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Fishing with Light: Ecological Consequences for Coastal Habitats

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Abstract

The use of artificial lights (metal halide lamp, incandescent lamp) for attracting fish and increasing catch is a common practice in the world fisheries and has been regarded as one of the most advanced, efficient and successful methods for capturing purpose as a result of our depleting fish stock resources, coral reef degradation, increased fishing input to low catch output and operational cost. This fishing aggregating method has been found to be environmentally -unfriendly due to catching of immature stocks, overfishing, high rate of by catch and discard and green gas emission. Therefore, there is an urgent need to develop an eco-friendly light fishing technology and fishing regulation in the near future. The purpose of this paper is to review some of the literatures on light fishing in relation to the impact on sustainable fisheries and proffer solutions.

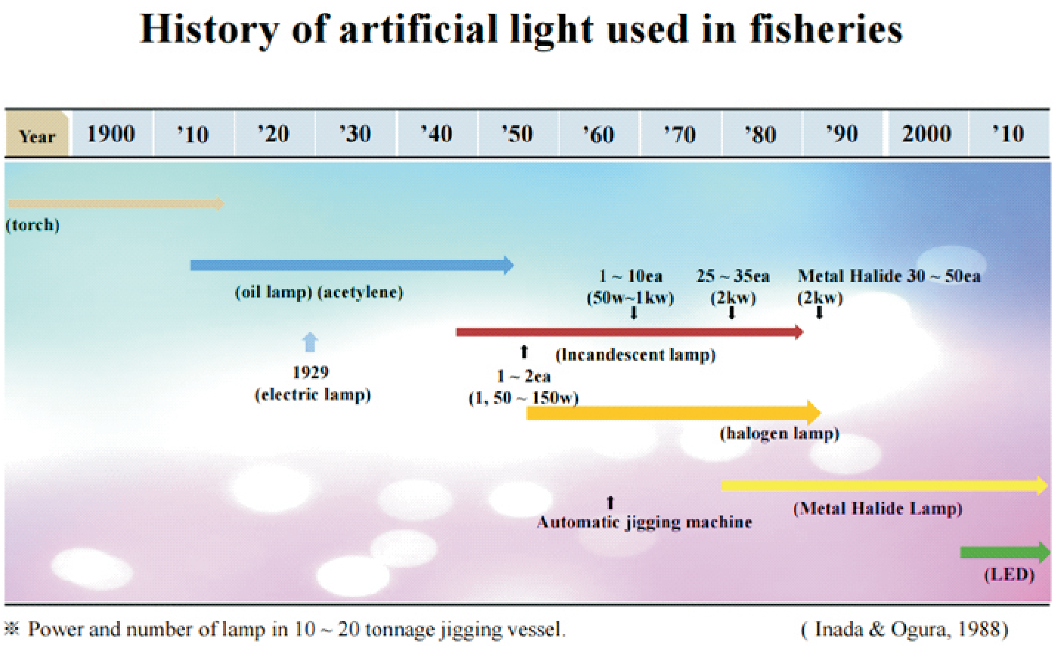
Keywords: *light fishing, incandescent, metal halide, eco-unfriendly, sustainable fisheries, solutions*

Background to the Study

The use of artificial light in fishing operations is a technique to attract and aggregate fish and eventually capture them using various fishing gears such as hooks, gill net, purse seine or other means (Dinglassan , 1972). Therefore, in a nutshell, Light fishing involves making use of lights attached to structures above water or suspended underwater to attract fish to specific areas and facilitate harvesting .This method has been one of the most advanced and successful means employed in some types of fisheries in the world today. It is a form of optical bait used to attract and concentrate fish to a spot. Many commercial and recreational fishermen are seen putting on the light on board in the night to attract the fish around their boats (Arimoto et al., 2001). This practice has been in existence since the olden days and described to be very effective in freshwater, brackish and marine ecosystems for catching and increasing landings of single and shoaling pelagic fish species such as sprat, herring and mackerel (Ben Yami, 1978; Ben Yami, 1988).

Historically, the source of light has changed with the centuries. It began with artificial light in form of fire lit at the beach which has been used for thousands of years (Ben Yami, 1978) when men discovered that some fish were attracted to light at the beach and they would silently enter the water with their family members, encircled the illuminated zone and dragged the fish to the shore with their legs and noise and killed them with stones, spears or clubs. The next development was the use of torches, being movable and made from coconut husk, split bamboo, carried by fishermen wading in water in the dark night to get the fish attracted, stunned and then captured with basket or spear. As time went on, the use of fuel oil; kerosene, gas and electricity, was introduced. Rasalan et al (1955) reported that Hawaiian and Philippine fishermen used to carry kerosene pressure tanks on their backs.

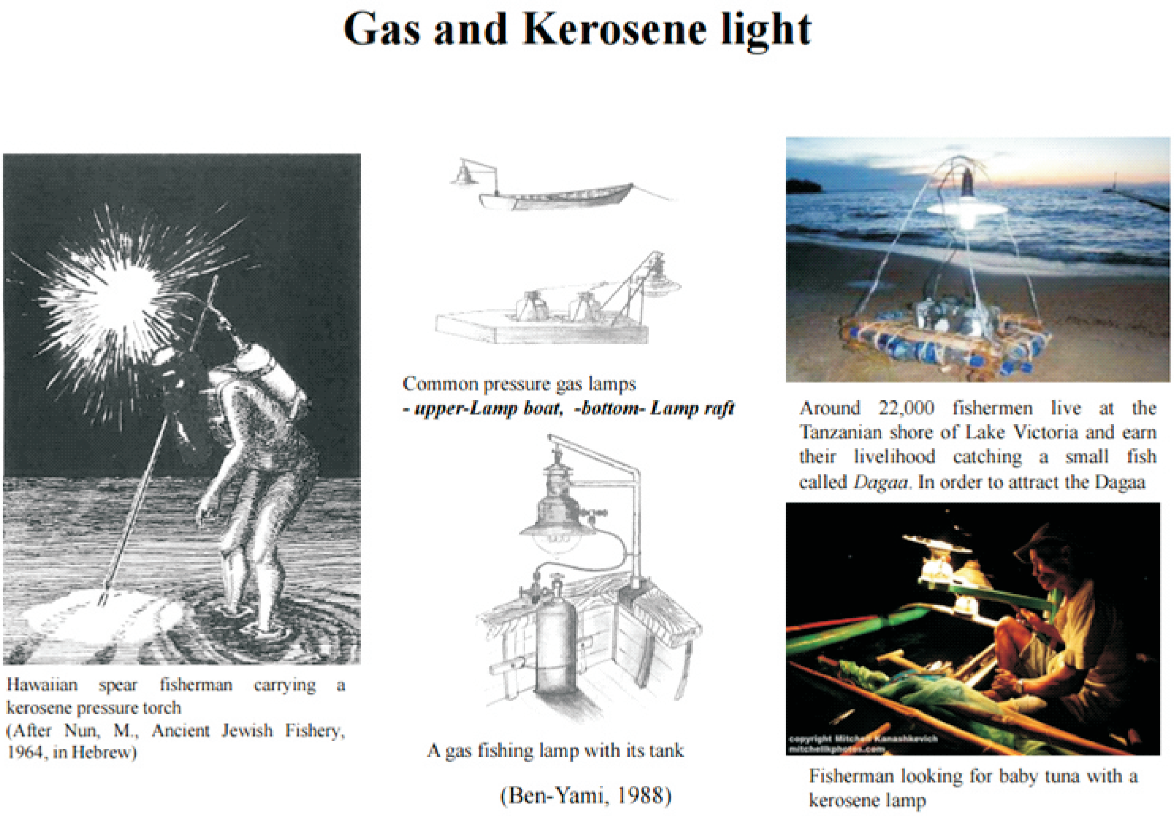
Nowadays, the use of powerful incandescent, fluorescent, led lamps and metal halides, is common as the source of light in commercial fisheries. They are more convenient, safer, move around, last longer but tend to be expensive, maintained and generate new problems such as increased competition among the commercial fishermen due to excessive level of light output (Matsushita et al., 2013), increased fuel cost, adverse environmental impact in terms of light pollution and green gas emissions e.g carbon(iv)oxide. If these are unchecked, could lead to overfishing, among other consequences. Many explanations have been offered to explain why fish respond to light whether attraction or repulsion. These include; to avoid predation or enhance their feeding efficiency by locating their food source or prey (Pitcher et al., 1993). These types of responses depend on factors such as species, ontogenic development, characteristics of the light source, intensity, colour and wavelength (Marchesan et al., 2005).It has been scientifically proven that fish and some of their food animals have eyes sensitive to blue and green colour because the water where these aquatic animals live in is bluish or greenish in colour and their long wavelengths making them to penetrate deeper in water column. This tends to attract and concentrate the fish on the water surface. Therefore, the aim and objectives of this study are; to review the impacts of light fishing on sustainable fisheries and suggest some control measures.



※ Power and number of lamp in 10 ~ 20 tonnage jigging vessel.

(Inada & Ogura, 1988)

Figure1: History of artificial light used in fisheries (Inada and Ogura, 1988)



Hawaiian spear fisherman carrying a kerosene pressure torch (After Nun, M., Ancient Jewish Fishery, 1964, in Hebrew)

Common pressure gas lamps
- upper-Lamp boat, -bottom- Lamp raft

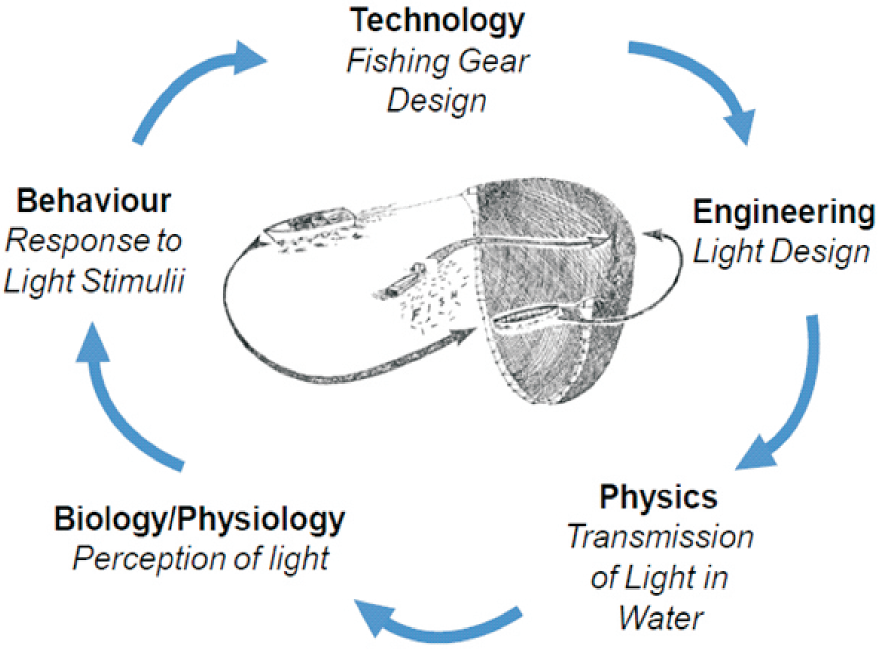
A gas fishing lamp with its tank

(Ben-Yami, 1988)

Around 22,000 fishermen live at the Tanzanian shore of Lake Victoria and earn their livelihood catching a small fish called *Dagaa*. In order to attract the Dagaa

Fisherman looking for baby tuna with a kerosene lamp

Figure 2: Gas and Kerosene Light (Ben-Yami, 1988)



Artificial Light in Fishing – a multidisciplinary challenge (Illustration from Ben Yami, 1978).

