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Assessment of Abalone Resources at the Channel Islands

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Abstract. Commercial and recreational landings data for 1983 to 1992 from the Channel Islands were examined to determine the resource condition of 5 abalones: black (*Haliotis cracherodii*), red (*H. rufescens*), green (*H. fulgens*), pink (*H. corrugata*), and white (*H. sorenseni*). Additionally, the results of fishery-independent intertidal and subtidal surveys were compared with landing data. These 3 databases yielded similar information about abalone resources at the Channel Islands, but fishery-independent data provided a more complete understanding of resource conditions. The black abalone has disappeared from most of the islands, a result of withering syndrome mortality. The red abalone has increased recently in commercial fishery and field transect data, but landings are still far below past levels. Green, and pink abalones are declining in the commercial and recreational fisheries, while available data suggest that the white abalone is now rare.

Keywords: California; Channel Islands; red abalone; black abalone; green abalone; pink abalone; white abalone; Assessment; Marine Fisheries Statistics.

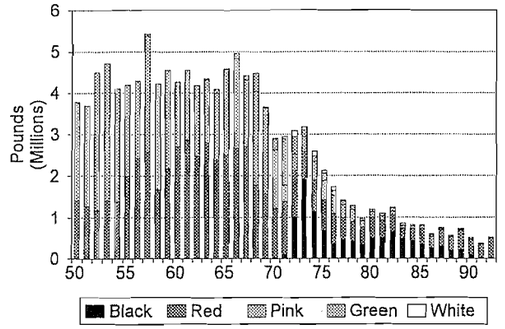

Figure 1. California commercial abalone landings from 1950 to 1992. (Data from CDFG Marine Fisheries Statistical Unit).

Introduction

Abalones are the subject of a valuable commercial and recreational fishery in California. Historically, 5 species comprised the California commercial and recreational abalone fishery: black abalone (*Haliotis cracherodii*), red abalone (*H. rufescens*), green abalone (*H. fulgens*), pink abalone (*H. corrugata*), and white abalone (*H. sorenseni*). Each is found in overlapping but generally distinctive habitats related to prevalent seawater temperatures and depth. While the ranges and local distribution of these large marine gastropods vary along the California coast, all occur around the California Channel Islands.

Two of these abalones occur throughout coastal California. The black abalone lives in rocky intertidal areas of the mainland and throughout the Channel Islands. The red abalone occur intertidally to 33 m along the mainland and along coasts of San Miguel, San Nicolas, and northern Santa Rosa islands, which are under the influence of cooler northern waters. Three species occur only south of Point Conception. The green abalone is a shallow subtidal species; the pink abalone occurs from about 7- to 40-m depths; and the white abalone is found from 20 to 60 m on rocky reefs. These species occur most commonly at Santa Catalina, San Clemente, Santa Barbara, Anacapa, Santa Cruz, and southern Santa Rosa islands, areas influenced by warm temperate waters.

The commercial fishery landed 4 million pounds annually from about 1952 to 1968 (Fig. 1). Since then, landings have dropped; about half a million pounds were landed in 1992. The once large fishery was displaced into southern California waters as sea otters recovered parts of their former range in central California (Hardy et al. 1982). As mainland stocks suffered from increasing impacts of a growing human population, such as habitat degradation and heavy harvesting, divers ranged farther to find abalone. Once protected by their remoteness, the Channel Islands abalone stocks became readily accessible (Table 1) with the development of fast fishing boats and improved diving equipment.

The availability of scuba diving equipment stimulated the recreational diving industry and provided the public access to deep water marine resources, including abalones. Large commercial passenger recreational dive

Table 1. Commercial abalone landings from northern and southern California and the Channel Islands from 1983 to 1992, with percentages of the total landings (% total) for southern, northern California, and Channel Islands, and the percentage of southern California landings (% S.C.).

Year	Total	Southern California	% of Total	Channel Islands	% of So. Cal.	% of total	Northern California	% of total
1983	634,138	336,301	53	276,111	82	44	21,726	3
1984	557,603	291,997	52	224,128	77	40	41,478	7
1985	454,885	269,601	59	138,055	51	30	47,230	10
1986	340,412	210,223	62	96,497	46	28	33,692	10
1987	386,922	251,168	65	101,686	40	26	34,068	9
1988	239,988	195,381	81	35,352	18	15	9,255	4
1989	313,212	244,143	78	55,693	23	18	13,376	4
1990	199,214	160,269	80	28,554	18	14	10,391	5
1991	163,002	109,893	67	50,896	46	31	2,213	1
1992	235,752	146,356	62	83,171	57	35	6,225	3

boats, and private vessels provided transport to the most remote locations (Parker et al. 1992; Tegner et al. 1992).

The combined effect of the commercial and recreational fishery on the resource is reflected by current landings, which are at all time low levels (Fig. 1). Current management has not been effective in protecting the abalone fishery from a continuous trend of declining landings. If there is to be abalone utilization in the future, there must be a change in the way the resource is managed, and to do that more biological information about abalones and their populations will be required.

Information used in the management of the California abalone fishery relies on fishery landing statistics, mostly obtained from the commercial landing database. There is a recreational fishery for abalones, and the number of recreational divers is thought to be large, but methodology necessary to assess that segment of the fishery is limited.

Current management is impaired by the lack of application of modern assessment techniques to the abalone fishery. This situation resulted from the ability to maintain fishery landings by expansion into new areas, such as the Channel Islands, and utilizing different species. The historic (pre-1965) steady landings fostered an allusion that the fishery was sustainable and did not need to be managed differently. Logistical constraints limited the ability to collect necessary biological information about 5 species along the California mainland and island coast, and hindered the development of suitable management plans using modern technology (Breen 1992).

