



Kalaupapa National Historical Park (KALA) Marine Fish Monitoring Program Annual Status Report for 2007

Pacific Island Network

Natural Resource Data Series NPS/PACN/NRDS—2012/282



ON THE COVER

Bluespine unicornfish (*Naso unicornis*) at Kalaupapa National Historical Park, Molokaʻi, Hawaiʻi.
Photograph by: Courtesy of Kalaupapa National Historical Park, Molokaʻi, Hawaiʻi.

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All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner.

Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

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Executive Summary

Kalaupapa National Historical Park (KALA) is located on the north shore of the island of Moloka'i and encompasses a wide variety of habitats from submerged marine resources to lowland coastal, mesic, and rainforest habitats as well as three offshore islands. The marine boundary of the park extends a quarter mile offshore around the park shoreline and encompasses approximately 2,000 acres.

The objective of the marine fish monitoring protocol is to annually determine the density and size of reef fishes at sites randomly selected on hard substrata in an isobath between the 10 and 20 m depths (Brown et al. 2011). From 2006-2007, a total of 30 transects (sites) were sampled each year. A split panel sampling design was used with 15 transects randomly established at the onset as fixed or permanent transects. These fixed transects were surveyed in 2006 and will be continually surveyed on an annual basis. The remaining 15 temporary transects were randomly selected each year and surveyed only in that year. Data collection consisted of a visual count and size estimation of all fish within 25 x 5 m underwater belt transects. Scientific divers were used to conduct this non-destructive technique and focused on the diurnal or day-active fish species that were highly visible due to their typically bright coloration and generally large size. This report includes the status of the fish populations at all 30 transects in 2007 and trends at the fifteen fixed transects from 2006-2007.

In 2007:

- Fish species richness ranged from 11 to 45 species per transect (125 m²). Species richness was lowest along the southeastern coast of the peninsula. Transects with the highest species richness values were concentrated near the northern tip of the peninsula, particularly along the northeastern coast.
- The density of fish at all transects ranged from 328 to 3,632 fish/km² x 1000. Densities were lowest at the western boundary of the park, and along the southeastern coast of the peninsula. Densities were highest near the northern tip of the peninsula.
- Fish biomass ranged from 36 to 538 metric tons/km² at almost all transects surveyed. The lowest biomass levels were found along the eastern boundary of the park, and the southeastern and northwestern coasts of the peninsula. The lowest biomass (just 4.12 metric tons/km²) was found at Fixed Transect 6, also located along this northwestern coast. Two transects had particularly high biomass values: Fixed Transect 3, located on the southwestern coast of the peninsula, had a biomass of 798.9 metric tons/km², while Temporary Transect 13, located just east of the peninsula, had a biomass of 1,049.8 metric tons/km².
- Fish diversity (H') was fairly evenly distributed throughout the park, ranging from 1.11 to 3.04. Transects with the lowest diversity levels were concentrated around the northwestern tip of the peninsula.
- Secondary consumers accounted for 74% of the fish density observed during surveys in 2007, while apex predators accounted for just 2%, with primary consumers making up the remaining 24%. In contrast, the relative biomass of secondary consumers was 30%, compared to 18% for apex predators and 52% for primary consumers.
- In terms of density, the secondary consumer *Chromis vanderbilti* was by far the most abundant species found. It was more than four times as abundant as the next most

common taxon in the park, the primary consumer *Kyphosus* spp. Seven of the top ten most abundant species by density were secondary consumers, while three were primary consumers.

- The bulk of the biomass was accounted for by *Kyphosus* spp. *Kyphosus* spp. accounted for approximately two and a half times the biomass as the second most abundant species by biomass, the apex predator *Caranx sexfasciatus*, which was observed on only one transect. The top ten most abundant species by biomass were composed of four primary consumers, three apex predators, and three secondary consumers.

Trends at the 15 fixed transects surveyed annually from 2006-2007 showed that:

- Mean fish species richness remained relatively stable (approximately 24 species per transect).
- Mean fish biomass remained relatively stable (approximately 162 mt/km²).
- Mean fish diversity (H') remained relatively stable at approximately 2.0.
- Mean fish density declined slightly from approximately 1,900 fish/km² x 1,000 in 2006 to 1,400 fish/km² x 1,000 in 2007.

Acknowledgments

We would like to thank Randall Watanuki, other KALA staff, and all the volunteers at Kalaupapa National Historical Park for their continuing logistical support in collecting the data for this report. Financial assistance was provided by the Pacific Island Network Inventory and Monitoring Program. We could not have done the work without this support.

List of Terms and Acronyms

KALA: Kalaupapa National Historical Park

PACN: Pacific Island Network

Trophic groups: groups defined by nutritional habits and requirements

Introduction

Because of their importance ecologically, culturally and economically, it is critical that Pacific Island Network (PACN) parks have scientifically rigorous data on the current health and long-term trends of the marine fish communities within their boundaries. In most Pacific parks, coral reefs form an important component of the ecosystem, and have been compared to tropical rainforests in terms of their high species diversity and complexity of interactions (Connell 1978, Birkeland 1997). Within coral reefs, marine fish are one of the most visible resources and certainly the most exploited.

Kalaupapa National Historical Park (KALA) in the PACN is located in Hawai'i on the north shore of the island of Moloka'i, and encompasses a wide variety of habitats from submerged marine resources to lowland coastal, mesic, and rainforest habitats as well as three offshore islands (Figure 1). The park preserves and interprets the Kalaupapa settlement and Hansen's disease patients, but public visitation is restricted. The marine boundary of the park extends a quarter mile offshore around the park shoreline and encompasses approximately 2,000 acres. Significant marine resources include the presence of threatened (green sea turtle) and endangered (monk seal, humpback whale) species, high wave energy coral reef communities, and relatively healthy marine intertidal and fish resources. The most common species of hermatypic corals occur at KALA, but prevailing oceanographic conditions prevent coral reef formation. The intertidal areas consist of exposed basalt benches, low and high cliffs, basalt boulder and cobble beaches, sand beaches, and numerous tide pools that provide habitat for juvenile fish species. Upland development (including sedimentation and other runoff-associated issues) and overfishing (including from commercial fishing vessels) are significant anthropogenic factors affecting fish communities at KALA.

The initial source of information on fish assemblages at KALA is from Beets et al. (2010) who surveyed the reefs from 2004 to 2005. Their data on species richness, numerical density, biomass, and diversity was the first known study to document fish habitat utilization patterns within the park boundaries. Recently, Coles et al. (2008) surveyed the offshore islands in and around the park for unique fish species, numerical density levels, biomass, and diversity. Reef Environmental Education Foundation (REEF; www.reef.org) also has two sites on the north coast of Moloka'i that provide species checklist information in similar habitats.

