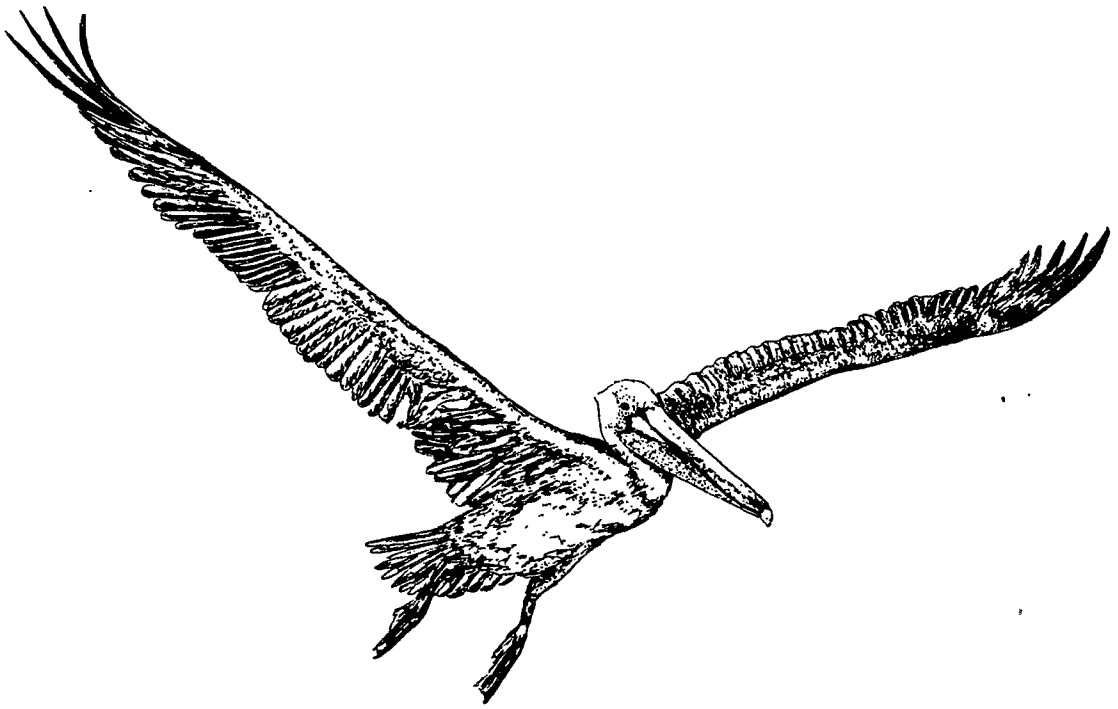

California Brown Pelican

Recovery Plan

THE CALIFORNIA BROWN PELICAN RECOVERY PLAN

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Frontispiece - California brown pelican adult with downy young at nest site on West Anacapa Island, California. Photograph by F. Gress, June 1978.

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PART I

INTRODUCTION

The California brown pelican (*Pelecanus occidentalis californicus*) breeding on offshore islands of southern California and northwestern Baja California experienced widespread pollutant-related reproductive failures during the late 1960's and early 1970's. Furthermore, the once large populations of the eastern brown pelican (*P. o. carolinensis*) along the southeastern and Gulf coast of the United States had seriously declined since the 1950's and disappeared in many parts of their former range. The only viable brown pelican colonies in the U.S. during the late 1960's and early 1970's were those in Florida (Schreiber and Risebrough 1972, Schreiber 1980a). Because of these declines, there was widespread concern for the welfare and future of the species in much of North America. Consequently, brown pelicans were classified as endangered by the U.S. Fish and Wildlife Service (USFWS) in 1970 (35 *Federal Register* 16047, October 13, 1970). The California subspecies was further protected when the California Fish and Game Commission also designated it as endangered in 1971 (California State Endangered Species Act of 1970)(Leach and Fisk 1972; California Fish and Game Commission 1981).

This recovery plan delineates steps and procedures believed necessary to return the California brown pelican to nonendangered status. A recovery plan has been developed for the eastern brown pelican (USFWS 1979); however, the present plan deals only with the

California subspecies. Conservation efforts and management plans have been in effect to protect the brown pelican population breeding in California since 1970. This recovery plan integrates those measures with others proposed to ensure long-term stability and protection of the subspecies throughout its range. Although this plan addresses the entire subspecies, it deals primarily with the northern population segment, referred to here as the Southern California Bight (SCB) population, which has shown the major declines that were the impetus for endangered classification (see Jehl 1970). Included in this group are those colonies (after the definition of "colony" used by Gochfeld 1980) which have experienced the most serious reproductive impairment. Other populations of the California brown pelican (i.e., those nesting in the Gulf of California and along the west coast of southern Baja California and mainland Mexico) have not suffered colony-wide reproductive failures from pollutants, such as those experienced by the SCB colonies. Human disturbance, however, is increasingly becoming a factor in affecting the breeding success of these colonies; if they are not protected, their present status could soon be reversed (see Anderson and Keith 1980). This plan takes into account the long-term needs for maintaining stable pelican populations in Mexico within the practical framework of instituting protective measures there.

Although the brown pelican is a conspicuous bird along the coasts of California and Baja California, few data are available concerning its past status. The breeding biology and natural

history of the California brown pelican were virtually unknown until intensive studies began in 1969. Continuous studies since that time have provided an extensive data base, much of it still in preparation for publication. With these long-term data, a more comprehensive management plan for the conservation and protection of the California brown pelican is possible. This recovery plan summarizes available biological information on California brown pelicans (data from 1981-82 pelican studies have not yet been completely analyzed and will therefore be included in this report only as available). Additionally, this plan gives background information on past and current population status, as well as the history of its reproductive problems in the SCB. Finally, it identifies protective needs and future potential threats, and taking these into consideration, formulates a management plan for restoring a stable *P. o. californicus* population in the SCB and maintaining currently stable populations in other parts of the range. Ultimately, successful implementation of the plan should result in removal of the subspecies from the endangered list.

