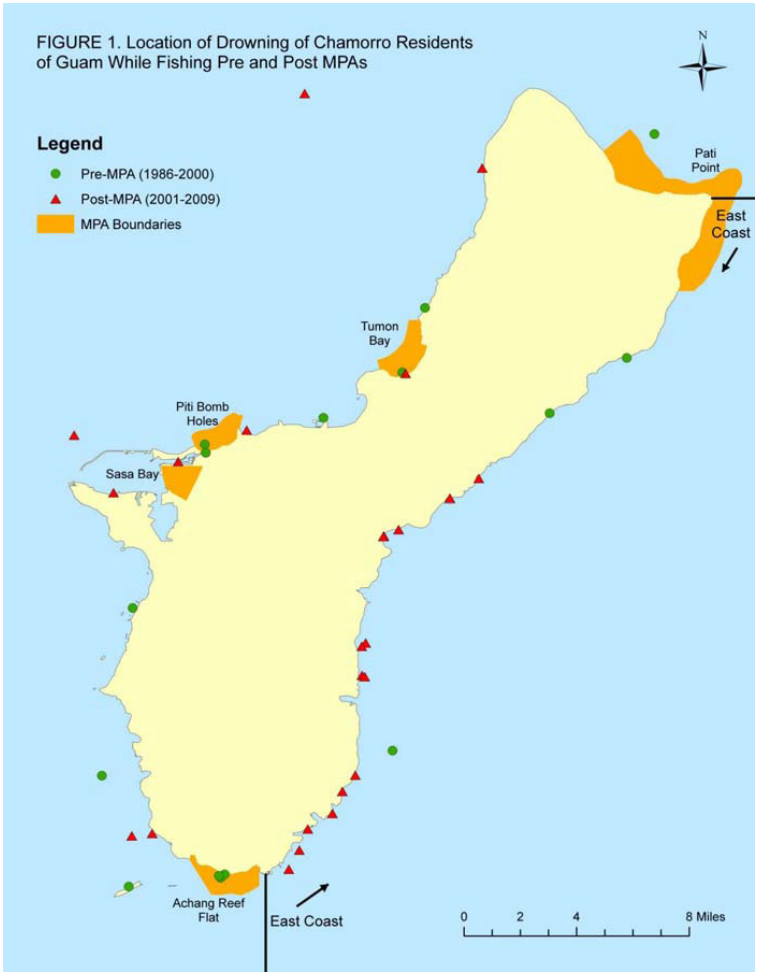
The Impact of Marine Preserve Areas on the Safety of Fishermen on Guam



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Western Pacific Regional Fishery Management Council
1164 Bishop Street, Suite 1400, Honolulu, HI 96813

Note: While MPAs in Guam are known as “marine preserve areas,” in other regions MPAs are more commonly known as “marine protected areas.”

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ABSTRACT

Background. For fishermen on Guam who have traditionally fished inshore, a major concern is the loss of accessible fishing grounds caused in part by the establishment of five marine preserve areas (MPAs) in 1997. MPAs limit fishing activities in areas that were traditional fishing grounds. Fishermen may be exposed to greater risks when they fish in unfamiliar and/or more hazardous waters. The purpose of this study was to measure the safety impacts of MPAs on the fishermen of Guam. Two hypotheses were tested in this study. First, the drowning rate of fishermen on Guam increased after the establishment of MPAs. Second, the location of fishermen drowning changed after the establishment of MPAs.

Methods. Drowning deaths were identified through a manual review of all death certificates issued on Guam between 1986 and 2009. The hypotheses were tested by calculating the relative risk of drowning pre- and post-MPAs, Chi-Square test for linear trend and geospatial analysis of drowning locations.

Results. There were 316 drowning deaths on Guam between 1986 and 2009, of which 68 (22 percent) were identified as Guam residents fishing at the time of drowning. The 68 residents of Guam were 57 percent Chamorro (n=39) and 43 percent non-Chamorro (n=29). During the period after MPAs were fully enforced (2001–2009), the drowning rate of Chamorro fishermen was more than two times higher than the pre-MPA rate (RR=2.25; CI=1.18-4.28). The proportion of drowning deaths to Chamorro fishermen that occurred on the East Coast (in more hazardous waters) increased from 20 percent between 1986 and 2000 to 63 percent between 2001 and 2009. Among non-Chamorro fishermen, the post-MPA drowning rates were about 50 percent lower than the pre-MPA rates, and there was no change in the location of drowning.