The methodology to monitor coral reef fish has been developed over the past 25 years, resulting in several commonly used survey techniques (e.g., Bohnsack and Bannerot 1986, Rogers et al. 1994, English et al. 1997, Samoilys 1997, Sweatman et al. 1998, Atlantic and Gulf Rapid Reef Assessment 2000, Hill and Wilkinson 2004). The technique adopted for PACN consists of a visual count and size estimation of fish by scientific divers along underwater 25 m x 5 m belt transects (Brown et al. 2011). This non-destructive technique focuses on one major component of the coral reef fish community—the diurnal or day-active fish species that are highly visible due to their typically bright coloration and generally large size. These species are the most heavily targeted by local fishers. While the small, cryptic or nocturnal species contribute to biodiversity and may be of ecological or management importance, the additional effort and time required to sample nocturnal and cryptic fish is not usually feasible with available resources. The visual estimate of fish size is an important component of these surveys for several reasons. First,

lengths allow a conversion from fish numbers to biomass by using established length-weight relationships. Second, lengths are often a useful indicator of fishing pressure or population dynamics, e.g., a trend of decreasing sizes may indicate overfishing, or recruitment year classes. Third, there is a strong positive correlation between fish size and fecundity (reproductive potential) which, along with recruitment success, is important in assessing ecological services provided by park fish stocks.

The purpose of this report was to document the status of the marine fish assemblage at KALA in 2007 and examine changes from 2006 to 2007. First, the status of the entire assemblage in 2007 was analyzed for species richness, density, biomass and diversity using spatial distribution maps. Second, the trophic composition of the entire assemblage in 2007 was examined for both density and biomass. Third, the top ten species in 2007 in terms of density and biomass were listed to examine specific components of the assemblage. Finally, trends in the entire assemblage from 2006-2007 were plotted for species richness, density, biomass, and diversity.

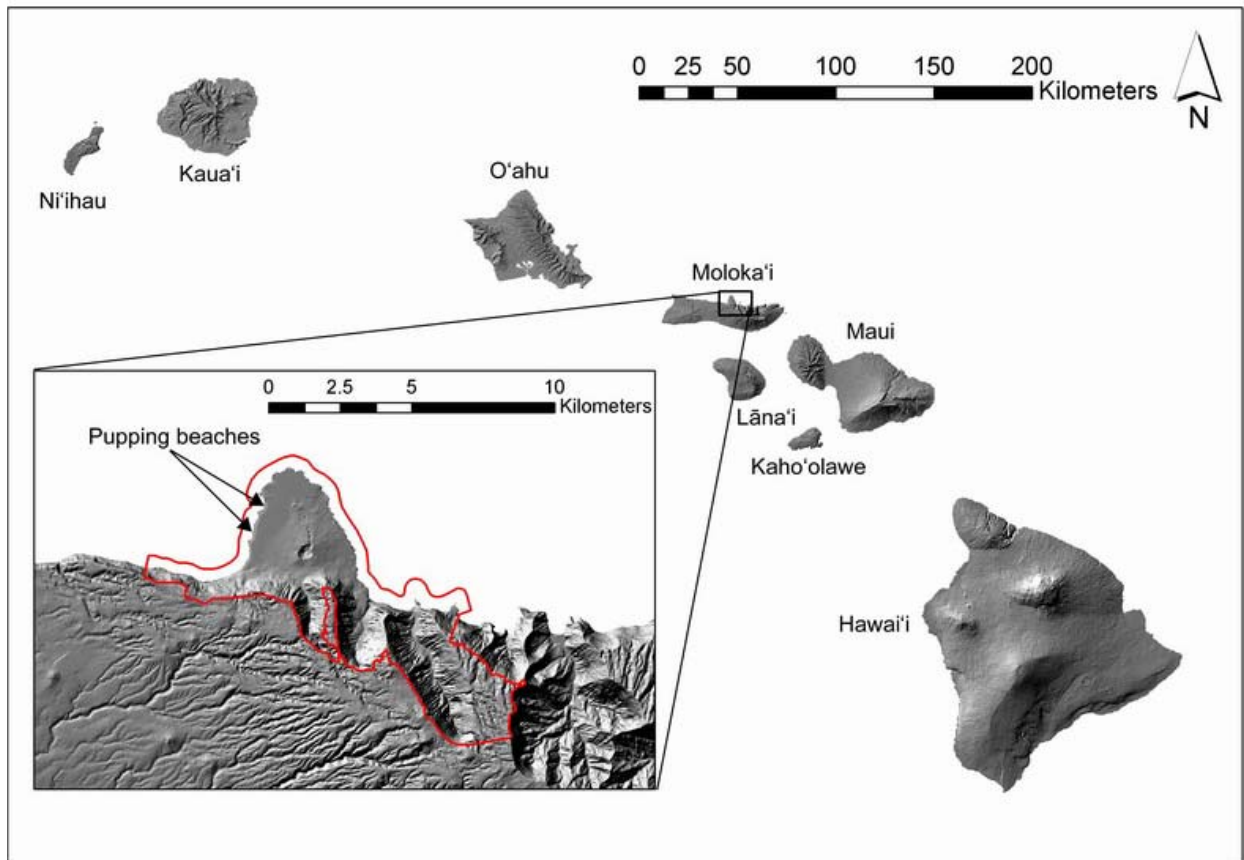


Figure 1. Map of the main Hawaiian Islands showing Kalaupapa National Historical Park with the park boundary delineated as a red line in the inset.

Methods

Sampling Locations

A split panel design was used with 30 belt transects (25 m long x 5 m wide) sampled annually in 2007 (Brown et al. 2011). All transects were randomly selected using ArcMap[®] within the KALA sampling frame on hard bottom substrate in the depth zone between the 10-20 m isobaths (Figure 2). Fifteen fixed (permanent) transects were randomly selected at the onset of the monitoring program in 2006 and marked with stainless steel pins for relocation purposes. These sites were again sampled in 2007. The remaining 15 temporary transects were randomly selected each year of monitoring and sampled only once. Transect locations were located in the field using a GPS unit.