Assessments relying on the commercial landing database provide little of the basic information necessary to evaluate the fishery scientifically, such as the condition of the sub-harvestable resource, settlement, growth, and survival. Direct assessment is logistically tedious and expensive, but may be a more reliable way to evaluate the entire resource including the sub-harvestable part. Here I examine data from traditional methods of abalone fishery assessment at the Channel Islands using commercial and recreational landing data from the period 1983–1992, and the results of long term field monitoring of abalones at the Channel Islands during the last 10 yr.

Methods

Commercial landing data

Landing receipts must be submitted to the California Department of Fish and Game (CDFG) when commercially caught marine organisms are landed. These receipts contain data about the location, amount, price, and catch (from CDFG statistical catch block). For abalones, the number landed is reported and later converted to pounds. Historical data (Fig. 1) is presented as pounds landed, as the original landing data in numbers is not available. The data are used to assess fishery taxes and to generate fishery statistics. The Department of Fish and Game publishes these statistics as Fishery Bulletins (e.g., Oliphant et al. [1976] or, since 1991, as annual Final Bulletin Tables for California commercial landings). Fish Bulletin 86 (California Department of Fish and Game 1952) contains a description of the methods used to collect this commercial fishery data.

Unfortunately, information on landing receipts is sometimes incomplete or ambiguous. Incomplete or incorrect fishing data may enter the database, resulting in under- or overestimation and improper allocation of landings. The block system itself has ambiguous blocks for several islands, i.e., Santa Cruz and Santa Rosa islands and Santa Rosa and San Miguel islands share common blocks. Here, half of the catch from those common blocks was allocated to each island. Some islands are covered by 2 or more blocks, and data for those blocks were combined into an island total. I extracted data for black, red, green, pink, and white abalones by island for the years 1983–1992. Numbers of abalone were sorted by island using CDFG statistical catch block location data. I used numbers of abalones landed, rather than weight, to compare commercial with recreational data, which is reported only in numbers.

Commercial passenger fishing vessel dive (CPFV-Dive) data

I examined the recreational fishery using numbers and species of abalones by island reported from CPFV-Dive log book data. These logs must be submitted to the department by operators of CPFV-Dive boats (California Department of Fish and Game 1952). Abalones taken by private boat owners and shore-based divers and pickers are not sampled or reported; thus total recreational abalone landings are unknown. Often abalones are not reported by species. We included these unidentified (UI) data as part of the total abalones landed. Data for 1984 and 1985 are not available.

Fishery independent monitoring

Since 1983, the National Park Service (NPS) has conducted a kelp forest monitoring program at Channel Islands National Park (Anacapa, Santa Rosa, Santa Cruz, San Miguel, and Santa Barbara islands) (Davis 1988 and 1989). Annually, red, green, and pink abalones are counted and measured within 12 randomly selected 3- x 20-m band transects (total area = 600 m^2 in 1983 and 1984, and 720 m^2 thereafter) along permanent 100-m transect lines at 16 subtidal locations at 5 islands; 3 at Anacapa, 5 at Santa Cruz, 3 at Santa Rosa, 2 at San Miguel, and 3 at Santa Barbara. Only emergent abalones (those visible without disrupting the substrate) and abalones in cracks and crevices are counted (Davis 1988). Subtidal surveys sites generally include only red and pink abalone habitats. Green abalones are occasionally recorded during the surveys, but the optimum habitat for the green abalone is shallower than the survey sites (G. E. Davis 1993, pers. comm.)

To obtain size frequency data, divers locate, identify, and measure the maximum shell length of abalones in the vicinity of the transect baseline until 30 individuals are found or as time permits. The area over which the data are collected is not determined, thus the numbers found cannot be used for comparison with other kinds of surveys.

Subtidal length frequency data are grouped as follows: abalone less than 100 mm (size at which many abalones become less cryptic); those between 100 mm and recreational minimum harvest sizes; those between recreational minimum and commercial minimum harvest sizes; and those greater than commercial harvest size. Minimum harvest sizes are 178 and 197 mm for reds, 152 and 178 mm for greens, and 152 and 159 mm for pinks, respectively.

Since 1985, NPS has conducted semiannual intertidal surveys to assess black abalone numbers and sizes (Richards and Davis 1993) at sites on Anacapa, Santa Rosa, San Miguel and Santa Barbara islands. Numbers of black abalones are reported by size groups: < 44 mm (the size at maturity), 44–145 mm, and > 145 mm (minimum recreational harvest size). The area of each survey is fixed but varies among sites.

I used counts and sizes collected at each location from subtidal and intertidal surveys to evaluate the condition of the abalone resources. Numbers and length frequencies in subtidal surveys were individually combined by island. Intertidal survey data were not combined because of inconsistent sampling periods. The 1983 and 1984 subtidal survey data were standardized to an area of 720 m^2. These data are presented by island and species (Fig. 2, 3, and 4).

Results

Black abalone

The 1992 commercial black abalone landings are about 2% of the highest landings in 1973, and comprised about 7% of the total 1992 abalone landings (Fig. 1). The 1983 and 1992 number and percent composition of the total landings reported from the Channel Islands were 196,012 (71%) and 8,132 (10%), a 96% decline (Table 2).

The commercial landing data (Fig. 5) present the declining trend in the number of black abalones at the Channel Islands. While the black abalone appeared in recreational landings (Fig. 6), it was not an important part of that fishery, comprising 0–1.7% of the landings (Table 3).

The NPS counted and measured black abalone semiannually at 5 islands (Fig. 4). In 10 of 11 intertidal surveys, black abalone numbers declined. The declines occurred in each of 3 size categories.