Summary. For Chamorro fishermen, the risk of drowning more than doubled after MPAs were enforced. Non-Chamorro fishermen experienced a sharp decrease in the risk of drowning after MPAs were established. Greater exposure to a high risk environment, as evidenced by the shift in location of drowning deaths among Chamorro fishermen, may explain the increase in the drowning rate post-MPAs.

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1 INTRODUCTION

Fishing is an important activity to the people of Guam, with between 35 and 45 percent of residents actively engaged in fishing (Van Beukering et al. 2007). Reasons for fishing are mixed between recreational, subsistence and commercial activities; and most fishermen report having multiple reasons to fish (Allen and Bartram 2008). Fish serve as a source of food, income and cultural value for many people on Guam, and most of the fish consumed (57 percent) come from local waters. Fishermen on Guam employ many techniques and types of fishing gear including hook-and-line, cast-net, trolling and spearfishing. On average fishermen operate once per week, but about 16 percent fish three or more times per week (Van Beukering et al. 2007). Although fishing is not a leading contributor to Guam's economy, for many fishermen it is an important source of household income, in addition to its subsistence value. Over 150 fishermen are members of the Guam Fishermen's Cooperative Association, a 30-year old non- profit organization which buys fish from local fishermen and sells it to the community (Allen and Bartram 2008). The Cooperative is also engaged in fisheries management, training of young fishermen and fisheries data collection.

A major concern for fishermen who have traditionally fished inshore is the loss of accessible fishing grounds caused by the establishment of five marine preserve areas (MPAs) in 1997. The five MPAs are: Tumon Bay, Piti Bomb Holes, Sasa Bay, Achang Reef Flat and Pati Point.

The MPAs are located in traditional Chamorro fishing areas along the West Coast (leeward side of the island) and on the Northern and Southern tips of the island (Figure 1). Fishing for most species and by most techniques is prohibited in the MPAs. Dip-netting, gill-netting, drag-netting, surround-netting and spearfishing are not allowed in MPAs. In Tumon Bay, cast-netting from shore and hook-and-line fishing from shore is allowed but only for certain species of fish. Pati Point also allows hook-and-line fishing from shore but local fishermen do not have access as it is blocked by US military land. All fishing is prohibited in the other three areas.

The MPAs were established in May 1997 but enforcement of fishing restrictions was phased in over several years. This allowed time for the public to be educated and for the boundaries to be marked. The fishing restrictions became partially enforced at the end of 1999. At that time, warnings were issued until the MPAs became fully enforced in January 2001. Since January 2001, fishermen caught fishing in MPAs can be fined up to $500.00, imprisoned up to 90 days, and must forfeit all equipment utilized for fishing including their vehicles (Guam Legislature 1997). The East Coast of the island (facing the Pacific Ocean) is free of MPAs but is frequently battered with harsh seas and is widely considered among Chamorro fishermen to be more dangerous than other parts of the Island. In addition, the east side is largely cliff-line or privately owned land which limits accessibility.

MPAs were established for the purpose of preserving local traditions and protecting the natural resource of fish (Guam Legislature 1997). Fishermen have reported that MPAs have displaced them from their traditional fishing grounds and prevent them from teaching fishing techniques in a safe environment to the younger generation (Allen and Bartram 2008). While the loss of inshore fishing grounds has generated some discussion regarding the impact on local culture, there does not appear to have been similar consideration in the literature given to the

potential safety implications. As fishermen on Guam become displaced from their usual fishing grounds by current and possibly future MPAs, attention must be given to the latent consequences of these restrictions. Fishermen may be exposed to greater risks when they venture to unfamiliar and more hazardous waters to find fish.

Drowning and other injuries to fishermen on Guam have not been studied. A search of the scientific literature and internet sources did not find any published studies or data sources for drowning on Guam. There were also no studies found on drowning for other islands in the Western Pacific Region. Between 1999 and 2007, the US had a drowning rate of 1.4 deaths per 100,000 residents (CDC 2010a). The drowning rate for Hawai‘i was 2.9/100,000 during the same time period.

Commercial fishing is the most dangerous occupation in the United States (BLS 2010). Among the 504 US commercial fishing fatalities reported between 200 and 2009, the majority were caused by drowning following a vessel disaster (i.e., a sinking, capsizing or fire in which the crew was forced to abandon ship) (261, 52 percent) or a fall overboard (155, 31 percent) (CDC 2010b).