Figure 3: Artificial Light Fishing (Ben Yami, 1978).

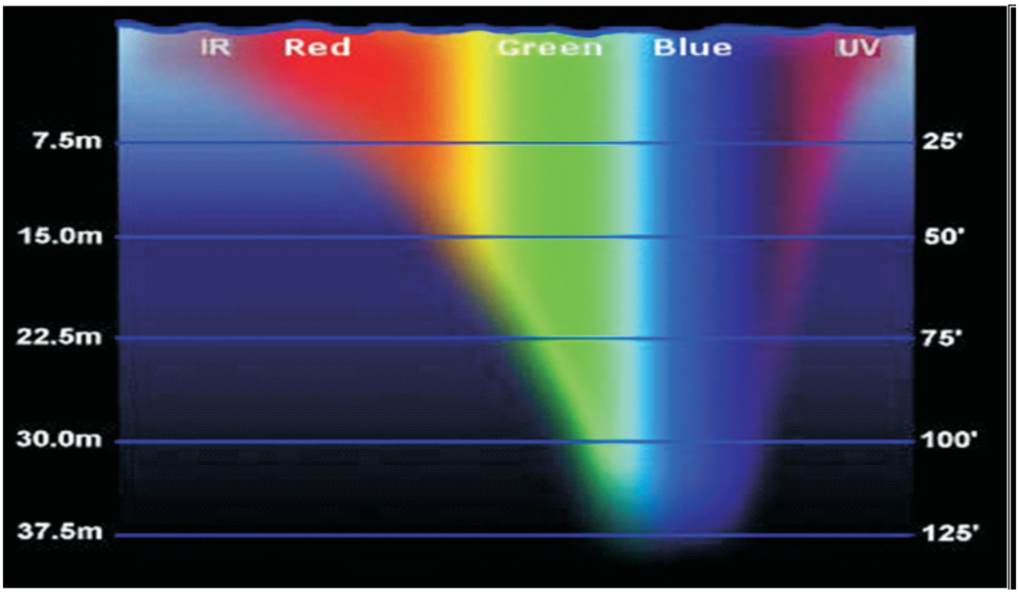


Figure 4.The spectral transmission of light in the open oceans: demonstrating the attenuation of different wavelengths of light, with greatest penetration in the middle wavelengths (450–570nm; blue and green) in comparison to longer (>620nm; red) andshorter (<450nm; violet and ultraviolet) wavelengths ((*Reprinted from*

http://ultramaxincorp.com/?p2=/modules/ultramax/catalog.jsp&id=23; cited by Arimoto et al., 2011).

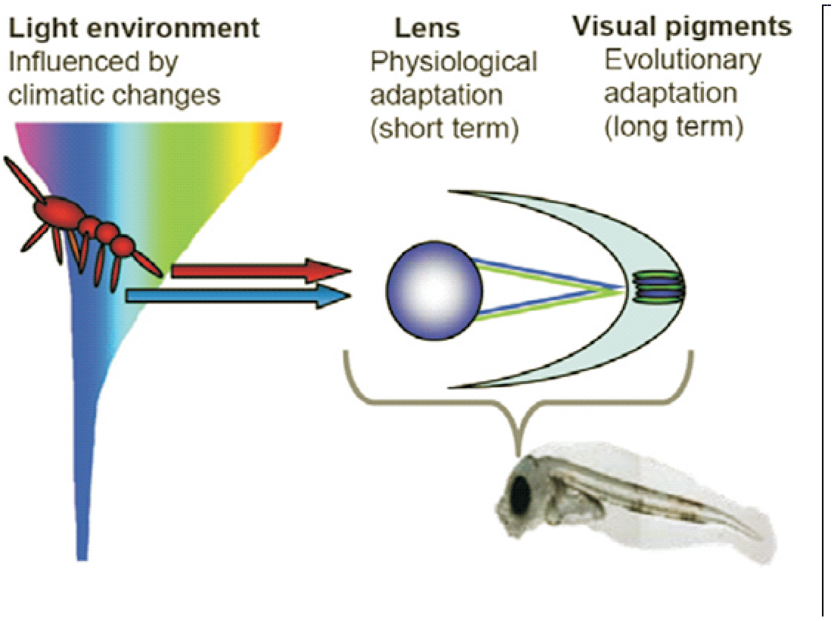


Figure 5: Visual detection in fish, which is influenced by the ambient light environment, short term physiological adaptations (e.g. in the structure of the lens) and long-term evolutionary adaptations (e.g. in the composition of visual pigments in the retina). Figure by Jon V. Helvig, Dept. of Biol., Univ. of Bergen.

Overview of the Use of Fishing with Light in the World Fisheries (Case Studies)

Indonesia

Due to the introduction of the electric lamps, the light fishing has been widely spread to the offshore fisheries to the large-scale commercial level for the boat seine, purse seine, Bagan (platform lift-net), by using electric lamps such as incandescent, fluorescent and mercury lamps. As the typical characteristics of the tropical fisheries in Indonesia, there are many types of fishing gears for a certain target species, and variety of catch species for a certain type of gear, for identifying the multi-species and multi-gear fisheries. South Sulawesi is one of the famous regions in Indonesia with the intensive fishing activities with light, with the specialized development of Bagan Rambo (Large scale lift-net operated from the platform raft) in Barru regency, and the purse seine in Jeneponto regency (**Hajar et al., 2014**). *Bagan*is a lift net formed of box-shaped net with fine mesh size of 0.5 cm, operated with lamp for attracting pelagic species. The small pelagic fisheries in the South China Sea and Andaman Sea have been exploited since 1970s. The dominant species caught are scads (Decapterusspp), Indian mackerel (Rastrelligerspp) and sardines (Sardinellaspp).Currently, the maximum sustainable yield of the small pelagic fish resources in the South China Sea of Indonesia has been estimated to be around 621.500 MT/year, whereas for the Malacca Strait, including the Andaman Sea reaches 147.300 MT/year

(Purwanto et al., 2010). The pelagic fish species make small school, usually shelter around FADs, and are attracted to light at night. With this characteristic, to catch fish by purse seine easily, most of the fishers using FAD and light to aggregate fish before the fish being caught. The use of FADs and lamps is able to improve fishing efficiency such that the ability of purse seine to catch fish increase (Purwanto et al., 2010). The increased catch ability of purse seine may result in over exploitation in certain waters.

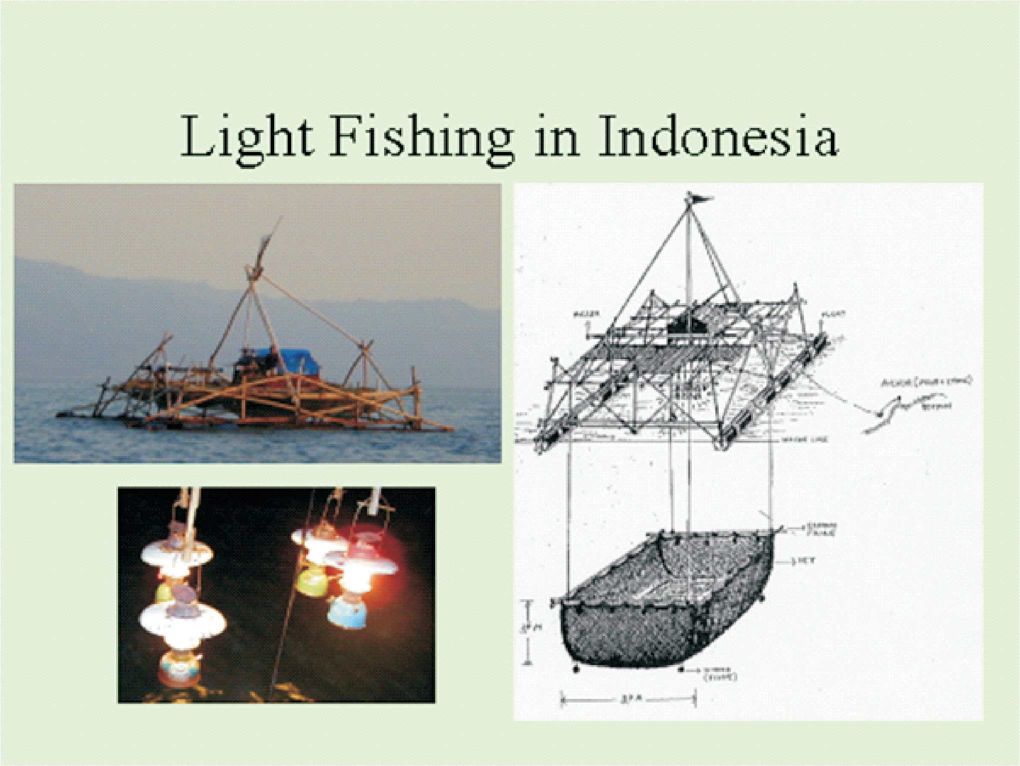
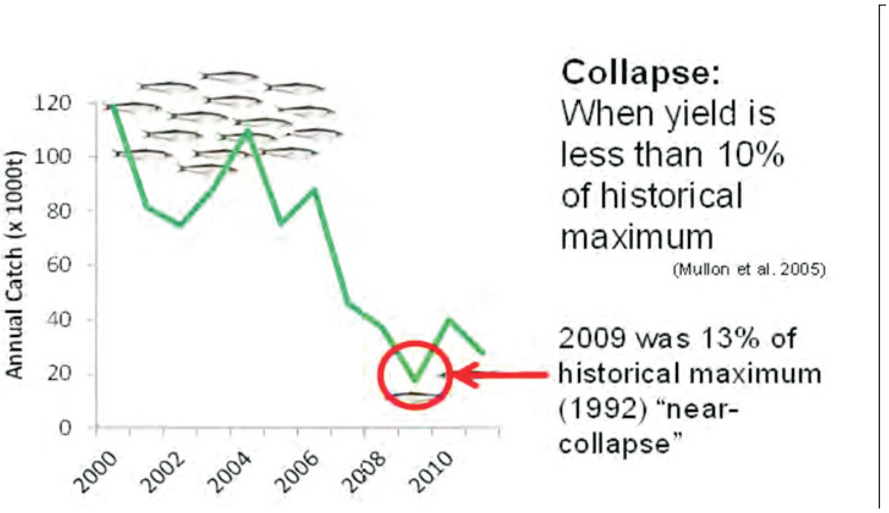

Light Fishing in Indonesia

Figure 6: Light fishing gear types used in Indonesia (http://www.soi.wide.ad.jp/class/20020017/slides/02/102.html)

Ghana

Bannerman et al (2004) reported that light fishing is commonly practiced in three coastal areas in Ghana, namely; Tema, Mumford & Elmina and Sekondi regions because they have port facilities for landing their catches operated by large inshore vessels using purse seine predominantly using light attraction. Currently, there are about 250 registered of such inshore vessels in the country whose size is 39-60 feet but only small fraction are still operating due to problem of spare parts and operation cost. Light fishing operation in Ghana usually operates using purse seine gear with small size generator for powering the incandescent lamp. They also make use of fish finders, a two-way radio communication gadget and diesel-driven winch drum to facilitate fish searching and catch hauling. Most of the targeted species are of herring group such as herring, sardines and anchovies. Others are horse-mackerel, bonitos and cephalopods (squids) which are caught using light attraction. These small pelagic fisheries are dominated by canoe fishery which lands 80% of the total catch in Ghana while the remaining 20% is covered by the inshore fishery (MFRD Statistics, 2003). This outcome has forced the inshore fishery to adopt advanced light fishing as a means of realizing economic returns through intense capitalization as a result of poor landings. This development has generated some conflicts between the inshore and canoe fishers. The canoe fishers complained about their poor landings and accused the inshore counterparts of their light as the reason for their declining catches. They reasoned that the light detains the fish further off-shore thus preventing the fish from coming to their area of operation.