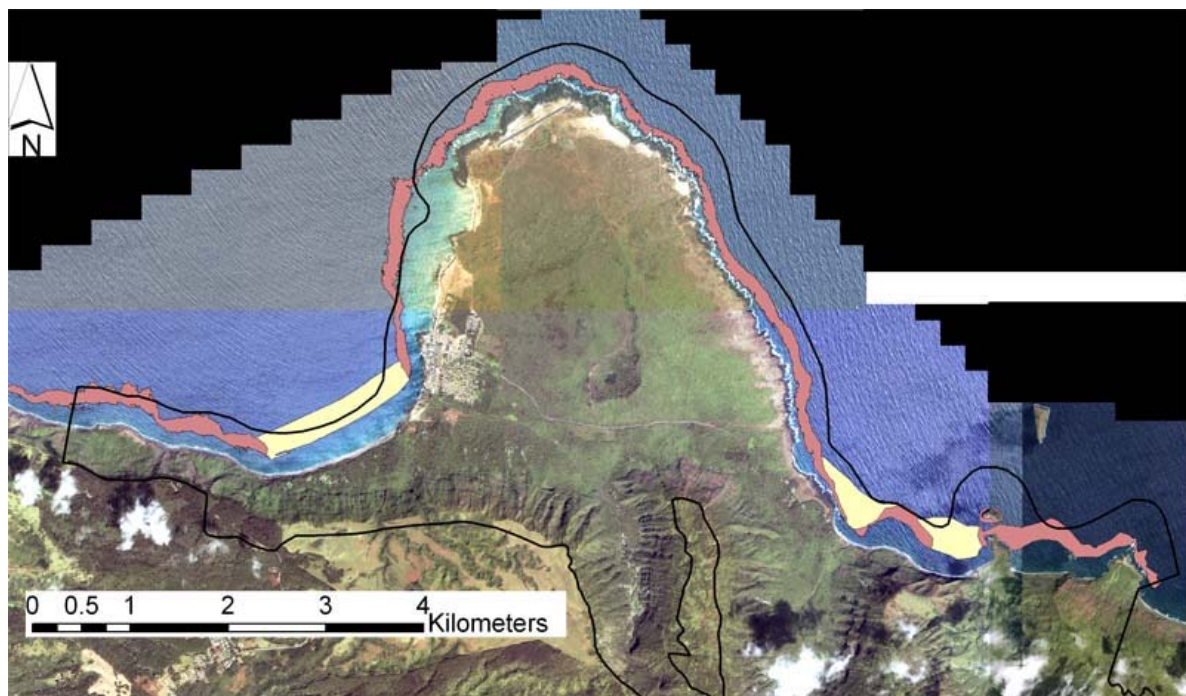


Figure 2. Light red polygons show sampling frame between 10 m and 20 m depth on hard bottom substrate at Kalaupapa National Historical Park. Sand habitat is shown by yellow polygons.

Survey Methods

Surveys occurred during the summer months from July through August. At each site, using SCUBA, the fish observer deployed a transect line along a constant depth contour which was typically parallel to shore. (Locations, bearings, and depths of all 2007 transects are in Table 1.) The observer counted and estimated the length (to the nearest centimeter) of all fish encountered along the distance of this transect. For this report, total length is used instead of standard length.

Data Analyses

Fish species richness for each transect was calculated by summing the number of different species observed per transect area (125 m²).

Fish density at each transect was the total number of fish observed within each transect area of 125 m². This initial value was extrapolated to the number of fish per square kilometer (no./km²) for display purposes and for comparison with other studies. To reduce the number of significant digits, fish densities represented in figures and tables are divided by 1,000, and need to be multiplied by 1,000 to get the actual density [(no./km²) x 1,000].

Length estimates of fishes were converted to biomass using the following length-mass relationship derived for each species: Mass = a*(Standard Length)^b where a and b are species-specific constants for the allometric growth equation, standard length (SL) is in millimeters, and mass is in grams (Kulbicki et al. 1993, Friedlander et al. 2003). Total length was converted to standard length using conversion factors obtained from FishBase (www.fishbase.org). Length-mass fitting parameters were available for 150 species commonly observed on visual fish transects in Hawai'i from the Hawai'i Cooperative Fishery Research Unit (Friedlander et al., 1997). This was supplemented with information from other published and web-based sources. In the cases where length-mass information did not exist for a given species, the parameters from similar bodied congeners are used. Biomass estimates for each transect were converted to metric tons per square kilometer (mt/km²) to facilitate comparisons with other studies worldwide.

The Shannon index (H') was used to calculate species diversity within each transect using the following formula:

$$H' = - \sum_{i=1}^S (p_i \ln p_i)$$

where S is the total number of species and p_i is the frequency of the i th species in that transect.

To determine the trophic composition of the fish assemblage, each species was classified as a primary consumer, secondary consumer, or apex predator. Information on fish trophic group classifications was obtained from Friedlander et al. (1997), Fishbase, and other web-based sources.

Table 1. Metadata for Kalaupapa National Historical Park in 2007.

Year	Transect Type	Transect	UTM Zone	Datum	X (UTM)	Y (UTM)	Survey Date	Bearing (°)	Depth (m)	Chain_length (m)	Tape_length (m)	Rugosity
2007	Fixed	1	4N	NAD83	706010	2344139	8/9/2007	90.00	17.50	38.18	25.54	1.49
2007	Fixed	2	4N	NAD83	706258	2344036	8/9/2007	120.00	12.90	34.96	25.12	1.39
2007	Fixed	3	4N	NAD83	708983	2344924	8/9/2007	0.00	14.20	41.98	25.38	1.65
2007	Fixed	4	4N	NAD83	708894	2345511	8/7/2007	30.00	18.50	36.16	25.25	1.43
2007	Fixed	5	4N	NAD83	709266	2346429	8/7/2007	90.00	11.20	37.28	25.83	1.44
2007	Fixed	6	4N	NAD83	709377	2346496	8/2/2007	30.00	12.70	31.31	24.98	1.25
2007	Fixed	7	4N	NAD83	709481	2346801	8/8/2007	60.00	20.90	57.15	26.40	2.16
2007	Fixed	8	4N	NAD83	710816	2347337	7/19/2007	90.00	15.00	49.42	25.41	1.94
2007	Fixed	9	4N	NAD83	711136	2347201	7/19/2007	120.00	15.90	42.12	25.12	1.68
2007	Fixed	10	4N	NAD83	712308	2345598	7/31/2007	150.00	16.30	37.40	25.12	1.49
2007	Fixed	11	4N	NAD83	712922	2344752	8/1/2007	150.00	15.30	40.32	25.07	1.61
2007	Fixed	12	4N	NAD83	713052	2344465	8/1/2007	180.00	17.30	43.84	25.05	1.75
2007	Fixed	13	4N	NAD83	713059	2343922	8/1/2007	150.00	13.60	35.44	24.90	1.42
2007	Fixed	14	4N	NAD83	715830	2342575	8/7/2007	210.00	14.30	37.24	26.02	1.43
2007	Fixed	15	4N	NAD83	716364	2342586	8/7/2007	270.00	13.70	39.05	25.10	1.56
2007	Temporary	1	4N	NAD83	705818	2344101	8/9/2007	0.00	17.10	34.81	25.00	1.39
2007	Temporary	2	4N	NAD83	706243	2344042	8/8/2007	30.00	14.70	35.82	25.00	1.43
2007	Temporary	3	4N	NAD83	708987	2345527	8/7/2007	40.00	12.90	42.01	25.00	1.68
2007	Temporary	4	4N	NAD83	709475	2346632	8/2/2007	140.00	12.60	46.71	25.00	1.87
2007	Temporary	5	4N	NAD83	709586	2346825	8/2/2007	160.00	20.00	45.28	25.00	1.81
2007	Temporary	6	4N	NAD83	710071	2347179	7/19/2007	180.00	11.20	31.01	25.00	1.24
2007	Temporary	7	4N	NAD83	710073	2347287	8/2/2007	160.00	17.70	48.35	25.00	1.93
2007	Temporary	8	4N	NAD83	711814	2346650	7/31/2007	150.00	15.90	44.02	25.00	1.76
2007	Temporary	9	4N	NAD83	711815	2346609	7/19/2007	160.00	16.20	47.92	25.00	1.92
2007	Temporary	10	4N	NAD83	712042	2346421	7/31/2007	180.00	17.70	47.77	25.00	1.91
2007	Temporary	11	4N	NAD83	712046	2346380	7/31/2007	180.00	15.00	47.83	25.00	1.91
2007	Temporary	12	4N	NAD83	713142	2344298	8/1/2007	160.00	18.80	35.72	25.00	1.43
2007	Temporary	13	4N	NAD83	713514	2342909	8/1/2007	90.00	11.70	40.49	25.00	1.62
2007	Temporary	14	4N	NAD83	715909	2342507	8/7/2007	270.00	12.40	33.68	25.00	1.35
2007	Temporary	15	4N	NAD83	716680	2342155	8/2/2007	90.00	11.40	42.18	25.00	1.69

Results

Metadata

A total of fifteen fixed and fifteen temporary transects were surveyed at Kalaupapa National Historical Park in 2007 (Table 1). The survey time period spanned 22 days from July 19, 2007 to August 9, 2007 with 7 days of actual field time to conduct the surveys.