An emerging body of research has begun to study the positive and negative impacts that fisheries management and marine policies can have on the safety of fishermen. For example, in the Alaska Halibut/Sablefish fishery, the fatality rate decreased by 81 percent after a major overhaul of the fisheries management regime that allowed for a consolidation of the fleet and an elimination of the “race to fish” (Lincoln et al. 2007). A meta-analysis of international studies on fisheries management and safety found many examples of policies that affect safety among fishermen around the world (Lincoln and Knapp 2009). Several case studies reviewed fisheries management policies in traditional artisanal (small-scale) fisheries such as those found on Guam. Although none of them specifically examined the impact of MPAs on safety, there was mention of fishermen having to travel farther from shore and to unfamiliar areas to fish and documented concerns for their safety (Table 1).

At the request of the Western Pacific Regional Fishery Management Council, the National Institute for Occupational Safety and Health Alaska Pacific Regional Office conducted this study to measure the safety impacts of MPAs on the fishermen of Guam.

The following hypotheses were tested in this study: 1) the drowning rate of fishermen on Guam increased after the establishment of MPAs and 2) the location of fishermen drowning changed after the establishment of MPAs.

Table 1 Sample of international case study evidence for fisheries management.

Country/ Region	Fisheries Studied	Summary of evidence provided by the study
Ghana	All	Managers are unable to protect fishery resources and constrain access to artisanal fisheries. Industrial fisheries further compete with artisanal fisheries for resources. As a result, fishermen fish increasingly far from shore and face greater risks.
Malawi	Southern Lake Malawi fisheries	Ineffective resource protection resulting in over-exploitation of inshore fisheries resources causes small-scale fishers to venture into unsafe offshore deep waters.
Pacific Islands	Tuna	The study cites several examples of the inability of managers to control catches or limit access which may potentially lead to more fishermen fishing farther offshore and taking greater risks.
Thailand	Trawl & purse seine fisheries	The report suggests that over-fishing of inshore resources may have contributed to greater fishing effort offshore, exposing inexperienced fishermen to new and less safe conditions.

Source: Lincoln and Knapp, 2009

2 METHOD

2.1 Data Collection

Drowning deaths were identified through a manual review of all death certificates issued on Guam between 1986 and 2009. A drowning death was defined as one which had "drowning" listed as the immediate or underlying cause of death on the death certificate. Presumptive drowning deaths (i.e., no body recovered) were also included. Drowning deaths in international waters (>200 miles offshore) were not included. Newspaper articles from the *Pacific Daily News* were collected and matched to death certificates to provide additional information. Data were entered into a Microsoft Access database for each drowning fatality including victim demographic characteristics, date and time of drowning, water type, activity and location.

Since fishing on Guam is more likely to be recreational or subsistence than occupational, fishermen were not identified by the occupation variable on the death certificates. Instead, fishermen were defined by their activity at the time of drowning. Victims were coded as fishermen if they were fishing when they drowned. The race and residence variables on death certificates were used to identify Chamorro residents of Guam, who are the traditional subsistence fishermen.

Latitude and longitude coordinates were generated for each death by plotting the location described on death certificates and in newspaper articles in Google Earth software (Google Earth

2010). The coordinate estimates were not highly precise locations but rather general locations within bays, harbors, MPAs, etc. Locations that were difficult to determine were reviewed by local residents and plotted on a map. All deaths were successfully geocoded with latitude and longitude coordinates.

2.2 Denominator

Three different denominators were required for various parts of the analysis. The first denominator was the mid-year population estimate of Guam for each year between 1986 and 2009 as reported by the US Census Bureau (US Census Bureau 2010). The second denominator was the mid-year estimate of Chamorro residents of Guam for each year during the same time period. The third denominator was the mid-year estimate of non-Chamorro residents of Guam. For the years from 2000 to 2009, the estimate was available from the US Census Bureau for each year. Prior to that period, estimates were only available for the first year of each earlier decade. The estimates for 1980 and 1990 were used, and the difference between them equally distributed across the other years in each decade assuming a linear change in the population over time. The US Census Bureau reported Chamorro race/ethnicity in two groups, those of one race/ethnicity (Chamorro only) and those of two or more races/ethnicities (Chamorro and another). For this study, both groups were considered to be Chamorro residents of Guam.

2.3 Analysis

Drowning fatality rates were calculated for each year between 1986 and 2009 for three different groups of victims: 1) all residents of Guam who drowned while fishing; 2) all Chamorro residents of Guam who drowned while fishing; and 3) all non-Chamorro residents of Guam who drowned while fishing.

The corresponding denominators were used in the rate calculations. The Chi-Square test for linear trend was performed for the 24-year period to identify any general trend over the whole time period for each group.

