A Retrospective Review of Marine Debris Deposition Data from Tern Island, French Frigate Shoals, 1990-2002

Carey Morishige[1], Christine Woolaway[2], Christopher Swenson[3], Mary Donohue[4]

1. University of Hawaii, Honolulu, HI.
2. Hawaii Sea Grant Program, University of Hawaii, Honolulu, HI.
3. U.S. Fish and Wildlife Service, Honolulu, HI.
4. Hawaii Sea Grant Program, University of Hawaii, Honolulu, HI.

Introduction

The Hawaiian Archipelago, mainly the Northwestern Hawaiian Islands (NWHI), is home to endangered Hawaiian monk seals, sea turtles, many species of seabirds, and 69% of the coral reefs in U.S. waters (Miller and Crosby, 1998). Because of the unique and distinct bathymetry, and relative geography of the NWHI, derelict fishing gear and other forms of maritime marine debris remain a continued threat to wildlife and coral reef ecosystems there (Donohue et al., 2001).

Hawaiian monk seals have the highest entanglement rates among pinnipeds and all main breeding subpopulations of this species are within the NWHI (Henderson, 2001). Endangered hawksbill, olive ridley and leatherback sea turtles also reside in the NWHI. There have been documented entanglements of these species as well as of the threatened green sea turtle (Balazs 1978, 1980, 1985; Henderson, 1984). Ingestion of debris is also a threat to many species of seabirds. They have been found having ingested plastics, styrofoam, fibers, bags, bottle caps and toys (Harrison et al., 1983; Dickerman and Goelet, 1987). Maritime marine debris also causes damage to coral reef ecosystems. Fishing gear can get snagged on a reef, leading to the breakage of coral heads (Donohue et al., 2001).

There have been recent efforts to remove derelict fishing gear and other marine debris from the NWHI. In 1999, a multi-agency effort was made to remove derelict fishing gear from Lisianksi Island and Pearl and Hermes Atoll in the NWHI. Fourteen tons of fishing gear was removed (Donohue et al., 2001). The U.S. Fish and Wildlife Service also has volunteers throughout the year at Tern Island, French Frigate Shoals, NWHI, who remove and catagorize beach debris. These efforts still continue today.

This paper is a retrospective review of marine debris deposition data from 1990 through 2002. The main objective of this project is to analyze existing data and produce a report describing the status and trends of marine debris deposition at Tern Island, French Frigate Shoals (FFS), Hawaii. The data was collected by U.S. Fish and Wildlife Service volunteers from the beaches of Tern Island commencing in 1990 and continues today.

Materials and Methods

Data for this study was collected from 15 March 1990 to 30 September 2002 on Tern Island, French Frigate Shoals, Hawaii. Every two weeks, a group of three U.S. Fish and Wildlife

Service (USFWS) volunteers went out to collect marine debris deposition data. Three beaches on this island were surveyed: Crab and Shell Beaches along the north side of the island and South Beach. East Beach is an ephemeral beach and was surveyed occasionally. Debris along the beaches and up to the landward berm was collected before 8 a.m. in order to minimize Hawaiian monk seal disturbance. Those debris items that may have been pushed up above the berm were also collected. All debris collected were of non-Tern Island origin. Debris items were catalogued by type using a Marine Debris Tally Sheet (Palermo, personal communication). The raw data was then entered into a Microsoft Excel.

Data was categorized based on seven categories excluding nets. The seven categories were as follows: plastic, styrofoam, rope/strapping, glass, metal, rubber/shoes and wood. Net data was calculated separately as measurements used (square feet and pounds) were not the same as those of the other debris categories (number of pieces).

Seasons were defined as follows: Winter = December 21 through March 19, Spring = March 20 through June 20, Summer = June 21 through September 20 and Fall = September 21 through December 20 (U.S. Naval Observatory, 2000). El Niño months were used instead of years. These El Niño months were defined as: June 1991 through June 1992, April through July 1993, October 1994 through January 1995, May 1997 through March 1998 and July through August 2002. La Niña months were defined as: December 1999 through March 2000 and September through January 2001 (Smith and Sardeshmukh, 2002).

Microsoft Excel 2000 was used to graph the data and MiniTab Statistical Software, Release 13.31 was used for statistical analysis.

Results

Yearly marine debris deposition

Since 1990, the total amount of marine debris deposited (in number of pieces) from the beaches of Tern Island has varied (Figure 1). The year with the greatest amount of marine debris deposited appears to be 1994 (4009 pieces). Noteworthy however is 2002 which had the second greatest amount of debris (3844 pieces) although data for November through December was not included. The lowest amount was in 2001 (1116 pieces). Yearly differences were significant in the amount of marine debris deposited on Tern Island ($P < 0.001$). Significant differences were found between the years 2001 and 1990, 1993-95 as well as between 2002 and 1999-2001.

