African Journal of Environmental Science and Technology Vol. 4(8), pp. 517-525, August 2010
Available online at http://www.academicjournals.org/AJEST
ISSN 1991-637X ©2010 Academic Journals

Full Length Research Paper

Catch rate of juveniles *Ethamatosa fimbriata*, *Sardinella maderensis*, and *Brachydeuterus auritus* fishing in Freetown Peninsular

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Accepted 13 July, 2010

We investigated the incidences of juvenile fishing according to fishing practices in Freetown peninsular. The industrial trawl fishing sector, despite its technology is not fully selective to avoid by-catch of juvenile fish, and artisanal fishing is so less for economic reasons. Ineffective enforcement of fishing regulations is a major cause to the catch of both targeted and non-targeted juvenile fish. We collected data on the quantity of juvenile fish and the daily duration of fishing trips in four landing sites over a two-week period Bernoulli random variables and properties of uniform distribution were used to analyze the data. Catch rates of juveniles *Ethamatosa fimbriata*, *Sardinella maderensis*, and *Brachydeuterus auritus* around the Freetown peninsular were 170.8, 212.4 and 194.60 kg per hour per day, respectively. This rate revealed that the current trend of juvenile fish landings is a threat to the sustainability of fishery capital, revenue, and biodiversity.

Key words: High juvenile, landing, national problem, Sierra Leone, by-catch juvenile.

INTRODUCTION

For decades now, several studies have reported significant decline in the worldwide catch of fish and fishery products mainly due to recruitment failure and problems to sustain global fishing capital (Watson and Pauly, 2001). Juvenile fishing is the harvesting of young and newly hatched fish and sometimes accidental harvesting of eggs laid by fish are causing over fishing and collapse of global fishing capital. Wrong fishing gears including net types are capable of catching large quantity of fish by-catch and have been identified as one of the most significant causes for overfishing and collapse of fishing capital worldwide (Pauly et al., 2002).

Juvenile fishing affects the fishing capital, employment and foreign earnings through reduction in species ratio and catch rate where target species reach a threatened threshold. The ratio of targeted and non-targeted juvenile fishes to the overall catch is very large especially in countries where various types of fishing gears are used under inadequate fishing regulations or ineffective enforcement of fishing regulations (Hall and Mainprize, 2005).

Evidence of recruitment failure from the continued exploitation of juvenile fishes including shrimp and high value fishes, lies not only in declining catch rates but also in reduced mean length of some inshore stocks, and changes in catch composition (Sobrino et al., 2003). The fishery of Sierra Leone is divided into two main sectors: Artisanal and Industrial. Commercially important species caught in the artisanal fisheries sector includes *Ethmalosa* species (local names "Bonga" and "awefu" juvenile) *Sardinella* species (local names "Herring" and "mina" juvenile), *Illisha Africana* (local name - "Lati"); *Pseudotolithus elongates* (local name - "Gwangwa"), *Pseudotolithus senegalensis* (local name - "lady fish"), *Dentex* species (local name- "snapper"), *Galoides*

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decadachtylus (local name- “shinenose”) and many others (Ndomahina and Chaytor, 1991). The marine artisanal fisheries sector produces about 78% of fish for the local market. Some 50% of these are small pelagic of which 20% are demersals (Seisay, 2005). Several gear types and strategies are used with expert and non-expert knowledge that differs from fisher to fisher or vessels to vessels to exploit the marine resource, and no gear is 100% selective, but some deliberately target unauthorized categories like the juvenile.

The main aim and objectives of this study is to investigate the catch rate of juveniles *Ethamatosa fimbriata* (“Awefu”), *Sardinella maderensis* (“Mina”), and *Brachydeuterus auritus* (“Caima”) fishing in order to review regulatory measures for management of fishery capital at the time when Sierra Leone is working hard to lift ban on export of fish and fishery products to developed countries through implementation of HACCP system.

Four out of fifty landing sites including Goderich”, “Tombo”, “Portee/Rokuprr” and “Levuma”, known to be well established communities for artisanal fishing were identified for 20 days sampling and data collection by direct observation, sorting, measurement and weighing. Direct measurement of fish length and sorting by species landed were the methods used to determine juvenile fish and species ratio. The fish length was compared to mean length of adult fish calculated during the two weeks pilot survey of the fifty landing sites along the Freetown peninsular. The ratio of means estimator was used to calculate the catch rate by calculating total average catch estimation (kg). Total average catch (kg) = Total average length of trip (Effort) (h) × catch rate (kg h^{-1}). For each boat, mixtures of juvenile and adult fish were landed, but the study did not investigate the ratio of juvenile and adult fish, because the aim of the study was to determine catch rate of juvenile. The determination of the ratio of juvenile to adult fish and subsequent estimation of stock level are significant areas this study recommended for future research.