The establishment and enforcement of MPAs occurred over several years with three distinct and potentially important cut-points: establishment in 1997, partial enforcement in 2000 and full enforcement in 2001. Three pre-post MPA time periods were created to test differences in the drowning rate in each group before and after each cut-point:

1) 12 years pre-MPAs establishment (1986 to 1997) and 12 years post-MPAs establishment (1998 to 2009).

2) 14 years pre-MPAs partial enforcement (1986 to 1999) and 10 years post-MPAs partial enforcement (2000 to 2009).

3) 15 years pre-MPAs full enforcement (1986 to 2000) and 9 years post-MPAs full enforcement (2001 to 2009).

The drowning rate for each pre- and post-MPA period was calculated, followed by the relative risk for each pre-post period with 95 percent confidence intervals. In addition, the Chi-Square test for linear trend was performed for each pre- and post-time period.

The location of drowning was analyzed using a geospatial analysis in ArcGIS software (ESRI 2009). Each death was coded with latitude and longitude coordinates in decimal degree format. The coordinates were loaded into a map of Guam with layers outlining the location of MPAs. Deaths were identified as having occurred pre- or post-MPAs for each of the three different cut-points. The spot map was analyzed by calculating the proportion of drowning deaths in each time period that occurred in areas considered safe (e.g., West Coast) and areas considered dangerous (e.g., East Coast). The East Coast (windward side of the island) is considered by traditional fishermen to be more dangerous than other parts of the island because the ocean currents and waves are more severe. The West Coast has calm, protected bays where fishermen traditionally operated.

3 RESULTS

There were 316 total drowning deaths on Guam during 1986-2009, of which 68 (22 percent) were identified as Guam residents fishing at the time of drowning. The hypotheses were tested by analyzing three groups of fishermen separately: residents of Guam (Tables 2–4), Chamorro residents of Guam (Tables 5–7) and non-Chamorro residents of Guam (Tables 8–10).

3.1 Group 1 – Residents of Guam Drowned While Fishing

All 68 residents of Guam who drowned while fishing between 1986 and 2009 were male with a mean age of 40 years. The youngest victim was 14 and the oldest 76. During the 24-year period, a minimum of one person drowned while fishing each year with a maximum of six deaths and a mean of 2.8 deaths per year (Table 2). The average annual drowning rate was 1.9 deaths per 100,000 residents.

Table 2 Frequency and rate of drowning of residents of Guam while fishing.

Year	Guam Population	No. of fatalities	Rate per 100,000	3-year avg fatalities
1986	122880	3	2.44	
1987	125724	3	2.39	
1988	127545	2	1.57	8
1989	130947	2	1.53	
1990	134125	2	1.49	
1991	138159	3	2.17	7
1992	142326	2	1.41	
1993	143825	3	2.09	
1994	143157	4	2.79	9
1995	144190	5	3.47	
1996	145324	1	0.69	
1997	146799	2	1.36	8
1998	149724	1	0.67	
1999	152590	1	0.66	
2000	155324	2	1.29	4
2001	158330	3	1.89	
2002	161057	2	1.24	
2003	163605	3	1.83	8
2004	166124	6	3.61	
2005	168614	4	2.37	
2006	171086	3	1.75	13
2007	173544	2	1.15	
2008	175991	5	2.84	
2009	178430	4	2.24	11
Total		68		68

The test for linear trend of the drowning rate by year from 1986 to 2009 showed no statistically significant trend (X2=0.068; p=.795). For the first pre-post MPA time period (1986–1997:1998-2009), no difference was found in the period drowning rates (RR=0.94; CI=0.58-1.51). For the other two pre-post MPA time periods (1986–1999:2000–2009 and 1986–2000:2001–2009), no differences were found in the period drowning rates (Table 3). The test for linear trend of the drowning rates by year for each pre-post MPA time period showed no statistically significant trends in any of the time periods.

Table 3 Drowning rates of residents of Guam while fishing pre- and post-MPAs at three cut-points.

Period	Guam Population	No. of fatalities*	Rate per 100,000	Relative Risk	95% CI	X^2 for trend	p-value
1986-1997	1645001	32	1.95	0.94	0.58-1.51	0.050	0.823
1998-2009	1974419	36	1.82			2.432	0.119
1986-1999	1947315	34	1.75	1.16	0.72-1.87	1.303	0.254
2000-2009	1672105	34	2.03			0.412	0.521
1986-2000	2102639	36	1.71	1.23	0.77-1.98	1.488	0.223
2001-2009	1516781	32	2.11			0.110	0.740

*n=68

The geospatial analysis revealed differences in the location of drowning pre- and post-MPA in each of the three pre-post MPA time periods. The greatest difference was found in the 1986–2000:2001–2009 time periods (Table 4). The proportion of drowning deaths that occurred on the East Coast increased from 14 percent between 1986 and 2000 to 53 percent between 2001 and 2009.

