Occurrence of Macro-algae in the By-catch of Beach Seine Fisheries at Sakumono, Ghana

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Abstract

Dense growths of macro-algae contribute to primary productivity in nearshore marine environments and their abundance has been correlated with fish catch. Though the two resources are captured together in beach seine nets, macro-algae are usually regarded as a nuisance by fishermen and discarded (as by-catch). The species composition, abundance and seasonality of macro-algal species in fisheries by-catch of beach seine nets at Sakumono, Ghana were determined between November 1999 and September 2001. Data was analysed using a combination of both univariate and multivariate procedures. The species richness of macro-algae in the catch was high and appeared to vary monthly. Biomass of macro-algae in the catch was found to be low (range 0–6.7%) and formed only 7.7% of the by-catch. The significance of macro-algae in by-catch is discussed.

Introduction

The nearshore marine environment, technically, comprises the shoreline, beach, surf zone and nearby offshore areas (Ross, 2000). Its exact expanse is variable depending on the geophysical nature, waves, tides and topography of the area. It serves as a nursery area for fishes and macro-crustaceans (feeding and spawning) and as a shelter from predation (Lasiak, 1981). Macro-algae may occur in rocky areas of nearshore waters and contribute to primary production of such areas. They also provide shelter for juvenile fish as well as protect them from predators (Lenanton, Robertson & Hausen, 1982; Peters, 1984). Robertson &Lenanton (1984) have demonstrated a significant correlation between the quantity of macro-algae and the numbers of fish caught in Australian beaches. Fish was two to 10 times more abundant in surf zones with macro-algae.

Marine fisheries in Ghana is dominated by artisanal fishery, which contributes about three-quarters of total marine production (FRUB, 1997). Most artisanal fishermen operate in relatively shallow waters (up to a depth of 30 m) on small scale; their operation is labour intensive and they use relatively unsophisticated gear such as beach seines. Beach seining is a popular mode of fishing that is widely practiced on the sandy beaches of Ghana. It contributes a significant 12% of total artisanal production. There are 790 beach seine units operating from 154 landing beaches along the coast of Ghana (Bannerman, Koranteng & Yeboah, 2001).

The incidental capture and subsequent discard of non-target species in fisheries catch has attracted worldwide attention in recent years (Saila, 1983; Alverson *et al.*, 1994; Kennelly, 1995; Nunoo, 1998). The non-targeted part of the catch, the by-catch, is defined as "that part of the gross catch which is captured incidentally to the species towards which there is directed effort" (Saila, 1983). The high mortality and destruction of biodiversity from the practice of discarding unwanted species from fisheries catch is likely to adversely affect productivity of the oceans, loss of biodiversity and ecological shifts in species assemblages (Andrew & Pepperell, 1992; Nunoo & Evans, 1997; Broadhurst, 2000). Alverson *et al.* (1994) estimated global discards in commercial fisheries as 27.0 million metric tonnes with a range of 17.9–39.5 million metric tonnes per annum. By-catch formed more than two-thirds of the catch from Ghana's industrial shrimp fisheries (Nunoo, 1998).

Generally, the components of the by-catch vary both temporally and spatially in quality and quantity. Much has been written on by-catch of shrimp trawl fisheries than other fisheries in the world. Components of shrimp fishery by-catch mainly include a variety of fishes, invertebrates, vertebrates such as sea turtles and sea snakes, and litter (Nunoo, 1998). There has been little or no mention of occurrence of macro-algae in by-catch of shrimp fishery. For instance, Nunoo & Evans (1997) and Nunoo (1998) did not indicate whether or not macro-algae occurred in the catch of offshore industrial shrimp fishery in Ghana. However, Nunoo & Quayson (2003) recorded the occurrence of dried algae at two sandy beaches in Accra that had ostensibly been left there by wave action and the cleaning of nets of fishers.

In Ghana the marine nearshore area with respect to macro-algae and fish interactions has not been adequately studied. The macro-algae inhabiting the intertidal and subtidal areas have been studied by Lawson and John (1987) and John , Lawson & Ameka (2003). Other interesting and important aspects of macro-algae and fish interactions are unknown. For instance, the species composition, abundance and seasonality of macro-algal species in fisheries by-catch are unknown. Information on abundance and seasonality, for example, could influence decisions by fishermen with respect to timing of fishing, fishing behaviour and fishing effort (Nash, 1992). The present investigation is the first, to the best of the authors' knowledge, to identify and quantify the algal component of beach seine fisheries catch in the West African sub-region.