Red abalone

The 1992 red abalone commercial landings comprised about 18% of the peak landings in 1962, and about 87% of the 1992 total landings (Fig. 1). The reported number and percentage of the total from the Channel Islands for 1983 and 1992 were 34,927 (13%) and 68,101

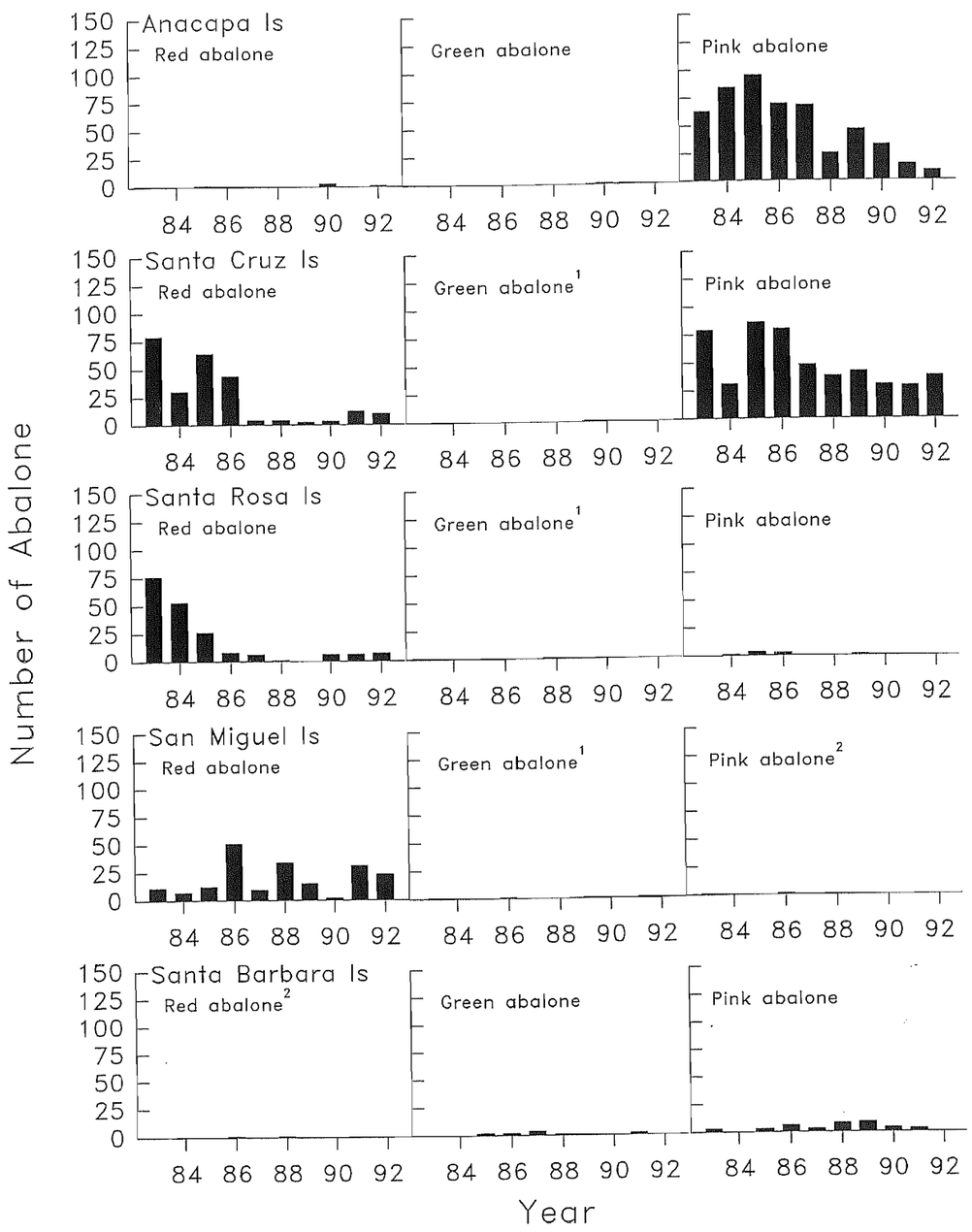

Figure 2. Red, green, and pink abalones on National Park Service subtidal band transects by island, 1984–1992; 1 = indicates transects are not placed to detect the species, 2 = a species not generally found at an island. (Channel Islands National Park Data).