Nomenclature

The California brown pelican, one of six recognized subspecies of the brown pelican (Wetmore 1945), was first described as a distinct species, *Pelecanus californicus*, by Ridgway (in Baird et al. 1884). Previously, all brown pelicans were known variously as *P. occidentalis* Linnaeus and *P. fuscus* Gmelin. Ridgway (ibid.) actually listed it as

P. (fuscus?) californicus, but P. californicus was more commonly used in the early literature. Ridgway (1897, in Oberholser 1918) later considered the California brown pelican as a subspecies of the eastern form P. occidentalis. Oberholser (1918) concurred with this view and gave his reasons. Nevertheless, P. californicus continued to be widely used until at least 1931. At that time Peters (1931) and the Fourth Edition of the American Ornithologists Union (AOU) Check-list (1931) treated all brown pelicans as a single species, with the California subspecies known as P. o. californicus. The population on the Galapagos Islands and in Ecuador was at one time considered as P. o. californicus, but Murphy (1936) and Wetmore (1945) both treated this population as a distinct subspecies. P. o. californicus Ridgway is presently attributed only to the population along the Pacific Coast of the U.S. and Mexico, including the Gulf of California (AOU 1957).

Description and Geographic Variation

There is little geographic variation other than size, among the various subspecies of brown pelicans (Wetmore 1945, Anderson and Hickey 1970). The California brown pelican (Frontispiece) can be distinguished from the eastern brown pelican by its larger size and its darker hindneck while in breeding plumage (Wetmore 1945); the California subspecies also has larger eggs (Anderson and Hickey 1970). Data based on egg volume related to body size (Anderson and Hickey 1970) suggest that, rather than distinct subspecific units (pertaining at least to these measurements), brown pelicans show continual

variation between subspecies. Unlike other brown pelican subspecies, the California brown pelican typically has a bright red gular pouch (basal portion) during the courtship and egg-laying period (see Keith 1978 for discussion of pouch coloration). The red pouch is rare in eastern brown pelicans (R. W. Schreiber, pers. comm.). Plumage characteristics and molt sequences are discussed by Palmer (1972: 271-274) and are summarized in detail in Figures 1 and 2 from more recent data (Anderson 1981). Five crude age-classes (representing a continuous change) can be discerned in the field by plumage coloration and external characteristics (D. W. Anderson, field notes); they are briefly described in Figure 2. Sexes are similar, but males are larger with longer bills (DWA and F. Gress, unpublished data). To the trained eye sexes can often be discerned in the field.

Range, Distribution and Population Numbers

Range. The California brown pelican is the Pacific Coast form of a more widespread species (see Wetmore 1945 and Palmer 1962). The breeding distribution of the subspecies ranges from the Channel Islands of southern California southward (including the Baja California coast and the Gulf of California) to Isla Isabela, Islas Tres Marias off Nayarit, Mexico (AOU 1957) and Isla Ixtapa off Acapulco, Guerrero, Mexico (Melo 1980) (Figure 3). Known intermittent breeding in the past extended as far north in California as Point Lobos near Monterey (Williams 1927, 1931), but successful nesting has not occurred there since 1959 (Baldridge 1974). Between breeding

seasons pelicans may range as far north as Vancouver Island, British Columbia, Canada and south to Colima, Mexico (Palmer 1962), although a recent band recovery was reported from El Salvador (DWA, unpublished data). Post-breeding dispersal patterns depend largely on oceanographic conditions which in turn influence food availability (see Anderson and Anderson 1976).

Distribution. Surveys of colonies in the Gulf of California and along the Pacific coast of Baja California suggest that *P. o. californicus* breeding populations can be differentiated crudely into identifiable and geographically separate entities (Anderson 1983) (Figure 3). These groups are somewhat isolated by long stretches of desert coastline where no pelican colonies are found; this is probably the result of a lack of suitable habitat rather than to specific barriers to dispersal (see Anderson 1983). Examples of barriers to continuous distribution of eastern brown pelicans are mentioned by Murphy (1936). Oceanographic features and patterns of prey distribution also affect locations of breeding colonies (see Anderson 1983).

By categorizing the various breeding groups of *P. o. californicus*, we do not suggest that these are isolated breeding populations; indeed, some exchange occurs among colonies by the recruitment of new breeders (DWA, field notes; Anderson and Gress 1983a). Isolating mechanisms no doubt operate on a much larger scale (see Anderson 1983). While separation into geographical units may be

artificial and does not imply isolated habitats in a genetic context, it serves to point out that these units tend to show differences in nesting substrate, habitat, and effects of climatic conditions; these might also serve as convenient management units. Data on the movements of SCB- versus Gulf of California-born pelicans, not yet analyzed entirely (DWA and FG, unpublished data and band recoveries on file), suggest, nonetheless, that each unit has its own dispersal patterns and that mixing is not entirely random. For example, of 10 pelican band recoveries in the winter of 1981-82 along the California coast, 9 came from the California or northwestern Baja California colonies and one was from the Gulf of California. This pattern persisted also in sightings of marked birds in December 1981 along the California coast, supporting the hypothesis of Anderson and Anderson (1976) that the majority of pelicans on the coast in late winter are locally-produced birds (i.e., from the SCB colonies).

For the purposes of this report, the discussions of Mayr (1964) are followed in defining "population" as a group of genetically related individuals that share common resources and life history characteristics (i.e., mortality, natality, productivity, age structure, etc.). Rates of genetic exchange between individuals of each unit described below would tend to be higher than among individuals between units. Thus, these units would not be expected to be totally isolated, nor would individual exchange between these units be entirely random (DWA, J.O. Keith and FG, unpublished data).

Within the breeding range of P. o. californicus (Figure 3), the following management units (which will be termed "populations") may be identified (DWA, field notes; also, see Anderson 1983):

1. The Southern California Bight (SCB) population includes the pelican colonies of the Channel Islands area of southern California and the islands along the northwest coast of Baja California south to Isla San Martin (Figure 4); these colonies are all influenced by the oceanographic conditions of the California Current.

