rates proportional to the declines in CPUE. Previous long-term studies of the ECS largehead hairtail fishery have alerted to an impending crisis in this industry (Yongjun and Jinlin, 1989). Similar conclusions have been reached for *Trichiurus haumela* fishery in the Zhejiang coastal waters of China (Wu *et al*., 1985; Wu, 1991; Ma, 1989; Xu *et al*., 2003). This study bridges an important gap between information for management and data. Our data provides information allowing resource managers to prioritize conservation of ECS fisheries and to contribute to curbing current overfishing and consequent stock depletion of largehead populations.

CONCLUSION

Keeping in view estimates of growth, mortality, exploitation and CPUE trends, this study would increase understanding of the current state of the stocks and prospect of future harvest strategy for sustainable exploitation of an economically and ecologically important fish species in this area.

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Statement of conflict of interest

Authors have declared no conflict of interest.

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