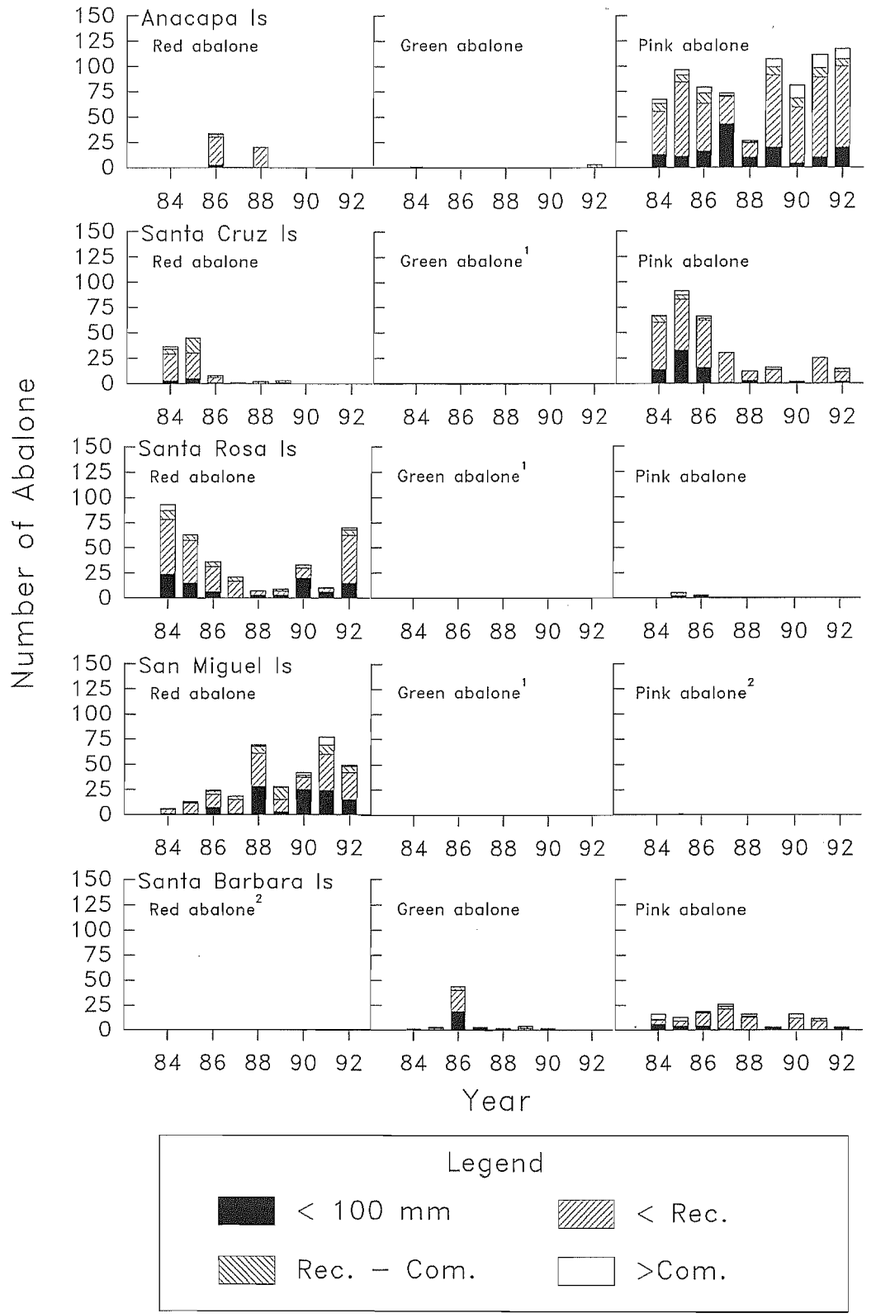

Figure 3. Red, green, and pink abalones measured along National Park Service subtidal transects at five Channel Islands, combined by island, from 1984 to 1992; 1 = indicates transects are not placed to detect the species, 2 = a species not generally found at an island. Rec. = recreational size for a species, Com. = commercial size for a species. (Channel Islands National Park data).

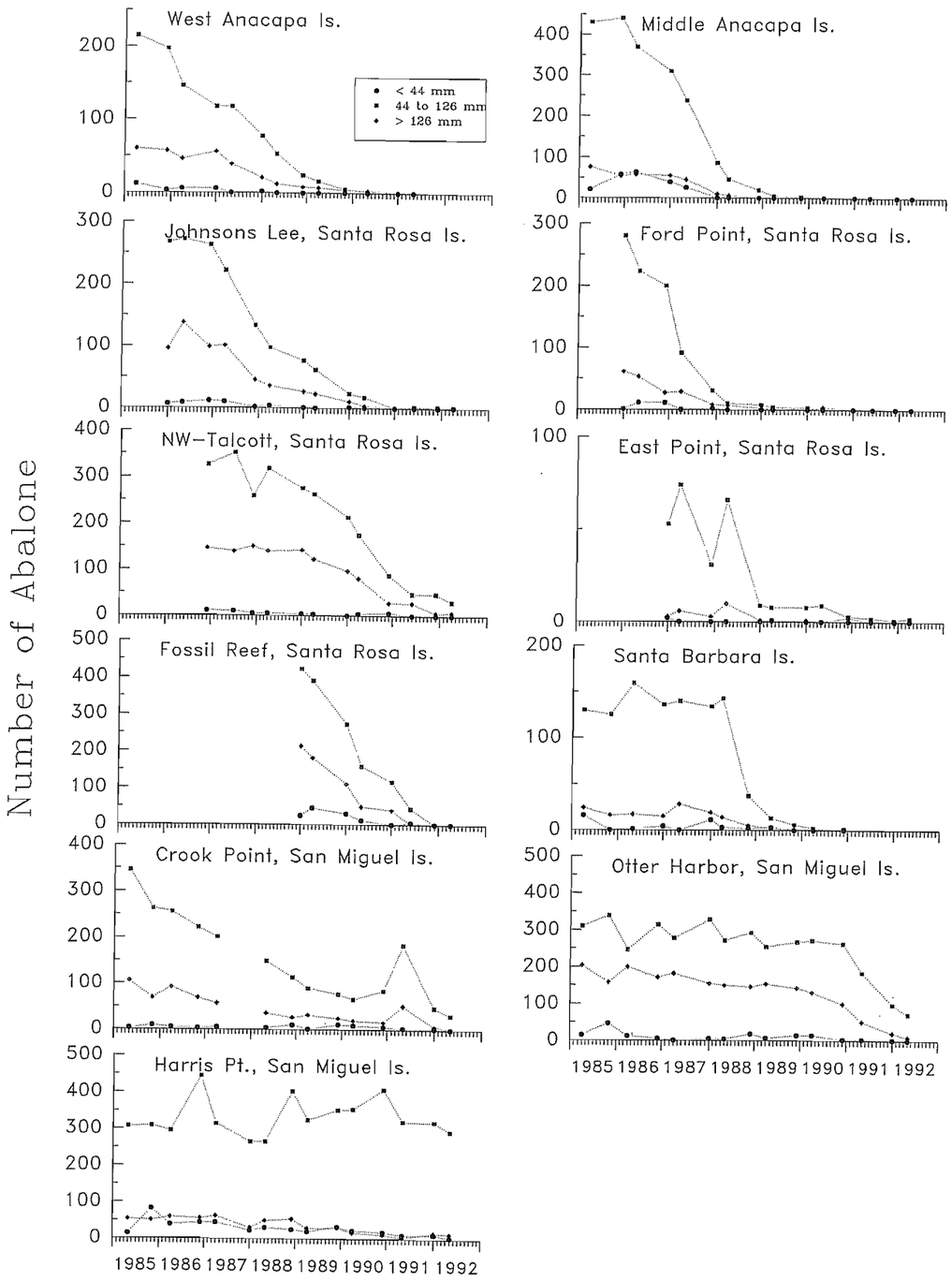

Figure 4. Black abalone abundance in intertidal plots by island, 1985–1992 at 11 sites at the Channel Islands. (Channel Islands National Park unpublished data).