It was found that the use of illegal mesh sizes were highly responsible for the catch of juvenile fish. The allowable mesh sizes in millimeter (mm) according to Sierra Leone fishery regulations are shrimp trawlers 42, fish trawlers 60 and artisanal 43 (MFMR, 2003; Thorpe et al., 2009). However, over 90% fishing nets observed during this study were 29 or below. This shows clear violation of national fishery regulation mainly due to ineffective enforcement by MFMR. The ministry is fully aware of these bad practices but little or nothing is done to combat the situation. In fact, survey report in Sierra Leone showed that 75% of driftnet and 85% of beach seine in the western area are illegal (MFMR, 2008; Thorpe et al., 2009).

Study area

Sierra Leone lies between Latitudes 7°N and 10°N, and between Longitudes 10°W and 13°W on the coast of West Africa. It is bordered on West, North and Northeast by the Republic of Guinea and to the Southeast by Liberia. Sierra Leone covers a total area of about 71,740 km^2 with a coastline of about 350 km. Sierra Leone has an estimated population of some 5.7 million and 55% of the population lived within 100 km of coastline (FAO, 2002).

The continental shelf of the coastline of Sierra Leone is about 100 km wide in the north and tapers to about 13 km in the south towards Liberia Figure 1, (MFMR, 2003). The total continental shelf area covers about 30,000 km^2. The coastline, which is some 500 km long, is characterized by extensive flora of mangrove plants, mainly the *Rhizophora* species, a number of estuaries and rivers that are navigable for short distances. The area of the 200 miles exclusive economic zone (EEZ) is about 15,700 km^2. The coastline of Sierra Leone stretches for about 560 km; its total shelf area is about 27,000 km^2 which descends to a depth of about 200 m (Thorpe et al., 2009). Most of the fishing activities take place within 17,000 km^2 of the exclusive economic zone (Seisay, 2005).

Maritime fisheries in Sierra Leone are classified into inshore and offshore zones. The inshore zone is officially reserved for artisanal fisheries and is extended up to 5 nautical miles from the baseline. Beyond this is the exclusive economic zone (EEZ), which constitutes the industrial fishing zone. There are about 321 landing sites along the coast and 530 landing sites nationwide, but only 9 of these landing sites do provide substantial quantities of fish landed (Seisay, 2005). There are about 50 landing sites along the Freetown peninsular in the western area of Freetown though only 4 are recognized and supervised by the Ministry of Fisheries and Marine Resources. The 4 are considered semi-urban fishing communities around the Freetown peninsular including “Goderich”, “Tombo”, “Portee/Rokuprr” and “Levuma”. “Goderich” and “Portee/Rokuprr” being the closest to the capital city Freetown are highly active and subjected to various studies, and majority of the fishes marketed in Freetown are from “Goderich” and “Portee/Rokuprr”. “Tombo” and “Levuma” are busy fishing towns that supply the provinces with fish mainly *Ethmalosa*, *Brachydeuterus* and *Sardenella* species.

METHODS

Data collection

A pilot survey was carried out along the Freetown peninsular covering 50 landing sites to examine the extent of fishing activities, the intensities of juvenile landing and supervision or enforcement put in place by Ministry of Fisheries and Marine Resources. The survey lasted for two weeks but only 4 landing sites were identified for sampling and data collection. The reasons are that these 4 sites are semi-urban communities that are actively involved in large scale artisanal fishing using different categories of gear-craft combination, and were the only sites where inspectors from MFMR are placed to