2. The southwest Baja California coastal population breeds on coastal islands of the Bahia Sebastian Vizcaino area (Islas San Benito and Isla Cedros) and in the Bahia Magdalena area; this area is south of the approximate limits of influence of the California Current.

3. The Gulf of California pelicans nest on desert islands in the Gulf of California. They are likely divisible into several populations (as yet not defined as to geographical extent) and are therefore combined here.

4. The Mexican mainland population nests primarily on mangrove islands and coastal wetlands (in mangrove trees) of Sinaloa and offshore islands of southern Sinaloa and Nayarit (including Islas Tres Marias).

Population numbers. The maximum breeding population of the California brown pelican throughout its range may number about 55,000-60,000 pairs (DWA, J.O. Keith and FG, unpublished data). Estimated numbers of pairs in each designated geographical unit are given in Table 1. Because it has not been possible to survey all colonies each year and because historical data are meager and colony sizes may vary considerably from year-to-year, these are only crude estimates. Estimated breeding numbers are given here. Total population data (including juveniles and non-breeding adults) are difficult to obtain and have a high variance. Data on number of pelicans breeding and their reproductive success are easier to gather because pelicans generally nest in traditional and predictable areas; breeding data probably reflect population trends (Schreiber 1979) but not short-term population status (Anderson and Gress 1983a). Two complete surveys of the total numbers of *P. o. occidentalis* (in 1974 and 1977; DWA, umpublished data) and 3 years (between 1975 and 1978) of population estimates in the SCB (Briggs et al. 1981) have been completed. However, it is not possible from this information alone to draw meaningful conclusions to predict overall population trends.

By far the largest breeding group of *P. o. californicus* is located in the Gulf of California (Figure 3). The colonies on these islands comprise an estimated 68 percent of the total breeding population. Pelicans nesting along the southwestern coast of Baja California make up about 10 percent of the total population. The mainland Mexican coast of Sinaloa and Nayarit and contiguous offshore

islands contribute about 16 percent to the total breeding population, while the Southern California Bight colonies comprise about 6 percent (although reduced in comparison to past populations there).

Southern California Bight Colonies. Because the emphasis of this plan is on the SCB population (for reasons given above), a more detailed description of the colonies in this unit is given. Brown pelicans in the SCB historically have nested on several of the Channel Islands in southern California and on the islands of Los Coronados, Todos Santos, and San Martin along the northwestern coast of Baja California (Figure 4). Among the Channel Islands, nesting has been recorded from the following islands and their outlying islets: Anacapa Island, Santa Barbara Island (including Sutil Island), Santa Cruz Island (Scorpion Rock), and San Miguel Island (including Prince Island). These islands are all part of the Channel Islands National Park, which was newly created in 1980; only Anacapa Island and Santa Barbara Island were part of its precursor, the Channel Islands National Monument, which was established in 1938.

Anacapa and Los Coronados historically have had the largest and most consistent brown pelican colonies in the SCB (Anderson and Gress 1983a). Records are scanty prior to 1968, but pelicans have nested on these two island groups (each consisting of 3 small islands) nearly every year, while at other colony sites nesting is ephemeral and irregular (i.e., not occurring every year). San Martin at one time also had a sizable breeding colony (Jehl 1973), but it has been

inactive since about 1972 (Anderson and Keith 1980); the Todos Santos colony has not been active since the 1920's (Kenyon, in Jehl 1973). Since 1968, the major SCB colonies have been on West Anacapa Island and Isla Coronado Norte. Minor colonies in the Channel Islands occurred on Scorpion Rock in 1972, 1974 and 1975 and on Santa Barbara Island in 1980. The number of pairs breeding in the SCB from 1969 through 1981 ranged from 339 to 3,510 (average = 1,228) (see Table 2).

The Los Coronados and Anacapa colonies are closely related (Anderson and Gress 1983a), and from a management point of view there are reasons for considering them either as a single unit or as separate units. Rationale for considering the two colony areas as a single unit when formulating management plans are as follows:

1). There is probable interchange of breeding pelicans between the two colonies and shifts occur from one area to the other (Anderson and Gress 1983a).

2). Both have simultaneously responded in the past to general levels of SCB-wide northern anchovy (Engraulis mordax) abundance (Anderson et al. 1982).

3). Both are included in the same management unit as the Northern Anchovy Fishery Management Plan [see Pacific Fisheries Management Council (PFMC) 1978].

4) Both are subject to the same oceanographic influences of the California Current (see Anderson et al. 1980).

On the other hand, there are equally compelling reasons to consider the two units separately:

1). They are separated by an international boundary which complicates management and conservation efforts, particularly when each country has different priorities (see Anderson and Gress 1981).

2). Each year, once the colonies are established on each island, they become independent units in response to local food supplies (see Anderson et al. 1983a).

3). Although the food source utilized by both colonies is defined as a single unit in the Anchovy Fishery Management Plan, it is separated by an international border and is thus under different fishing regimes (Anderson and Gress 1983b).

How the two colony areas are viewed is a matter of choice for resource managers. Ideally, and if it were possible, considering them as a single management unit would seem to be the option most beneficial to the pelican population.

Although the effectiveness of recovery actions in Mexico is uncertain, the recovery plan for the SCB brown pelican population, nevertheless, should include colonies in both California and Mexico. Pelicans breeding at Los Coronados and Anacapa are not year-round residents of these islands (Gress 1970, Anderson and Anderson 1976, Briggs et al. 1981). After breeding the birds may disperse widely (DWA and FG, unpublished data); also, during the late summer and fall, an influx of dispersing, nonresident birds from other Mexican colonies greatly increases the number of pelicans along the California coast (Anderson and Anderson 1976; Briggs et al. 1981; DWA and FG, unpublished data). Management plans for *P. o. californicus*, therefore, cannot be developed for California colonies alone.

