A Biosocioeconomic Evaluation of Shipwrecks Used for Fishery and Dive Tourism Enhancement in Kenya

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Abstract—The use of artificial reefs as a management tool to enhance both dive tourism and fisheries has been poorly studied, often resulting in permanent structures created with little knowledge of their impacts. This study specifically evaluated the use of three shipwrecks, off the coast of Kenya, using biosocioeconomic assessments to quantify the benefits. The results show a short-term increase in fish catch for speargun fishermen but a decrease for hook and line fishermen and no evidence for the sustainable use. The economic benefit to the speargun fishermen was estimated to be an additional US$1,000 annually, although from the use of semi-structured interviews, the fishermen perceived little benefit from the shipwrecks. The economic benefit from enhanced dive tourism was estimated as US$75,000-$174,000 annually and there was generally a high awareness by all stakeholders of the social benefits of the shipwrecks to the local community. The results from the present study suggest that the major use of shipwrecks is to enhance dive tourism and not the enhancement of fisheries. Diver operators are the main beneficiaries of shipwrecks and should, therefore, be closely involved in the sinking and management, such that conflicts do not arise among marine resource users.

INTRODUCTION

The first recorded account of the use of artificial reefs was in Japan in the late 1700s (Meier, 1989). These early structures were developed to replace other natural or man-made structures in response to declining fisheries in previously productive areas (Christian *et al.*, 1998). It is the ability of artificial reefs to attract and to potentially increase local fish catches that makes them an attractive management tool (Meier, 1989). Nonetheless, the debate over whether artificial reefs act to simply attract fish or to enhance their production continues and remains an unresolved issue concerning the management of marine resources (Pickering & Whitmarsh, 1997). In contrast to the frequently stated benefits, artificial reefs can potentially have deleterious effects on fish populations by increasing the catch per unit effort, increasing access to previously unexploited stock, and increasing the probability of overexploitation by concentrating stocks (Grossman *et al.*, 1997). Yet despite the scientific uncertainty on their effectiveness to increase fish production (McGlennon & Brandon, 1994), artificial reef deployment is still commonly used in the hopes of enhancing fisheries.

In addition to fishery enhancement, artificial reefs are an attractive management tool to increase dive tourism. Brock (1994) showed that there can be substantially greater economic gain when used for dive sites rather than for commercial fishing, with the gross revenue from the commercial fishery

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of one artificial reef at only 4% of the annual profit of dive tours. Artificial reefs that have been constructed and deployed by diving clubs for recreational uses may, however, lack the resources or inclination to properly research the sites, design, materials, and socioeconomic effects. The lack of studies incorporating socioeconomics into the evaluation of artificial reefs means little is known about who benefits economically, and yet artificial reefs primarily serve social functions by providing services or resources to user groups (Milon, 1991). In order to offset the expense of creating artificial reefs and to reduce economic inefficiency, resulting from stakeholder conflicts, it is vitally important that both the economic benefits and the social interactions within the local community be quantified (Samples, 1989; Baine, 2001). With responsible deployment, artificial reefs should represent the best long-term management strategy compared to the use of other management tools, regardless of any potential short-term increase in fishery production or economic gain (Polovina & Sakai, 1989).

This study represents the first such research in East Africa on shipwrecks. Shipwreck deployment began in 2001 through the initiative of the dive industry with collaboration from Kenya Wildlife Service. The intention of this study is to provide coastal managers with a current evaluation of the existing artificial reefs in Kenya, specifically shipwrecks, as a management tool for both enhancement of fisheries and dive tourism. From the results of our study, recommendations were developed, intended to assist coastal managers with the responsible and sustainable use of artificial reefs that maximise the socioeconomic benefits.

MATERIALS AND METHODS

Study sites and shipwrecks

Three shipwrecks were evaluated in this study; the Globestar, the MV Dania (both in Mombasa) and the MV Alpha Funguo (in Diani). The Globestar consists of the remains of a grain carrying cargo ship that hit a sand bank in the early 1970s and lies at a depth range of 7-10 metres and is within the Mombasa Marine National Reserve. The MV

Dania is Africa's largest shipwreck (Buccaneer Diving, 2006), a 75m decommissioned livestock vessel which lies 50 metres seaward of the reef off Bamburi Beach, within the boundaries of the Mombasa Marine National Park at a depth of 30 metres. The wreck was deliberately sunk in October 2002 by a local dive operator, Buccaneer Diving. The MV Alpha Funguo is a 44.5 metre-long fishing vessel with a gross weight of 385 tons and is located 50 metres from the fringing reef, off Diani beach at a depth of 28 metres. It was the first artificial reef used for dive tourism enhancement in Kenya and was sunk by another dive operator, Diving the Crab, in February 2001.

Data collection

The social and economic data were collected for 8 weeks from May to July 2004, using semi-structured interviews with individuals from different stakeholder groups (Table 1). The semi-structured interviews were based on a combination of short answer, open-ended and Likert scale questions, to provide both qualitative and quantitative socioeconomic data (see appendix A). The short answer questions involved the interviewee answering either yes or no, whereas the open-ended questions allowed the interviewee to give an opinion on a particular topic. The Likert scale questions provided quantitative data on stakeholder perceptions. They involved the interviewee placing a mark on a 10-cm line, representing a continuous scale, between two extremes of a particular variable. The interviews for all the stakeholders focused on the following areas; conflicts associated with using the wrecks, perceptions of the effects and suitability of the wrecks, and the economic effects of the wrecks. The interviews with the fishermen were conducted in Swahili, through a local interpreter.