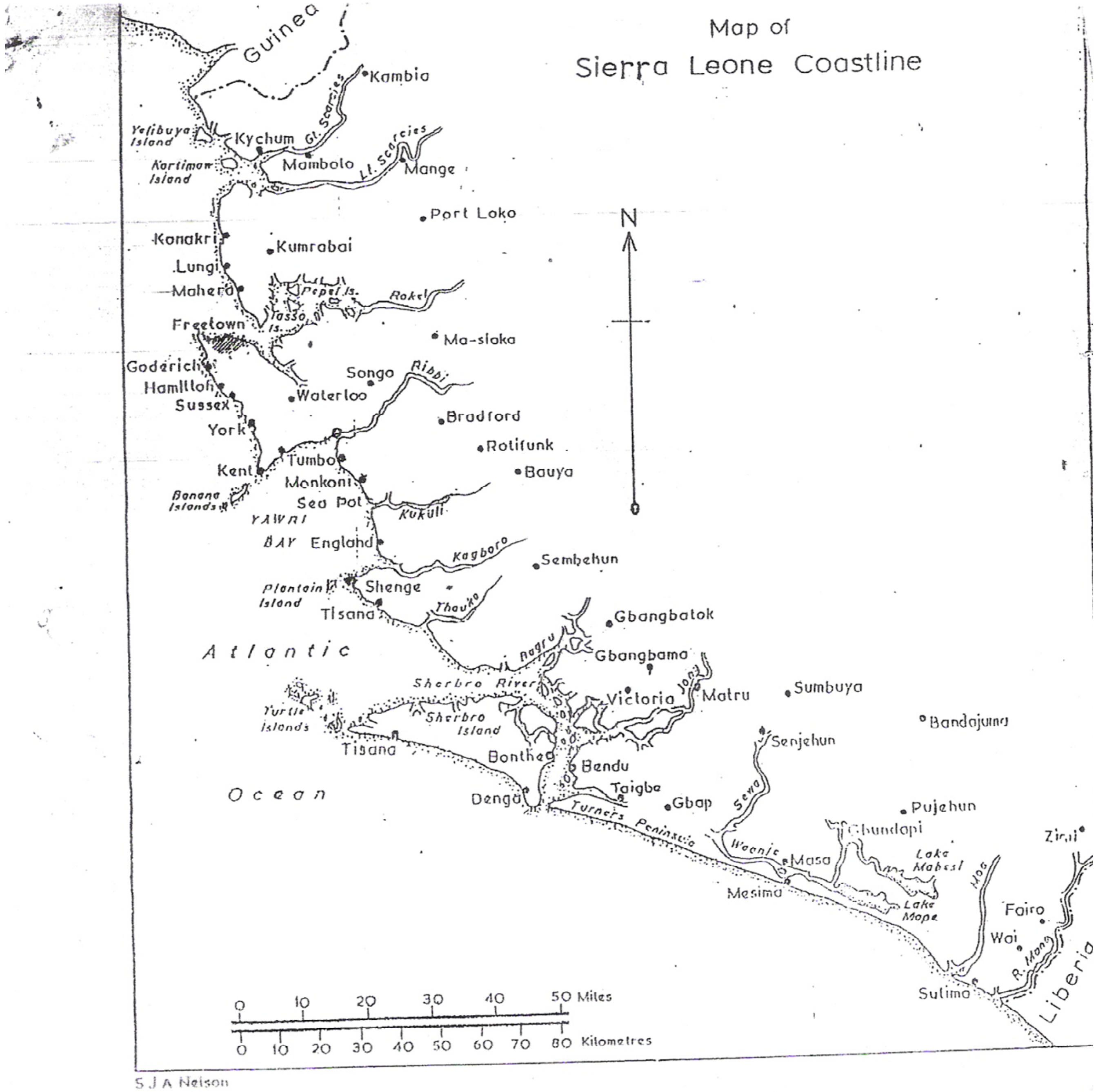

Figure 1. Ministry of Fisheries and Marine Resources (MFMR) (2003) Sierra Leone Coastline.

enforce national fishery regulations.

Sample was any article of fishing boat selected at the landing site per day, unloaded, examined, sorted, measured and weighed all juvenile fish using measuring tape and weighing scale calibrated in centimeter (cm) and kilogramme (kg), respectively. The data were the quantity of juvenile fish in kg and the duration of fishing trip in hours obtained per boat per day. The duration of fishing hours was obtained by face-to-face interviewing of fishermen per boat per day. The data were therefore collected from any similar boat landed and sampled on the same day of sampling at a particular landing site. The data for quantity of juvenile fish in kg and duration of fishing trip in hours for 10 boats per day or 200 boats per 20 days were standardized into averages for *E. fimbriata* ("Awefu"), and *S. maderensis* ("Mina"). The data for quantity of juvenile fish in kg and duration of fishing trip in hours for 10 boats per day or 50 boats per 5 days were standardized into averages for *B. auritus* ("Caima"), because this species was identified at only one landing site called "Levuma". (see Table 1 and Figure 2, for more information on data on juvenile fish for the three species collected from all the 4 landing sites for 20 days.