The California brown pelican has a long-term historical presence in the SCB (see historical section). It should not, therefore, be considered a founder population because of its location at the periphery of the subspecies range. Theoretically, such populations should have different balances between *r* and K natural history traits than more central ones (see Horn 1978). Thus, SCB pelicans may be expected to have higher (or at least equal) long-term reproductive rates and, furthermore, might also be genetically less variable (as the result of different selection pressures) than populations in the Gulf of California in the center of the subspecies range (see discussion in Mayr 1964). As such, the SCB population might be somewhat genetically distinct. Unfortunately, no data are available

to test such hypotheses, although genetic studies are planned and analyses of morphological variation are underway (DWA and FG, unpublished data; DWA and R.W. Schreiber, in preparation).

Habitat Description and Requirements

The basic habitat needs of the California brown pelican are: 1) a disturbance- and predator-free nesting area, 2) offshore habitat with an adequate food supply, and 3) appropriate roosting sites for both resident and migrant pelicans.

Nesting habitat. Nesting habitat varies throughout the range of *P. o. californicus*. Among the colony sites in the SCB, Anacapa has relatively dense shrubby vegetation, whereas the islands farther south along the Pacific coast of Baja California are more xeric and more sparsely vegetated. These islands all have in common steep, rocky slopes utilized for nest sites (Figure 5). Pelicans use whatever vegetation is available for nest-building; in the SCB colonies (particularly on the Channel Islands where an abundance of nesting material is available) large, bulky stick nests lined with grasses and forbs are built on the ground or in brush (Figure 6) (Gress 1970). Sub-colony sites may be used in subsequent years or new areas may be colonized. Individual nests may on occasion be re-used or rebuilt, but most often are not (FG and DWA, field notes). On more xeric islands, where less vegetation is available, nests are generally not as large and bulky and a greater percentage are built on the ground.

The Gulf of California colonies are located on desert islands which have high ground temperatures during the breeding season and extreme xeric conditions (Figure 7). Cacti, woody shrubs, and annual plants are the primary vegetation on these islands. Here, with vegetation for nesting material and substrate so sparse, pelicans build minimal nest structures usually on the ground, in arroyos, on rocky ridges, or on flat areas. Pelicans of the Mexican mainland populations build nests primarily in mangrove trees on mangrove islands and marshes close to the mainland along the Sinaloa coast (Figure 8); estuarine vegetation is used almost exclusively for nest material. Climatic conditions in this area are very nearly tropical. Along the southern Sinaloa and Nayarit coasts, pelicans nest in trees on offshore islands.

Brown pelicans are colonial nesters and require nesting grounds that are free from both mammalian predators and human disturbance (Anderson and Keith 1980, see also Anderson 1983); an adequate and consistent food supply must also be available (Anderson et al. 1982, Anderson and Gress 1983a). Several rocky offshore islands in the SCB, particularly Anacapa and Los Coronados, provide these criteria. The rugged terrain and general inacessibility of these islands are, for the most part, deterrents to man-caused disturbances. Less frequently-used colony sites may be utilized in rare times of locally abundant food supplies at the appropriate time in the breeding cycle, or during longer term trends of favorable oceanographic conditions affecting a wide geographical area (Anderson et al. 1982). Some

former nesting areas are no longer usable because of continued human disturbance (e.g., San Martin and Todos Santos). Destruction of nesting habitat, however, is not a problem at this time; despite their nearness to major human population centers, the Channel Islands and Los Coronados remain essentially natural. Since creation of the Channel Islands National Park and development of a resource management plan for the park by the National Park Service (NPS) (NPS 1980), continued protection of pelicans nesting on the Channel Islands seems assured. National Park Service protection of colony sites on West Anacapa Island since 1970 and Santa Barbara Island in 1980 has been essential in aiding recovery efforts.

Presently there is little or no protection of most colony sites located in northwestern Baja California, although the nesting colony at Coronado Norte receives indirect protection through the Instituto Nacional de Pesca and Armada de Mexico (Mexican Navy), which allow no access to the island without special permits. The reasons for restricted access in northwestern Baja California relate to security and fisheries protection. Some islands in the Gulf of California are also official sanctuaries (see Anderson et al. 1976, and Anderson and Keith 1980). Enforcement of prohibition of access is sometimes conducted by the Armada de Mexico, while Isla Rasa (not a pelican colony) on occasion has wardens stationed there during the breeding season. More protective enforcement in the Gulf is needed.

Offshore Habitat. Offshore waters associated with island colony sites are also essential habitat for brown pelicans. Like most seabirds, brown pelicans are dependent on food resources near the colony site during the breeding season. The offshore zone within 30-50 kilometers of the colony is critical to pelicans for food supplies, especially when young are being fed (Anderson et al. 1980; Anderson et al. 1982; FG and DWA, field notes). Waters near the colony sites are also important for wintering migratory birds and for newly-fledged young when they begin feeding for themselves. The environmental quality of offshore habitat is a major factor in determining the population status of pelicans and the degree of breeding success. The definition of such areas in terms of brown pelican needs and multiple-use offshore wildlife sanctuaries is still a matter open to further quantification and interpretation (see Anderson and Gress 1981).

The concept of offshore sanctuaries for seabird colonies is becoming increasingly more important with the acceleration of development, use and exploitation of coastal zones. Offshore protection zones restrict and regulate certain human activities potentially detrimental to seabird breeding such as net fishing, petroleum development, dredging activities, discharge of contaminants, certain vessel operation and air traffic (reviewed by Anderson and Gress 1981). Offshore sanctuaries, in essence, provide a buffer zone between human activities and breeding seabirds, thus ensuring a reasonably disturbance-free environment. Providing offshore sanctuaries may also be a means of securing foraging areas adjacent to

colony sites during the breeding season. Sanctuaries, however, would not provide complete protection for food sources which are, of course, highly mobile and not confined by sanctuary boundaries.