Fisheries catch data were collected at different landing sites throughout each year from 1995-2003 for both Mombasa and Diani as part of a fish catch monitoring program of the Coral Reef Conservation Project (CRCP) (McClanahan, T. unpublished data). Standard methods were used to record the wet weight of landed fish, by family, to the nearest half kilogram, as described in McClanahan & Mangi (2001). The landed fish
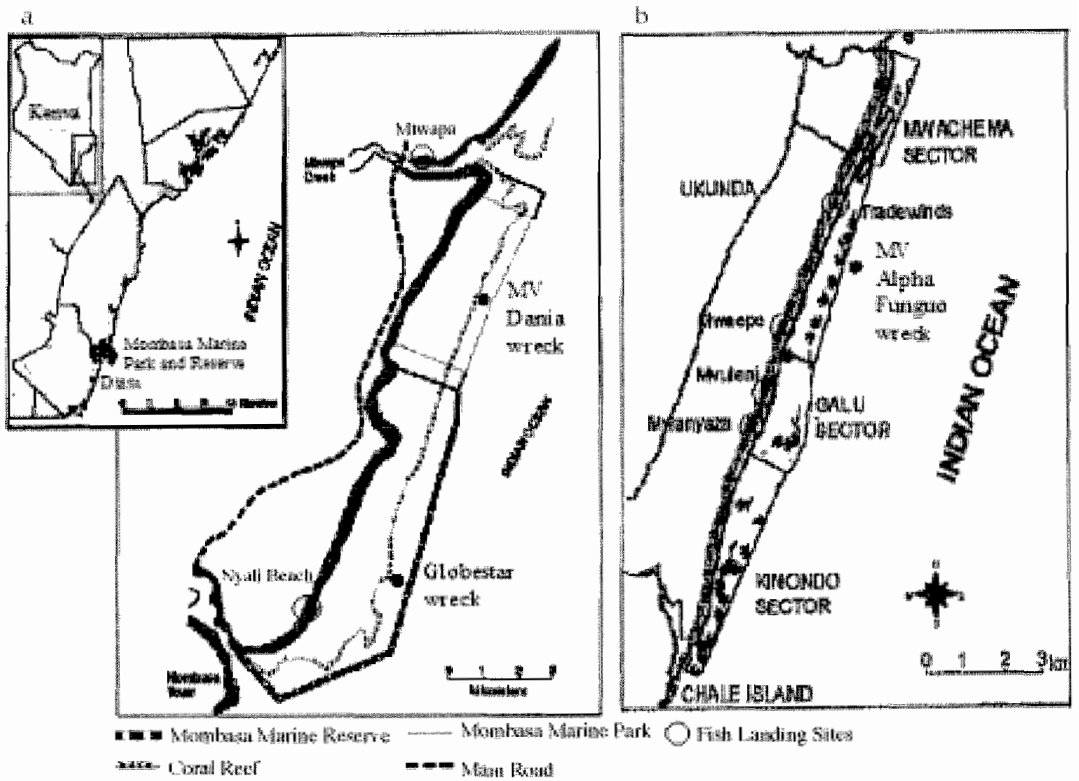
Fig. 1. (a) The locations of the Mombasa Marine Park and Reserve and Diani on the Kenyan coastline (inset) and the locations of the fish landing sites, the MV Dania and the Globestar shipwrecks within the Mombasa Marine National Park and Reserve. (b) The locations of the MV Alpha Funguo shipwreck and fish landing sites within Diani

were identified to six major groups: 1) octopus, 2) goatfish (Mullidae), 3) parrotfish (Scaridae), 4) rabbitfish (Siganidae), 5) scavengers (Lethrinidae, Lutjanidae and Haemulidae) and 6) mixed species, which included more than 150 species not easily separated into the previous five groups. The number of fishermen, the gear types used, the income generated from the catch, the name of the landing site and the date the fish were caught were also recorded. Each landing site was sampled between two and ten days per month.

Data analysis

Biological assessment
The fish catch data were sorted to allow comparison between landing sites where fishermen used the wreck and control landing sites where fishermen did not use the wreck. Since the MV Dania is located within the Mombasa Marine National Park, where fishing is prohibited, this

wreck was not included in the biological assessment. Based on the wreck-use information from the results of the semi-structured interviews, only catch data from the speargun (a hand-held spear propelled by rubber) and line fishermen were analysed for both the Globestar and MV Alpha Funguo wrecks. Only data from the calm and dry northeast monsoon season (December-March) were analysed, because fishermen could only regularly access the wrecks during this season.

Table 1. The number of interviews conducted within each stakeholder group at Diani and Mombasa

Stakeholder	Mombasa	Diani	Total
Fishermen	50	38	88
Dive tourists	22	0	22
Hoteliers	20	9	29
Dive operators	18	18	36
Kenyan Wildlife Service	12	0	12
Total			**187**

These preliminary results were also used to show the proportion of both line and speargun fishermen that used the shipwrecks from each landing site. The fishermen were classified as wreck users if they fished within 50 metres of the shipwreck since the mean dispersal distance for most fish families is considered to be less than 50 metres (Corless *et al.*, 1997).

The Globestar wreck sank before the collection of fish catch data by CRCP had begun, preventing a comparison of catch data before and after the presence of the wreck. The biological assessment of this wreck required the analysis of catch data from the nearest landing site, Nyali beach (~ 2 km from wreck), which was directly compared to the control, Mtwapa landing site (~ 10 km from wreck). For the MV Alpha Funguo wreck the nearest landing sites were Tradewinds and Mwaepe (both ~ 3 km from wreck), which were compared to Mvuleni (~ 5 km from wreck) and Mwanyaza (~ 6 km from wreck) landing sites, both before and after wreck deployment. The data were not normally distributed and, therefore, tested for differences between landing sites using the non-parametric Mann-Whitney and Kruskal-Wallis statistical analyses.

Social assessment

The data were obtained from the Likert scale questions by measuring the distance from the left end of the measured line to the mark placed by the interviewee. This distance was then divided by the total length of the line to produce a proportion, ranging from 0 to 1, in discrete 0.1 cm intervals, with 1 representing an agreement and 0 representing an agreement with the other extreme of the statement. These data were sorted and the non-parametric Mann-Whitney and Kruskal-Wallis statistical analyses were used to test for differences in perceptions, both between and within stakeholder groups.

Economic assessment

To quantify the total economic benefits for each stakeholder group, the following assumptions were used, based on personal communications and previous findings:

- The proportion of dive tourists, who were qualified divers and who actually dived during

their holiday, was 90% (B. Philips, personal communication, 24th May 2004).