Table 2. The reported number of commercial abalone landed, by species, and percentage of the total Channel Island landings.

Year	Total	Black	% of total	Red	% of total	Green	% of total	Pink	% of total	White	% of total
1983	276,111	196,012	71	34,972	13	22,075	8	22,915	8	115	0.042
1984	224,128	156,730	70	38,949	17	9,831	4	18,441	8	178	0.079
1985	138,055	98,699	71	18,012	13	7,759	6	12,972	9	613	0.444
1986	96,497	67,871	70	8,513	9	8,850	9	9,737	10	182	0.189
1987	101,686	63,434	62	20,796	20	9,463	9	7,711	8	1	0.001
1988	35,352	21,058	60	3,446	10	6,229	18	4,619	13	0	0.000
1989	55,693	31,512	57	13,125	24	6,005	11	5,051	9	0	0.000
1990	28,554	10,739	38	6,745	24	7,126	25	3,934	14	10	0.035
1991	50,896	7,109	14	37,771	74	3,024	6	2,992	6	0	0.000
1992	83,171	8,132	10	68,101	82	3,616	4	3,322	4	0	0.000

(82%), an increase of 33,174 (95%) (Table 2). The 1991 and 1992 commercial landings increased from preceding years (Fig. 5). Most red abalone were taken from Santa Rosa and San Miguel islands.

The reported red abalone recreational landings (Table 3) comprised about 3–13% of the total reported from the Channel Islands.

The NPS surveys (Fig. 3) from 1983 to 1989 revealed declining numbers of red abalones at Santa Rosa and Santa Cruz islands, while numbers increased at San Miguel. There were increased numbers at all 3 locations in 1991 and 1992.

The NPS size frequency surveys (Fig. 4) found populations containing a broad range of sizes, and persistent occurrence of the smallest sizes at Santa Rosa and San Miguel islands.

Green abalone

The 1992 commercial landings are about 1% of the highest landings in 1971, and comprised about 2% of the total 1992 abalone landings (Fig. 1). In 1983 and 1992, numbers and percentages of the total from the Channel Islands were 7,037 (33.3%) and 359 (4.3%), a 95% decline.

Green abalones were important in the CPFV-Dive landings, which varied from 3.5 to 33.3% of the total landings, exceeding other species every year (Table 3).

Green abalones did not appear often in the NPS transects (Figs. 2 and 3).

Pink abalone

The 1992 commercial landings were about 0.5% of the peak pink landings in 1952, and comprised about 3.5% of the 1992 total landings (Fig. 1). In 1983 and 1992, reported landings and percentage of the total number landed from the Channel Islands were 22,915 (8%) and 3,322 (4%), an 86% decline. The pink abalone was an important part of the commercial fishery in the early 1950s (Fig. 1), when it comprised 74% of the commercial landings. By 1988 landings dwindled, but small quantities are still landed.

The CPFV-Dive boat landings comprised 18.5% of the Channel Islands landings in 1983, but decreased to 2.9% in 1993 (Table 3). It appeared as the second most taken abalone in the recreational landings, after green abalone.

The NPS transect surveys found declining pink abalone populations on transects at Anacapa and Santa Barbara islands, while the numbers have leveled at Santa Cruz Island (Fig. 2).

Size frequency surveys (Fig. 3), revealed populations of pink abalone at Anacapa Island with a broad range of sizes that persisted from 1984 to 1992. Pink abalone populations at Santa Cruz and Santa Barbara islands contained mostly sub-harvestable sizes, and there were few in the < 44 mm size.

White abalone

Historical white abalone commercial landings were as high as 143,819 pounds (≈ 86,000 individuals) in 1972. Reported landings for 1983, 1984, 1985, and 1986 were 482, 449, 1,654, and 876 pounds, respectively. After 1986, reported landings never exceeded 25 pounds, and none were reported in 1992 (Fig. 1).

White abalones comprised 1% or less of the total reported recreational landings from 1983 to 1992 (Table 3). In 1982, 236 were reported, but since then 10 or fewer individuals were reported annually.

White abalone is not detected in NPS surveys because its depth range is deeper than the transects.