Status of Fish Assemblage Characteristics

Fish species richness ranged from 11 to 45 species per transect (125 m²; Figure 3). Species richness was lowest along the southeastern coast of the peninsula. Transects with the highest species richness values were concentrated near the northern tip of the peninsula, particularly along the northeastern coast.

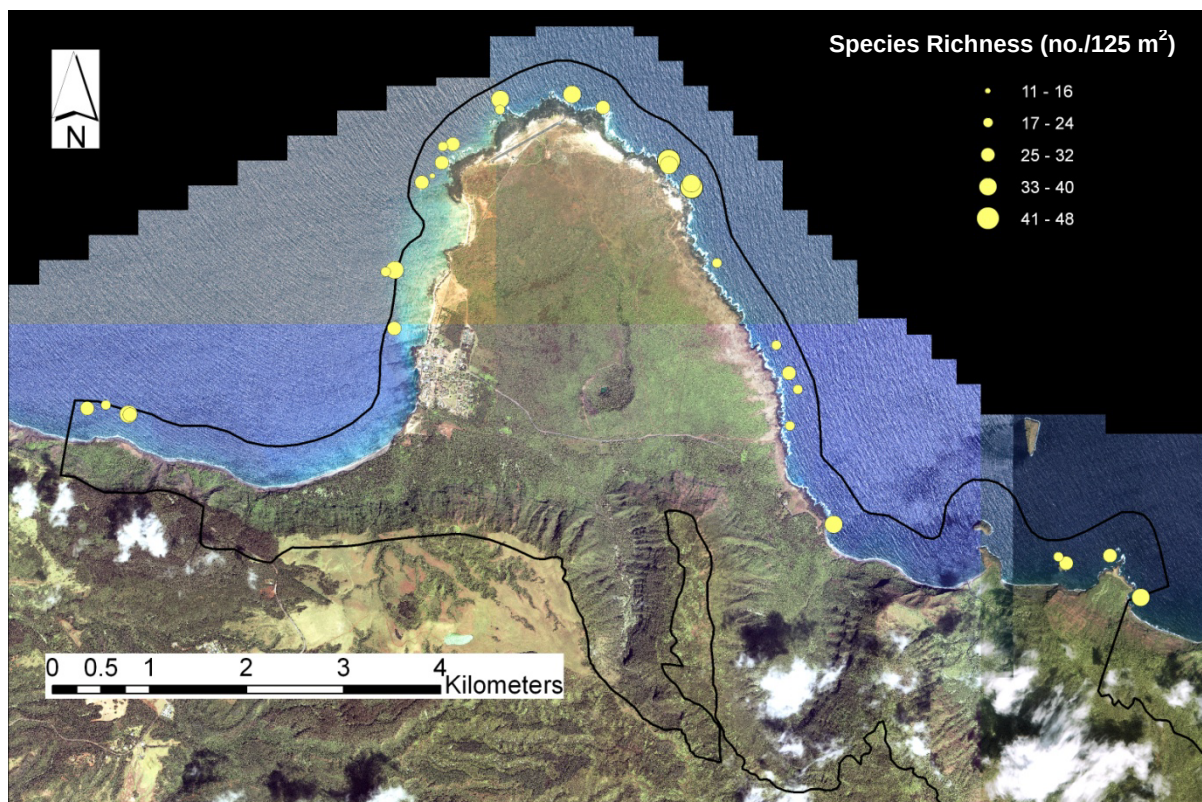


Figure 3. Fish species richness (no./125 m²) at Kalaupapa National Historical Park in 2007.

The density of fish at all transects ranged from 328 to 3,632 fish/km² x 1000 (Figure 4). Densities were lowest at the western boundary of the park and along the southeastern coast of the peninsula. Densities were highest near the northern tip of the peninsula.

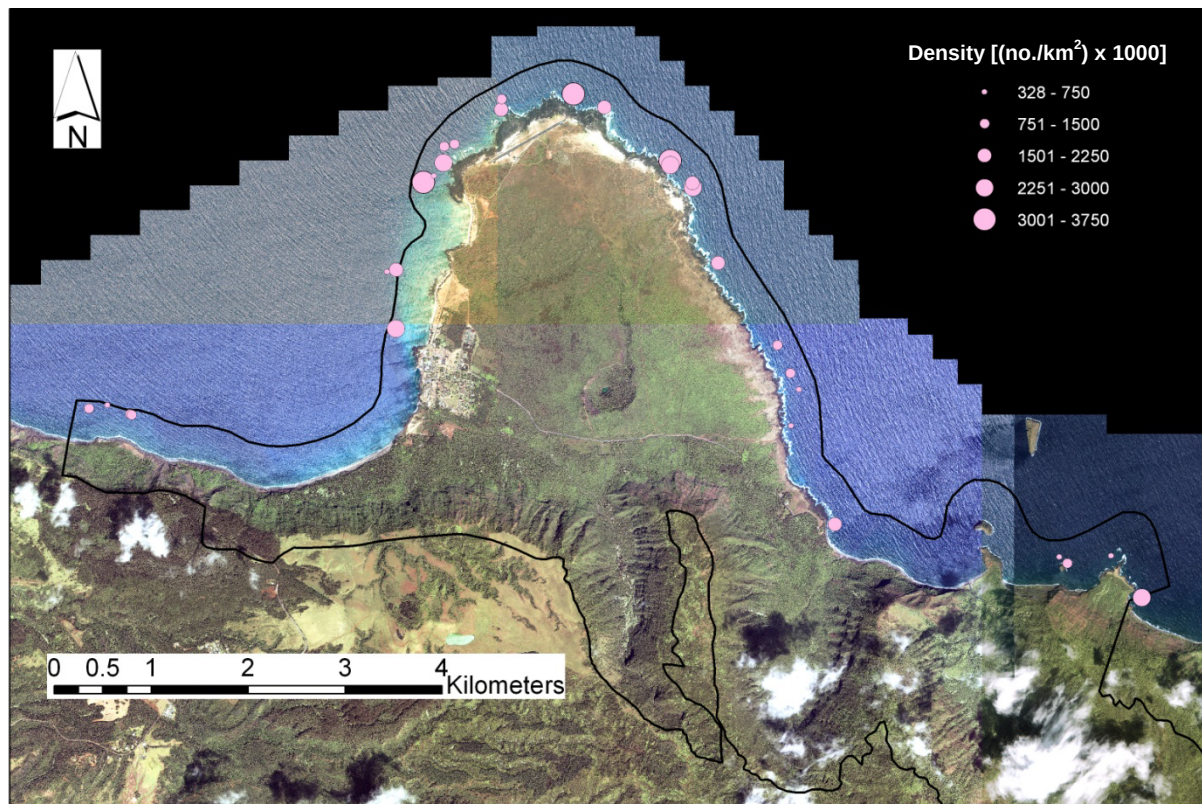


Figure 4. Fish density [(no./km²) x 1000] at Kalaupapa National Historical Park in 2007.