Roosting Sites. Essential habitat also includes roosting and loafing areas for breeding birds and non-breeding local and Mexican migrants alike. Offshore rocks and islands, river mouths with sand bars, and the many breakwaters, pilings and jetties along the U.S. and Mexican west coasts are important to brown pelicans as roosting sites (DWA and FG, field notes). These habitats are declining along the coast of California as development and use increase (USFWS 1980a), and only a few are being created through the incidental use by pelicans of man-made structures such as breakwaters and jetties. Many roosting areas are subject to frequent and repeated disturbance by people, dogs, vehicles, aircraft, boats, etc. Major roosts are probably few and are difficult to identify because of their ephemeral nature; nevertheless, these sites need to be determined and management plans developed and implemented for protection in areas where needed.

Major roosting areas during the breeding season, particularly those closest to colony sites, are the most important to protect; the potential impact of disturbance on productivity probably diminishes with distance from the colony. But if left undisturbed, major roosting areas on islands near the colonies have the best opportunity to become nesting areas if the appropriate conditions exist. There are also certain roost sites important to non-breeders during the

breeding season; whereas breeders are tied to the colony at this time, non-breeders are not. Thus, non-colony associated aggregation points remain important during the breeding season. The colony site is only important during the breeding season when it is the center of activity; during the non-breeding period this center shifts to major roost sites. Effects of disturbance to roost sites of non-breeding birds in fall and winter habitats are probably not as critical as disturbance to breeding season roosts. Pelicans at this time are not held to a relatively limited geographic area as they are during the breeding season and are probably more flexible in their response to disturbance.

Estuarine habitat, which includes roosts for pelicans, is extremely reduced along the California coast (USFWS 1980a). Less than 20 percent of the original salt marshes along the California coast are left [P.R. Kelly, California Department of Fish and Game (DFG), pers. comm.]. Here the protection of roost sites for pelicans per se involves the larger issue of coastal marsh preservation for many wildlife species. This aspect of recovery (i.e., marsh preservation and restoration on the California coast) for pelicans must go hand-in-hand with other programs to protect coastal habitats and wildife, such as the California least tern recovery plan (USFWS 1980b), DFG marine ecological reserves, California State parks and beaches, USFWS refuge acquisition and California Coastal Commission decisions.

Breeding Biology

California brown pelicans are colonial nesters utilizing relatively small, inaccessible coastal islands for colony sites. They generally begin to breed when 3 to 5 years old. Females tend to first breed at a younger age than males. Rarely a 1- or 2- year old bird will nest, but their degree of success is generally lower (FG and DWA, field notes). Adult plumage is usually attained in the fourth year (see Figure 2). Seasonal changes in appearance of adult California brown pelicans during an annual cycle are described in Figure 1. Adult pelicans attain breeding plumage prior to the onset of courtship behavior and begin molting while raising their young. Attainment and loss of breeding plumage is an 8 to 9 month process (FG and DWA, field notes; also Schreiber 1980b).

Since 1969, the earliest breeding on Anacapa was initiated in early January (in 1979-1981); the 1980 Santa Barbara Island colony began in late December. The latest date for initiation of nesting on Anacapa during this same period was in mid-May (in 1972 and 1975; in each of these years there was an earlier colony on nearby Scorpion Rock) (Figure 9). The Mexican colonies are generally active several weeks or even months before those in California; some have begun as early as November (DWA, field notes). As discussed in another section, nesting may be a synchronous effort or may consist of several sub-colony units (i.e., breeding sub-units within a colony) breeding asynchronously over a period of several months in one or several locations on an island colony site.

Pair bonds are formed at the nest site and eggs are usually laid one to two weeks after commencement of courtship and nest-building. A description of the nest and nesting substrate is included in the section describing habitat. Schreiber (1977) describes in detail the breeding behavior of eastern brown pelicans; behavior of the California subspecies is similar (Keith 1978; R.W. Schreiber and FG, unpublished data).

Brown pelicans usually lay a 3-egg clutch; description of the eggs, measurements, and comparisons between subspecies and populations are given in Anderson and Hickey (1970). Incubation begins with the laying of the first egg, and both parents participate. The red pouch of adults begins fading to a dull orange as incubation progresses (see Keith 1978). The incubation period is about 30 days.

There is little evidence that California brown pelicans regularly renest (i.e., lay a replacement clutch if the contents of the first nest are destroyed or abandoned) (see Gress 1970, 1981; and Jehl 1973). There have been no accurate estimates of renesting in brown pelicans, which is not possible without marked individuals on nests. Nonetheless, experiences of a number of pelican researchers (DWA; FG; J.R. Jehl, Jr.; J.O. Keith and R.W. Schreiber) leave the impression that renesting rates are relatively low and are probably negligible (i.e., not a significant bias) in comparisons of reproductive rates between various populations. Schreiber (1979) reported a mean of 9 percent renesting in Eastern brown pelicans during an 8-year study.

In the SCB colonies, however, the amount of renesting that could have occurred and not be accounted for would contribute only a small error to the overall estimate (FG and DWA, unpublished data). Based on plumage characteristics, color of soft parts, and behavior, it appeared that 1978 was the only year since 1969 in which significant renesting occurred at Anacapa Island (see Table 2) (Gress 1981; Gress et al. ms.)

The newly-hatched young are naked and helpless (altricial); they are unable to hold their heads upright and are uncoordinated for 5 to 7 days. They require constant attention and protection from temperature extremes and predation until about 3 to 4 weeks of age. Down appears on the back and rump in 10 to 12 days. Scapulars are the first dark feathers to emerge; these begin showing after about 30 days. As the young pelican approaches 9 to 10 weeks of age, most of the down has disappeared and the head, neck and back are brown (see Schreiber, 1976, for a detailed description of plumage development in the similar eastern brown pelican). Fledging generally occurs at 11 to 13 weeks in age (13 is more typical of the California subspecies); Schreiber (1976) gives an average of about 76 days for eastern brown pelicans.