Collapse:
When yield is less than 10% of historical maximum
(Mullon et al. 2005)

2009 was 13% of historical maximum (1992) "near-collapse"

Figure 7a:Ghanaian canoe catch of sardinella spp.
(Source credit: Proceedings of the 3rd National Fisheries Dialogue: WorldFish)

East Africa (Lakes Victoria and Tanganyika)

Lake Victoria is the world's third largest but Africa's largest lake with an area of 68,800 square kilometres and average depth of 40metres.It is bordered by Tanzania, Uganda and Kenya. The first night fishing was recorded dated back to 1960s (Gibbon, 1997) and fishing techniques differ among locations. Canoe fishery predominates in the Lake Victoria with average canoe-size measuring 4m long and 1.5m wide and fishermen occur in crew of four. The kerosene lanterns are tied to the small wooden floats (60cm by 60cm), each float carries one light. The floats are usually four in number with each carrying a piece of kerosene lantern. This means that there are four lanterns per boat. The floats are anchored to a stock (rock) to prevent it from being swept away. The fishermen would then encircle the float with net forming a diameter of about 30 metres, with the float and light at the centre. Then, they begin to haul and close the net through hauling operation. The fish targeted and landed on-board are usually Dagaa (a small pelagic spp belonging to sardine family). The fishermen usually work between 14-21 nights per month for eight to twelve hours per night. At both Lake Victoria and Lake Tanganyika, the night fishermen have their own fishing camps which vary in size from beaches with few boats to a large camp containing 200 boats (Nsinda, 2005). They are registered as Beach Managing Units (BMUs) which is a co-management institution whose mandate is to manage, regulate and monitor fishing activities and ensure socio-economic development of its members. The fish traders who often visit the lake to buy fish provide and supply the necessary equipment and fuel to these camps. Over 175,000 fishermen are working as full-time operators around the lake. Out of this number, 31,891 fishermen with 8272 vessels are engaged in night fishing especially for Dagaa (Legros et al., 2011). It is important to know that there have been decline in the fish landings over the years and this has resulted to the seasonal migration of fishermen to different sites in searching for a better fishing conditions and prices. Odongkara et al (2007) cited by Gengnagel et al (2013) conducted a survey and found out through interview that half of the fishermen interviewed in 2007 stated to have moved their fishing sites to a better location.

Figure 7b: Fishing technique at Lake Victoria (Gengnagel et al., 2013)

Lake Tanganyika is the second deepest lake in the world and second largest in Africa in terms of surface area. It is bounded by four countries namely, Burundi, Zambia, Tanzania and Congo Democratic Republic. Over 10 million people depend on the lake for their livelihoods as it offers vital resources including fish, domestic water and serves as a means of transportation (Mushagalusa et al., 2015). The lake is famous mostly for two commercially important pelagic, non-cichlid species, which are clupeids; Limnothrissamiodon (Boulenger, 1906) and Stolothrissatanganicae. Most of the fishing operations is done in the night using different gears such as purse-seine net, lift net, and rely on clupeids attracted to light. Most night fishing operations cease every month during the period of full moon. Three types of fisheries are found in the Lake, these are; 1) Artisanal Fishery characterized by 6-7m long wooden plank hulls, lift net, 6-7 lamps and 4-7 fishers. (2) Traditional or subsistence fishery characterized by using gears such as gill-net, hook and line, scoop net which are less efficient than artisanal. (3) Semi-industrial fishery are characterized by the use of purse seine net, 16-20m long steel vessel, auxiliary steel boat, 5 lamps and a crew of 30-40 fishers. There has been a decline of the catch per-unit-unit-effort (CPUE) recorded over the last ten years for the semi-industrial as well as the traditional fisheries within Burundi waters. The average CPUE/night for the semi-industrial fishery in Burundi decreased from 1173 kg/night/unit in 1983 to 150 kg/night/unit in 1993 and now appears to be unprofitable. However, the artisanal lift-net fishery, due to the use of bigger nets, better fishing lamps and the choice of more productive fishing grounds, manages to maintain its CPUE at a profitable level.

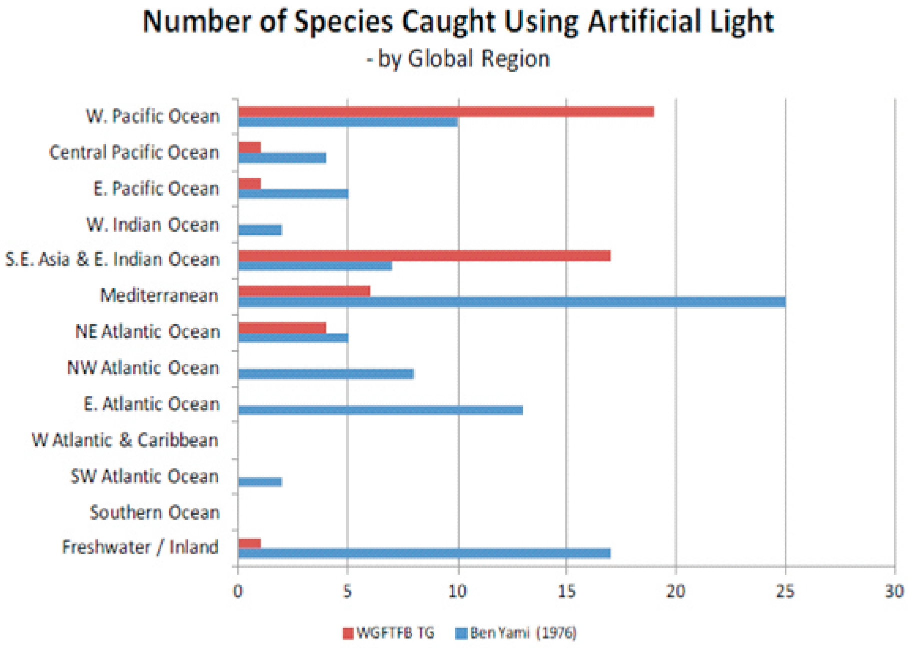


Figure 8: Overview of number of species using artificial light by global region (Ben - Yami, 1976)

Description of light fishing techniques – industrial and artisanal

The origin of jigging dates back to antiquity in many parts of the world. The use of artificial light combined with jigging has been found to be highly successful for attracting and concentrating squid at night and several important squid fisheries have been established in recent years. Jigging for squid is perhaps one of the oldest methods used in Japan and other countries including Norway, United Kingdom and some Pacific Islands (Rathjen,1984).Almost all aspects of jigging fishery have undergone rapid changes within past few decades (Saharuddin et al., 1990). Automatic squid jigging and computer operated automatic jigging machines were introduced and developed in 1965 and late 1980s respectively (Lee et al., 1997). Court (1980) reported that about 70% of squid's landingsin Japan are captured by jigging method which makes use of overhead bright light in the night to attract squids to the surface. The squids attack the jigs, which are lures, arranged and separated at intervals of 90cm on a microfilament, and their tentacles become hooked. The jigs are then reeled aboard and squids disengaged in the process. Squid jigging boats in Japan are classified into three based on their capacity in tonnage; small scale (1-30 ton), medium scale (30-100 ton) and large scale (100-500 ton).Small boats are made of either wood or ferro-reinforced plastic while large boats have steel hulls. Squid's landings made by these boats are in proportion to their capacities/sizes and focus from coastal to offshore waters. For instance, over 50% of the total landings are made by the large scale boats because they are well equipped with powerful electric generators which provide highly demanding squid-attracting lights of over 300kW and have larger freezing or cold storage facilities of 10-17 tons per day. Although, squid jigging fishery was not regulated until 1969 because there was glut of the resource before then, but with decreasing CPUE over time, there have been serious competitions among the large number of boats posing a big problem for the fishery.

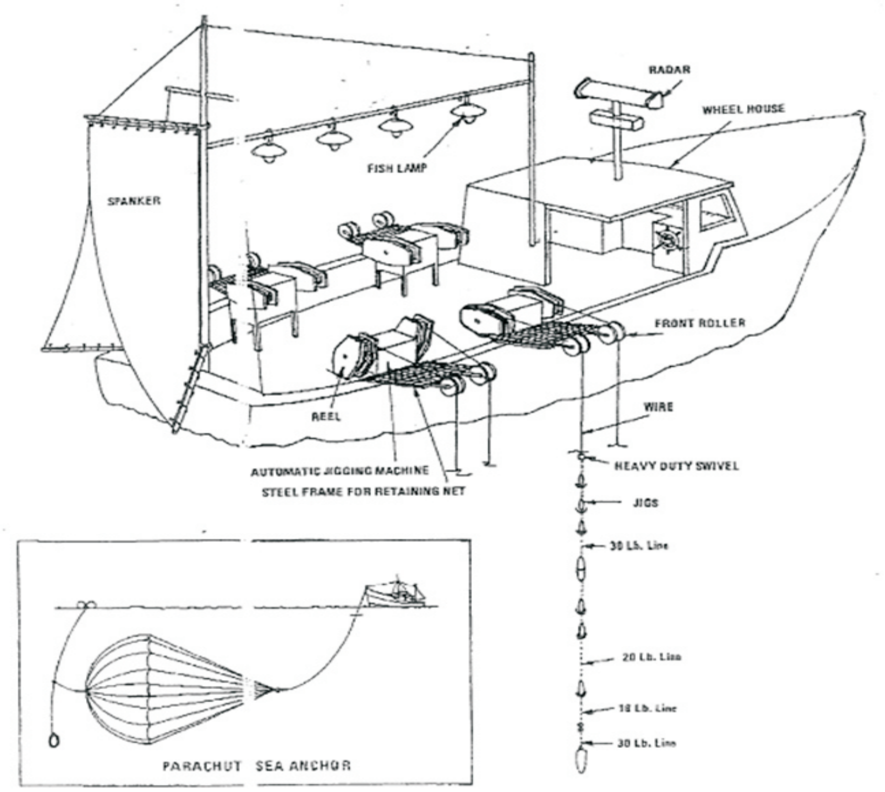


Figure 20. A typical small squid fishing boat rigged for jigging squid (adapted from Rathjen, 1984).