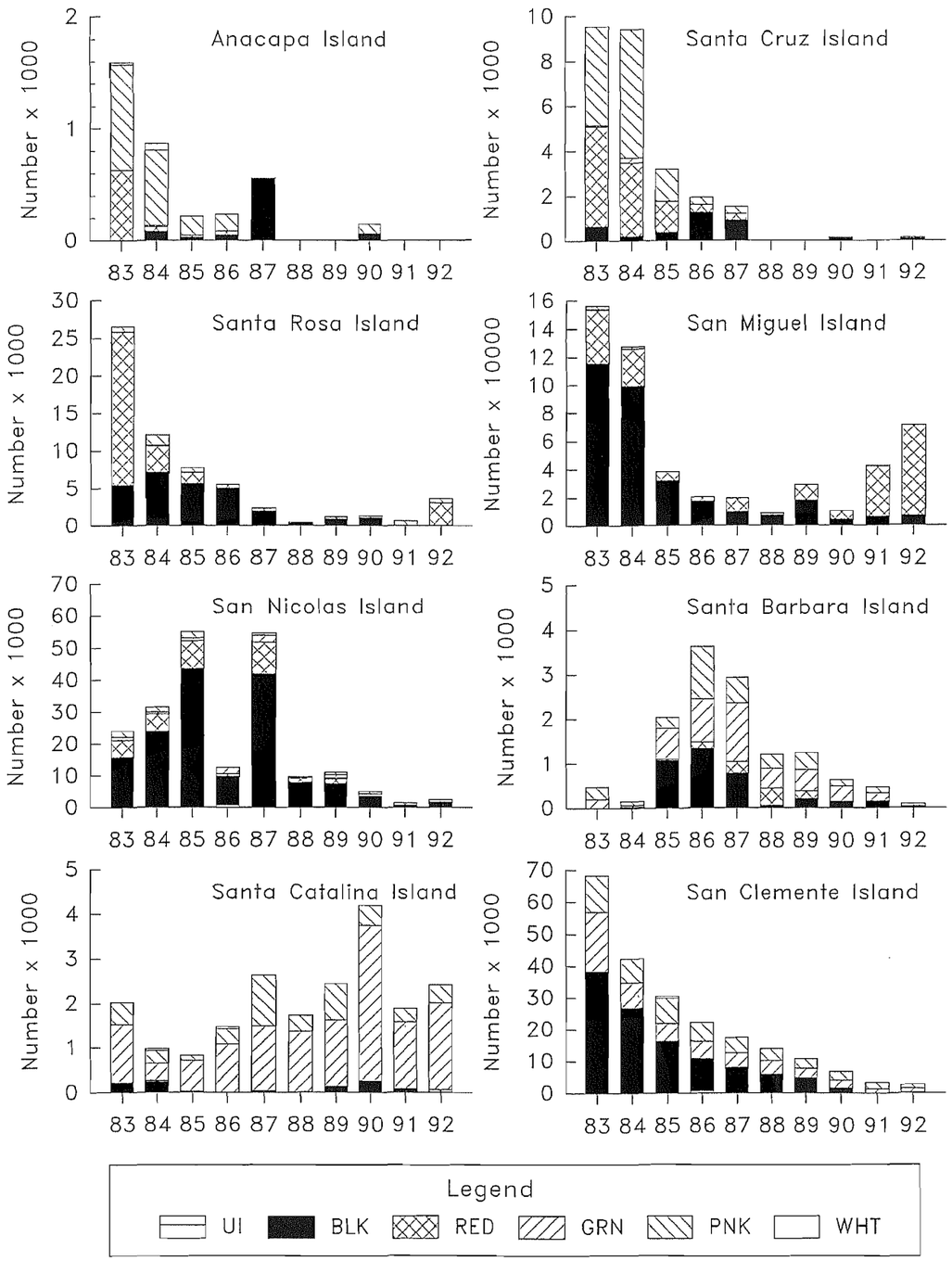

Figure 5. Commercial abalone landings from the Channel Islands, 1983–1992, by species.