Table 4 Location of drowning of residents of Guam while fishing pre- and post-MPAs at three cut-points.

Period	No. of fatalities†	No. fatalities on E. Coast	Proportion of fatalities on E. Coast	Z-score*	p-value
1986-1997	32	5	16%	2.73	0.006
1998-2009	36	17	47%		
1986-1999	34	5	15%	3.08	0.002
2000-2009	34	17	50%		
1986-2000	36	5	14%	3.43	0.001
2001-2009	32	17	53%		

†n=68

*Two sample test of proportion

3.2 Group 2 – Chamorro Residents of Guam Drowned While Fishing

Chamorro fishermen accounted for 39 of the 68 drowning deaths. The mean age was 42 years old (range 14 to 76). During the 24-year period, the mean number of deaths per year was 1.6 with an average annual drowning rate of 2.5 deaths per 100,000 Chamorro residents. Three individual years prior to 2000 had no drowning deaths (Table 5).

Table 5 Frequency and rate of drowning of Chamorro residents of Guam while fishing.

Year	Guam Chamorro Population	No. of fatalities	Rate per 100,000	3-year avg fatalities
1986	54057	0	0.00	
1987	54954	2	3.64	
1988	55851	1	1.79	3
1989	56748	1	1.76	
1990	57648	1	1.73	
1991	58408	2	3.42	4
1992	59168	1	1.69	
1993	59928	1	1.67	
1994	60688	1	1.65	3
1995	61448	2	3.25	
1996	62208	1	1.61	
1997	62968	1	1.59	4
1998	63728	0	0.00	
1999	64488	0	0.00	
2000	65243	1	1.53	1
2001	66729	3	4.50	
2002	67878	2	2.95	
2003	68947	1	1.45	6
2004	69999	5	7.14	
2005	71042	4	5.63	
2006	72076	2	2.77	11
2007	73103	1	1.37	
2008	74124	3	4.05	
2009	75139	3	3.99	7
Total		39		39

The test for linear trend of the drowning rate by year for 1986–2009 did not show a statistically significant linear trend (X2=3.115; p=.078). The drowning rate increased in each post-MPA time period over the pre-MPA rate, with the largest increase in the third pre-post MPA time period (1986–2000:2001–2009), in which the post-MPA drowning rate was 125 percent higher than the pre-MPA drowning rate (RR=2.25; CI=1.18-4.28) (Table 6). The test for linear trend of the drowning rates by year for each pre-post MPA time period showed no statistically significant trends in any of the time periods.

Table 6 Drowning rate of Chamorro residents of Guam while fishing pre- and post-MPAs at three cut-points.

Period	Chamorro Population	No. of fatalities*	Rate per 100,000	Relative Risk	95% CI	X^2 for trend	p-value
1986-1997	704074	14	1.99	1.51	0.79 - 2.91	0.018	0.894
1998-2009	832496	25	3.00			2.626	0.105
1986-1999	832290	14	1.68	2.11	1.10 - 4.06	0.750	0.386
2000-2009	704280	25	3.55			0.092	0.761
1986-2000	897533	15	1.67	2.25	1.18 - 4.28	0.673	0.412
2001-2009	639037	24	3.76			0.035	0.852

*n=39

The geospatial analysis revealed differences in the location of drowning pre- and post-MPA in each of the three pre-post MPA time periods (Figure 1). The greatest difference was found in the 1986–2000:2001–2009 time periods (Table 7). The proportion of drowning deaths that occurred on the East Coast increased from 20 percent between 1986 and 2000 to 63 percent between 2001 and 2009.

Table 7 Location of Drowning of Chamorro Residents of Guam While Fishing Pre and Post MPAs at Three Cut-Points.