Materials and methods

Sakumono is a small peri-urban village located along the Accra-Tema highway in Ghana. It is 3 km west of Tema and about 18 km east of Accra. The beach occupies an area between two lagoons: Mukwe (near Accra) and Sakumo II (near Tema). Sakumo II lagoon is an internationally and ecologically important Ramsar wetland, noted for its high biodiversity (e.g. migrating shore-birds and waterfowl). The Sakumo II lagoon is opened to the adjacent sea *via* a culvert. There is daily tidal exchange of waters between the sea and the Sakumo II lagoon. The Sakumono beach is located between 005° 57' 18" N, 000° 58' 54" E and 005 ° 36' 46" N, 000° 02' 16" W with maximum water depth ranging between 8.7 m and 9.7 m (Fig. 1).
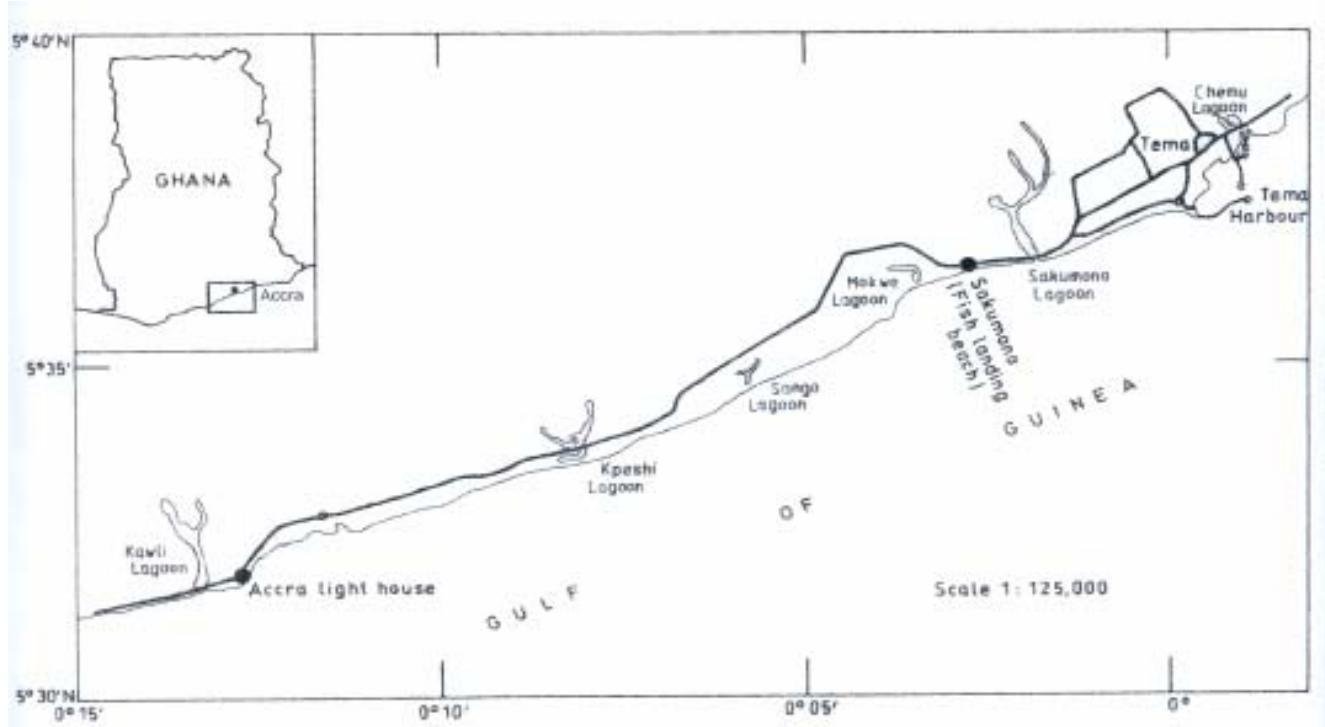

Fig. 1. Map showing the location of Sakumono fish landing beach in Accra, Ghana (after Nunoo, 2003)

Data collection was over a 23-month period from November 1999 to September 2001. The study was entirely fishery-dependent, and because of this there was no sampling in July 2001 when fishermen did not go fishing. Fishing gear and skill of fishers were kept constant as far as possible throughout the study period by sampling from same net and crew. A total of 94 beach seine hauls were sampled during the study period.