Figure 9: A typical small squid fishing boat (Adapted from, Rathjen,1984)

Commercial squid fishing boat, Obama, Japan

A commercial squid fishing boat in the port of Obama, Japan on the Sea of Japan. The lights are used to attract squid to the boats where they are then captured. There was perhaps 40-50 boats in the harbor.

Photo: July 2012

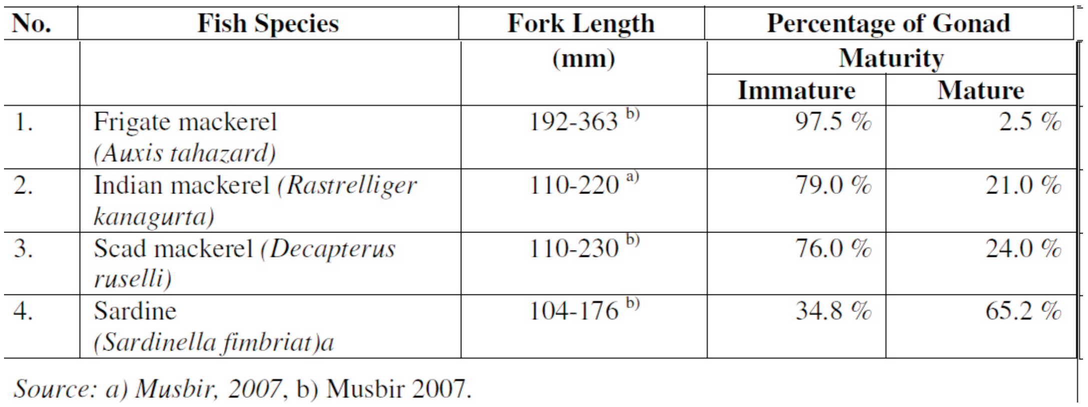
Figure 10: Commercial Squid fishing boat, Obama, Japan) (http://www.aslo.org/photopost/showphoto.php/photo/2141/title/commercial-squid-fishing-boat-2c-obama-2c-japan/cat/506)

Ecological Impacts of Fishing with Light

Overfishing/Undersized or Immature target fish species/Catch trend/Size Composition of Main Species

The use of purse seine and lift net have prevailed in the coastal fisheries for pelagic fish around Flores Sea in Indonesia. These two fishing gears are characterized by different catches per trip in the region. Most of the purse seine used in the region are of the mesh size of 2.5mm. Musbir et al (2007) experimented and reported the diversity of the various fish species which were caught using light attraction in Flores sea. The result shows that most of the species caught were small size and of immature gonads as shown in **figure11.**This means that the spawning, reproductive activities and most especially population dynamics (low recruitment)of the species concerned would be adversely affected in the following season. Therefore, it is necessary to ensure sustainability of the pelagic species concerned by regulating the mesh size of the fishing gear (Moore, 1999 and Sinclaira et al., 2002).

Figure 11: The Fork length and Gonad Maturity of fish catch by purse seine in Flores Sea.



No.	Fish Species	Fork Length (mm)	Percentage of Gonad Maturity	
			Immature	Mature
1.	Frigate mackerel *(Auxis tahazard)*	192-363 b)	97.5 %	2.5 %
2.	Indian mackerel *(Rastrelliger kanagurta)*	110-220 a)	79.0 %	21.0 %
3.	Scad mackerel *(Decapterus ruselli)*	110-230 b)	76.0 %	24.0 %
4.	Sardine *(Sardinella fimbriat)a*	104-176 b)	34.8 %	65.2 %

Source: a) Musbir, 2007, b) Musbir 2007.

On the other hand, the research conducted by Tham (1965) in Singapura strait showed that Bagan Rambo also tends to be environmentally unfriendly to four dominant pelagic species (anchovy, Russell's scad, Indian mackerel and sardine) which were caught within the size range of 5.7-9.2cm. He found out that the standard length for anchovy at 5cm is considered as the first maturity stage. This was supported by Tiews et al(1970) that anchovy in Manila Bay spawned at 6-6.5cm. Sudirman (2003)found out the same result for Russell's scad and Indian mackerel in Makassar strait as the size of the species caught were small and immature as shown in figure 12a,b and c.

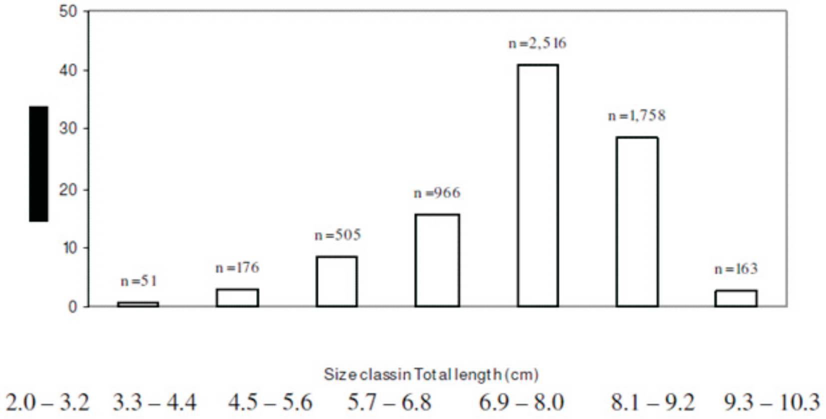


Figure 12a: Length frequency distribution of anchovy caught by bagan Rambo.

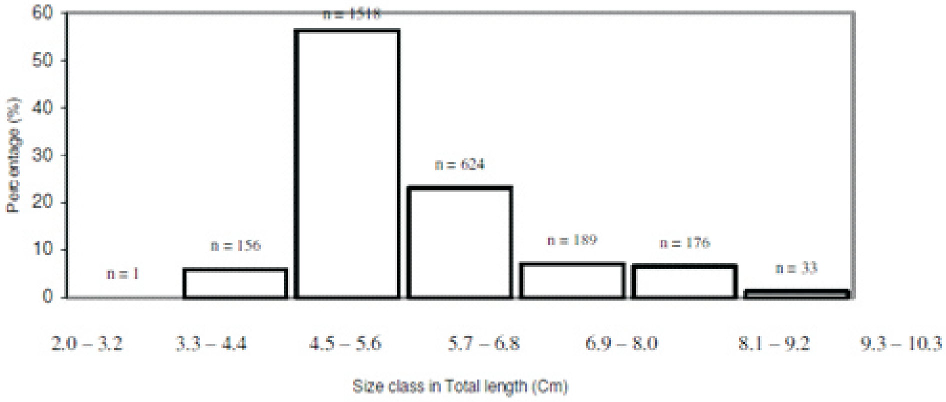


Figure 12b: Length frequency distribution of Russell's scad (Sudirman, 2003) caught by bagan Rambo.

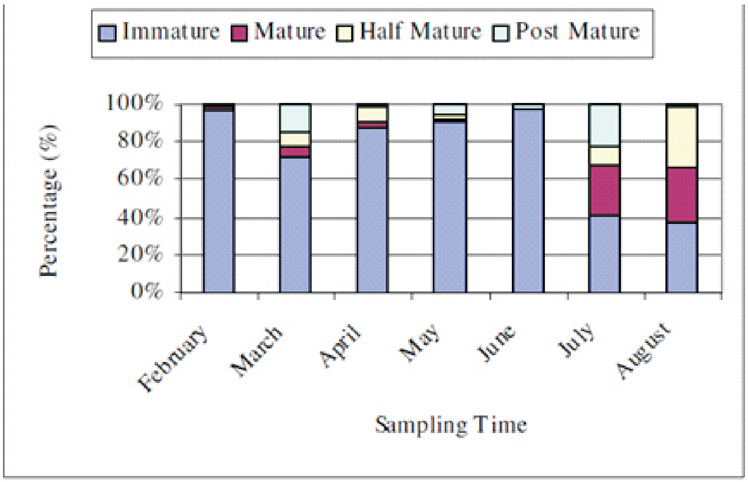


Figure 12c: Gonad maturity stage caught by bagan Rambo in Makassar Strait (sample size=2777 individuals).

Mallawa et al(1991) also reported the small size and immaturity of the pelagic species caught during their experiment using Bagan Rambo as shown in **table1**and Khair(2000) reported the same finding during his experiment in Bone Bay South Sulawesi as shown in **table2**.Najamuddin and Palo (1994) and Nadir (2000) have also measured fish length for the four dominant catch in their experiment for anchovy, scad, Rastralliger and sardine in Makassar Strait.

In regards to overfishing/catch trend, the result of the hauling experiment conducted by Sudirman(2003) using bagan Rambo indicated that the catch of the pelagic species tend to decrease in weight with time as more than 22% of the catch fall within the range 0-400kg as shown in **figure13.**Sudirman et al(2001) reported that in Bone Bay (Sinjai water) total fishing effort using bagan Rambo tends to increase over 8 years,total production and catch per unit effort decreased over the same period as shown in figure **14**.

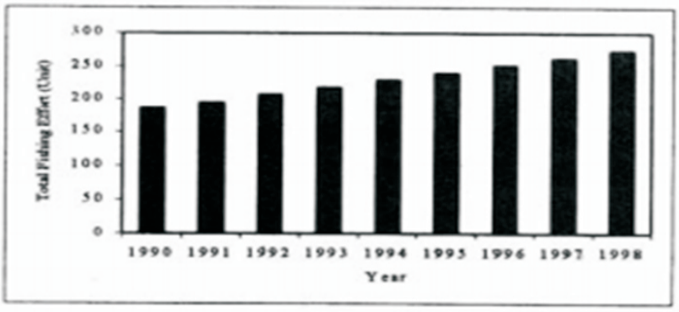


Figure 33. Total Fishing Effort (Boat Bagan) by year in Sinjai waters, South Sulawesi