- The proportion of dive tourists who wreck dive was 52% and the proportion of dive tourists who only dive on artificial reefs was 40.2%, based on a study conducted by Ditton *et al.* (2002) in the USA.

- In Mombasa, 70% of dive tourists used the MV Dania and 30% used the Globestar wreck, because the MV Dania wreck was close to the hotels and within the Mombasa Marine National Park (B. Philips, personal communication, 24th May 2004).

- In Diani, 75% of dive tourists used the MV Alpha Funguo and 25% used the Waa wreck, which was not included in the study, due to the close proximity of hotels to the MV Alpha Funguo wreck (K. Gundrum, personal communication, 7th June 2004).

- The tourist high season lasted for 5 months and the low season for 7 months of the year (B. Philips, personal communication, 24th May 2004).

- The proportion of dive tourists conducting the Professional Association of Dive Instructors (PADI) wreck diving speciality courses was 20% (B. Philips, personal communication, 24th May 2004).

- The proportion of the PADI wreck diving speciality courses conducted in Mombasa was 30% on the MV Dania wreck and 70% on the Globestar wreck, due to the Globestar wreck lying at a shallower depth (B. Philips, personal communication, 24th May 2004).

- In Diani, 100% of the PADI wreck diving speciality courses were conducted on the MV Alpha Funguo wreck, due to its close proximity to the hotels (K. Gundrum, personal communication, 7th June 2004).

The economic benefits from enhanced dive tourism from each wreck were calculated using the assumptions combined with interview results showing; the number of dive tourists using each wreck, the average length of stay for each dive tourist, the average number of dives conducted by each dive tourist, the average cost of a hotel room, the average cost of a wreck dive, the average cost of a wreck speciality course, the average willingness-to-pay per wreck dive and the cost for

a tourist to enter the Mombasa Marine Park, during the low and high seasons for both Mombasa and Diani.

The economic benefits from fishery enhancement from the MV Alpha Funguo wreck were calculated using interview results on the level of fishing effort (average number of days per fishermen spent fishing on the wreck per year) combined with the change in daily income for the fishermen after the wreck was sunk, obtained from the fish catch data from CRCP.

RESULTS

Biological assessment

The Globestar wreck
This wreck was established before the initiation of the measurements of the fish-catch monitoring and therefore, comparison is made only of landing sites near and far from the wreck. No significant difference in the fish catch between Nyali and

Mtwapa landing sites was found. This was particularly clear for speargun fishermen catches (Nyali = 2.46kg/fisher/day; Mtwapa = 2.43kg/fisher/day; Mann-Whitney W=618.5, p=0.43), but the catch by line fishermen was marginally higher in Nyali than Mtwapa (Nyali = 4.50kg/fisher/day; Mtwapa = 3.31kg/fisher/day; Mann-Whitney W=597.5, p=0.054).

The MV Alpha Funguo wreck
The fish-catch monitoring data at this site was collected both before and after the establishment of the wreck. No strong significant difference was found in fish catches between all landing sites for line fishermen both before (Kruskal-Wallis H = 7.21, p= 0.066) and after the placement of the wreck (Kruskal-Wallis H = 5.28, p=0.152). However, a significant decrease in the fish catch for line fishermen of 30% at the Mwaepe landing site was found, as was some indication of change at the Tradewinds landing site, but the difference was not statistically significant (Fig. 2). Similarly
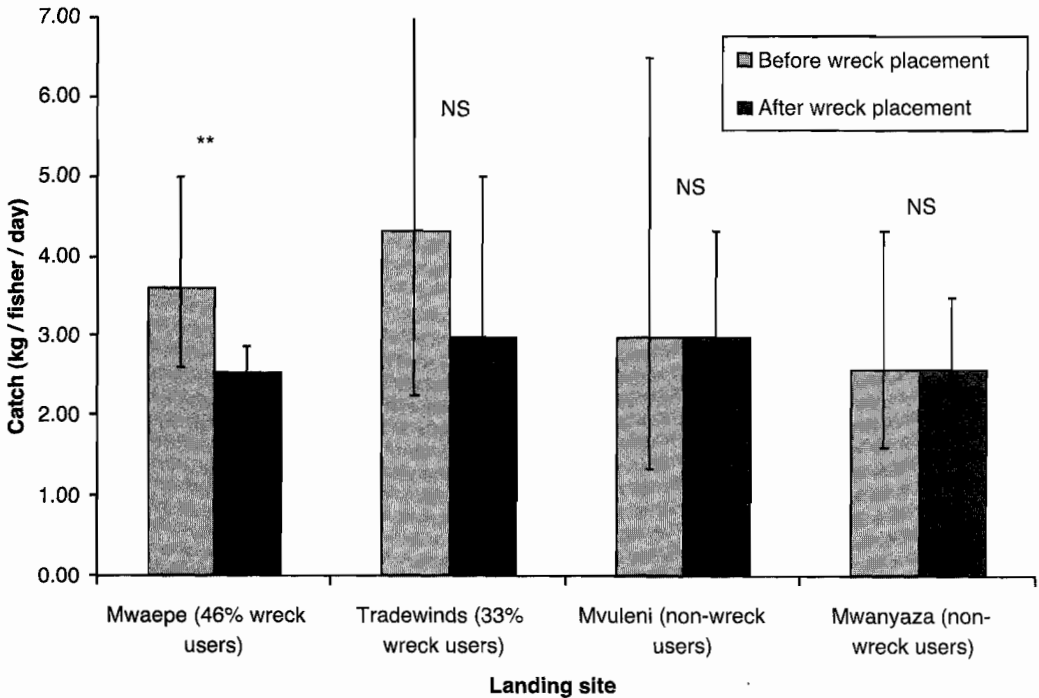

Fig. 2. The median catch for each landing site by line fishermen before and after the placement of the MV Alpha Funguo wreck. The results of Mann-Whitney tests between catches before and after the wreck are shown; Mwaepe (W = 548, p = 0.002), Tradewinds (W = 219, p = 0.1421), Mvuleni (W = 126, p = 1.000), Mwanyaza (W = 294, p = 0.4387). NS = not significant, ** = p < 0.01. 95% Confidence Intervals of the median are shown

there was no significant difference in the fish catch between all landing sites for speargun fishermen before and after the placement of the wreck (Kruskal-Wallis H=6.84, p=0.08). However, there was a significant difference between landing sites for speargun fishermen after the placement of the wreck (Kruskal-Wallis H=14.63, p=0.002), with a significant increase of 44% at the Tradewinds landing site (Fig. 3).