When catch was landed, the total biomass in each haul was estimated from the number of full bowls taken (each bowl weighed approximately 5 kg when full). From each estimated number of bowls from a haul, approximately 10% of the catch was sampled before normal sorting by fishermen. Each sample from a catch was placed in labelled polyethylene bags and kept in a freezer at a constant temperature of -40 °C (within 1 h of landing). Samples preserved in the freezer were analysed within 7 days. Samples from a given catch were thawed overnight prior to species identification and biomass determination. Macro-algae were taxonomically identified as far as possible using a guide (Lawson & John, 1987). The biomass of macro-algae in each sample was determined.

The data collected were coded, formatted and analysed using a combination of both univariate and multivariate procedures in the SAS computer software version 8.2 (SAS Institute Inc., 2001). The months of the year were coded starting from January as 1 up to 12 for December. To facilitate a test for seasonality, the months of the year were also coded into four seasons based on wet and dry seasons in Ghana as follows:

Season 1: heavy and wet, months 5–7 (May–July);
Season 2: light and wet, months 8–10 (August–October);
Season 3: light and dry, months 11–1 (November–January);
Season 4: very dry, months 2-4 (February –April).

Further, all data were first tested to ensure normality and homogeneity of variances. In instances where variances were heterogeneous, $\log_{10}(X + 1)$ transformed data were used. This served to reduce the effect of zeros and large numbers in records.

Results and discussion

Macro-algae in by-catch of beach seine nets at Sakumono
The catch composition in beach seine nets at Sakumono varied with time but was usually composed of targeted fish (including Sardine, *Sardinella maderensis*; Barracuda, *Sphraena sphyraena*; Burito, *Brachy-deuterus auritus*; West African ilisha, *Ilisha africana*; Bumper, *Chloroscombrus chrysurus;* and Cassava croaker, *Pseudo-tholithus senegalensis*) and crustaceans (including Pink shrimp, *Penaeus notialis* and Lobster, *Panulirus regius*) forming 97.5%. The by-catch included macro-algae, some invertebrates and marine debris (2.5%). The by-catch, other than algae, in the present investigation is shown in Table 1. Macro-algae formed a mean of 0.75% (standard error = 0.08, range = 0–6.65) of monthly catch and 7.69% of by-catch.

TABLE 1

Components of by-catch of beach seine nets other than macro-algae

Faunal by-catch	*Marine debris*
Thais haemastoma (Phylum Mollusca)	Pieces of plastics
T. nodosa (Phylum Mollusca)	Pieces of twigs
Aurelia auritus (Phylum Cnidaria)	Pieces of aluminium cans
Echinometra lucunter (Phylum Echinodermata)	Pieces of fishing nets
	Pieces of Styrofoam
Plastic drinking straws	

The macro-algae found in the by-catch are shown in Table 2. Eighteen species in 17 genera were identified. There were seven Chlorophyta, four Phaeophyta and seven Rhodophyta species. The macro-algae are usually attached to rock surfaces in the inter-tidal and sub-tidal areas. Wave action including upwelling and other factors can cause the plants to detach from the substrata and float in the water and become caught in and /or entangled in fishermen's nets.

TABLE 2

Macro-algae in by-catch of beach seine nets at Sakumono

Chlorophyta (Green algae)

Bryopsis pennata Lamouroux
Caulerpa taxifolia (Vahl) C. Agardh
Chaetomorpha antennina (Bory) Kützing
Cladophora prolifera (Roth) Kützing
Codium guineense P. C. Silva ex G. W. Lawson & M. D. John
Enteromorpha flexuosa (Wulfen ex Roth)
   J. Agardh
Ulva lactuca Linnaeus

Phaeophyta (Brown algae)

Dictyopteris delicatula Lamouroux
Dictyota dichotoma (Hudson) Lamouroux
Padina durvillei Bory
Sargassum vulgare C. Agardh

Rhodophyta (Red algae)

Bryocladia thyrsigera (J. Agardh) Schmitz
Centroceras clavulatum (C. Agardh) Montagne
Gelidium arbuscula (Montagne) Børgesen
Gracilaria verrucosa (Hudson) Papenfuss
Hydropuntia dentata (J. Agardh) Wynne
Hypnea musciformis (Wulfen) Lamouroux
Laurencia majuscula (Harvey) Lucas

The authors observed that macro-algae got caught in the nets of beach seine fishers resulting in the need to clean nets. The process of cleaning the nets is laborious and time-consuming. During the cleaning process the nets sometimes became damaged and need repair or replacement. Net repair or replacement can represent a huge investment of money and time to the fishermen. It increases expenditure and at the same time reduces income particularly if the net was temporarily out of action and the fishermen could not go to sea. Customers regarded macro-algae as marine debris and hence offered lower prices for fishers' catch that was tainted with macro-algae compared to that of catch without macro-algae. Because of this the fishermen made painstaking efforts to remove the macro-algae before selling their catch.