Regressing debris amounts against time resulted in a slight downward trend, which was not significant (P = 0.178, r-squared = 8.2%) (Figure 2). However, the year 1991 and 2002 were noted to be outliers and when removed, the result was a significant downward trend in debris deposition over the years (P = 0.002, r-squared = 62.1%) (Figure 3).

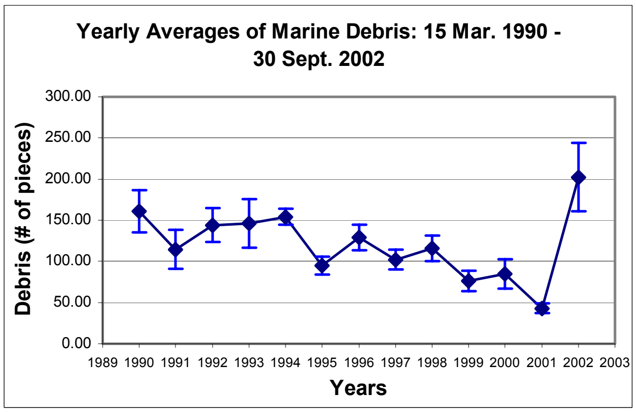


Figure 1. Yearly averages of marine debris from 1990-2002.

Figure 2. Regression of Tern Island marine debris totals from 1990-2002.

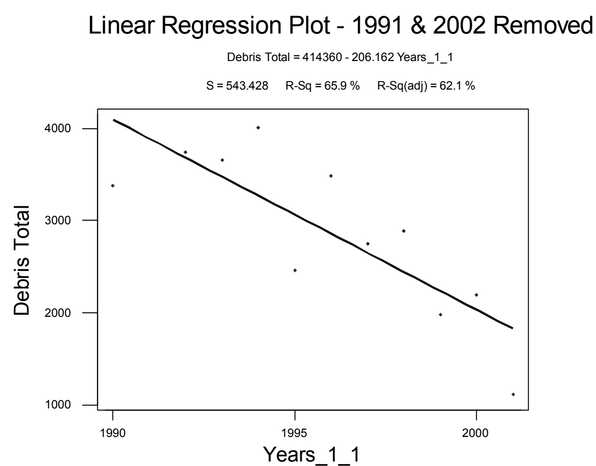


Figure 3. Regression of Tern Island marine debris totals with years 1991 and 2002 removed as outliers.

Seasonal effect on marine debris deposition

Figure 4 presents a plot of yearly debris totals for each season at Tern Island. There are no significant trends in these data nor were there significant changes by season (Figure 5; General Linear Model (GLM) ANOVA).

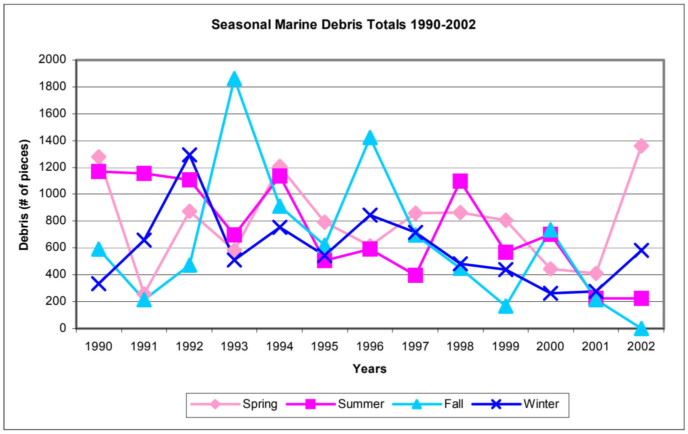


Figure 4. Tern Island seasonal debris totals. There is no statistically significant difference between debris deposition in spring, summer, fall and winter.