The composition of fish catch from line fishermen were found to generally consist of fish categorised as scavengers, contributing 33% of the fish catch, and a selection of mixed fish species, contributing 34% of fish catch. In contrast, the composition of fish catch from speargun fishermen mainly consisted of octopus, contributing 41% of the total catch, parrotfish, contributing 30% of the total catch and a selection of mixed fish species, contributing 18% of the total catch. There was a significant increase in the catch of octopus by speargun fishermen of 57% at the Tradewinds landing site, after deployment of the MV Alpha Fuguo wreck (Table 2).

Social assessment

Stakeholder perceptions

From the interviews conducted, a significant difference was found between stakeholder perceptions of the effect of the wrecks on fishing (Kruskal-Wallis H=7.91, p=0.0192) and the environment (Kruskal-Wallis H=41.22, p<0.0001) as well as a perceived large effect on the level of dive tourism by all stakeholders (Table 3). Similarly, there was a significant difference between stakeholder perceptions on how the level of dive tourists had changed since the sinking of the wrecks (Chi square X^2=14.26, p=0.0065), with an increase perceived by dive operators and KWS while the hoteliers thought there had been no change (Table 4). The attraction of dive tourists (24%) was the most frequent advantage of shipwrecks mentioned by all stakeholders.

From the interviews with fishermen, a significant difference was found between wreck users (n=45) and non-wreck users (n=43) on their perception of how fish abundance had changed since the wrecks sunk (Chi-square X^2=10.97,
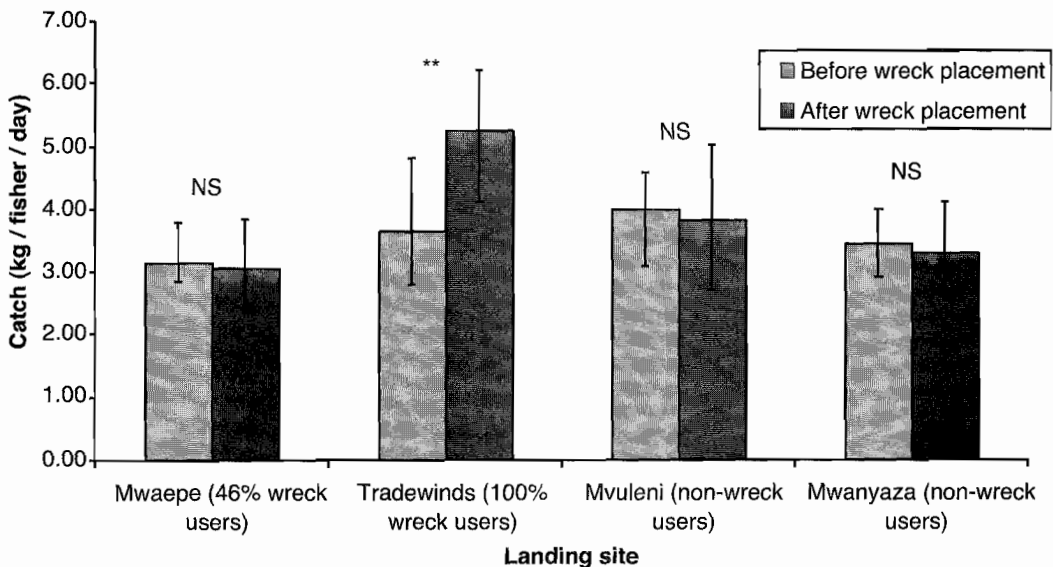
Fig. 3. The median catch for each landing site by speargun fishermen before and after the placement of the MV Alpha Funguo wreck. The results of Mann-Whitney tests between catches before and after the wreck are shown; Mwaepe (W = 2042.0, p = 0.6730), Tradewinds (W = 677.0, p = 0.0091), Mvuleni (W = 1340.5, p = 0.7980), Mwanyaza (W = 1393.5, p = 0.9235). NS = not significant, ** = p < 0.01. 95% Confidence Intervals of the median are shown

Table 2. The median catch (kg / fisher / day) from each landing site for the categories with the greatest contribution to the total fish catch before and after the placement of the MV Alpha Funguo wreck, for both line and speargun fishermen. The numbers in parenthesis are the 95% confidence limits of the median. The results of Mann-Whitney tests between catches before and after the wreck are shown; Line fishermen-scavengers Mwaepe (W = 464.0, p = 0.0966), Tradewinds (W = 231.0, p = 0.0519,), Mvuleni (W = 125.5, p = 0.9738), Mwanyaza (W = 288.0, p = 0.3758), mixed fish Mwaepe (W = 403.0, p = 0.8729), Tradewinds (W = 183.5, p = 0.9525), Mvuleni (W = 125.5, p = 0.9738), Mwanyaza (W = 253.0, p = 0.6923); Speargun fishermen-mixed fish Mwaepe (W = 1838.0, p = 0.2339), Tradewinds (W = 789.0, p = 0.4110), Mvuleni (W = 1230.0, p = 0.0980), Mwanyaza (W = 1302.5), octopus Mwaepe (W = 2051.0, p = 0.2833), Tradewinds (W = 650.5, p = 0.0024), Mvuleni (W = 1250.0, p = 0.1728), Mwanyaza (W = 1274.0, p = 0.2008), parrotfish Mwaepe (W = 2180.5, p = 0.0141), Tradewinds (W = 758.5, p = 0.1906), Mvuleni (W = 1532.5, p = 0.0061), Mwanyaza (W = 1491.0, p = 0.0761). NS = not significant, n = sample size, * = p < 0.05, ** = p < 0.01