While macro-algae in by-catch may be undesirable to fishermen the plants might be useful to the student of phycology. Collection of macro-algae for teaching and research in the inter-tidal area is practicable only during low tides at daytime. The variety of algae found in the by-catch indicates that it can be a source of algae for teaching and research at periods when low tide is at night and thus difficult to collect algae during the day. Furthermore, some deep-sea macro-algae (at depths of 10-20 m) might get detached during upwelling and get caught in the fishermen's nets and become part of the by-catch and, thus, become available to the phycologists. Usually deep sea macro-algae are collected by SCUBA divers or collected from the cast-up.

Monthly variation in species composition of macro-algae in by-catch

Table 3 shows the monthly occurrence of macro-algae in by-catch at Sakumono beach. *Sargassum vulgare* was the most frequently encountered alga. It occurred about 86% of the time during the sampling period. Nine (*Bryocladia, Centroceras, Dictyopteris, Enteromorpha, Hydro-puntia, Hypnea, Padina, Sargassum* and *Ulva*) of the 18 species occurred 50% or more of the time. Of these, five (*Dictyop-teris, Hydropuntia, Hypnea, Sargassum* and *Ulva*) occurred more than 80% of the time. In recent years, there is an increase in investigating algal products for commercial use. In this respect the species, which occur frequently in the by-catch, could be investigated for use as food supplement (for instance *Ulva*) and soil additives or amendments (e.g., *Hydropuntia* and *Sargassum* by local farmers).

TABLE 3

Monthly occurrence of macro-algae in beach seine nets at Sakumono

('+' indicates presence; '–' indicates absence)

Occurrence of macro-algae

Species	1999						2000					
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
CHLOROPHYTA												
Bryopsis pennata	+	-	-	-	-	-	-	-	-	-	-	+
Caulerpa taxifolia	-	+	+	+	+	-	+	+	-	-	-	+
Chaetomorpha antennina		-	-	-	-	-	-	-	-	-	-	+
Cladophora prolifera	+	-	-	-	-	-	-	-	-	-	-	+
Codium guineense	-	-	+	+	-	-	-	+	-	-	+	-
Enteromorpha flexuosa	-	-	-	-	+	+	+	+	+	+	+	+
Ulva lactuca	+	+	+	+	+	+	+	+	+	+	+	+
PHAEOPHYTA												
Dictyopteris delicatula	+	+	+	+	+	+	+	+	+	+	+	+
Dictyota dichotoma	-	-	-	+	-	-	-	-	-	-	-	-
Padina durvillei	+	+	+	+	+	+	+	+	+	+	+	-
Sargassum vulgare	+	+	+	+	+	+	+	-	+	+	+	+
RHODOPHYTA												

Species											
Bryocladia thyrsigera	+	+	-	+	+	+	+	+	+	-	+	+
Centroceras clavalatum	+	-	+	-	-	+	+	+	+	+	+	+
Gelidium arbuscula	-	-	-	-	-	-	-	-	-	-	-	-
Gracilaria verrucosa	+	+	-	-	+	+	-	-	+	-	-	-
Hydropuntia dentata	+	+	+	+	+	+	-	-	+	+	+	+
Hypnea musciformis	+	+	+	+	+	+	+	-	+	+	+	+
Laurencia majuscula	-	+	-	-	-	+	-	-	+	+	+	+

Monthly occurrence of macro-algae in beach seine nets at Sakumono
('+' indicate presence; '–' indicate absence). (Fishing did not occur in July 2001.)