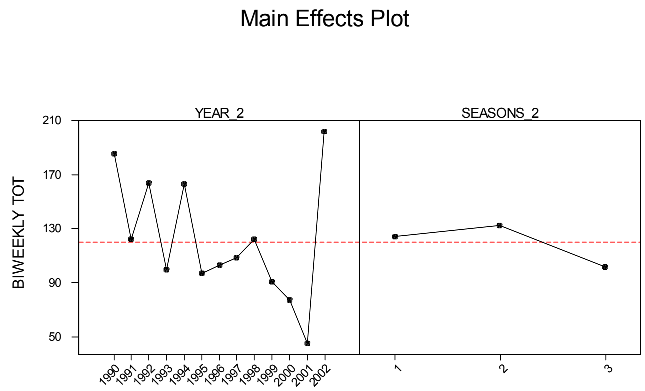
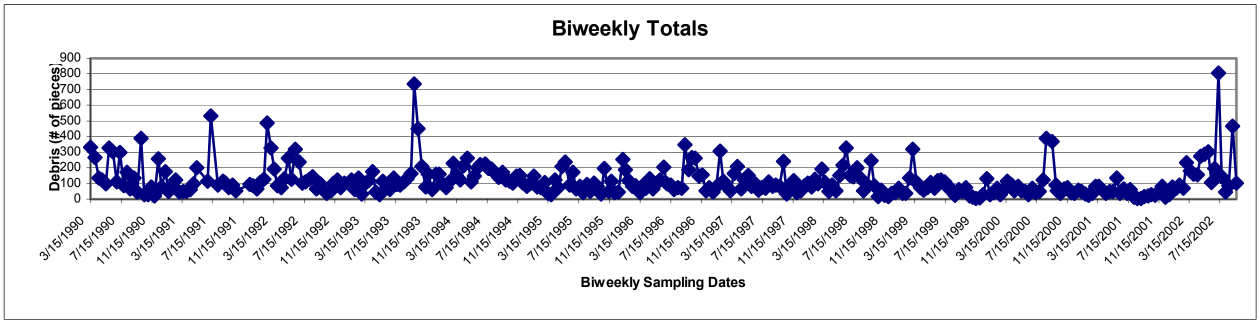


Figure 5. Main effects graph of Years and Seasons using biweekly totals of marine debris.

El Niño effect on marine debris deposition

There appeared to be no significance of El Niño or La Niña on biweekly marine debris deposition totals (Figure 6 and 7). However, there was a significance of El Niño/La Niña cycles on biweekly marine debris deposition totals (P = 0.012). These cycles were defined as the period of time before an El Niño or La Niña and through the end of that event. There are a total of six cycles – four El Niño events and two La Niña events. When analyzing the statistics for these cycles, data from 6 February 2001 and on were not included due to the fact that they did not contain a complete cycle.



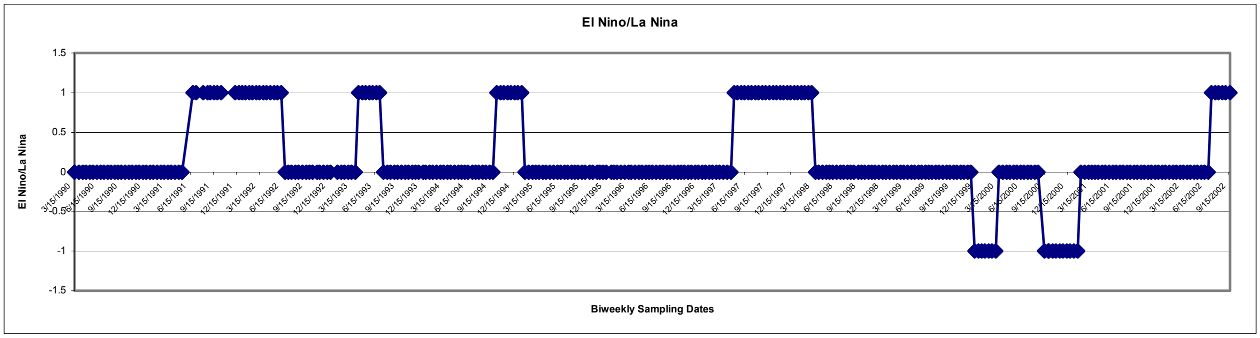


Figure 6 and 7. El Niño and La Niña months from 1990 through 2002. El Niño is indicated as 1 and La Niña is indicated by –1. Below that is a graph of biweekly debris totals from 1990 through 2002 as a comparison.

Intraspecific variation in marine debris type

There was a great difference between the amounts of synthetic and natural materials found (Figure 8). Plastic made up the bulk of marine debris deposited 68% (Table 1). Plastic was followed by glass (19%), styrofoam (6%), rope (4%), metal (2%), rubber (1%) and wood (0.3%). The amounts of plastic and glass were found to be statistically different from all other debris types.