Period	No. of fatalities†	No. fatalities on E. Coast	Proportion of fatalities on E. Coast	Z-score*	p-value
1986-1997	14	3	21%	2.34	0.019
1998-2009	25	15	60%		
1986-1999	14	3	21%	2.34	0.019
2000-2009	25	15	60%		
1986-2000	15	3	20%	2.62	0.009
2001-2009	24	15	63%		

†n=39

*Two sample test of proportion

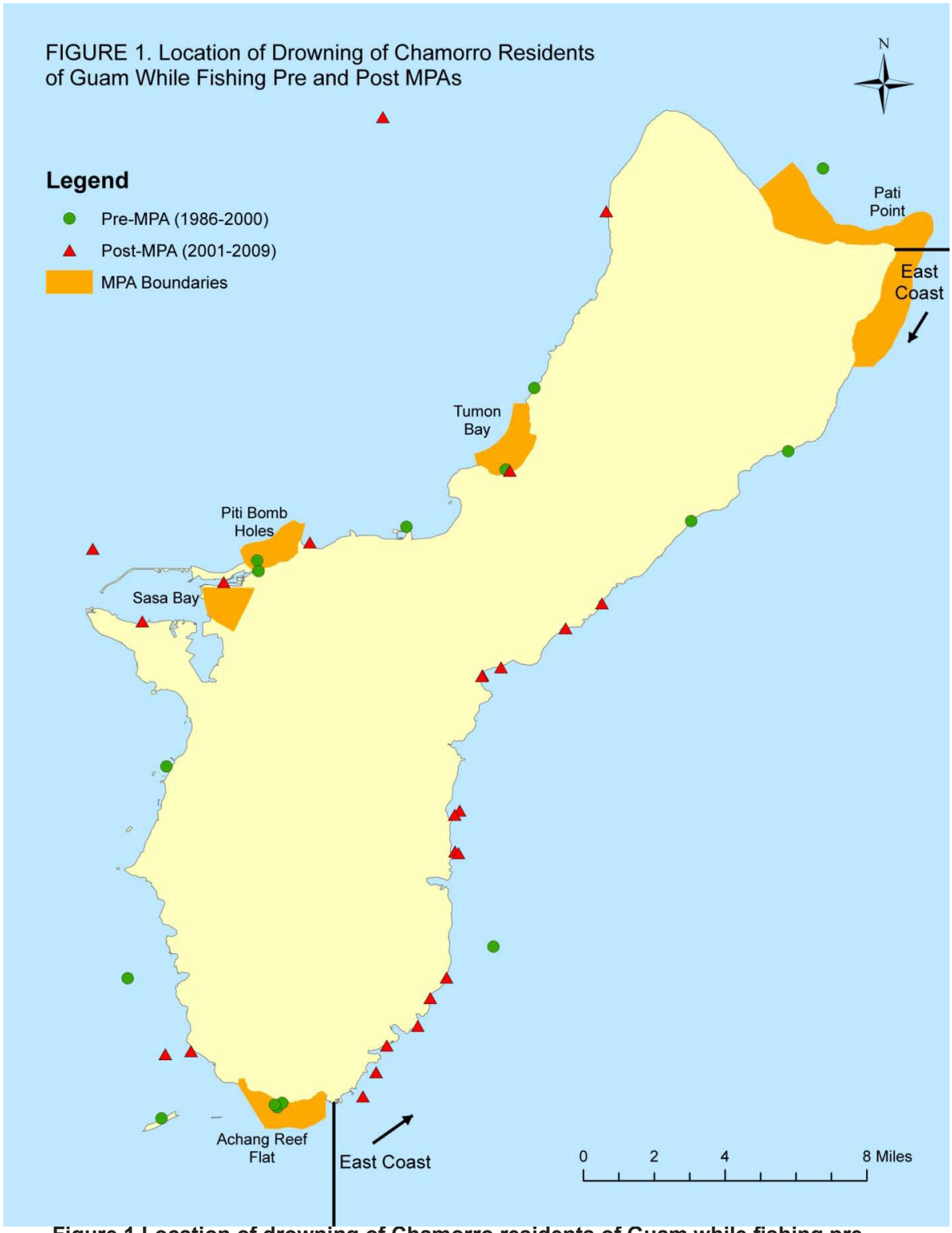

Figure 1 Location of drowning of Chamorro residents of Guam while fishing pre- and post-MPAs.

3.3 Group 3 – Non-Chamorro Residents of Guam Drowned While Fishing

There were 29 residents of Guam who drowned while fishing between 1986 and 2009 that were non-Chamorro. The age of this group ranged from 24 to 60 years old with a mean of 37. During the 24-year period there was a mean of 1.2 deaths per year, with an average annual drowning rate of 1.4 deaths per 100,000 non-Chamorro residents (Table 8).

Table 8 Frequency and rate of drowning of non-Chamorro residents of Guam while fishing.