Both parents care for and feed the young. Schreiber (1976) reports growth rates and food intake of the eastern subspecies. When food resources are scarce, breeding success is reduced and mean brood size decreases (FG and DWA, unpublished data). Productivity (fledging

rate), mortality and relationships to food availability are discussed in another section. Once the young birds leave the nesting colony, they seldom return to the nest site, although fledged young are often seen begging from adults in the colony area. They are not proficient in feeding themselves soon after fledging; as a result, postfledging mortality is generally high. Weight at fledging most often exceeds that of adults, thus some energy reserves are provided until the young pelican becomes more adept in feeding itself. Food and feeding habits are discussed elsewhere.

Historical Accounts of the Individual SCB Colonies

For purposes of discussion in this report, we consider population estimates prior to 1968 as "historical"; these are discussed separately. The first complete and known to be accurate censuses were initiated in 1968 by Schreiber and DeLong (1969). Each year thereafter until the present (1982), there have been periodic, and in some years (1970-1972, 1978-1982), monthly surveys of all known brown pelican colonies in the SCB during the breeding season. Population and breeding data since 1968 are discussed separately in the next section.

Anacapa Island. Historical records of brown pelicans nesting on Anacapa (reviewed by Schreiber and DeLong 1969, Anderson and Hickey 1970, and Gress 1970) are scant. Until 1969, the Anacapa colony was little studied; consequently, few detailed historical data exist.

Visits to the colony were infrequent and gaps of information over a period of several years occurred. Earlier accounts of visits were largely anecdotal, but rough population estimates were usually given. In addition to giving approximate breeding numbers, the early population data indicate year-to-year fluctuation in colony size (see Willett 1912, 1933; Bond 1942; and Anderson and Hickey 1970) and suggest long-term oscillations in breeding effort. No hypotheses or speculations as to causes were previously given, although such oscillations are now thought to be food-related (Anderson and Anderson 1976). The known history of the Anacapa pelican population indicates that nesting occurred there nearly every year. Only rarely in some years did pelicans apparently not nest on Anacapa (Willett 1912, 1933; Wright and Snyder 1913; Howell 1917). Brown pelican nesting on Anacapa is no doubt a long-term phenomenon; in fact, the native American Chumash name for Anacapa was "Pi awa phew." which means "house of the pelican" (Applegate 1975).

Brown pelicans breeding in California were first noted on West Anacapa Island in 1898 (Holder 1899), but no population estimates were given at that time. Willett (1910) was the first to give detailed information on this colony; he reported 500 nests on East Anacapa in 1910. Pelicans apparently did not nest on East Anacapa in 1911 (Burt 1911; Willett 1912), but Peyton (1917) reported 200 pairs nesting presumably on West Anacapa in both 1911 and 1912. In 1915 the colony had "increased noticeably" (no numbers given), and "at least 1,500 pairs" were nesting there in 1916; in 1917 the colony size estimate increased to "at least 2,000 pairs" (Peyton 1917).

Most visits to Anacapa prior to the late 1930's were for the purposes of egg collecting. Published accounts of these visits and collection records on data-slips provide sketchy information on population sizes and breeding site localities (Anderson and Hickey 1970). Estimates of colony size on Anacapa must therefore be viewed with caution. Not only are these estimates subject to observer error, but it is evident that not all possible breeding sites on the three islands of the Anacapa group (or other Channel Islands) were surveyed in each year that population estimates were given. Obtaining accurate systematic data on breeding numbers is difficult. Several visits during a season are required. Logistics and weather usually pose problems, and nesting sites are generally inaccessible or difficult to reach. Also, there is considerable shifting of site location, and pelicans on Anacapa often breed asynchronously (i.e., there may be several cohorts nesting at different times within a single season either at one site or at several sites) (FG and DWA, field notes). Although the early historical accounts do not give a complete picture of pelican nesting on Anacapa, they do indicate general trends and fluctuations in numbers over the years.

Historical estimates of numbers of nests or pairs were most often from one-time visits. Population estimates since 1968 represent total seasonal nesting attempts and are therefore not easily compared to historical data. Thus, an estimate of nests or breeding pairs from a one-time visit may vary considerably from the actual number of nesting attempts over the course of the entire breeding season. This is

particularly true in asynchronous nesting where several cohorts may be nesting at different times and in various areas. It would not be possible, therefore, to determine the total seasonal breeding effort from a one-time visit. However, asynchronous nesting does not always occur and a visit at or near the peak of nesting might be sufficient to determine the extent of the season's breeding effort.

There are no published records of brown pelican colonies on the Channel Islands during the 1920's, although Peyton (in Anderson and Hickey 1970) on an egg collection data slip estimated (a perhaps exaggerated) 5,000± pairs breeding on Anacapa in 1920. Anderson and Hickey (1970) speculate that numbers of breeding pelicans probably increased on Anacapa during the late 1920's, and because breeding occurred as far north as Monterey County (Williams 1927), this period may have been one of population increase (see also Baldridge 1974). Bond (1942) reported that (according to an Anacapa resident) pelicans nested on West Anacapa every year from 1930 through 1941, but apparently no nesting occurred on Middle or East Anacapa during that period. The lighthouse presently standing on East Anacapa was built during the 1930's, and it is possible that disturbance from construction and men living on the island created undesirable conditions for nesting. There are no published reports of nesting on Middle Island, but a charter boat operator bringing Audubon Society groups to the islands from Ventura recalls that nesting occurred there irregularly until at least 1963 (FG, field notes).

The only published account of nesting pelicans on the Channel Islands during the early 1930's was a report of 200 nests in 1930, presumably on the west island (Ashworth and Thompson 1930). The population apparently increased greatly by the late 1930's; about 2,000 pairs were reported on the west island in 1935 (Bond 1942), 1936 (Stevens, in Anderson and Hickey 1970), and 1939 (Sumner 1939, Bond 1942).