| | | Line fishermen | | Speargun fishermen | | |
		Scavengers	Mixed fish	Mixed fish	Octopus	Parrotfish
Mwaepe	Before wreck placement	1.25 (0.45,2.00) n=18	1.00 (0.60,1.53) n=18	0.41 (0.20,0.68) n=50	1.32 (1.07,1.40) n=50	1.05 (0.83,1.20) n=50
	After wreck placement	0.46 (0.18,1.09) n=25	1.00 (0.56,1.50) n=25	0.57 (0.32,0.76) n=27	1.07 (0.78,1.50) n=27	0.58 (0.33, 1.01) n=27
	Statistical significance	NS	NS	NS	NS	*
Tradewinds	Before wreck placement	2.00 (1.35,4.33) n=11	1.00 (0.00,2.57) n=11	0.44 (0.25,0.58) n=29	1.75 (1.22,2.05) n=29	1.17 (0.92,1.50) n=29
	After wreck placement	1.00 (0.00,1.61) n=21	1.00 (0.00,2.00) n=21	0.44 (0.30,0.76) n=28	2.74 (2.10,3.20) n=28	1.33 (1.17,1.81) n=28
	Statistical significance	NS	NS	NS	**	NS
Mvuleni	Before wreck placement	1.00 (0.31,1.54) n=11	0.67 (0.00,2.04) n=11	0.68 (0.45,0.79) n=42	1.35 (1.10,1.47) n=42	1.39 (1.23,1.80) n=42
	After wreck placement	1.00 (0.00,2.03) n=11	1.00 (0.00,1.58) n=11	0.78 (0.56,1.14) n=21	1.64 (1.32,1.96) n=21	1.04 (0.51,1.36) n=21
	Statistical significance	NS	NS	NS	NS	**
Mwanyaza	Before wreck placement	0.93 (0.33,1.08) n=16	0.71 (0.42,2.00) n=16	0.46 (0.37,0.61) n=42	1.28 (0.95,1.50) n=42	1.25 (1.01,1.41) n=42
	After wreck placement	0.30 (0.00,1.12) n=16	0.90 (0.60,1.56) n=16	0.62 (0.27,0.84) n=22	1.47 (1.13,1.94) n=22	0.96 (0.74,1.24) n=22
	Statistical significance	NS	NS	NS	NS	NS

p=0.004), with an increase perceived by wreck users but non-wreck users perceived no change (Table 5). Similarly, a significant difference was found between wreck users and non-wreck users with their perception of the change in catch composition since the wrecks were sunk (Chi-square X^2=10.39, p=0.0013), with a change perceived by wreck users but not by non-wreck users (Table 5). The difference in the perception between wreck users and non-wreck users of how the weight of the daily catch of fish had changed since the wrecks were sunk was nearly significant

Table 3. The median values of the Likert scale in response to each question for each stakeholder for all three wrecks, except for question 1 which only concerned the MV Alpha Funguo wreck. Values range from 0 to 1 and indicate the interviewee's perception of the significance, with low values corresponding to low significance, and vice versa. The results of each Kruskal-Wallis analysis are also shown. NS = not significant, * = $p < 0.05$, *** = $p < 0.001$

Question	Fishermen	Dive operators	Hoteliers	Dive tourists	KWS	Statistical significance
1. How significant do you think the effect of the wreck is on fishing?	0.2	0.1	0.6	n/a	n/a	*
2. How significant do you think the effect of the wreck is on the level of dive tourism?	0.8	0.8	0.7	0.6	0.7	NS
3. How significant do you think the effect of the wreck is on the environment?	0.2	0.7	0.8	0.7	0.6	***

Table 4. The percentage of respondents answering the question as either increased, decreased or no change within each stakeholder group. The result of the chi-square analysis is also shown. ** = $p < 0.01$

Question	Dive operators	Hoteliers	KWS	Statistical significance
How has the level of dive tourists changed since the sinking of the wrecks?	47 (increased) 6 (decreased) 42 (no change)	7 (increased) 0 (decreased) 38 (no change)	58 (increased) 17 (decreased) 8 (no change)	**

Table 5. The percentage of respondents answering each short-answer question as either increased, decreased or no change or as either yes or no for both wreck users and non-wreck users. The results of each chi-square analysis are also shown. NS = not significant, ** = $p < 0.01$, *** = $p < 0.001$

Question	Wreck users	Non-wreck users	Statistical significance
1. Have you noticed any change in the abundance of fish since the sinking of the wreck?	76 (increased) 11 (decreased) 13 (no change)	44 (increased) 12 (decreased) 44 (no change)	**
2. Have you noticed any change in the catch composition since the sinking of the wreck?	78 (yes) 22 (no)	42 (yes) 58 (no)	***
3. Have you noticed any change in the weight of your daily catch since the sinking of the wreck?	47 (increased) 16 (decreased) 38 (no change)	23 (increased) 21 (decreased) 56 (no change)	NS

(Chi-square $X^2 = 5.31$, $p=0.070$). Although, a significantly greater number of fishermen than expected within the stakeholder group perceived no change in the weight of daily catch (Chi-square $X^2 = 10.14$, $p=0.006$) (Table 5).

Stakeholder conflicts

A strong significant difference was found between stakeholder perceptions on the suitability of the location (Kruskal-Wallis H=19.50, p<0.001) and

the depth of the wrecks (Kruskal-Wallis H=72.15, p<0.001), with the fishermen perceiving the lowest suitability of both the location and the depth (Table 6). In Mombasa 14% and in Diani 50% of the fishermen fish in the same areas used by dive tourists. Fifty seven percent of these fishermen in Mombasa (n=7) and 47% in Diani (n=19) stated they had encountered conflicts with the dive tourists. A significant difference was found between stakeholder perceptions on the effect of

dive tourists on fishing (Kruskal-Wallis H=8.20, p=0.042), with a greater effect perceived by fishermen than either dive operators or dive tourists (Table 6). The fishermen also perceived a significantly greater effect of dive tourists scaring fish away than either the dive tourists or the dive operators (Kruskal-Wallis H=71.49, p<0.001) (Table 6).

The fishermen perceived a significantly greater number of fishermen using the Globestar wreck compared to the MV Alpha Funguo wreck (Mann-Whitney W=422.0, p<0.001) with greater conflicts perceived between the wreck-users on the Globestar wreck compared to the MV Alpha Funguo wreck (Mann-Whitney W=357.5, p<0.001) (Table 7).