Year	Guam Non-Chamorro Population	No. of fatalities	Rate per 100,000	3-year avg fatalities
1986	68823	3	4.36	
1987	70770	1	1.41	
1988	71694	1	1.39	5
1989	74199	1	1.35	
1990	76477	1	1.31	
1991	79751	1	1.25	3
1992	83158	1	1.20	
1993	83897	2	2.38	
1994	82469	3	3.64	6
1995	82742	3	3.63	
1996	83116	0	0.00	
1997	83831	1	1.19	4
1998	85996	1	1.16	
1999	88102	1	1.14	
2000	90081	1	1.11	3
2001	91601	0	0.00	
2002	93179	0	0.00	
2003	94658	2	2.11	2
2004	96125	1	1.04	
2005	97572	0	0.00	
2006	99010	1	1.01	2
2007	100441	1	1.00	
2008	101867	2	1.96	
2009	103291	1	0.97	4
Total		29		29

The test for linear trend of the drowning rate by year for 1986–2009 did not show a statistically significant trend (X2= 2.652; p=.103). For all three pre-post MPA time periods, the post-MPA drowning rates were about 50 percent lower than the pre-MPA rates (Table 9). The test for linear trend of the drowning rates by year for each pre-post MPA time period showed no statistically significant trends in any of the time periods.

Table 9 Drowning rate of non-Chamorro residents of Guam while fishing pre- and post-MPAs at three cut-points.

Period	Non-Chamorro Population	No. of fatalities*	Rate per 100,000	Relative Risk	95% CI	X^2 for trend	p-value
1986-1997	940927	18	1.91	0.50	0.24-1.07	0.173	0.677
1998-2009	1141923	11	0.96			0.148	0.701
1986-1999	1115025	20	1.79	0.52	0.24-1.14	0.585	0.444
2000-2009	967825	9	0.93			0.549	0.459
1986-2000	1205106	21	1.74	0.52	0.23-1.18	0.819	0.365
2001-2009	877744	8	0.91			0.975	0.323

*n=29

The geospatial analysis revealed no differences in the location of drowning pre- and post-MPA in any of the three pre-post MPA time periods (Table 10).

Table 10 Location of drowning of non-Chamorro residents of Guam.

Period	No. of fatalities†	No. fatalities on E. Coast	Proportion of fatalities on E. Coast	Z-score*	p-value
1986-1997	18	2	11%	0.530	0.594
1998-2009	11	2	18%		
1986-1999	20	2	10%	0.870	0.385
2000-2009	9	2	22%		
1986-2000	21	2	10%	1.04	0.300
2001-2009	8	2	25%		

†n=29

*Two sample test of proportion

4 DISCUSSION

When all residents of Guam who drowned while fishing between 1986 and 2009 were analyzed as a complete group, there was no evidence that the drowning rate changed after MPAs were established or enforced. Analysis of two subgroups, Chamorro and non-Chamorro fishermen, demonstrated that diverging trends in the drowning rates were masked in the analysis for the complete group. Among Chamorro fishermen, there was a 125 percent increase in the rate after MPAs were fully enforced in 2001. For non-Chamorro fishermen the converse was true: a 50 percent decrease in the drowning rate post MPAs. The increase in one group and decrease in the other group explained why there was no observable difference in the initial, aggregate analysis of all residents of Guam who drowned while fishing (Figure 2).

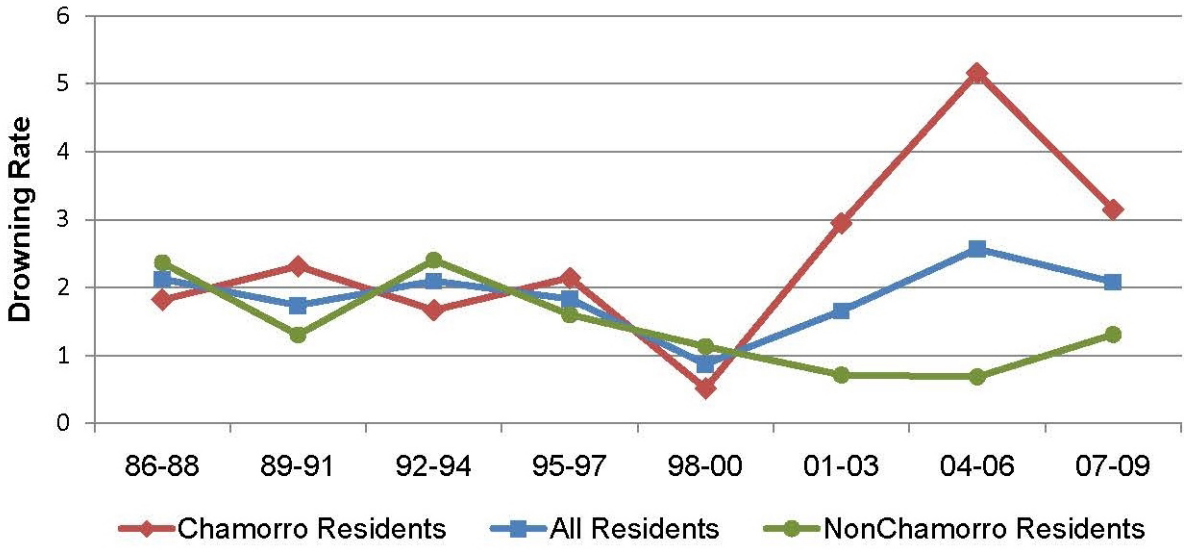

Figure 2 Drowning rate of fishermen by three-year intervals.