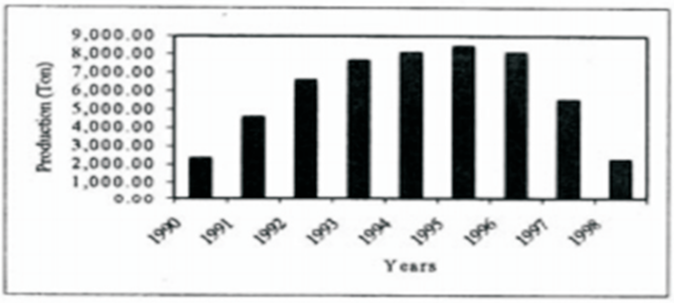


Figure 34. Total Production of Boat Bagan in Sinjai Waters, South Sulawesi

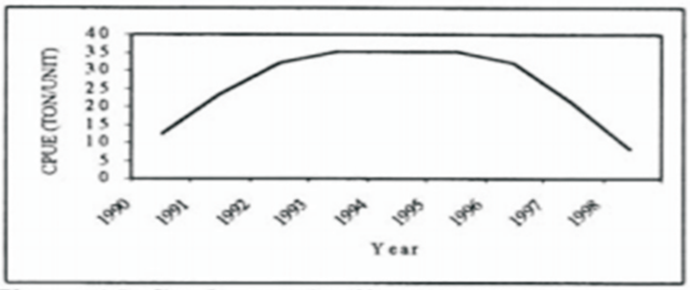
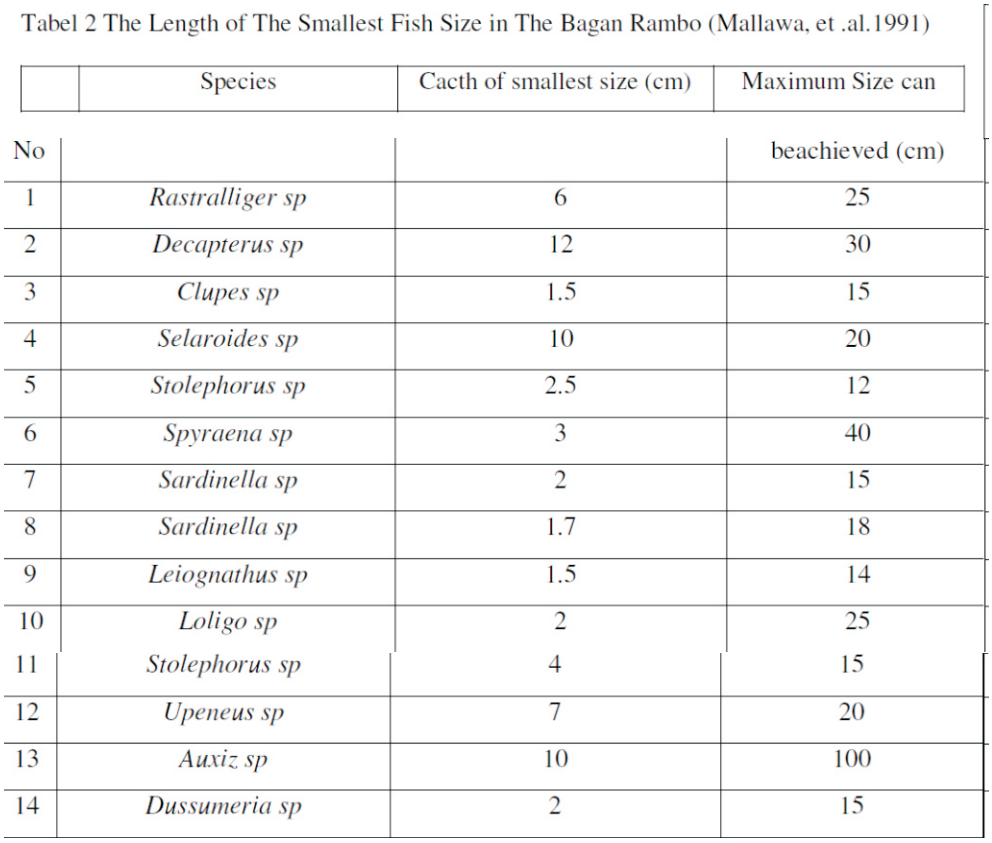


Figure 35. Catch perunit effort (CPUE) by year in Sinjai waters South Sulawesi

Figure 14: **Total Fishing Effort, Total Production and CPUE in Sinjai Waters (Sudirman et al., 2001).**

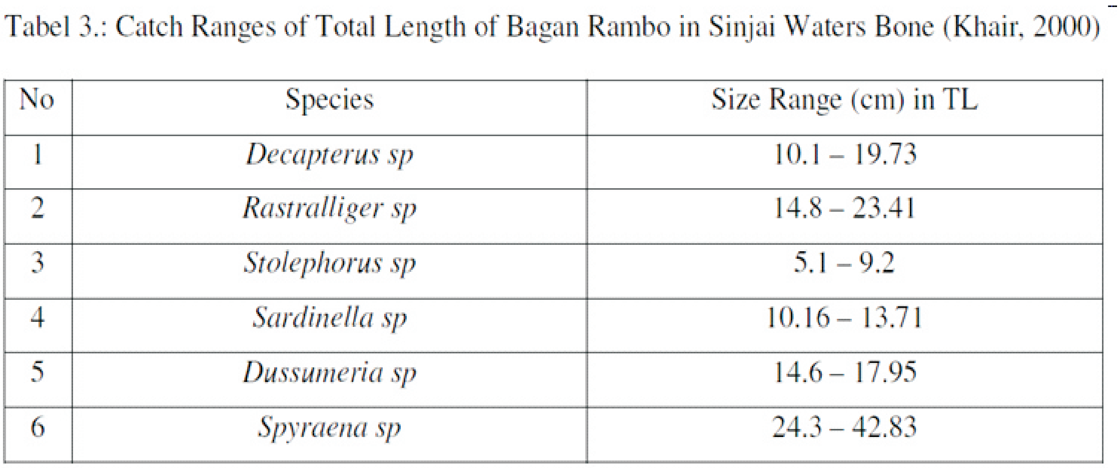
Table 1: Length of smallest fish caught using bagan Rambo (Mallawa et al., 1991.



Tabel 2 The Length of The Smallest Fish Size in The Bagan Rambo (Mallawa, et .al.1991)

No	Species	Cacth of smallest size (cm)	Maximum Size can beachieved (cm)
1	*Rastralliger sp*	6	25
2	*Decapterus sp*	12	30
3	*Clupes sp*	1.5	15
4	*Selaroides sp*	10	20
5	*Stolephorus sp*	2.5	12
6	*Spyraena sp*	3	40
7	*Sardinella sp*	2	15
8	*Sardinella sp*	1.7	18
9	*Leiognathus sp*	1.5	14
10	*Loligo sp*	2	25
11	*Stolephorus sp*	4	15
12	*Upeneus sp*	7	20
13	*Auxiz sp*	10	100
14	*Dussumeria sp*	2	15

Table 2: Catch ranges of Total Length of Bagan Rambo (Khair,2000)



Tabel 3.: Catch Ranges of Total Length of Bagan Rambo in Sinjai Waters Bone (Khair, 2000)

No	Species	Size Range (cm) in TL
1	*Decapterus sp*	10.1 – 19.73
2	*Rastralliger sp*	14.8 – 23.41
3	*Stolephorus sp*	5.1 – 9.2
4	*Sardinella sp*	10.16 – 13.71
5	*Dussumeria sp*	14.6 – 17.95
6	*Spyraena sp*	24.3 – 42.83

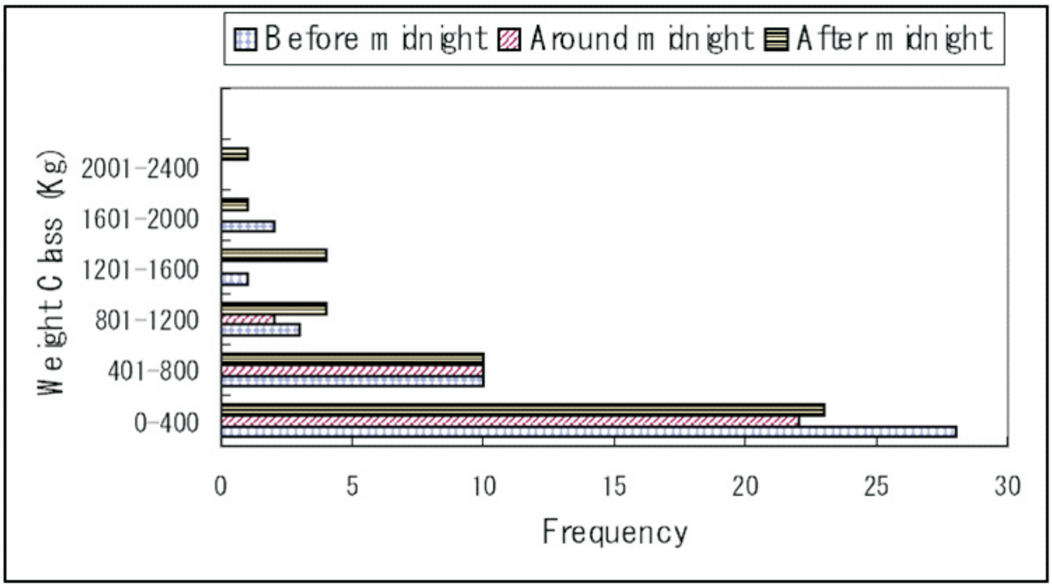


Figure 13:Catch trend of landings (Sudirman,2003)

Figure 15: A fixed bagan platform inIndonesia(http://www.google.de/imgres?imgurl=http://c8.alamy.com/comp/CBCGMN/fishing-platform-called-bagan-cenderawasih-bay-west-papua-indonesia-CBCGMN.jpg&imgrefurl=http://www.alamy.com/stock-photo-fishing-platform-called-bagan-cenderawasih-bay-west-papua-indonesia-41458501.html&h=447&w=640&tbnid=mqBhAb_hWGAdIM:&tbnh=135&tbnw=194&usg=__4tQU4TKLpGxJz

siwxyYY-qFZaMg=&docid=xWeQvuSmwoRy-M&client=opera&sa=X&ved=0CCYQ9QEwAWoVChMI1d6bxMKqxwIVQlwUChoS1wi0)

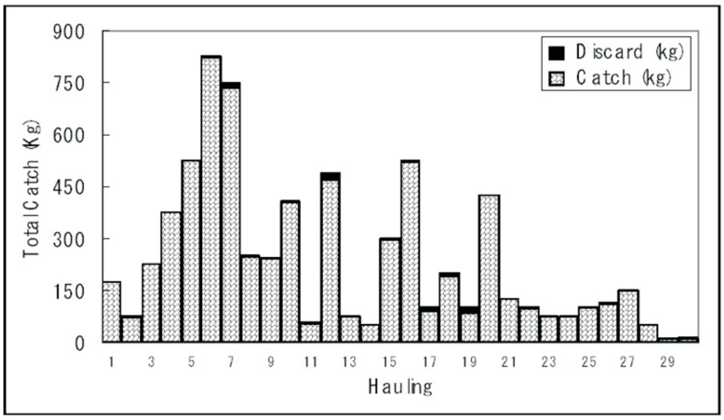
Increased By-Catch and Discard Rate

The issue of By-catch in global fisheries has become a conservation concern especially in areas where ecosystems are seriously degraded (Harrington et al., 2005). Bycatch is regarded as the incidental catch of non-target species which are often discarded due to their unmarketable size, command low price or regulatory restrictions (Dunn et al., 2011; NMFS, 2011). Most commonly bycatch species unintentionally caught during fishing with light operations include marine mammals, turtles, birds and invertebrates. Some of them are retained while others are thrown back into the sea due to regulatory purpose. The survival rates for discarded by-catch as well as the impacts on marine ecosystem, are highly variable (Chopin et al., 1995 reviewed in Alverson et al., 1994; Davis, 2002; Kelleher, 2005). Bycatch leads to wasting of living resources, threatening of the population of endangered species, changes in trophic structure (Alverson et al., 1996; Crowder et al., 1998; Morgan et al,2003).Because of persistent decline in the global fish landings and increased competition for depleted stocks, the socio-economic and ecological arguments to decrease bycatch have received much attentions from policy makers and general public (Alverson et al.,1996).