There are few data available for pelicans breeding on Anacapa during the 1940's. Bond (1942), without giving any numbers, indicated that in 1940 and 1941 the colony was "still about the same size" it had been in 1939 (i.e., about 2,000 pairs). Based on population indices, Anderson and Anderson (1976) projected a late-1940's population at Anacapa of about 2,000 pairs. Thereafter, a slow continuous decline occurred in the pelican breeding population from the mid-1950's until the mid-1970's. The estimated breeding population [as determined by population indices (Anderson and Anderson 1976)] did not approximate 2,000 pairs again until 1980 (Gress 1981, Gress et al. ms.). The maximum number breeding during the 1950's and 1960's was estimated at 1000 pairs in 1964 (Anderson and Anderson 1976). Banks (1966) noted that pelicans breeding on Anacapa in 1963 and 1964 showed "little change in size of the population since the earliest reports," but gave no data. Schreiber and DeLong (1969) reported from Banks' unpublished field notes that "hundreds or perhaps a thousand pairs" were present in both 1963 and 1964.

Santa Barbara Island. In those years when pelicans did not nest on Anacapa, colony sites may have shifted to nearby islands, such as Santa Barbara Island (see Hunt and Hunt 1974, reviewed by Gress 1981). Santa Barbara Island is considered the second most important brown pelican breeding area along the California coast (Schreiber and DeLong 1969, Gress 1970), but historical data are scant. Willett (1912) reported a colony consisting of 25 pairs in 1911, and Wright and Snyder (1913) reported another of 300-400 "birds with downy young" in 1912. In subsequent years, brown pelicans probably nested there sporadically, but no further information was published until 1968, with the exception of a report of possible breeding in 1940 (Dunkle, in Philbrick 1972). Schreiber and DeLong (1969) reported no nesting on Santa Barbara Island in 1968, but stated that NPS photographs showed pelicans breeding there in 1967 (files, Channel Islands National Park). Although this observation was published, interpretation of the photos was later found to be incorrect, and pelicans probably did not nest on Santa Barbara Island in 1967 after all (R.W. Schreiber, pers. comm.). Another probable erroneous report of brown pelican breeding on Santa Barbara Island was published in 1971 (McCaskie 1971). DFG aerial surveys and NPS personnel on the island on 1971 could not confirm the reported breeding effort. In both cases, young-of-the-year birds (most likely from Mexico) were probably roosting on abandoned cormorant nests late in the season and were mistaken for birds hatched on Santa Barbara Island. Brown pelicans nested on Santa Barbara Island in 1980; details of this breeding effort are discussed in another section.

Other California Colonies. Sporadic nesting has also been reported on Santa Cruz Island (site unknown) and Prince Island (a small island offshore from San Miguel Island; see Figure 12) in the early 1900's (Willett 1910, 1912; Howell 1917). Although little published information exists, nesting on these islands appears to have been irregular and confined to relatively few nests. Nesting was reported on Santa Cruz Island only in 1909, when "several nests" were found (Willett 1912). Because of sketchy information, it is not known if this small colony was on Santa Cruz Island or on outlying islets, such as Gull Island or Scorpion Rock. Colonies on Prince Island were reported in 1910 (5 nests; Willett 1910) and 1939 (about 200 nests; Sumner 1939). Like Santa Barbara Island, no doubt there were other years in which pelicans nested on these islands, but because of difficult logistics and access, visits were infrequent. Prince Island may have once been a significant colony site. From the information available, however, it is not possible to determine the size or consistency of this colony; it has not been active in any year since at least the early 1960's.

In 1927 a colony (which may have also been active in 1925 and 1926) was reported on Bird Island off Point Lobos in Monterey County (Williams 1927). Breeding occurred on Bird Island sporadically from the late 1920's to 1960 (Williams 1931, Baldridge 1974); young have not been seen on Bird Island since 1959 (Baldridge 1974). The Bird Island colony was relatively small and generally consisted of less than 20 nests and in some years none at all. The most successful year

was in 1929 when 55 nests were built and 79 young were observed (Williams 1931).

Interestingly, the last period of pelicans breeding on Bird Island coincided with the last significant year of the Monterey sardine fishery (see MacCall 1983). The occurrence of pelicans breeding on Bird Island apparently coincided with periods of ocean "warm water years" when prey species may have migrated farther northward than usual (Radovich 1961, Baldridge 1974, Anderson and Anderson 1976). Also, the availability and diversity of prey species may have been greater at that time.

Northwest Baja California Colonies. The following historical information is summarized from Jehl (1973). Brown pelicans have most likely been long-time breeders on the Baja California islands. They have probably nested on nearly every island along the Baja California coast, with the exception of Guadalupe about 160 miles offshore. From the late 1880's until 1920, approximately 500 to 1,000 pairs nested on Los Coronados, mostly on the north island. Los Coronados is the site of the largest pelican colony off the northwestern Baja California coast; historically it is similar in size to the Anacapa colony (Anderson and Gress 1983a). Like Anacapa, the size of the Los Coronados colonies varied greatly from year to year, but fewer historical data are available (Anderson and Hickey 1970; Jehl 1973). During the period for which data area available, the colony was apparently at maximum abundance in the 1930's, with "about 5,000 birds" nesting on the north island and about 100 on both the middle

and south island. "Several thousand pairs" were estimated to be nesting on Los Coronados in the late 1940's (Walker, in Schreiber and DeLong 1969). While this estimate may have been high, nevertheless, it indicates that a large number of pelicans nested there during that period of time. Colony size declined on the north island during the 1950's, but a "sizable colony" was located on the south island at least into the 1950's. Little information on breeding is available from the 1960's, but the north island colony apparently declined until little or no nesting occurred there by the end of the decade, while the south island had declined to about 300 pairs.