Fish biomass ranged from 36 to 538 metric tons/km² at almost all transects surveyed (Figure 5). The lowest biomass levels were found along the eastern boundary of the park, and the southeastern and northwestern coasts of the peninsula. The lowest biomass (just 4.12 metric tons/km²) was found at Fixed Transect 6, also located along this northwestern coast. Two transects had particularly high biomass values: Fixed Transect 3, located on the southwestern coast of the peninsula, had a biomass of 798.9 metric tons/km², while Temporary Transect 13, located just east of the peninsula, had a biomass of 1,049.8 metric tons/km².

Fish diversity (H') was fairly evenly distributed throughout the park, ranging from 1.11 to 3.04 (Figure 6). The transects with the lowest diversity levels were concentrated around the northwestern tip of the peninsula.

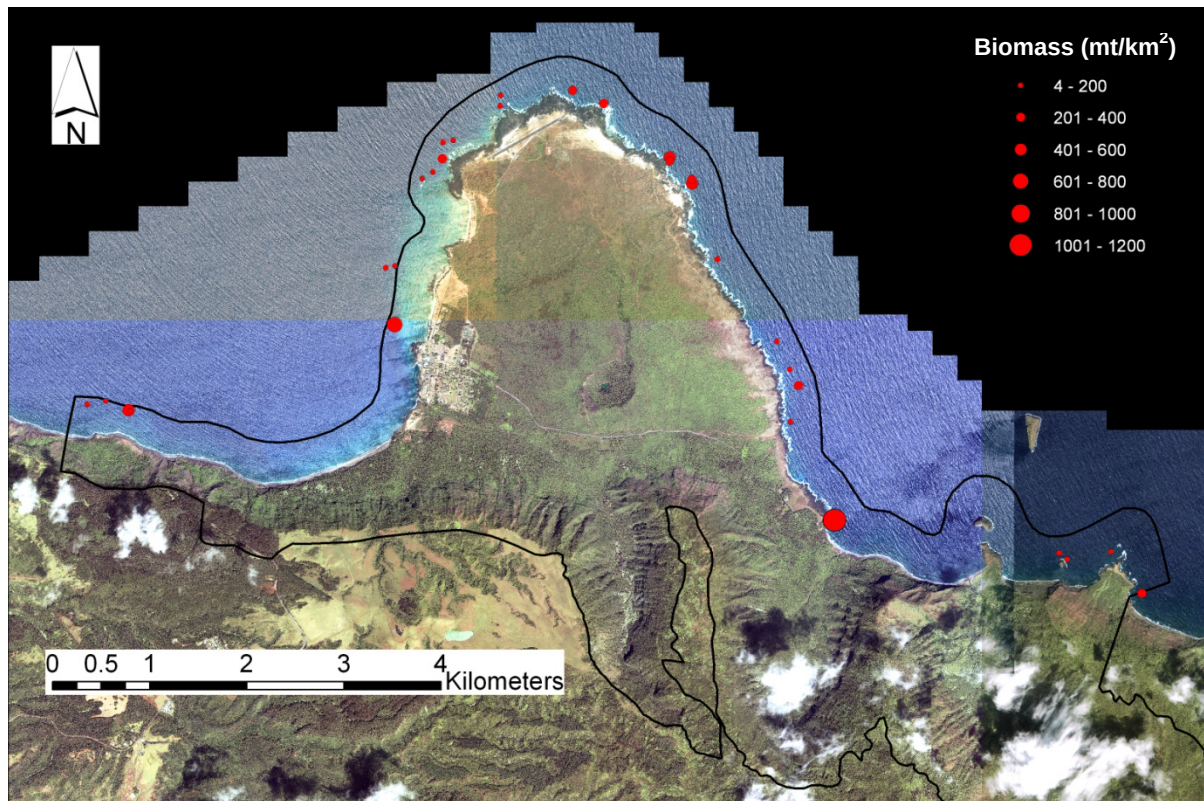


Figure 5. Fish biomass (mt/km²) at Kalaupapa National Historical Park in 2007.

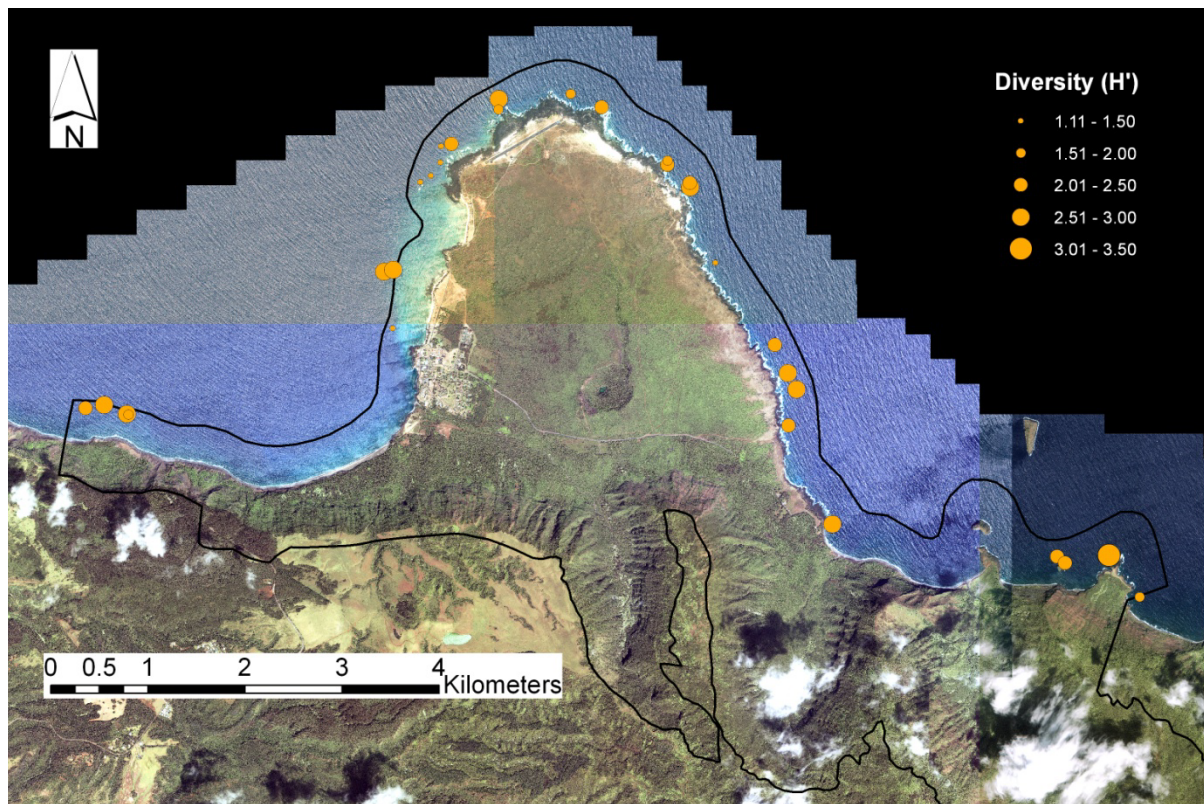


Figure 6. Fish diversity (H') at Kalaupapa National Historical Park in 2007.