		Occurrence of macro-algae									
	2000		2001								
Species	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
CHLOROPHYTA											
Bryopsis pennata	-	+	+	+	-	-	+	+		+	+
Caulerpa taxifolia	-	+	-	-	-	-	-	-		-	-
Chaetomorpha antennina	-	-	-	+	-	-	-	+		-	-
Cladophora prolifera	-	-	-	-	-	-	-	-		-	+
Codium guineense	-	+	-	+	-	-	-	-		-	-
Enteromorpha flexuosa	+	+	+	+	-	+	+	+		-	+
Ulva lactuca	+	+	+	+	-	+	+	+		+	+
PHAEOPHYTA											
Dictyopteris delicatula	+	+	+	+	-	+	+	+		-	+
Dictyota dichotoma	-	-	-	-	-	-	-	-		-	+
Padina durvillei	-	-	+	+	-	+	-	+		+	-
Sargassum vulgare	+	+	+	+	-	+	+	+		+	
RHODOPHYTA											
Botryocladia thyrsigera	-	+	+	-	-	+	-	-		-	+
Centroceras clavalatum	-	-	+	+	-	+	+	+		-	+
Gelidium arbuscula	-	-	-	-	-	+	-	-		-	-
Gracilaria verrucosa	-	-	-	-	-	-	-	-		-	-
Hydropuntia dentata	+	+	+	+	-	+	+	+		+	+
Hypnea musciformis	+	+	+	+	-	+	+	+		+	+
Laurencia majuscula	-	+	-	-	-	-	-	-		-	-

Changes in biomass of macro-algae in by-catch

Biomass of macro-algae in the catch per haul was found to be generally low, ranging between 0–6.7%. Average monthly abun-dance of macro-algae ranged between 0.4–1.72%, and was notably high in the upwelling months of July–September and December–February (Fig. 2). Macro-algal biomass in catch did not vary significantly with season (ANCOVA; $F = 0.87$, $p = 0.46$). The macro-algal biomass formed only 7.7% of the by-catch. This biomass of macro-algae is generally low compared with that for the targeted fish, which formed 97.5%. Local fishermen have confirmed

that the weight of the macro-algae in the by-catch is not important to their trade. They maintain, however, that the time spent in sorting and removing algae from both fish and nets is of prime concern to them. Furthermore, according to the fishermen, fish with pieces of algae attached are referred to as 'unclean or tainted fish' and sell at a lower price than fish without attached algae, that is, 'clean fish'. The current investigation, the authors believe, will stimulate research on macro-algae in by-catch in the West African sub-region.
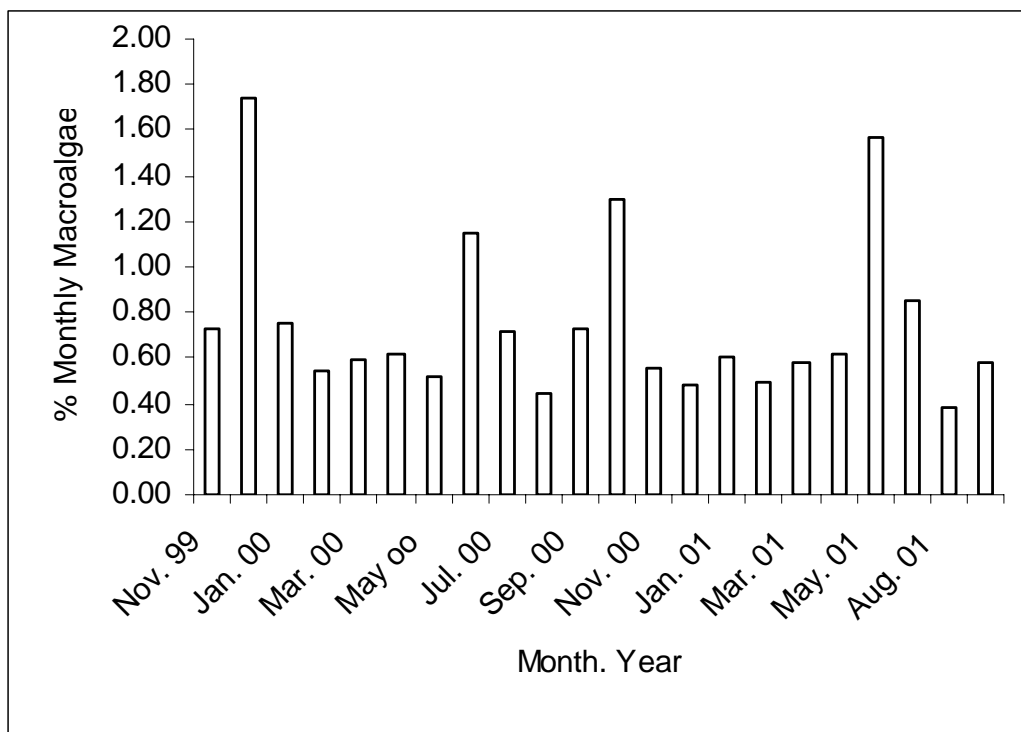

Fig. 2. Average monthly abundance of macroalgae in beach seine nets at Sakumono during November 1999 - October 2001

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