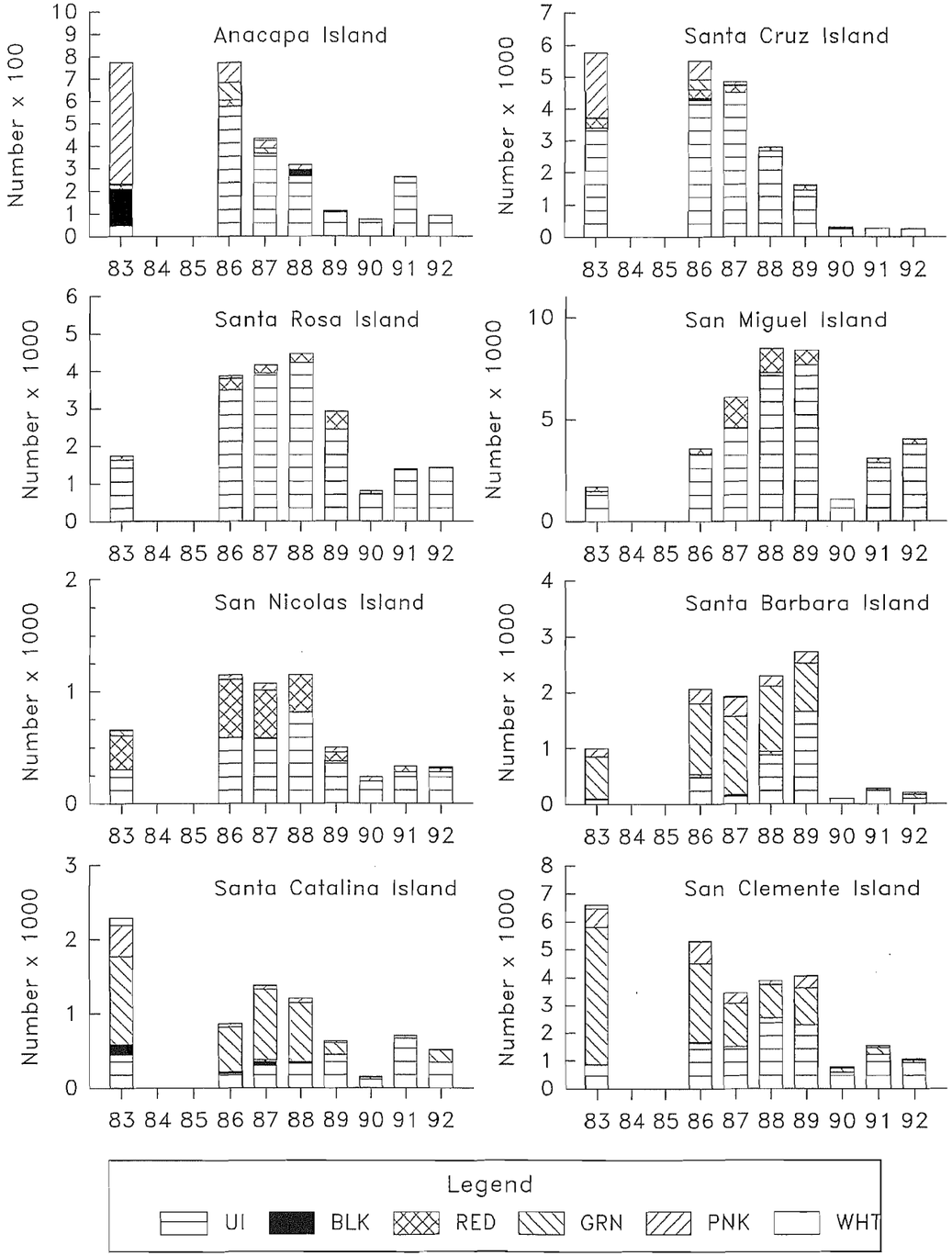

Figure 6. Commercial Passenger Fishing Vessel dive boat abalone landings from the Channel Islands, 1983–1992, by species.

Table 3. The number of abalone, by species, reported from recreational (CPFV-Dive) logbook data, with percentage of the total landings from the Channel Islands.

Year	Total	UI	% of total	Black	% of total	Red	% of total	Green	% of total	Pink	% of total	White	% of total
1983	21,138	8,556	40.5	368	1.7	1,020	4.8	7,037	33.3	3,921	18.5	236	1
1984	—	—	—	—	—	—	—	—	—	—	—	—	—
1985	—	—	—	—	—	—	—	—	—	—	—	—	—
1986	24,533	15,093	61.5	215	0.9	1,933	7.9	5,217	21.3	2,039	8.3	36	0.15
1987	19,505	11,589	59.4	81	0.4	2,615	13.4	4,033	20.7	1,144	5.9	43	0.22
1988	25,664	19,660	76.6	70	0.3	2,042	8.0	3,349	13.0	536	2.1	7	0.03
1989	22,093	16,941	76.7	13	0.1	1,671	7.6	2,521	11.4	937	4.2	10	0.05
1990	2,250	2,281	90.5	2	0.1	104	4.1	87	3.5	44	1.7	2	0.08
1991	8,722	7,760	89.0	0	0.0	463	5.3	381	4.4	118	1.4	0	0.00
1992	8,409	7,591	90.3	1	0.0	289	3.4	359	4.3	163	1.9	6	0.07

Discussion

Black abalone

Black abalone landings declined after 1985, when withering syndrome (WS) began affecting its populations at the Channel Islands. By 1990, it had disappeared from Anacapa, parts of Santa Rosa, Santa Barbara, and Santa Catalina islands, but populations remained at San Nicolas and San Miguel islands. The 1992 landings increased over 1991, from about 26,226 to 37,966 pounds, most likely the result of an increased effort in anticipation of a harvest moratorium. The numbers of black abalone landed at each island (Fig. 6) clearly detail the decline in the resource at Channel Islands.

Intertidal survey results (Fig. 4) show the effect of WS mortality on all sizes of black abalones throughout the Channel Islands. This disease eventually led to the near extirpation of this species from 7 islands (Anonymous 1993; Lafferty and Kuris 1993). The fishery was closed for 2 yr in 1993, to protect surviving abalone that may contribute to future stock recovery. Legislative action in 1994 extended the commercial fishing closure until 1997. Present population levels are so low that a quick recovery is unlikely. Had black abalone monitoring not been in place, the decline of the black abalone fishery likely would have been attributed to excessive harvest alone, and WS might not have been discovered (Davis et al. 1992; Haaker et al. 1992; Steinbeck et al. 1992; Anonymous 1993). This example emphasizes an advantage of the usefulness of fishery independent surveys.

Red abalone

Red abalone landings from San Miguel and Santa Rosa islands increased in 1992, and were detected in the fishery independent data at those islands and at Santa Cruz. The size frequency data (Fig. 3) indicated that there were relatively high numbers of sub-harvestable sizes and, in addition, there were many < 100-mm sizes at both locations. The presence of these size groups indicated a possibility of continued landing increases. Recent inspections at San Miguel Island revealed the presence of many red abalones. We measured about 50 abalones per diver hour at several locations there.

San Nicolas Island was a source of red abalones until 1988 (Fig. 6), when landings dropped. The translocation of sea otters there may have caused the decrease by predation, or the decreased landings might have resulted from discouragement of diving at San Nicolas during translocations.

The reported red abalone recreational landings (Fig. 2) did not reflect many red abalones, but most of the unidentified landings from San Miguel, San Nicolas, and parts of Santa Rosa islands were likely red abalones.

San Miguel and Santa Rosa islands, where recent indications of red abalone recovery (e.g., increasing landings and the presence of broad size distributions) occurred, face southward flowing currents from along the central California coast. This suggests the possibility that red abalones along mainland central California may provide regular larval infusion by current transport, enhancing juvenile settlement.

Green abalone

Green abalone landings were about 4% of the commercial (Table 2) and the recreational (Table 3) landings in 1992, but the number taken in the former increased from 1991. Commercial landings from Santa Catalina Island indicated recent (1990) increased landings, but those have decreased since then (Fig. 5). Fishery independent surveys would be valuable to determine if Santa Catalina Island has the capacity for continued harvest.

Green abalones did not appear in sufficient numbers in the NPS surveys to form any conclusions about population structure. The surveys need to be expanded to include green abalone habitat. The species' low numbers in commercial and recreational landings are an indication that populations may not be able to support further harvest. There is a definite need to get more information about the populations of this abalone. Its shallow habitat requirements and its past importance to the recreational fishery, about 33% of the landings in 1983, make this species a candidate for a skin diving only recreational fishery.