Trophic Composition of the Fish Assemblage

Secondary consumers accounted for 74% of the fish density observed during surveys in 2007, while apex predators accounted for just 2%, with primary consumers making up the remaining 24% (Figure 7). In contrast, the relative biomass of secondary consumers was 30%, compared to 18% for apex predators and 52% for primary consumers (Figure 8).

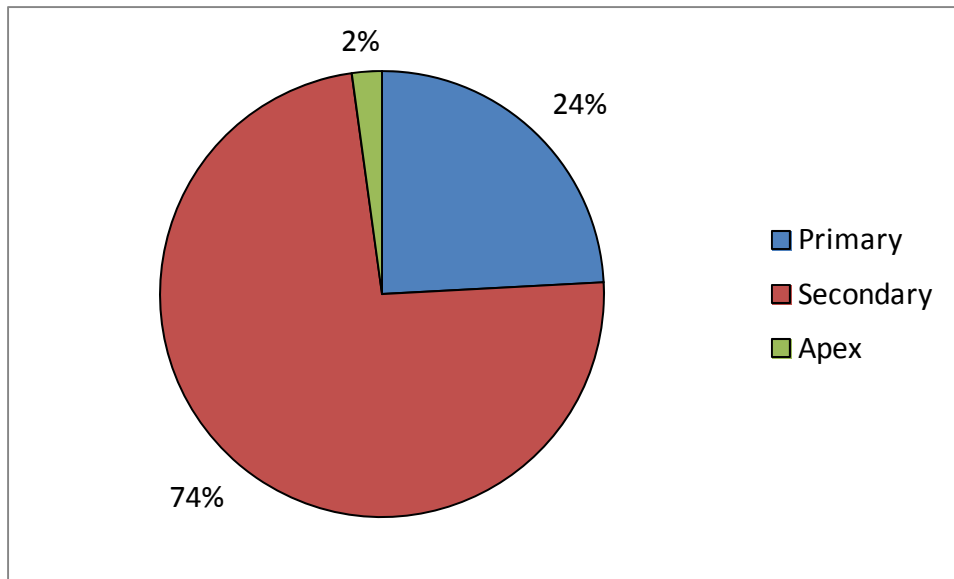


Figure 7. Relative density of fish consumer groups at Kalaupapa National Historical Park in 2007.

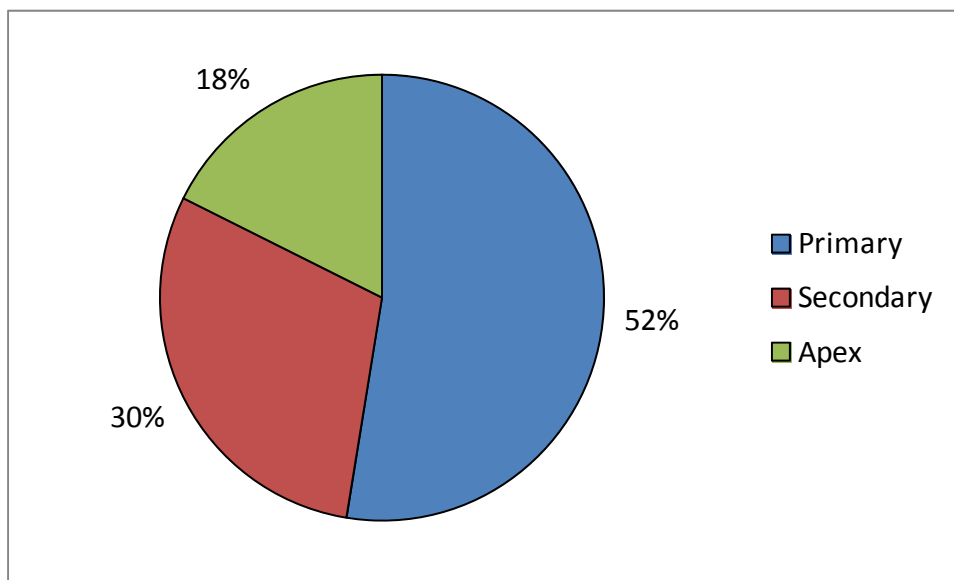


Figure 8. Relative biomass of fish consumer groups at Kalaupapa National Historical Park in 2007.

Top Ten Fish Species

In terms of density, the secondary consumer *Chromis vanderbilti* was by far the most abundant species found at Kalaupapa in 2007 with $20,592 \pm 124 \text{ SE/km}^2 \times 1,000$ documented (Table 2). It was more than four times as abundant as the next most common taxon in the park, the primary

consumer *Kyphosus* spp. The bulk of the biomass, however, was accounted for by *Kyphosus* spp. (Table 3), which had approximately two and a half times the biomass ($1,726 \pm 29$ SE mt/km^2) as the second most highest biomass species, the apex predator *Caranx sexfasciatus* ($695 \text{ mt}/\text{km}^2$; only observed on one transect). Seven of the top ten most abundant species by density were secondary consumers, while three were primary consumers (Table 2). In comparison, the top ten most abundant species by biomass were composed of four primary consumers, three apex predators, and three secondary consumers (Table 3).

Table 2. Top ten fish species by density [(no./ km^2) x 1000] at Kalaupapa National Historical Park in 2007. Common names are from Randall (1996).

Species	Common Name	Hawaiian Name	Consumer Group	Density [(no./ km^2) x 1000]
<i>Chromis vanderbilti</i>	Blackfin Chromis	unknown	Secondary	20592
<i>Kyphosus</i> spp.	Rudderfish	nenu	Primary	4696
<i>Thalassoma duperrey</i>	Saddle Wrasse	hinālea lauwi	Secondary	1536
<i>Paracirrhites arcatus</i>	Arc-eye Hawkfish	piliko'a	Secondary	1504
<i>Acanthurus leucopareius</i>	Whitebar Surgeonfish	māikoiko	Primary	1504
<i>Chromis ovalis</i>	Oval Chromis	unknown	Secondary	1456
<i>Acanthurus nigrofasciatus</i>	Brown Surgeonfish	mā'i'i	Primary	1424
<i>Ctenochaetus strigosus</i>	Goldring Surgeonfish	kole	Secondary	1256
<i>Mulloidichthys vanicolensis</i>	Yellowfin Goatfish	weke 'ula	Secondary	1048
<i>Abudefduf abdominalis</i>	Hawaiian Sergeant	mamo	Secondary	728

Table 3. Top ten fish species by biomass (mt/km^2) at Kalaupapa National Historical Park in 2007. Common names are from Randall (1996).