The sampling and data were collected from 13th April to 9th May 2009, excluding Fridays and Saturdays, which are considered holidays and non-fishing days for all the four landing sites. Sample or data per fishing boat does not always require the same day fishing

Table 1. Average catch composition of juveniles *Ethamatosa fimbriata* (“Awefu”), *Sardinella maderensis* (“Mina”) and *Brachydeuterus auritus* (“caima”) landed at Goderich”, “Tombo”, “Portee/Rokuprr” and “Levuma” wharfs by 200 boats in 20 simulation days and an average of 149 h of fishing and travelling.

Day no.	Location of landing site/wharf	Average starting time of fishing trip (am)	Average ending time of fishing trip (pm)	Average duration of fishing trip (h)	No. of boat per day	Average quantity of juvenile fish landed and weighed (kg)		
						Awefu	Mina	Caima
1	Tombo	8	4	8	10	2,130	1,210	0
2	Tombo	8	4	8	10	2,250	970	0
3	Tombo	9:30	4:30	7	10	2,110	1,330	0
4	Tombo	7:30	4:30	9	10	2,190	1,290	0
5	Tombo	8:30	4:30	8	10	2,260	1,150	0
6	Goderich	7	4	9	10	980	2,510	0
7	Goderich	7:30	3:30	8	10	1,010	2,680	0
8	Goderich	8:30	4:30	8	10	1,000	2,780	0
9	Goderich	7:30	2:30	7	10	660	2,760	0
10	Goderich	7:30	2:30	7	10	340	2,660	0
11	Portee/Rokuprr	8	3	7	10	1,830	1,570	0
12	Portee/Rokuprr	8	3	7	10	1,840	1,450	0
13	Portee/Rokuprr	9	3	6	10	1,730	2,130	0
14	Portee/Rokuprr	8	3	7	10	1,970	1,830	0
15	Portee/Rokuprr	9	3	6	10	1,890	1,630	0
16	Levuma	7:30	3:30	8	10	310	910	1,530
17	Levuma	7:30	2:30	7	10	130	820	1,630
18	Levuma	7	3	8	10	260	890	1,320
19	Levuma	8	2	6	10	330	410	1,630
20	Levuma	7:30	3:30	8	10	230	670	1,090

boat for next day's trips. The data in this study were collected to uncover mainly the catch rate, but measurements of size and species ratio were also investigated to help achieve the research objectives.

Data analysis

The data on catch rate shows the fishing power per effort or boat per hour per trip per day. That is catch per unit of fishing effort. Though the statistical theory and modelling for estimating the fishing effort from instantaneous or progressive counts is fully established, there are still lot of confusions regarding the correct method of catch rate of fish (Van den Avyle, 1986; Pollock et al., 1994). The total effort could be estimated in fishing hours and the catch rate in fish per hour, while the total catch is estimated as the product of total efforts and catch rate, and thus Total catch = total effort × catch rate or Catch rate = total catch/total effort (Hoenig et al., 1997; Greene et al., 1995; Pollock et al., 1994; Wade et al., 1991; von Geldern and Tomlinson, 1973). Therefore, the researcher used the ratio of mean estimator to estimate the total catch rate of all boats sampled using the following formula:

Catch rate = {[Total of average juvenile fish landed (kg)] / [Total of average length of trip (effort) (h)]}.

Catch rate for juvenile E. fimbriata (“Awefu”)

Given:
Total of average juvenile “Awefu” landed (kg) = 25,450 kg
Total of average length of trip (effort) (h) = 149 h

Therefore:
$\hat{C}$R of “Awefu” = [(25,450 (kg) / 149 (h)] = 170.8 kg/h

Catch rate for juvenile S. maderensis (“Mina”)

Given:
Total of average juvenile “Mina” landed (kg) = 31,650 kg
Total of average length of trip (effort) (h) = 149 h

Therefore:
$\hat{C}$R of “Mina” = [(31,650 (kg) / 149 (h)] = 212.4 kg/h

Catch rate for juvenile B. auritus (“Caima”)

Given:
Total of average juvenile “Caima” landed (kg) = 7,200 kg
Total of average length of trip (effort) in hours = 37 h
Therefore:

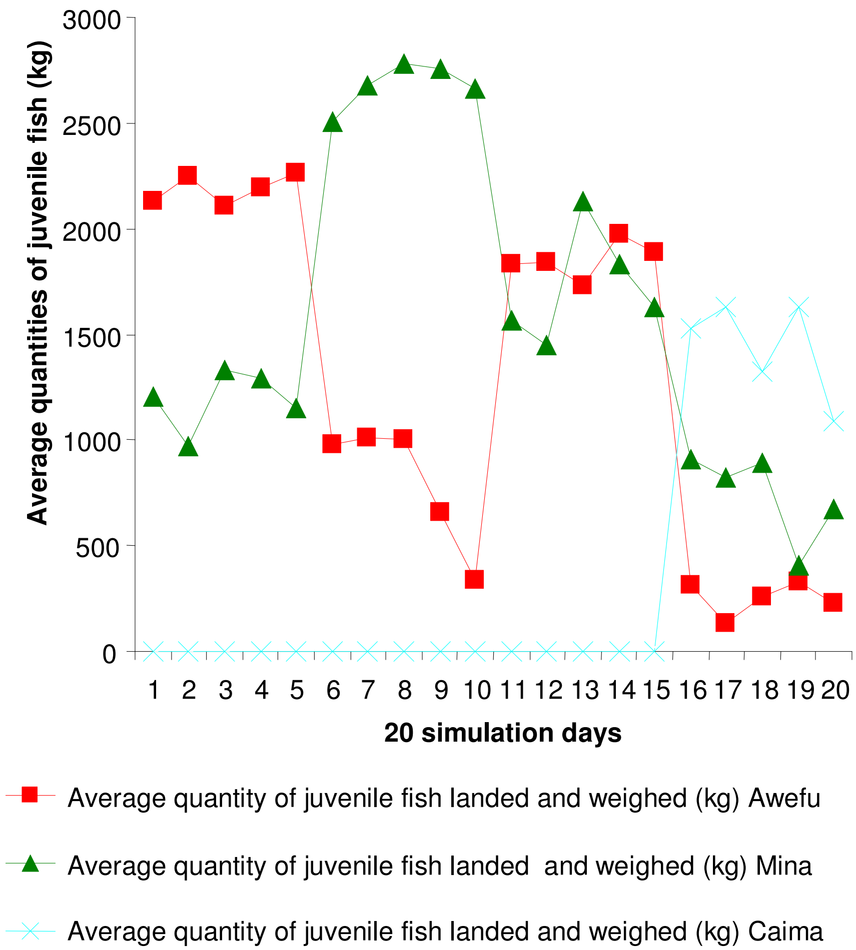

Figure 2. Average catch composition of juveniles *Ethamatosa fimbriata* (“Awefu”), *Sardinella maderensis* (“Mina”) and *Brachydeuterus auritus* (“caima”) landed at Goderich”, “Tombo”, “Portee/Rokuprr” and “Levuma” Wharfs by 200 boats in 20 simulation days and an average of 149 h of fishing and travelling.

$\hat{C}R$ of “Caima” = 7,200 kg / 37 h = 194.60 kg/h

The standardized sum catches of species for 20 days in kg show no consistent trend in catch rates of *E. fimbriata* (“Awefu”), *S. maderensis* (“Mina”) and *B. auritus* (“Caima”). During some days, the catch rates increase rapidly, followed by a steep decline on other days, and so on and forth. Thereafter, the catch rates show a generally increasing trend throughout the data collection exercises. The comparative estimated catch rate of "Awefu", "Mina", and "Caima" are at highest in "Tombo", "Goderich" and "Levuma" respectively, but the catch composition for all these species are still higher in all the landing sites and creating a potential treat of recruitment failure, stock depletion and damage to biodiversity.

From ratio of mean estimator we can deduce the following equation to estimate relationship between data (Hoenig et al., 1997; Greene et al., 1995; Pollock et al., 1994; Wade et al., 1991; von Geldern and Tomlinson, 1973):

$$\hat{C}R = \frac{\sum_{j=1}^{n} C_j}{\sum_{j=1}^{n} L_j} = \frac{\sum_{j=1}^{n} C_{j/n}}{\sum_{j=1}^{n} L_{j/n}} \qquad (1)$$

This equation can also be viewed as the ratio of mean catch to mean effort. That is:

$$\left(\sum_{j=1}^{n} = 1\ C_{j/n}\right) : \text{Mean effort } \left(\sum_{j=1}^{n} = 1\ L_{j/n}\right)$$

Where:
C_j = Total juvenile fish caught by boat j up to the time it landed at the wharf for weighing in kg and unloading; L_j = Length of the trip (effort) in hours from the time of

departure up to the time it landed at the wharf; L_j^* = Length of the total trip in hours unknown per day; n = number of boat encountered and interviewed at the wharf after fishing and landed per day; $\hat{C}R$ = catch rate.