After the 30 days Hauling experiment for the catching tendency of Bagan Rambo in Makassar Strait by Sudirman et al(2006), they reported that the catches could be grouped into 3; the Main Catch (which include the pelagic species, anchovy, squid, mackerel); the By-catch (*Caesiosp, Siganussp, Caranxsp, Theroponsp, etc) and the Discard catch (Apogonsp, Priachantussp, Anomalpssp, Amansessp, Chandasp, Chantigastersp* ,etc.) with Average of discard rate of *bagan Rambo* during 30 hauling indicated 2.18%.Some reasons for discard catch are; inedible, unmarketable and unfamiliar by the people.Comparison was made between the Main Catch and the Discard for each hauling during the experimental days as shown in figure 16. Discard catch was very high in day 7 but tends to decrease as hauling day progresses. It was also found out that by-catch species predominantly vertebrates and invertebrates were to be discarded and were of higher quantities than the main catch. This is a wasteofresources, could result to economic loss and affect the population dynamics. Their total lengths, number and percentage during experiment are shown in tables 3 and 4.

Table 3: Range of total length and number of the by-catch (vertebrate) during the experiment

Figure 16: Comparison of catch and discard each hauling of baganRambo



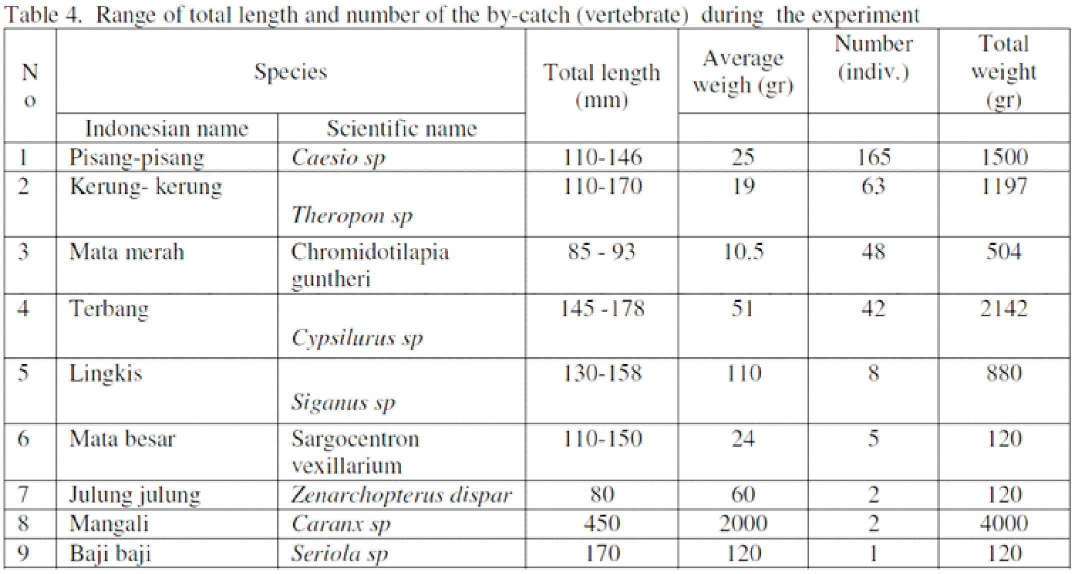


Table 4. Range of total length and number of the by-catch (vertebrate) during the experiment

No	Species		Total length (mm)	Average weigh (gr)	Number (indiv.)	Total weight (gr)
	Indonesian name	Scientific name				
1	Pisang-pisang	*Caesio sp*	110-146	25	165	1500
2	Kerung- kerung	*Theropon sp*	110-170	19	63	1197
3	Mata merah	Chromidotilapia guntheri	85 - 93	10.5	48	504
4	Terbang	*Cypsilurus sp*	145 -178	51	42	2142
5	Lingkis	*Siganus sp*	130-158	110	8	880
6	Mata besar	Sargocentron vexillarium	110-150	24	5	120
7	Julung julung	*Zenarchopterus dispar*	80	60	2	120
8	Mangali	*Caranx sp*	450	2000	2	4000
9	Baji baji	*Seriola sp*	170	120	1	120

Table 4: Discard composition and their percentage caught by bagan Rambo during the 30 day hauling experiment

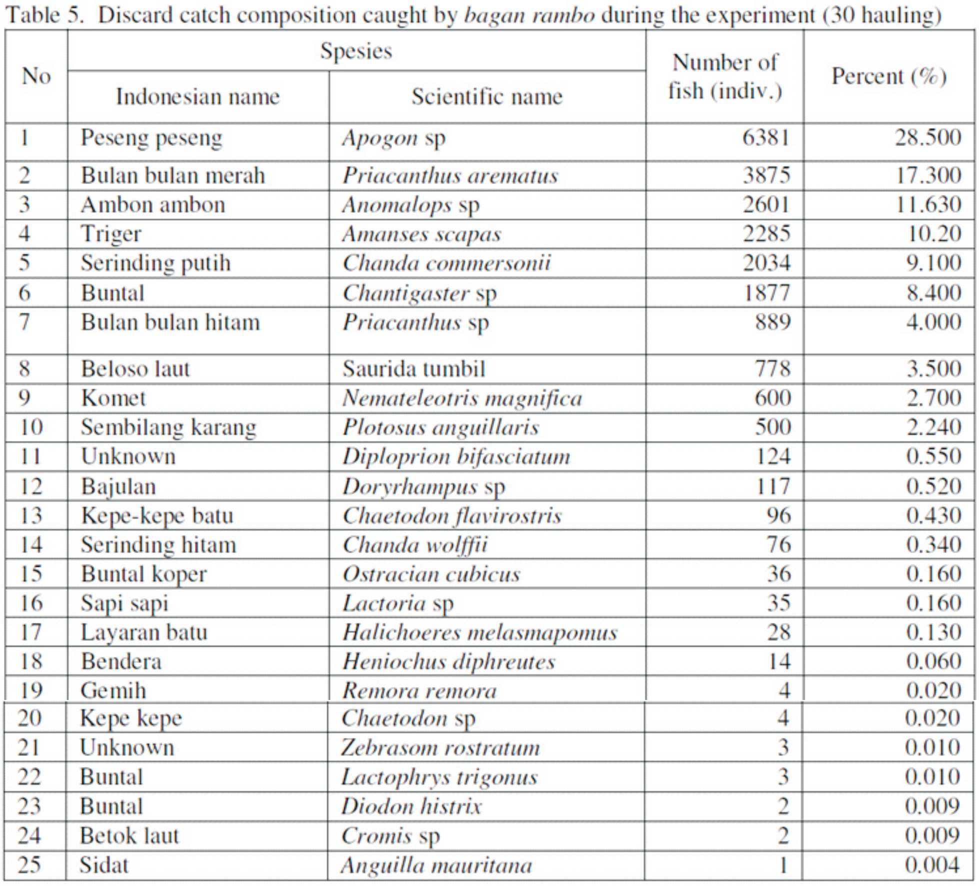


Table 5. Discard catch composition caught by *bagan rambo* during the experiment (30 hauling)

No	Spesies		Number of fish (indiv.)	Percent (%)
	Indonesian name	Scientific name		
1	Peseng peseng	*Apogon* sp	6381	28.500
2	Bulan bulan merah	*Priacanthus arematus*	3875	17.300
3	Ambon ambon	*Anomalops* sp	2601	11.630
4	Triger	*Amanses scapas*	2285	10.20
5	Serinding putih	*Chanda commersonii*	2034	9.100
6	Buntal	*Chantigaster* sp	1877	8.400
7	Bulan bulan hitam	*Priacanthus* sp	889	4.000
8	Beloso laut	Saurida tumbil	778	3.500
9	Komet	*Nemateleotris magnifica*	600	2.700
10	Sembilang karang	*Plotosus anguillaris*	500	2.240
11	Unknown	*Diploprion bifasciatum*	124	0.550
12	Bajulan	*Doryrhampus* sp	117	0.520
13	Kepe-kepe batu	*Chaetodon flavirostris*	96	0.430
14	Serinding hitam	*Chanda wolffii*	76	0.340
15	Buntal koper	*Ostracian cubicus*	36	0.160
16	Sapi sapi	*Lactoria* sp	35	0.160
17	Layaran batu	*Halichoeres melasmapomus*	28	0.130
18	Bendera	*Heniochus diphreutes*	14	0.060
19	Gemih	*Remora remora*	4	0.020
20	Kepe kepe	*Chaetodon* sp	4	0.020
21	Unknown	*Zebrasom rostratum*	3	0.010
22	Buntal	*Lactophrys trigonus*	3	0.010
23	Buntal	*Diodon histrix*	2	0.009
24	Betok laut	*Cromis* sp	2	0.009
25	Sidat	*Anguilla mauritana*	1	0.004

The experimental fishing conducted by Supongpan et al (1992) in the coastal areas off Prachuab Kirikhan, Chumporn and SuratThani provinces of Thailand between May 29th to June 26th 1987 which aimed to analyze the catch of Indian squid Loligoduvauceli by light luring fishing in relation to the abundance of other species and the size structure of main by-catch species, Indian mackerel, Rastrelliger kanagurta. Sixty experimental light luring fishing were made using stick-held cast net (2.5cm mesh) with a mouth surrounding length 50m and thirty four incandescent bulbs (500W) including two red spot-lights on board the research vessel SPT-9 (14.8m, 74HP) from the Eastern Marine Fisheries Development Center, Rayong. Six bamboo poles (6m length) having bulbs were made to stand out from vessel. The result shows that the catches were made up of the high diversity of pelagic and demersal fish. Five species of Cephalopoda (51.31%), twelve commercially important fish groups (38.68 %), other twelve fish groups (5.19%), two Crustaceans (0.28%) and unclassified fish and Crustacean (4.54 %) were found as shown in the **table 5**below;

Table5: Percentage occurrences of cephalopods, commercially important fish, other fish, crustaceans and others.