Species	Common Name	Hawaiian Name	Consumer Group	Biomass (mt/km^2)
<i>Kyphosus</i> spp.	Rudderfish	nenu	Primary	1726.47
<i>Caranx sexfasciatus</i>	Bigeye Trevally	pake ulua	Apex	695.21
<i>Chlorurus perspicillatus</i>	Spectacled Parrotfish	uhu uliuli, uhu 'ahu'ula	Primary	318.98
<i>Naso lituratus</i>	Orangespine Unicornfish	umaumalei	Primary	315.28
<i>Bodianus bilunulatus</i>	Hawaiian Hogfish	'a'awa	Secondary	297.82
<i>Acanthurus leucopareius</i>	Whitebar Surgeonfish	māikoiko	Primary	282.73
<i>Caranx melampygus</i>	Bluefin Trevally	'ōmilu	Apex	255.53
<i>Monotaxis grandoculis</i>	Bigeye Emperor	mu	Secondary	238.10
<i>Cephalopholis argus</i>	Peacock Grouper	roi	Apex	212.66
<i>Ctenochaetus strigosus</i>	Goldring Surgeonfish	kole	Secondary	209.26

Trends of Fish Assemblage Characteristics

At the 15 fixed transects surveyed annually, mean fish species richness (24.6 ± 0.3 SE species/125 m²; Figure 9) remained relatively stable from 2006 to 2007. Mean fish density (Figure 10), on the other hand, declined slightly from $1,904.5 \pm 445.5$ SE fish/km² x 1,000 in 2006 to 1405.9 ± 264.0 SE fish/km² x 1,000 in 2007. Like species richness, mean fish biomass (162.1 ± 8.3 SE mt/km²; Figure 11) and mean fish diversity (H' ; 2.02 ± 0.006 SE; Figure 12) also remained relatively stable from 2006 to 2007.

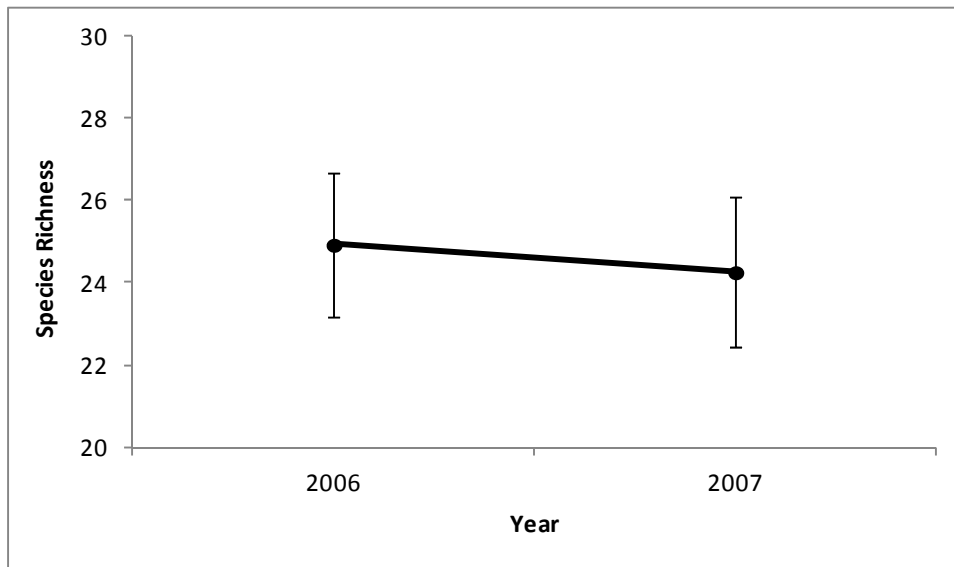


Figure 9. Fish species richness (no./125 m²) at Kalaupapa National Historical Park from 2006-2007. Error bars are one standard error of the mean.

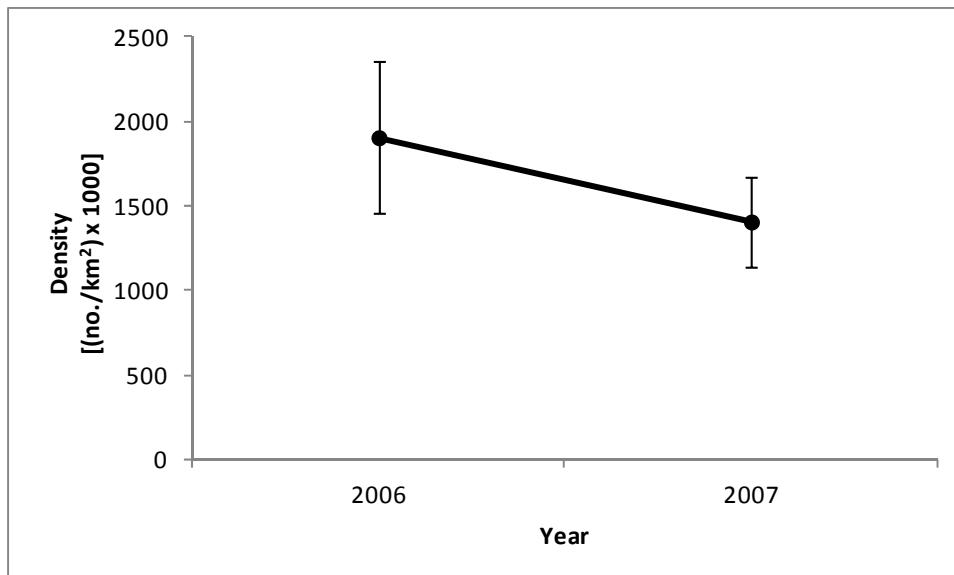


Figure 10. Fish density [(no./km²) x 1000] at Kalaupapa National Historical Park from 2006-2007. Error bars are one standard error of the mean.

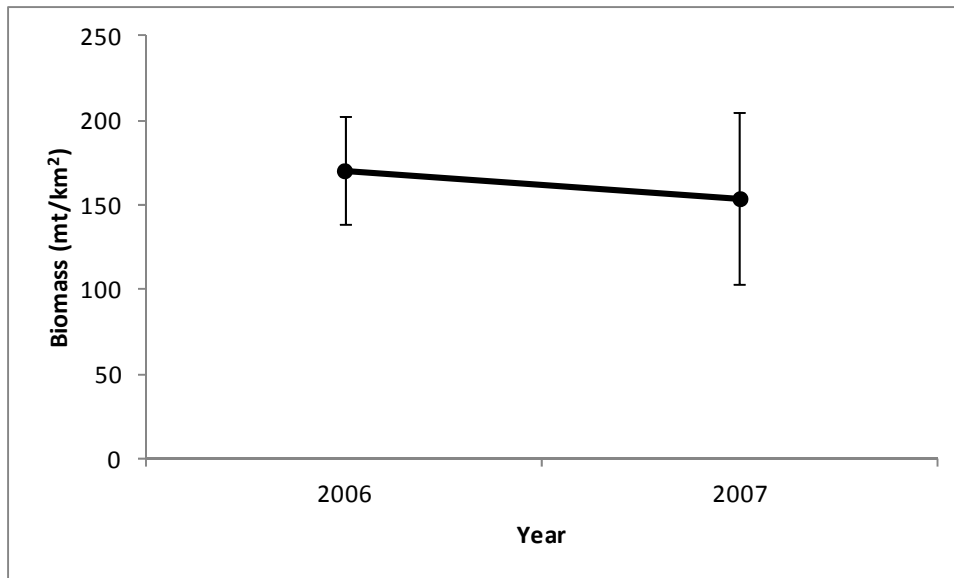


Figure 11. Fish biomass (mt/km²) at Kalaupapa National Historical Park from 2006-2007. Error bars are one standard error of the mean.