Some important relationships and assumptions:

i) For each boat j, fishing is a stationary process; ii) The rate of fishing does not vary with the boat starting time or with the length of fishing trip; iii) Since the researcher did not witness the boat during traveling and fishing, the data collected on catch and effort provided only an estimate of the actual catch rate for the completed trip.
Therefore, let:

$$n = \sum_{j=1}^{N} X_j \quad (2)$$

X= Vector of the indicator variables X_j

The probability of encountering and interviewing a boat is proportional to the length of time the boat fishes per day and the tendency to arrive at wharf for unloading at the time of sampling. The boats sampled indicated a representative fraction of all the fishing boats per day. Thus:

$$P(X_j = 1 \mid L_j^*) = L_j^*/T \quad (3)$$

X_j = Bernoulli random variable with expectation and variance given by

$$E(X_j \mid L_j^*) = L_j^*/T \text{ and } V((X_j \mid L_j^*) = (L_j^*/T)(1- L_j^*/T) \quad (4)$$

The Bernoulli random variable and expectation take only two values 1 and 0 with probability p and 1−p with 0 < p < 1; for example

$P(X = 1) = p$ $P(X = 0) = 1 - p$; We write X _ Ber(p)

Where:

T = Number of time in hours in fishing on the fishing day ≈ Time required for the researcher to make one complete circuit of sampling of fishing boat at the wharf per day; N = Number of boats fishing per day; $\check{R}_j$ = Stationary catch rate; that is number of fish per hour of a single boat j (j =1,…………N); L_j = Length of trip (h) till the time boat landed, encountered and interviewed; j (J =1 ,….N). L_j was defined to be 0 (zero) if the boat was not interviewed; L_j^* = Total trip length (h) of boat j(j =1,…………N); L* = Total hours of fishing in the day, $L^* = \sum_{j=1}^{N} L_j^*$; L = Vector of the trip length up to the time landed, encountered and interviewed, L_j; C_j = Catch of boat j at the time of interview (j = 1, …….N). C_j was defined to be 0 (zero) if the boat was not interviewed; C_j^* = Catch of boat j at the completion of the fishing trip (j = 1,……..N);
n = Number of boats encountered and interviewed; X_j = Variable indicator; that is, let:
X_j = 0, if boat j was not encountered and interviewed; X_j = 1, if boat j was encountered and interviewed.

Bernoulli random variable is a variable that has 2 possible outcomes: \success", or \failure". Success occurs with probability p and failure with probability 1 – p; and it is used to model binary outcomes like True/False, Up/Down, Success/Failure (Carlos and Francois, 2003). It is easy to verify that

$$E X = p \text{ and } Var X = p \cdot (1 - p).$$

Indeed, $EX = 1 \cdot p+0 \cdot (1 - p) = p$ and; $Var X = (1 - p)^2 \cdot p+(0 - p)^2 \cdot (1 - p) = (1 - p) \cdot (1 - p) \cdot p+p \cdot p \cdot (1 - p) = p \cdot (1 - p) \cdot (1 - p+p)$

It is the starting point to define another important random variable and a realization
of one of the values of X called a Bernoulli trial (Carlos and Francois, 2003). The length of time a boat fishes and arrives at the wharf before being encountered and interviewed, assuming that the boat was encountered and interviewed, is a uniform random variable (U). Therefore:

$$L_j \sim U(O, L_j^*) \text{ given } X_j = 1 \quad (5)$$

From properties of uniform distribution, lets assume that $X_1, X_2, ..., X_n$ represent a set of independent and identically distributed random variables and denote the corresponding order statistics by $X_1{:}n, X_2{:}n, ..., X_n{:}n$. In cases of various properties of order statistics we may refer to Ahsanullah and Nevzorov (2002), Arnold et al. (1992) and David (1981). Therefore:

$$E(L_j \mid L_j^*, X_j = 1) = L_j^*/2 \text{ and } V(L_j \mid L_j^*, X_j = 1) = L_j^{*2}/12 \quad (6)$$

Equation 5 means the expected value and variance of the reciprocal of fishing trip length at the time of boat encountered and interviewed (given the completed trip length and the fact that $X_j = 1$) are infinite. Therefore the expected catch at the time of encountered and interviewed, given that the boat was interviewed when the fraction
$L_j \mid L_j^*$ of the trip is over, is the total catch for the trip times fraction of the completed trip. That is:

$$E(C_j \mid L_j, C_j^*, L_j^*, X_j = 1) = C_j^* L_j / L_j^* \quad (7)$$

And

$$V(C_j \mid L_j, C_j^*, L_j^*, X_j = 1) = C_j^* (L_j / L_j^*) (1- L_j / L_j^*)$$

This supports the assumption that fishing is a stagnant process. Therefore, the catch rate does not vary over time. On average, a fishing boat was encountered and interviewed by the time the fishing was completed on that fishing day and the whole trip catch was sampled and analyzed at the time of encounter and interview. Thus the catch per fishing trip on any given day arises from a stagnant process and the expected catch per trip is:

$$E(C_j^*| L_j^*) = \check{R}_j L_j^* \quad (8)$$

Therefore the variance is:

$$V(C_j^*| L_j^*) = \check{R}_j L_j^*$$

The approximated Řj is weighted average of the individual species catch rates. Thus, the approximate expectation is the ratio of total catch to effort. This provides theoretical estimation for calculating catch rate using catch per unit effort in juvenile fishing.