The dive operators perceived low levels of conflict between dive tourists and fishermen in both Mombasa and Diani (Table 8). Thirty five percent of dive operators who used the wrecks in Mombasa (n=17) and 19% in Diani (n=16) stated that they had encountered conflicts with fishermen on the wrecks. The analysis revealed a significant presence of conflict between dive operators in Mombasa compared to Diani (Mann-Whitney W=76.5, p=0.007) (Table 8).

Twenty five percent of the KWS staff stated they had seen fishermen on or near the MV Dania wreck. Although they perceived little conflict between dive tourists and fishermen within the Mombasa Marine National Park, with a low median score on the Likert scale at 0.1.

Economic assessment

The interviews revealed that the average length of stay per dive tourist was 14 days and the average number of dives conducted per dive tourist was 10. The total number of dive tourists who used any of the three wrecks was 664 for the high season and 244 for the low season, and 455 for the high season and 147 for the low season in Diani and Mombasa, respectively. Fishermen in Diani used the wreck on average 130 days a year. There was no significant difference found between the

Table 6. The median values for the Likert scale in response to each question for each stakeholder for all three wrecks. Values range from 0 to 1 and indicate the interviewee's perception of the benefits, with low values corresponding to low benefits or significance, and vice versa. The results of each Kruskal-Wallis analysis are also shown. * = p < 0.05, *** = p < 0.001

Question	Fishermen	Dive operators	Hoteliers	Dive tourists	KWS	Statistical significance
1. What do you think of the positioning of the wreck?	0.5	0.9	0.8	0.8	0.8	***
2. What do you think of the depth of the wreck?	0.1	0.9	n/a	0.8	n/a	***
3. How significant do you think the effect of dive tourists is on fishing?	0.5	0.1	0.5	0.1	n/a	*
4. What do you think about dive tourists scaring fish away?	0.9	0.1	n/a	0.1	n/a	***

Table 7. The median values for the Likert scale in response to each question from local fishermen for the Globestar and MV Alpha Funguo wrecks. Values range from 0 to 1 and indicate the interviewee's perception of the conflicts, with low values corresponding to low conflicts, and vice versa. The results of each Mann-Whitney analysis are also shown.*** = p < 0.001

Question	Globestar	MV Alpha Funguo	Statistical significant
1. What do you think about the number of fishermen who fish close to the wreck?	0.7	0.1	***
2. What do you think about the conflict between fishermen near the wreck?	0.5	0.1	***

Table 8. The median values for the Likert scale in response to each question from dive operators in Mombasa and Diani for all three wrecks. Values range from 0 to 1 and indicate the interviewee's perception of the conflicts, with low values corresponding to low conflicts, and vice versa. The results of each Mann-Whitney analysis are also shown. NS = not significant, ** = p < 0.01

Question	Mombasa	Diani	Statistical significance
1. How would you rate the conflict between dive operators?	0.5	0.1	**
2. How would you rate the conflict between dive tourists and fishermen?	0.1	0.1	NS

Table 9. The economic costs and benefits used to calculate the total gross benefits from each shipwreck for Mombasa and Diani (US$). * The increase in income was calculated for all speargun fishermen at the Tradewinds landing site in Diani

Factor used in calculations	Mombasa	Diani
The average willingness-to-pay per wreck dive	13	Unknown
Cost of Mombasa marine park fee	5	n/a
Average cost of wreck dive	43	42
Average cost of hotel room - high season	64	80
Average cost of hotel room - low season	44	64
Average cost of wreck speciality course	Unknown	245
Average increase in income for fishermen per day *	n/a	9

Table 10. The annual gross economic benefits from each wreck for each stakeholder (in '000s US$)

Stakeholder	Globestar	MV Dania	MV Alpha Funguo
Dive operators	39	65	65
Hoteliers	31	91	84
KWS	0	3	0
Dive tourists	5	16	11
Fishermen	0	0	1
Total	**75**	**174**	**161**

average number of fishermen using the Tradewinds landing site before (7 fishermen/day) and after (8 fishermen/day) wreck deployment (Mann-Whitney W=879.5, p=0.448). Additionally, the economic data gathered from stakeholders showed differences between Mombasa and Diani, with higher average costs for hotel rooms in Diani (Table 9). The annual gross benefits for each stakeholder from the wrecks showed substantial differences both between the wrecks and between the stakeholders, with the hoteliers and dive operators benefiting the most (Table 10).

DISCUSSION

Fishery enhancement

The enhancement of local fisheries by the shipwrecks was first assessed using historic fish catch data. The fish catch for speargun fishermen at the Tradewinds landing site increased significantly after deployment of the MV Alpha Funguo wreck, however, the fish catch significantly decreased for hook and line fishermen

at the Mwaepe landing site using the same wreck. The most likely cause of these contradictory results is a change in the abundance of species specifically targeted by each gear type. However, the composition of the catch can only partially explain the effects of the shipwreck, with a significant increase in octopi at the Tradewinds landing site for speargun fishermen and yet also a decrease at the Mwaepe landing site. In addition to the ambiguous results, both speargun and hook and line fishermen only fished near the shipwrecks for approximately half of their fishing trips. Therefore, since the historic fish catch data did not contain the location of each fishing trip any increase in the quantity of catch can only be tentatively linked to the effects from the shipwreck.

There was also a lack of any evidence supporting fishery enhancement from the Globestar wreck, with no significant difference between landing sites for both gear types. This lack of fishery enhancement by the Globestar is most likely due to the disintegration of the wreck reducing the available habitat, resulting from the substantial period of time the wreck has been submerged. The possibility of any fishery enhancement from the MV Alpha Funguo wreck is likely to follow the same fate and thus be unsustainable.