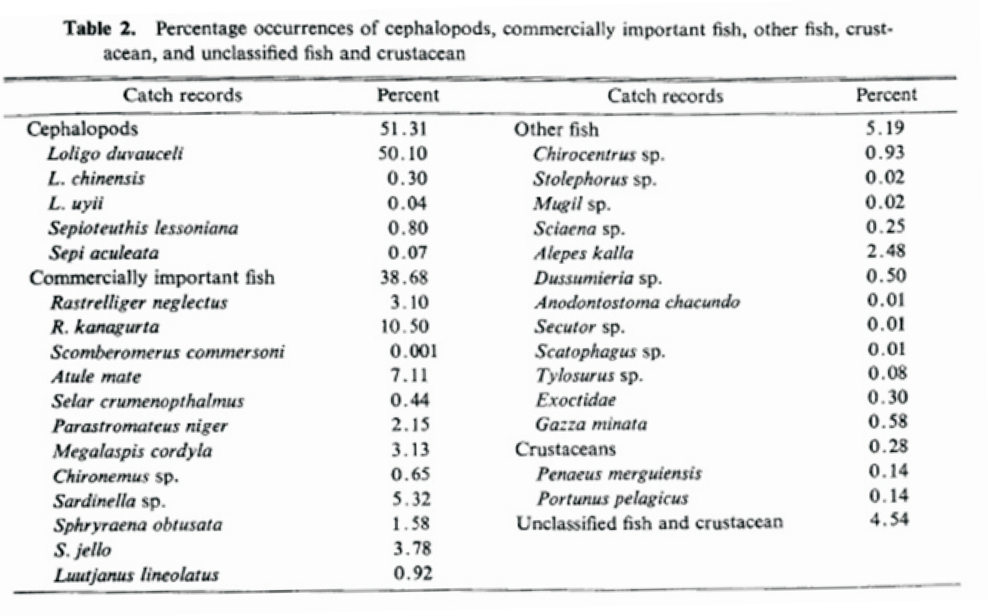


Table 2. Percentage occurrences of cephalopods, commercially important fish, other fish, crustacean, and unclassified fish and crustacean

Catch records	Percent	Catch records	Percent
Cephalopods	51.31	Other fish	5.19
Loligo duvauceli	50.10	*Chirocentrus* sp.	0.93
L. chinensis	0.30	*Stolephorus* sp.	0.02
L. uyii	0.04	*Mugil* sp.	0.02
Sepioteuthis lessoniana	0.80	*Sciaena* sp.	0.25
Sepi aculeata	0.07	*Alepes kalla*	2.48
Commercially important fish	38.68	*Dussumieria* sp.	0.50
Rastrelliger neglectus	3.10	*Anodontostoma chacundo*	0.01
R. kanagurta	10.50	*Secutor* sp.	0.01
Scomberomerus commersoni	0.001	*Scatophagus* sp.	0.01
Atule mate	7.11	*Tylosurus* sp.	0.08
Selar crumenopthalmus	0.44	*Exoctidae*	0.30
Parastromateus niger	2.15	*Gazza minata*	0.58
Megalaspis cordyla	3.13	Crustaceans	0.28
Chironemus sp.	0.65	*Penaeus merguiensis*	0.14
Sardinella sp.	5.32	*Portunus pelagicus*	0.14
Sphryraena obtusata	1.58	Unclassified fish and crustacean	4.54
S. jello	3.78		
Luutjanus lineolatus	0.92		

Weeber (2004) reported that squid fisheries may experience significant interactions with marine mammals, sea-birds and sea turtles. Some species of marine mammals,e.g Sperm whales, prey on squids and therefore might approach jigging vessels. Jigs pulled through the water column in a faster rhythmic jerking movement might pose a greater danger of accidental hooking. Crespo et al (1997) reported the results of monitoring interactions between marine mammals and the squid jigging fleet in the central Patagonian coast. Records of the interactions were made but not quantified but Southern Sea-lions and Commerson's dolphins were reported entangled with the lines of jigging machine, prey on squids and scatter the school. Alverson et al (1992) cited by Harris et al (1999) reported that squid fishing have very low fish by-catch and was regarded to be highly selective fishing method in Maldvies coast. The most commonly caught by-catch by the High Sea, US squid jigging fleet are small number of blue sharks whose weight break the 30-60lb test-line.

Other impacts of light fishing include;

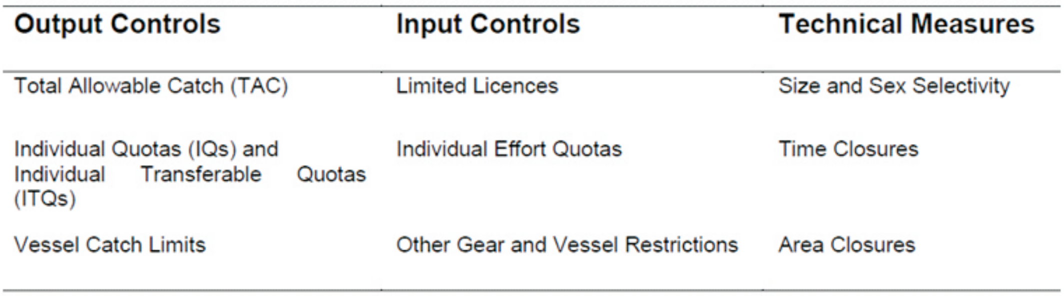
1. Greenhouse gas emissions: The annual carbon-dioxide gas emission from 110,000 pressurized kerosene lanterns was estimated to be 85,000 Metric tons per year. This can contribute to global warming.
2. Kerosene spillage
3. Human Health

General Control Measures

During night fishing, there is evidence, as discussed earlier, that the use of small boats – skiffs using underwater lights to attract fish and the main vessel catching bait – can increase catch rates (Rawlinson et al., 1992), as can employing above water lights in addition to the usual underwater ones (Sharma et al., 1990; Hallier et al., 1982). This statement is strongly supported by Arimoto et al (2001) that with continuous perfection and advancement in light and lighting technology, light fishing operation becomes one of the highly effective fishing methods. However, as noted above, there is evidence that using lights to aid in bait capture can substantially increase incidental capture of juveniles and by-catches, so caution and management actions are required. A combination of actions are therefore needed to rebuild the small pelagic stocks and for these actions to bring desired results of stock recovery and sustainable fisheries, all stakeholders, including the fishermen, fish processors, fish mongers and the government (co-management), must work together and follow the agreed rules with proper monitoring and surveillance.

The specific instruments considered are listed in Table 6 below.

Table 6: Control measures to avert negative impacts of light fishing



Output Controls	Input Controls	Technical Measures
Total Allowable Catch (TAC)	Limited Licences	Size and Sex Selectivity
Individual Quotas (IQs) and Individual Transferable Quotas (ITQs)	Individual Effort Quotas	Time Closures
Vessel Catch Limits	Other Gear and Vessel Restrictions	Area Closures

Input & Output Controls

Input controls describe the capacity and efforts of the fishing fleets and seek to limit the total size and the fishing activity of the fleet which can eventually reduce fishing mortality on the entire species complexes i.e multi-species fisheries. Catch controls in form of fishing limitations and quota scan help to directly and indirectly reduce fishing mortality on target species and protect the associated species (by-catch) as well (Charles,2000). Issuing of licenses to fishermen with canoe or vessel registration will ensure proper monitoring, control catch and effort and long term sustainability of fish stocks. Fishing ban is also another tool that ensures fish stock sustainability. Fishing with electric light was recently forbidden in Ghana (Saminu, 2011).

Technical Measures

Size selectivity of target species is achieved through the adoption of mesh size restrictions which helps to avoid capturing of target species at their immature stage. This allows them to grow bigger and have the ability to spawn at least once before they are caught. Reduction of non-target species selectivity is effected using By-catch Reduction Devices such as Turtle Excluding Devices, sorting grids that allow unwanted by-catch to escape. Spatial and temporal controls on fishing are achieved by restricting fishing activities to certain closed areas (establishment of Marine Protected Areas) and seasons of the year. These help to protect the spawning biomass which can replenish surrounding fished areas (Charles, 2000). For instance, fishery closure was imposed in the Bay of Biscay off the coasts of France and Spain and within few years later the fishery returned to a more healthy state.

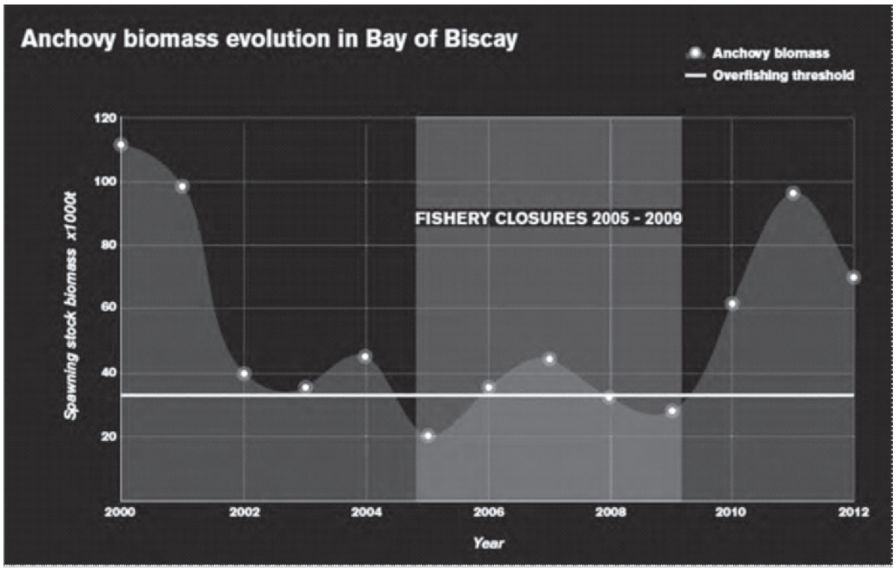


Figure 17: **(Source credit: Oceana Magazine Fall 2012: "Anchovy's Return")**

.Conclusion & Recommendations

Light fishing at present acts as a good means and efficient way of obtaining adequate catches of bait-fish and cephalopods such as sardines, herring, anchovies, mackerel, squids, etc. Light fishing itself is not necessarily destructive but tends to eliminate traditional rest period of fish and pose more problems or have negative impacts on sustainable fisheries than expected coupled with and exacerbated by non-selective unregulated fishing gears used (purse-seine and lift-net).It is therefore important that fishing regulations (mesh-size, closed seasons, closed area, etc) should be in place, enforced and monitored which can serve as positive resource management measures. Furthermore, strict compliance with the light fishing ban is one way to reduce fishing effort, allow fish stock to increase and give rest period to grow and reproduce. Governments should also provide alternative sources of income for the fishermen. In addition, an environmental-friendly light fishing technology should be researched on and enforced in the near future. Ciriaco et al (2003) reported that it would be highly beneficial if the application of underwater illumination through the use of appropriate lamps (setting agreed maximum lighting output) coupled with selective fishing is adopted. This will conserve our marine environment by reducing the disturbance caused to all organisms involuntarily.

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Competing Interest
The authors declare that no competing interest exists.

References

Alverson, D.L & Larkin, P. (1992). *Fisheries science and management; Century 21.* In: Proceedings of the World Fisheries Congress, Athens, Greece, May 3-8,1992

Alverson, D., Freeberg, M., Murawski, S. & Pope, J. (1994). *A global assessment of fisheries by catch and discards*. FAO Fisheries Technical Paper 339, Food and Agriculture Organization of the United Nations, Rome, Italy, 233 pp.

Alverson, D. & Hughes, S., (1996). *By catch , from emotion to effective natural resource management*. Reviews in Fish Biology and Fisheries 6, 443–462.

Arimoto, T., Jaya, I.T.(2001). Lighting and optical methods to support Light fishing activities. In Light Fishing in Japan and Indonesia. Fishing Technology Manual Series 1.The *JSPS-DGHE International Workshop. TUF JSPS International* Vol.11. Dept. of Fisheries Resources Utilization.

Arimoto, T., Glass, C. W., & Zhang, X. (2011). Fish Vision and its role in Fish Capture. *In:* Pingguo He (Ed.), *Behaviour of Marine Fish: Capture Processes & Conservation Challenges* (pp. 25–43).