A simulation work was developed to analyze the data. Several simulation activities have been adapted and utilized by various programmes to estimate catch rate (Green et al., 1995). 20 simulated days were spent in all of the four landing sites and the researchers spent six hours per simulation day. In all the four landing sites, each boat had catch rate parameter that was independent of the length of the trip. This was verified where the boat fished for 9 h and caught less fish than boat that fished for 10 h. Similarly boat that fished for 6 h caught more fish than boat that fish for 7 h, and so on. This means that fishing is a stationary process and does not vary with the length of fishing trip.

DISCUSSION

Lack of proper enforcement of fishery policies and regulations compounded with inadequate capacity and capabilities of the Ministry have certainly accelerated the juvenile fishing throughout the coastal stretch that harbours millions of fishermen. These have elevated the landings of juveniles, which are mainly due to intensive targeted artisanal fishing and inter-coastal community fishing competition.

From the economics point of view, the demand for juvenile by consumers also encourages this method of fishing (Boyce, 1996); low income earners in capital city Freetown and its environs go in for “mina” juvenile *sardinelle,* “Awefu” juvenile *E. fimbriata* and "Caima" juvenile *B. auritus* as cheap source of protein. Majority of fishermen go in for low production efforts by purchasing cheap and destructive methods of fishing, such as using drift net, beach seines, channel net, poisons and dynamite that directly target juvenile species. To achieve sustainable fishery practice, juvenile fishing should on no account be acceptable (Pascoe, 2006). Fisheries resources are renewable, if given a chance to rejuvenate (Hall and Mainprize, 2005).

Juvenile fishing will lead to loss of biodiversity in the marine ecosystem (Hall et Al., 2000). Fishing serves as one of the main revenue earner for the Government of Sierra Leone, through licensing, donor and honorariums etc (MFMR, 2008), and the fisheries actually contribute about 9.4% to the national gross domestic product (NGDP) (MFMR, 2003). The importance of the fisheries sector in the economic development of any country is revealed in its share of the gross national product (GNP) and by its participation in employment and growth adjustment process like food security and external trade (Pascoe, 2006). The government provides fishery management strategies and policies for sustainability in view of development with its foreign exchange earnings that foster industrialization and settlement of debt. Coastal dwellers depend on fish and fishery products for their livelihood and employment. With this kind of trend of juvenile exploitation, it is clear that the major share of GNP and main source of national protein is therefore under serious threat.

Conclusion

Catch rates of juvenile *E. fimbriata* (“Awefu”), *S. maderensis* (“Mina”), and *B. auritus* (“Caima”) around Freetown peninsular are 170.8, 212.4 and 194.60 kg per hour per day, respectively. During the two weeks pilot survey, the researcher, calculated the mean length of the following adult species in "Tombo", “Goderich”, "Portee/ Rokuprr", and "Levuma" including, *E. fimbriata* 19.6 cm, *P. elongates* 23.3 cm, *S. sphyraena* 41.3 cm, *S. maderensis* 17.9, and *T goreensis* 25.0 cm. Comparatively, the exploitation of the clupeid was found to be high in these four landing sites at length for juveniles *S. marderensis* below 14 cm and *E. fimbriata* with an average of 6 cm.

The maximum length of adult *E. fimbriata* examined in the four landing sites was between 30 - 40 cm, but a length of 6 cm of juveniles were landed as well. The lengths of 30 - 40 cm of *E. fimbriata* in these areas were caught by ring net of mesh size 43 mm. The boat type of standard 3 - 5 and driftnet with mesh size of 29 mm for “Mina” and “Awefu”, beach seining for “Caima” were encountered and interviewed. The ring net of mesh size 29 mm catches the highest percentage of up to about 30% of juvenile *E. frimbriata* (awefu) in all the four landing sites. The use of illegal mesh size of fishing net is the key cause of juvenile mortality (Reithe and Aschan, 2004).