The hypothesis that the drowning rate of fishermen on Guam increased after the establishment of MPAs was supported by the analysis but with some specification. The establishment of MPAs seemed to affect the drowning rates of two groups of fishermen differently. In the case of Chamorro fishermen, the risk of drowning more than doubled after MPAs were enforced. For that group, the hypothesis was correct. On the other hand, non-Chamorro fishermen experienced a sharp decrease in the risk of drowning after MPAs were established, and the opposite of the hypothesis was true.

There was a substantial change in the location of drowning deaths among Chamorro fishermen. This change was discovered during the geospatial analysis, and was found in each of the three pre-post MPA time periods; although it was most evident in the periods before and after the MPAs were fully enforced in 2001. Between 1986 and 2000, only 20 percent of the drowning deaths took place on the East Coast. The East Coast (windward side of the island) is considered by traditional fishermen to be more dangerous than other parts of the island, because the ocean currents and waves are more severe. The West Coast has calm, protected bays where fishermen traditionally operated. Prior to the establishment of MPAs, fishermen would choose to fish primarily in areas along the West Coast or Southern Tip of the island rather than on the East Coast (M. Duenas, Guam Fishermen's Cooperative Association, personal communication, June 15, 2010).

During the nine years after MPAs were fully enforced (2001–2009), 63 percent of Chamorro drowning deaths occurred off the East Coast. This difference (20 percent pre-MPA vs. 63 percent post-MPA) coupled with the sharp increase in the drowning rate may indicate that after MPAs were enforced, Chamorro fishermen relocated their fishing activities to higher risk areas along the East Coast.

Greater exposure to a high risk environment, as evidenced by the shift in location of drowning deaths among Chamorro fishermen, may explain the increase in the drowning rate post MPAs. Among non-Chamorro fishermen, the location of drowning deaths did not change in a similar fashion. The only change measured in the analysis for the non-Chamorro group was a

decrease in the number and rate of drowning deaths. Since the denominator used (non- Chamorro population of Guam) did not account for exposure, it is not possible to determine whether the decrease in the drowning rate was a result of safety improvements or simply a function of less fishing activity (not reflected in the denominator); although the latter seems a more likely explanation.

5 LIMITATIONS

The findings and conclusions of this study are subject to several limitations. First, while great effort was made to identify every drowning death on Guam between 1986 and 2009, there may be cases missing from this analysis. For example, if a drowning victim's body was not recovered and the family did not request a presumptive death certificate be issued, that case may not have been identified and included in the analysis. Second, the denominators used in the analysis were the best available but were not the most ideal match for the fatality data. Not all of the people in the denominator were fishermen and there was no way to measure exposure (time spent fishing). This was especially concerning in the analysis of non-Chamorro fishermen, where a decrease in the drowning rate was most likely a result of less people fishing rather than a sudden improvement in safety. Third, small numbers in the analysis made it difficult to detect statistically significant differences. Finally, this analysis did not control for possible confounders such as changes in the economic structure or environmental conditions, which could explain the trends observed in the study.

6 CONCLUSION

Before MPAs were established in 1997, residents of Guam fished primarily in protected areas of the Western (leeward side) and Southern Coasts. Non-Chamorro residents were predominantly recreational users, while Chamorro fishermen were more likely to subsist on the resource. As MPAs were established and enforced, the traditional and popular fishing grounds on the West Coast and Southern tip of the island were restricted. Non-Chamorro recreational fishermen most likely scaled back their fishing activities since few accessible, safe areas remained open. That reduction in fishing activity would explain the sharp decrease in the number and rate of drowning deaths among non-Chamorro fishermen.

At the same time, Chamorro subsistence fishermen began fishing more heavily on the East Coast (windward side of the island). That increased exposure to more hazardous conditions, which resulted in a higher risk of drowning. The rise in fatalities after MPAs were enforced may be a result of fishermen operating in more dangerous waters off the East Coast.

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