The absence of a comparison between fish catch data specifically from natural reefs near the shipwrecks and fish catch data from other natural reefs prevented quantification of the effect of these shipwrecks on fish production and/or attraction, required to help resolve the current "production-attraction" debate (Osenberg et al., 2002). This is particularly important since the MV Alpha Funguo wreck lies at a depth of 28 metres and so any possible benefit to the speargun fishermen, who on average dive to a maximum depth of 7 metres, would not be from the wreck itself but from the shallower and more accessible natural reefs near the wreck. However, attraction and production probably interact to drive the dynamics of an artificial-natural reef complex (Wilson et al., 2001) and therefore evidence supporting either process is only of limited value.

The findings from the social assessments demonstrate that the fishermen should have benefited from the shipwrecks, with significantly more wreck-users stating an increase in fish abundance and a change in catch composition than non-wreck users. However, both wreck users and non-wreck users generally perceived no change in the weight of their daily catch and, consequently, perceived very little effect from the wrecks on fishing. The overall lack of perceived benefits to the fishermen is probably due to the perceived unsuitable depth of the wrecks and the limited time the wrecks are available for fishing, during the calm and dry northeast monsoon season (December-March).

The economic benefit of fishery enhancement to the local fishermen was restricted to only one wreck in this study. Furthermore, the results demonstrate that only speargun fishermen at one landing site (Tradewinds in Diani) have gained any economic benefit from the shipwrecks, with an increase in daily income of 9US$. This equates to around 80Ksh per fishermen per day (using an exchange rate of US$1=72.05Ksh) and is approximately 30% of a fishermen's daily income of around 270Ksh. The total economic benefit to all speargun fishermen at this landing site, resulting from possible fishery enhancement from the MV Alpha Funguo wreck, was estimated at US$1,000 a year. Since the number of fishermen using the Tradewinds landing site remained relatively constant during the period of data collection it can be assumed that the level of fishing effort also remained constant.

Dive tourism enhancement

Due to time constraints with the duration of the field work, a biological assessment was not conducted on the wrecks in view of quantifying the abundance and community composition of the fish communities on each of the wrecks. However, from interviews with fishermen and dive tourists the species present on the wrecks include jacks (Carangidae) and snappers (Lutjanidae), including red snappers (*Lutjanus bohar*), in large abundance, as well as groupers (Serranidae) and even a resident whaleshark (*Rhincodon typus*) on the MV Alpha Funguo wreck. These findings in conjunction with previous research showing that artificial reefs can significantly increase local fish abundance (Bohnsack, 1989) and species richness and

diversity (Fabi & Fiorentini, 1994) compared to natural reefs, suggest that these shipwrecks are likely to attract dive tourists to the area. However, even without the presence of fish, shipwrecks will attract dive tourists to the area, highlighted by Ditton *et al.* (2002) who showed that 68% of sport divers in America chose shipwrecks as their "most preferred" desirable attribute of artificial reefs when responding to a mail questionnaire.

Although the social assessment indicates that not all of the stakeholders agreed that dive tourism had increased since the wrecks were sunk, all of the stakeholders did perceive a very large effect of the shipwrecks on the level of dive tourism, suggesting high awareness of the benefits of shipwrecks used for this purpose. The perceived benefits are not only economic but also include large positive environmental effects, such as diverting diver pressure from natural reefs to the shipwrecks and thereby reducing the impacts on the natural reefs.

The economic assessment showed substantial gross economic benefits resulting from dive tourism enhancement. When compared to previous research, showing that in excess of $1 million Canadian dollars can be generated annually by sinking decommissioned military warships in British Columbia, Canada (Jones & Welsford, 1997), the economic benefits resulting from a less developed dive industry in Kenya would be expected to be significantly lower. Despite the relatively undeveloped dive industry, the economic benefits are substantially greater compared to using the shipwrecks for fishery enhancement. These findings concur with research conducted by Brock (1994), who showed that the gross revenue from the commercial fishery of one artificial reef was only 4% of the annual profit of dive tours on the same reef.

Stakeholder conflicts

The most likely stakeholder groups to conflict with each other when using shipwrecks for both fishery and dive tourism enhancement are the dive operators and the fishermen. The findings of this study show a difference between the level of conflict that actually occurs and the perceptions of the stakeholders on the potential conflicts. In

reality, there is little conflict occurring, highlighted by only 8% of fishermen and 35% of dive operators in Mombasa and 26% of fishermen and 19% of dive operators in Diani encountering conflicts. However, this is mainly due to the fishermen keeping their distance when dive operators use the wrecks and generally not fishing in areas used by the dive operators, including the Globestar which was not sunk by a dive operator. The reason for the deliberate avoidance of conflict by the fishermen is highlighted by their significantly greater perceptions of the effect of dive tourists on fishing compared to both dive tourists and dive operators, with the fishermen perceiving a significantly greater effect of dive tourists scaring away the fish. During interviews, the fishermen often stated that they would prefer wrecks to be sunk purely for the use of fishery enhancement and clearly perceived much greater benefits from the shipwrecks if the dive tourists were removed.

Interestingly, the conflict between fishermen using the shipwrecks is significantly higher in Mombasa than in Diani, although this is most likely due to the significantly greater number of fishermen using the wreck in Mombasa. Likewise the conflict between dive operators was significantly higher in Mombasa than in Diani, which could be due to the difference in ownership of the wreck. In Mombasa the dive operator who owns the MV Dania simply receives a fee from other dive operators who use the wreck. However, in Diani the dive operator who owns the wreck also received financial assistance from the other dive operator in the area with costs for the initial cleaning and sinking. The increased investment in the shipwreck from the onset by both the dive operators in Diani most likely reduces potential conflict.

The presence of the Mombasa Marine National Park did not appear to have a significant effect on the level of conflict between dive tourists and fishermen, as perceived by the dive operators. This is further emphasised with only 14% of fishermen using the same areas as dive tourists in Mombasa, compared to 50% in Diani, and yet the amount of conflict between the two stakeholder groups is relatively similar (57% in Mombasa and 47% in Diani). It therefore seems that although little conflict occurred within the MMNP, as perceived

by the KWS, the overall effect on the level of conflict was minimal, due to an increase in the conflict outside the MPA boundary.