The study revealed that the current trend of juvenile fishes landings has threatened the potential fishery capital, revenue, and biodiversity. It is timely for the government to pay more attention to the artisanal sector by bringing the resource users together, educate and sensitize them on responsible fishing practice. Fishermen should be involved in planning and decision making and be empowered by providing alternative livelihood to allow recruitment of the species. To enforce proper policy and regulation, a co-management system of bottom to up approach should be used as a tool to achieve the management of marine protected areas, seasonal closures, gears, crafts and meshes size regulations. The government strongly needs to discourage the use of illegal mesh sizes of nets and in fact ban the importing, selling and use of illegal gears.

The government should also ban pair trawling in the industrial fisheries and beach seining in the artisanal sector. The shrimpers in the industrial sector should only trawl at night instead of day time, because target shrimps are highly caught at night rather than day time when most landings are by-catch juveniles (Reithe and Aschan, 2004). By-laws should be developed and properly enforced to help promote compliance and enforcement on the bans of fishing gears and methods like, dynamites (explosive), poisons, channel nets, monofilament nets, import, sale and use of illegal fishing gears with illegal mesh sizes. The mesh sizes for all artisanal fishing nets should be increased to at least 50 mm, and complete ban of beach seining in all fishery practices.

Seasonal closure policy should be developed and fully enforced in all fishery sectors to allow exploited resources to rejuvenate. It can also serve as conservation measures and can be a management plan for marine protected areas. Seasonal closure must be included in the overall fishery resource conservation policy and regulation. Fishermen who are specialised in fishing juvenile species should be interviewed for grow out. Juvenile fishing fishermen to a larger extent possess relevant information on seasonality nursery, spawning, ecological niche, habitat preferences, and periodical trends in abundance of the targeted species in their territorial waters. These types of information are sacrosanct because fishers who possess them depend on them for their livelihoods, and are therefore considered invaluable and reliable to researchers, industry and government (Johannes, 1981). Sierra Leone government should seek not only single objectives of fishery resources management but must incorporate a wide-range of other objectives.

Government needs to investigate and understand social and economic benefits of relevant fishing communities, in order to educate and sensitise the fishers about their rights and obligations to protect their habitats from poachers and destructive fishing activities. Fishers understanding such rights and obligations can serve as motivations and incentives to build their habitats and even protect those that are built for them by their ancestors. Subsequently, such rights and obligations can groom fish aggregating devices to establish and reinforce the impetus for improved, sustainable and community based fishery and marine conservations for current and generations yet unborn. These can also stimulate ownership, proprietary and protective interest in surrounding fishery territories and significantly discourage and decline destructive fishing practices such as the use of illegal craft–gear combination, explosives or dynamites and poisons (Galvez, 1991).

Fishermen should also be granted the right to involve in licensed fishery on an exclusive basis in the licensed fishery territories. Such rights should be based on the use of fishery territories which have been classified in coastal waters long period of time. Fishery right should be granted through lifting of prohibiting measures but various regulations such as craft-gear combination, closed areas and seasons as well as size structure caught limits must still remain in full force. License should be given to applicants based on their qualifications in the order of priority of proven record of compliance in fishery policy and regulations. Fishery right system should be allocated only to artisanal fishermen's groups vetted and registered by government that are residing in the coastal areas. Transfer and loan of such rights must be strictly prohibited and liable to criminal offence.

It is justifiable that stopping juvenile fishing will help improve catch rate of adult species, and the overall state of the fishery. Increase in the average size of the fish will lead to improvement in socio-economic benefit and livelihood. Though the market demand for juvenile by low income earner consumers indicates high socio-economic benefit, the biology, if neglected will lead to future economic losses and recession in fisheries production. Considering the significance of fishery sector in the share of GNP, the government of Sierra Leone should be careful and mindful of fish depletion.

Further research is recommended to determine the ratio of juvenile and adult fish that landed along Freetown peninsular and subsequently, estimate the impact of juvenile fishing on national fishery capital.

ACKNOWLEDGEMENTS

The suggestions, critical reviews and motivations by my supervisors, Professor Ernest Tom Ndomahina, Director, Institute of Marine Biology and Oceanography, Fourah Bay College, University of Sierra Leone, Kevin Kane, and Professor Eunice Taylor, International Center for HACCP Innovation, University of Salford, Manchester, United Kingdom are gratefully acknowledged. Mr Jude K Boateng and Ms Ranita Sandi were my study partners who voluntarily provided suggested comments and direct contributions in the data collection and analysis as part of their academic and professional capacity building throughout this work. I thank my wife Madam Omneya Khamis Mahmoud Badr for her academic, moral, financial and clerical supports during this study and preparation of the manuscript.

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