Bannerman, P & Quartey, R., (2004). *The Marine Fisheries Research Division* (MFRD), Tema Report on the Observations of Commercial Light Fishing Operation in Ghana, February–June 2004, MFRD, Tema, Ghana: (2004)

Ben Y., M. (1976). *Fishing with Light* (p. 121). England: FAO fishing manual Fish News Books, Surrey. (1976)

Ben Y., M., (1978). *Fishing with Light.* Publisher; State Mutual Book and Periodical Services, Limited, 1978. ISBN; 0785569286 Ben Yami, M., 1988.Attracting fish with light.FAO.

Ciriaco,S., Marchesan, M., Verginella, L.,Vinzi, E., Ferrero, E. A. & Spoto, M. (2003). *Preliminary observations on the effects of artificial light on the marine environment, with special reference to three fish species of commercial value protected,* by Miramare Marine Reserve. Bollettino di GeofisicaTeoricaed Applicata.Vol. 44, n. 1, pp. 19-26

Charles, A. T. (2000). Use rights and responsible fisheries: limiting access and harvesting through rights-based management, in *A fishery manager's guidebook – Management measures and their application*, K.L. Cochrane (ed.), FAO Fisheries Technical Paper, No. 424, pp. 131–157

Chopin, F. & Arimoto, T. (1995). *The condition of fish escaping from fish gears – a review*. Fisheries Research21, 315–327.

Court,W.G., (1980). *Japan's Squid Fishing Industry*.

Crespo, E. A., Pedraza, S. N., Dans, S. L., Alonso, M. K., Reyes, L. M., Garcia, N. A., Coscarella, M. & Schiavini, A. C. M. (1997). Direct and indirect effects of the highseas fisheries on the marine mammal populations in the Northern and Central Patagonian Coast. *Journal of Northwest Atlantic Fishery Science* 22:189-207.

Crowder, L. & Murawski, S. (1998). *Fisheries bycatch: implications for management.* Fisheries 23, 8–16.

Davis, M., (2002). Key principles for understanding fish bycatch discard mortality. *Canadian Journal of Fisheriesand Aquatic Sciences* 59, 1834–1843.

Dinglasan, P.P. (1972). *Purse seining with light attraction*. Inf. Rep. Fish. Res. Unit, Tema, (J)

Dunn, D.C; Boustany ,A. M & Halpin, P. N., (2011). Spatio-temporal management of fisheries to reduce by-catch and increase fishing selectivity. *Fish and Fisheries* 12:110-119

Gengnagel, T.,Wollburg, P & Mills, E., (2013). *Alternatives to Fuel-based Lighting for Night Fishing.* Field Tests of Lake and Ocean Applications in East Africa.

Gibbon, P., (1997). *The Poor Relation: A Political Economy for the Marketing Chain for Dagaa in Tanzania, CDR Working Paper 97.2.The Danish Institute for International Studies*. Denmark: Copenhagen,

Hajar, M. A., Sudirman, M., & Arimoto, T. (2014). *Fishing method and catch composition of light fishing in Indonesia.*

Hall, M., Alverson, D. & Metuzals, K. (2000). *By catch, problems and solutions*. Marine Pollution Bulletin 41, 204–219

Hallier, .J .P., Kearney, R. E. & Gillett, R.D. (1982). *Baitfishing methods used by the skipjack survey and assessment programme and recommendations on baitfishing techniques for the tropical Pacific*. In Methods used by the South Pacific Commission for the survey and assessment of skipjack and baitfish resources. Technical Report - SPC. SPC, pp. 71-107. Available at: http://www.documentation.ird.fr/hor/fdi:16537.

Harrington, J. M., Myers, R. A. & Rosenberg, A. A. (2005). *Wasted Resources: By catch and discards in US Fisheries*. Oceana, Washington, DC, 282 pp.

Harris, A. & Ward, P. (1999). *Non-target species in Australia's Commonwealth Fisheries.* A critical Review.152pp.

Inada, H. & Ogura, M. (1988). *Historical changes of fishing light and its operation in squid jigging fisheries*. The report of the Tokyo University of Fisheries, 24, 189-207

Kelleher, K., (2005). *Discards in the world's marine fisheries: an update*. FAO Fisheries Technical Paper No. 470, Food and Agriculture Organization of the United Nations, Rome, Italy, 131 pp.

Khair, M., (2000). *Effect of using Bagan rambo toward conservation of Pelagic Fisheries Resources in Sinjai Waters*. Undergraduate Skripsi, Fisheries Utilization Study Program, Dept. of Fisheries, Fac. of Mar. & Fish.Sci., Hasanudd in University Makassar, Indonesia. 34p.

Lee, D. C., Sedell, J. R., Rieman, B. E., Thurow, R. F & Willams, J. E. (1997). Broadscale assessment of aquatic species and habits in quigley, T. M. And S. Arbelbide, Tech. Eds., *an assessment of ecosystem components in the interior columbia basin*. Vol. III. USDA Forest Service, Pacific northwest research station. General Technical Report PNW-GTR-405.

Legros, .D & Luomba, J. (2011). *Dagaa value chain analysis and proposal for trade dement*. IOC- smartfishprog.techn.devment.

Mallawa, A., Sudirman, M., & Musbir, E. (1991). *Study on bagan Rambo fisheries in Barru waters, Makassar Strait*. Research Report Project. Research Institute of Hasanuddin University. Makassar, (In Indonesia)p40.

Marchesan, M., Spoto, M., Verginella, L., & Ferrero, E. A., (2005). *Behavioral effects of artificial light on fish species of commercial interest*. Fish Res. 73: 171-185

Moore, P.G., (1999). Fisheries exploitation and marine habitat conservation: a strategy for rational coexistence. *Aquatic Conservation: Marine and Freshwater Ecosystem*, 9: 585-591.

Morgan, L. & Chuenpagdee, R., (2003). *Shifting Gears: Addressing the Collateral Impacts of Fishing Methods in USA Waters*. Island Press Publication Services, Washington, DC.

Mullon, C., Freon, P & Curry, P., (2005). *The Dynamics of collapse in world fisheries; Fish and Fisheries.* volume 6.pp.111-120

Murata, M., (1990). *Oceanic resources of squids*. Mar.Behav.Physiol.18:19-71

Musbir, O. (2007a). Analisis Populasidan PemanfaatanIkan Kembung Lelaki (*Rastreligerkanagurta*) di Perairan Laut Flores Sulawesi Selatan. Disertasi Doktor. Program Pasca Sarjana Universitas Hasanuddin. Makassar.273 hal.

Musbir, (2007b). Analisis Keramahan Lingkungan Berdasarkan Ukuran Panjangdan Kematangan Gonad Ikan Hasil Tangkapan Purse Seine di Laut Flores Sulawesi Selatan. Data Penelitian. Tidakdipublikasikan

Mushagalusa, C., Jean-Claude, M, Gaspard, N & Nshombo, M., (2015). *Brief evaluation of the current state of fish stocks landed by artisanal fishing units from the extreme northwest part of Lake* . Tanganyika: pp 2

Nadir, M., (2000). *Light fishing technology in Barru Waters, Makassar Strait.* MSc thesis, postgraduate studies, Bogor Agric. Univer. Bogor: 87p.

Najamuddin & Palo, M., (1994). *Study on Fishing with bagan using electrical lamp in Makassar Strait, South Sulawesi.* Lutjanus Bulletin, Polytechnic of AgricMandalle, Hal. 49-56

National Marine Fisheries Service. (2011). U.S. National Bycatch Report. *National Oceanic and Athmospheric Administration.*

Nsinda, P., Wandera, S. B. & Rabour, C., (2005). *Off-Shore Dagaa-Fishing in Lake Victoria*. The Lake Victoria Fisheries Organisation.Jinja, Uganda

Odongkara, K. & Ntambi, B., (2007). *Migration of fishermen and its impacts on fisheries management on lake victoria*. Uganda: IFMP Socioeconomics Series 7. National Fisheries Resources Research Institute, Jinja, Uganda.

Pitcher, T. J. & Parrish, J. K., (1993). *The functions of shoaling behaviour. In The behaviour of teleost fishes.* 2nd ed. pp. 363–439.Ed. by T. J. Pitcher. Chapman and Hall, London. 715 pp.

Purwanto, W., Santria, Proctor, C., West, .R .J & Milton, D. .A., (2010). *Bali Strait Lemuru final report. Australian National Centre for Ocean Resources and Security.* University of Wollongong,Australia. 34pp.

Rasalan, S. B & Villadolid, D.V.,(1955). *The basing, a bagnet for pelagic fishing in Phillipines*. Phil. J. of Fisheries 3(1): 1-28

Rathjen,W.F., (1984). *Squid Fishing techniques.* NOAA 9 pages

Rawlinson, N .J .F., Milton, D. A. & Blaber, S. J. M., (1992). *Tuna Baitfish and the Pole-and-Line Industry in Kiribati.* ACIAR.

Saharuddin, A.,Ogura, M.,Arimoto,T & Inada, H., (1990). *(abstract).The history and development of squid jigging fisheries in Japan*. Proceedings of the Second Asian Fisheries Forum, Tokyo, Japan, 17-22 April 1989. Online: http://www.squidfish.net/squidbiology.shtml#sci.

Saminu, Z .R., (2011). *Fishermen divided over ban of light fishing as Sekondi petitions CHRA Parliament*. All Africa.com, Feb. 14.

Sharma, S. P. & Adams, T.J.H., (1990). *The Fiji tuna bait-fishery*. Blaber, SJM and Copeland, JW (eds.).

Shibata, K & Flores, E. E. C., (1972). Echo traces typical of squids in water surrounding Japan. FishCirc.FAO.(142) 7-13

Sinclaira, M., Arnasonb, R., Csirkec, J., Karnickid, Z., Sigurjonssone, J., RuneSkjoldalf, H. & Valdimarsson,G., (2002). *Responsible fisheries in the marine ecosystem. Fisheries Research*, 58: 255-265.

Sudirman. (2003). *Fish behaviour analysis for environmentally friendly technology in fishing process of bagan*. Rambo (large typed lift net with light attraction). Disertation. Bogor Agricultural University.P.306.

Sudirman, Baskoro, M. S., Purbayanto, A. ,Monintja, D. R., Arimoto, T. (2001). Review of Bagan Rambo (Large-Typed Lift Net) with Electric Mercury Lamp in South Sulawesi, Indonesia

Sudirman, E. & Musbir, A. (2006). *Impact of light fishing on sustainable fisheries in Indonesia*. Fisheries Resources Utilization Study Program Fisheries Department, Fac. of Marine Science and Fisheries Hasanuddin University,Makassar 90245. Indonesia.

Supongpan, M., Sinod, M. & Boongerd, S., (1992). *Catch analysis of Indian squid Loligoduvauceli by light-luring-fishing in the Gulf of Thailand*. Nippon Suisan Gakkaishi 58: 439– 444.

Tham, A. K., (1965). Notes on the Biology of the Anchovy, *Stolephoruspseudoheterolobus*Handerberg. Bull. Nat. Mus. Singapura 33,(4)23-26.

Watson, R. & Pauly, D., (2001). *Systematic distortions in world fisheries catch trends*. Nature 414, 534–536.

Weeber, B., (2004). *Squid fishing increase would kill 500 more albatross and petrels, Forestand Bird*. http://www.forest
-bird.org.nz/mediarelease/2004/0406_squidincreasekills.