Previous studies have shown more positive results, since despite the additional loss of fishing grounds, the use of MPAs in conjunction with artificial wrecks was shown to have widespread support from Hong Kong fishermen. This was due to the offshore location of the artificial reefs minimising the loss of fishing ground and the potential to substantially enhance the local fisheries via the "spillover" effect (Wilson *et al.*, 2002). However, the issue of MPAs actually enhancing fishery yields via 'spillover' still remains controversial (Sale *et al.*, 2005).

The creation of an MPA is also likely to further increase the number of dive tourists to the area since the special features and values of MPAs are often the reasons that attract divers (Davis & Tidsdell, 1996). However, the support from local stakeholders should be considered vital, particularly from fishermen. A small amount of non-compliance would rapidly erode benefits (Pitcher *et al.*, 2000).

CONCLUSIONS AND RECOMMENDATIONS

Based on the findings of this study the use of shipwrecks to enhance local fisheries would seem a misplaced management justification, due to the lack of biological data as unequivocal evidence of sustainable benefits from increased fish production. The economic benefits to the local fishermen were also calculated without consideration of the costs of deployment and, the addition of this cost, would further reduce the attractiveness of this management option.

The use of shipwrecks for the enhancement of dive tourism is, however, recommended as a management option. The findings of this study demonstrate that shipwrecks can be successfully used to generate significant economic and social benefits, although these benefits can only be fully realised if there is a sufficiently developed dive industry to promote the shipwreck (Enemark, 2000). It is recommended that dive operators concerned with using the shipwrecks as dive sites

should be more actively involved with the deployment, contributing towards the cost of cleaning and sinking of the wrecks, in order to reduce potential conflict once the wrecks are sunk.

Future work should include investigating the "spillover" effect to quantify the enhancement of fisheries by MPAs and shipwrecks. Further biosocioeconomic evaluations of shipwrecks and other artificial reefs, including more detailed assessments, such as cost-benefit analyses and quantitative assessments on fish production should also be undertaken. This would allow greater comparison between management options and their possible integration, particularly the combination of using shipwrecks within MPAs.

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APPENDIX A

Generic stakeholder questions

1. Do you know the whereabouts of any artificial wrecks in the area?

   Yes   No

2. What do you think are the advantages of artificial wrecks?

   _____

   _____

   _____

3. What do you think are the disadvantages of artificial wrecks?

   _____

   _____

   _____

4. Do you think there should be more wrecks sunk in the area?

   Yes   No

5. How has the number of dive tourists changed since the sinking of the wreck?

   Increased   Decreased   No Change

6. (a) Do you encounter any conflicts on the wreck?

   Yes   No

   (b) If yes, what are these conflicts?

   _____

   _____

   (c) How do you think these conflicts can be resolved?

   _____

   _____

7. Have you ever seen any fishermen on the wreck?

   Yes   No

Likert scale questions

8. How significant do you think the effect of dive tourists is on fishing?

   Not significant   Highly significant

9.   How significant do you think the effect of the wreck has on fishing?

      Not significant   Highly significant

10.   How significant do you think the effect of the wreck is on the level of dive tourism?

      Not significant   Highly significant

11.   How significant do you think the effect of the wreck is on the environment?

      Not significant   Highly significant

12.   What do you think of the positioning of the wreck?

      Highly unsuitable   Highly suitable

13.   What do think of the depth of the wreck?

      Highly unsuitable   Highly suitable

14.   What do you think about dive tourists scaring fish away?
      Not significant   Highly significant

15.   How would you rate the conflict between dive operators?
      No conflict   Major conflict

16.   How would you rate the conflict between dive tourists and fishermen on the wreck?
      No conflict   Major conflict

Additional questions for dive operators

1.   On average how many dive tourists do you have each season?

      High season _____ _____ _____

      Low season _____ _____ _____

2.   How much does a wreck dive cost? _____ __ _____

3.   How much does it cost for a wreck diving speciality course? _____ _____ _____

Additional questions for fishermen

1.   How often do you fish?

      Dry season __ _____ ___ _____ Wet season _____ _____ _____

2.   What type of fishing gear do you use?

Trap   Beach Seine

Gillnet   Speargun

Line   Other

3.   (a) How deep do you fish in the lagoon? _____

      (b) How deep do you fish in the open sea? _____

4.   (a) Do you fish on or near any of these wrecks?

          Yes   No

      (b) If yes, why and how often?

_____

_____

5.   How close to the wreck do you fish? _____

6.   (a) Have you noticed any change in the abundance of fish since the sinking of the wreck?

      Increased   Decreased   No Change

      (b) If any change, which species have increased?

_____

_____

      (c) If any change, which species have decreased?

_____

7.   Have you noticed any change in the weight of your daily catch since the sinking of the wreck?

      Increased   Decreased   No Change

8.   (a) Have you noticed a change in the catch composition since the sinking of the wreck?

      Yes   No

      (b) If yes, which species? _____

_____

9.   Do you fish in the same areas used by dive tourists?

      Yes   No

10.   Do you encounter any conflicts with the dive tourists?

       Yes   No

Likert scale questions

11.   What do you think about the number of fishermen who fish close to the wreck?

       Too few   Too many

12.   What do you think about the conflict between fishermen near the wreck?

       No conflict   Major conflict

Additional questions for dive tourists

1.   Assuming that artificial wrecks are more costly to dive on. How much extra money are you prepared
       to pay per holiday in Kenya to experience artificial wreck diving?

       Please number the following boxes 1,2 or 3 (1 refuse to pay, 2 would not mind paying, 3 strongly
       agree to pay)

       $0
       <$2
       <$5
       <$10
       <$15
       <$20
       <$25
       <$30
       <$35
       <$40
       <$45
       <$50
       >$50

Likert scale question

2. How important was the presence of artificial wrecks in your decision to come to Kenya?

       Not important   important

Additional questions for hoteliers

1.   How much does it cost to stay in the hotel?

       High season - Single room _____   Low season - Single room _____

                     Double room _____   Double room _____

2.   On average, how long do tourists stay in the hotel?

Additional questions for KWS

1.   How much does it cost to enter the Mombasa Marine National Park?

Tourist   Local resident

Likert scale question

2.   How significant is the effect of people visiting the marine park without paying?

Not significant   Highly significant