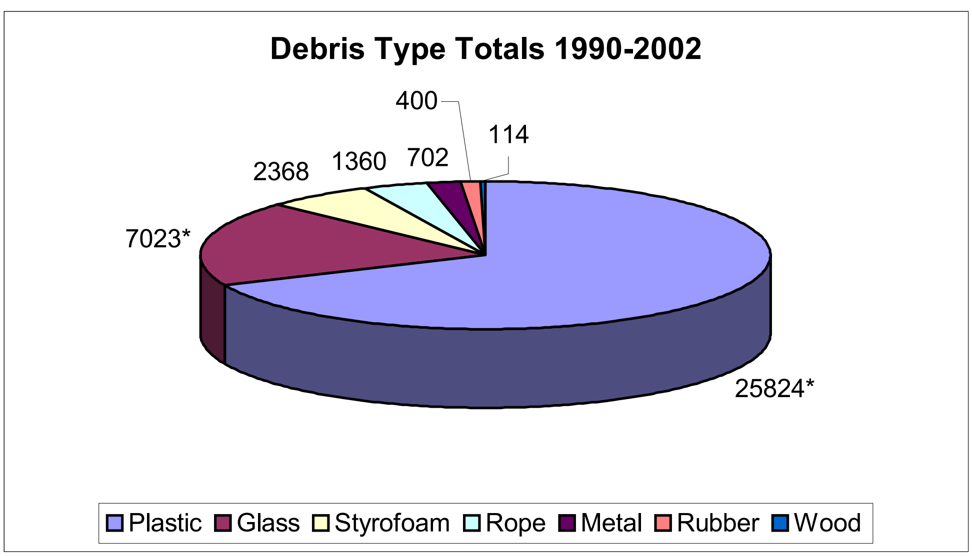


Figure 8. Tern Island marine debris totals by type from 1990-2002.

YEARS	Plastic	Styrofoam	Rope	Glass	Metal	Rubber	Wood	Yrly. Tls.
1990	2586	248	59	401	46	30	4	3374
1991	1626	105	51	414	70	12	10	2288
1992	2571	260	93	709	61	49	2	3745
1993	2397	469	103	584	78	17	3	3651
1994	2843	128	73	842	62	34	27	4009
1995	1774	71	73	457	49	35	3	2462
1996	2506	353	59	460	54	40	7	3479
1997	2011	171	97	432	65	72	5	2853
1998	1763	125	97	692	61	45	8	2791
1999	1575	57	96	204	30	13	5	1980
2000	1295	80	271	479	48	20	6	2199
2001	688	68	62	249	24	14	11	1116
2002	2189	233	226	1100	54	19	23	3844
Totals	25824	2368	1360	7023	702	400	114	37791
Percent	68.33%	6.27%	3.60%	18.58%	1.86%	1.06%	0.30%	

Table 1. Tern Island marine debris type totals from 1990-2002.

Seasonal effect on deposition of debris types

A GLM ANOVA was run on the different debris types to discern seasonal effects. Only glass was significantly affected by the seasons ($P < 0.001$) (Figure 9). All other debris types were not significantly affected by seasonality.

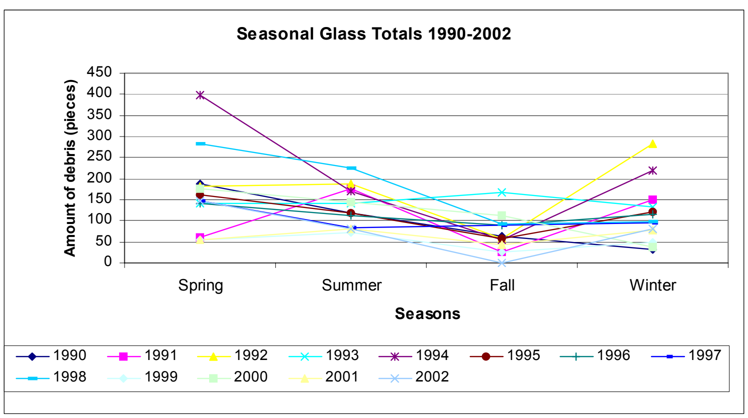


Figure 9. Yearly seasonal debris totals of glass.

NETS AND GILLNETS

Yearly and seasonal effects on deposition of nets and gill nets

There were two main categories for the net data: small nets/gill nets, in square feet, and large nets/gillnets, in pounds. Each of these two categories contained both net and gill net sub-categories. When looking at yearly effect on the deposition of net and gill net, there appeared to be a significant effect of years on small gill net debris deposition ($P = 0.013$) (Figure 10). This may be due to the significant difference between 2002 and 1990-96, 1998-2000. There appeared no significant seasonal effect on either large or small net/gillnet deposition, nor was there any significant seasonal effect on the four individual sub-categories.