Pink abalone

The pink abalone supported the commercial fishery during the 1950s when annual landings of 2 to 3 million pounds were frequent. Currently, it comprises about 4% of the total commercial abalone landings at the Channel Islands. This species, like the green, was important in recreational landings (18.5% in 1983).

The NPS transect surveys found declining pink abalone populations on transects at Anacapa and Santa Barbara islands, while the numbers have leveled at Santa Cruz Island (Fig. 3). The apparent inconsistency between transect counts and length frequency data at Anacapa Island (Fig. 4) can be attributed to differences in the survey methods, the first being a search of a pre-established area, and the other being a haphazard search for a minimum number of measurements. At Anacapa Island, 2 of the 3 transects used in grouping this data are within invertebrate harvest closures. Inconsistences may have arisen from the grouping of data by island, rather than by site.

Size composition data indicate that moderate numbers of cryptic (< 100 mm) pink abalones were present continually over the last decade (Fig. 4). Abalones from 100 mm to sport legal size were the most abundant size class during most years. Sport legal, and even commercial legal abalones were found in higher numbers here than at other islands (Fig. 4). The continuous presence of pink abalones in all size groups at Anacapa Island, a condition not found at any other site, is evidence that protection of stocks may be beneficial to enhancement, reproduction, and settlement.

White abalone

White abalones disappeared from the commercial landings in 1992, and only 11 were landed since 1987. Recreational landings were less than 1% of the total landings at the Channel Islands since 1983.

The white abalone is not detected in the NPS surveys because its depth range is deeper than the transects, but searches of suitable habitat at the Channel Islands for live white abalones since 1992 found only 1 white abalone in 20 diver hours of searching (Davis and Haaker in prep.). There is little justification for a continued harvest of this abalone. Its population may be so dispersed and numbers so low that it may be in danger of extinction.

Assessment Methodology

Fishery landing data were useful in obtaining a historical perspective of the commercial abalone fishery. The data can be broken into smaller sets based on a variety of parameters, i.e., location, species, and year. Findings based on landing information were corroborated by both the CPFV-Dive logbook data and fishery independent abundance surveys. Commercial landing figures are the main database used in the management of the abalone, and most other commercial fisheries in California. Nevertheless, landing data do not supply the information to manage a fishery in a systematic manner. It records data derived only from the part of the fishery that is allowed to be fished, without detecting all the biological aspects of the sub-harvestable population. An example can be found in black abalones. Black abalone populations began to decline around 1985. In 4 yr, landings dropped from 138,000 to about 32,000 abalone. If surveys at the Channel Islands had not discovered WS and its lethal effects on black abalones, the decline in landings would probably have been attributed solely to excessive harvest.

The CPFV-Dive data suffer from the same criticisms as commercial landing data. In addition, these data record only landings from a single part of the recreational fishery. Divers from private boats and the shore divers are not included. Because CPFV-Dive boats usually go to the islands, recreational abalone landings from mainland areas are not included. Data from logbooks, such as species landed, are not as useful as they could be, because many abalones are reported as unidentified. Information about species is useful to determine what abalones are targeted, or available, to the recreational diver, as well as addressing species-related biological questions.

Fishery-independent surveys, such as were conducted at the Channel Islands, gather useful information about the population size structure. Surveys of red abalones found that there was a broad size structure, and continual presence of the smallest sizes at locations where red abalones have recently recovered. A similar situation was found in pink abalones at Anacapa Island. Fishery-independent data are not easily obtained. They require extensive field work, and the logistics are often difficult. But the information gained about the resource is necessary for the maintenance of a healthy fishery.

Conclusions

Commercial and recreational landings from the Channel Islands of green, pink, black, and white abalones are at historic low harvest levels. The results of transect surveys conducted from 1983 to 1992 support this finding. Management options about how to improve the recreational fishery need to be investigated and implemented, with the goal of maintaining the resource into the future.

The black abalone has disappeared from most of the Channel Islands, because of WS and continued harvest during the spread of WS. The harvest of black abalones was prohibited until 1997, but there is little expectation that stocks will recovery soon. No harvest should be resumed until recovery is assured, as evidenced by the presence of a broad range of below harvestable sizes, and commercial-sized black abalones at many locations.

The red abalone is the most important species in the commercial fishery, but landings are low. Recent signs of population recovery at San Miguel and Santa Rosa islands should be closely monitored. Further research should be conducted to investigate the possibility that the central California coast might be a source of red abalone larva.

Green abalone management options should be investigated and implemented. Its low occurrence in the commercial landings is an indication that this abalone cannot support continued commercial harvest.

The pink abalone, once a mainstay of the commercial and more recently, the recreational fishery, occurs only occasionally in the recent commercial landings. As in the green abalone, its low occurrence in the commercial landings is an indication that this abalone is no longer suitable for commercial harvest.

The white abalone is not available in sufficient numbers to support any harvest. Management options with the goal of protecting the species until population recovery can be demonstrated.

Pink abalone populations in protected locations at Anacapa Island had broader size frequency distributions than those in unprotected areas. Further research into the use of protected areas to assist in management and replenishment of abalone resources should be conducted.

Assessment of the commercial abalone resource using fishery landing data is relatively simple, but it yields limited information about the population density or size structure, which can aid in fishery evaluation and prediction of landings. Landing data will continue to be the primary source of fishery information, but the quality of the information could be improved by including specific catch locations and scientific sampling of the catch.

Recreational assessment from CPFV-Dive logbook data is inaccurate, and provides no data on total recreational take. A better means of getting data on recreational landings is needed, including port, shore, marina, CPFV-Dive boat, and private boat sampling.

Fishery-independent assessment provides a more complete view of the condition of a resource since it includes data about the sub-harvestable part. These methods yielded more specific information about the condition of the fishery than did either commercial or recreational landing data. Such methodology should be improved and expanded to include other islands, mainland areas, and the habitat of green abalones.

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