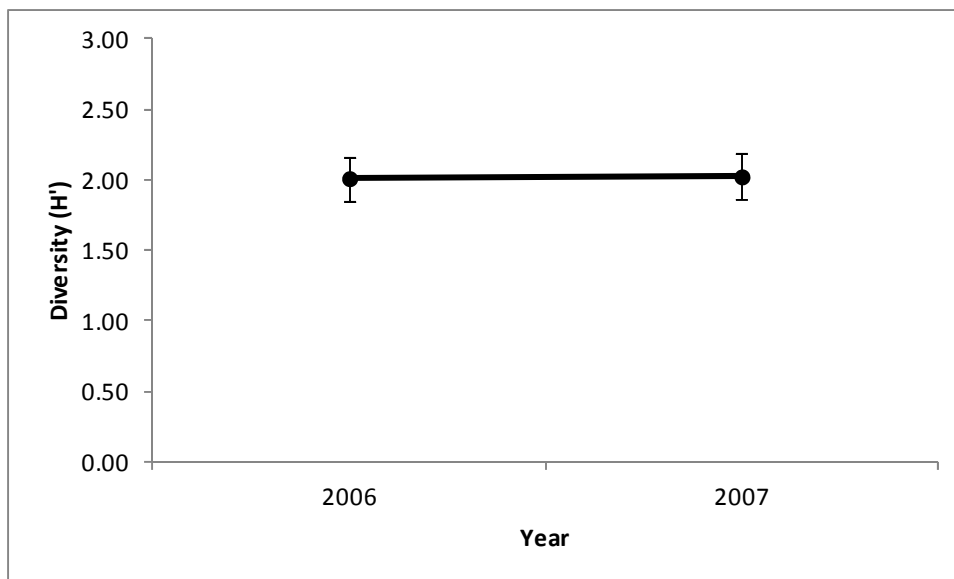


Figure 12. Fish diversity (H') at Kalaupapa National Historical Park from 2006-2007. Error bars are one standard error of the mean.

Discussion

Survey results from 2007 indicated that the southeastern coast of the Kalaupapa peninsula had the lowest fish species richness and fish density values in the park (Figures 3 and 4). Low fish densities were also found at the western boundary of the park. Species richness and density were highest near the northern tip of the peninsula. Fish diversity was fairly even throughout the park, but transects with the lowest diversity levels were concentrated near the northwestern tip of the peninsula (Figure 6).

Low levels of fish biomass were also found along the southeastern coast of the peninsula, as well as along the northwestern coast of the peninsula and at the eastern boundary of the park (Figure 5). Temporary Transect 13, located just east of the peninsula, had an unusually high biomass (1049.75 metric tons/km²) due largely to the presence of a large school of the apex predator *Caranx sexfasciatus*. This species is nocturnal, but can form dense schools by day (Randall 1996). It was not observed on any other transect in 2007.

Three fish taxa, *Chromis vanderbilti*, *Kyphosus* spp. and *C. sexfasciatus*, largely influenced the relative density of the various consumer groups as compared to biomass. *C. vanderbilti*, a secondary consumer, was more than four times as abundant as any other fish species surveyed at Kalaupapa (Table 2). Thus, secondary consumers account for 74% of the individual fish observed in 2007 (Figure 7). However, due to the small size of this species (up to about 7 cm, Hoover 2008), the relative biomass of secondary consumers is comparatively small, only 30% (Figure 8). Rather, the majority of the biomass (52%) is accounted for by primary consumers, including the second most abundant taxon in the park (Table 2), *Kyphosus* spp., which attains sizes up to 60 cm (Randall 1996). Finally, despite accounting for only 2% of the relative density of the three consumer groups (Figure 7), apex predators accounted for 18% of the relative biomass in 2007 (Figure 8). This was largely due to a school of *C. fasciatus* (the number two species in terms of biomass; Table 3) observed on one transect. This relatively large species can attain lengths up to 85 cm. (Randall 1996). Apex predators such as *C. fasciatus* are of particular importance to the PACN parks. Worldwide, large apex predators have been on the decline with many, including sharks, disappearing at alarming rates (Worm et al. 2006). These (typically) large predators are important to the reef because their absence can cause dramatic shifts in the species composition and dominant taxa of a reef.

While fish species richness (Figure 9), fish biomass (Figure 11), and fish diversity (Figure 12) remained relatively stable from 2006-2007, fish density has declined since monitoring was initiated (Figure 10). Further data collection and rigorous statistical analyses in subsequent reports will help us learn if this decline is significant and a cause for concern.

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Appendix A: Database Queries Used to Generate Reports

STATUS MAPS (for all transects):

	Data	Excel File	Columns in Excel File	Database Query
1.	Species richness	Fish Summary Status Maps	Sp Richness	qs_f021_Fish_Summary_by_Transect
2.	Density/abundance	Fish Summary Status Maps	Density (Num/km2)x1000	qs_f021_Fish_Summary_by_Transect
3.	Biomass	Fish Summary Status Maps	Biomass (mt/km2) <i>Note: mt=metric tons</i>	qs_f021_Fish_Summary_by_Transect
4.	Diversity	Fish Summary Status Maps	Div	qs_f021_Fish_Summary_by_Transect

TREND LINE GRAPHS (fixed transects only (combined); units the same as in status maps):

	Data	Excel File	Columns in Excel File	Database Query
1.	Species richness	Fish_SpRichness_Trends	All years	qs_fr041_Fish_Species_Richness_Trend
2.	Density/abundance	Fish_Density_Trends	All years	qs_fa041_Fish_Density_Trend
3.	Biomass	Fish_Biomass_Trends	All years	qs_fb041_Fish_Biomass_Trend
4.	Diversity	Fish_Diversity_Trends	All years	qs_fd041_Fish_Diversity_Trend

PIE CHARTS (for all transects combined):

	Data	Excel File	Columns in Excel File	Database Query
1.	Trophic composition by density	Fish_Trophic_Chart	Primary, Secondary, Apex	qs_ft001_Fish_Trophic_Abundance
2.	Trophic composition by biomass	Fish_Trophic_Chart	Primary, Secondary, Apex	qs_ft002_Fish_Trophic_Biomass

TABLES (for all transects combined):

	Data	Excel File	Columns in Excel File	Database Query
1.	Metadata	Metadata	All columns	qs_md001_Metadata_by_Transect
2.	Top ten species by density	Fish_Top_Ten_Density	TaxonName, SumOfNum_km2 x 1000, Consumer	qs_fa061_Fish_Top_Ten_Density
3.	Top Ten species by biomass	Fish_Top_Ten_Biomass	TaxonName, SumOfBio_mt/km2, Consumer	qs_fb061_Fish_Top_Ten_Biomass