On Islas Todos Santos about 200 pairs of pelicans nested on two small islands during the 1920's (Van Denburgh 1923). This colony disappeared soon afterwards, apparently because of human disturbance; nesting has not been observed there since. Pelicans apparently once nested on Isla San Martin in "large numbers". Historical data are lacking, but remains of old nests indicate that the colony was at one time quite extensive.

Population Status Since 1968 and Reasons for Decline

In 1968 the Smithsonian Institution Pacific Ocean Biological Survey Program conducted a survey of seabirds breeding on the Channel Islands and Los Coronados and found pelicans breeding only on West Anacapa Island. No nesting was observed on other Channel Islands nor on Los Coronados (Schreiber and DeLong 1969). The pelican population

had not only declined (there were only about 100 pairs nesting on Anacapa), but there was lowered reproductive success as well. The Anacapa colony had apparently been abandoned before young pelicans could have fledged; successful breeding in the SCB in 1968, therefore, could not be verified. The result of these surveys were the first indication that brown pelicans breeding in the SCB were experiencing reproductive problems.

Because of high levels of pollutants observed in studies of seabirds along the California coast (see Risebrough et al. 1967, 1968) and because of the lack of successful pelican breeding in the SCB in 1968, detailed studies of the SCB brown pelican colonies were initiated in 1969. In March 1969 nearly 300 nests on West Anacapa Island were examined and only 12 contained intact eggs (Risebrough et al. 1971). Crushed eggs were found in 51 nests and the colony was littered with broken shells which were deficient in calcium carbonate and thus too thin to withstand incubation; the thin shells resulted in breakage and reproductive failure. A sample of 85 shell fragments collected on Anacapa in 1969 had a mean thickness that was 50 percent less than that of museum specimens collected on Anacapa prior to 1943 (Risebrough et al. 1970, 1971; Risebrough 1972). From a minimum of 1,272 nests, at most 4 young fledged from the Anacapa colony that year; almost all eggs laid had collapsed during incubation because of excessive shell thinning.

Chemical analyses of contents of eggs collected in 1969 showed high levels of DDT compounds, particularly DDE, the principal isomer of commercial DDT (Risebrough et al. 1970, Keith et al. 1971, Risebrough 1972, Blus et al. 1972). Subsequent studies demonstrated a concentration effect relationship between DDE in the lipids of pelican eggs and the degree of shell thinning (Risebrough 1972, Blus et al. 1972). Shell thickness was inversely correlated to concentrations of DDT compounds in the egg yolk. The effects of pollutants on California brown pelican populations are discussed in the following section.

Extremely low productivity on Anacapa because of hatching failures caused by eggshell thinning also occurred from 1970 through 1973 (Table 2) (Gress 1970, Anderson et al. 1975). DDE-induced shell thinning was implicated in similarly lowered reproductive success of brown pelicans nesting on Los Coronados during the same period (Jehl 1973) (Table 2). Baja California colonies south of Los Coronados had better breeding success; DDE residue levels averaged lower, and mean shell thickness was greater than in the more northern colonies (ibid.).

The pelican colony on Isla San Martin in 1969 consisted of 800 nests; productivity was estimated at 0.11 young/nest (Jehl 1973). The poor reproductive success was related in part to pollutants, but factors other than shell thinning were also suspected (ibid.). Pelicans failed to breed on San Martin in 1970, possibly because of

local food shortages (ibid.). In 1971 about 500 nests were built, but productivity was very low (0.02 young/nest); repeated human disturbance was considered the major cause of the lowered productivity (ibid.). From 1972 through 1974 the San Martin colony showed little or no successful breeding, most likely because of human disturbance (Anderson and Keith 1980). The colony failed to show signs of expected recovery after pollutant levels decreased (Anderson et al. 1975). Attempted breeding has not occurred on San Martin since 1974 (Anderson and Keith 1980; DWA, field notes), at least through 1980. After extirpation of the colony, former San Martin breeders may have nested on Los Coronados and Anacapa, thus potentially increasing the size of the breeding populations on both islands (Anderson and Gress 1983a).

Scorpion Rock, an islet offshore Santa Cruz Island about 10 km west of Anacapa (Figure 4), was the site of another brown pelican colony on the Channel Islands in 1972 (in addition to one on West Anacapa). Reproductive success (31 young from 112 nests), like that on Anacapa, was very low. The combined productivity of the two islands, however, showed significant improvement over that of 1969-1971 on Anacapa (Table 2). The Scorpion Rock colony was not active in 1973, but breeding resumed there in 1974 (105 nests, 75 young) and was active again in 1975 (97 nests, 77 young). As of 1982, there have been no further successful breeding attempts on Scorpion

Rock possibly because of continued human disturbance. It nonetheless represents a potential brown pelican colony site for consideration by resource managers.

Productivity of the pelican colonies on Anacapa/Scorpion Rock and Los Coronados increased dramatically in 1974 (an average of 0.92 young fledged per nesting attempt) and showed an even greater increase in 1975 (1.05 young fledged per nesting attempt) (Table 2). Improved breeding success in 1974 and 1975 was attributed to increased mean eggshell thickness (resulting from reduced DDE levels in the SCB) and, also, to an increase in northern anchovy abundance in the SCB (Anderson et al. 1975, 1977). As discussed in another section, anchovies are the principal prey of brown pelicans breeding in the SCB (Gress et al. 1980; Kelly, Gress, and Anderson, in preparation). Pelican productivity in 1974-1975 was the highest recorded in the SCB from 1969 through 1981 (see Table 2) and was concurrent with a correspondingly high abundance of anchovy (Mais 1974; Anderson et al. 1975, 1980; PFMC 1978).

From 1976 through 1978 there was a general decline in mean annual anchovy abundance (from apparent natural causes); pelican productivity at both Anacapa and Coronado Norte decreased as well (Figure 10) (Anderson et al. 1980, 1982). A high incidence of nest abandonment and poor survival of young--characteristics of food stress reported in other seabird species (Dorward 1962, Hunt 1972, Nelson 1978)--characterized these breeding attempts. For example, in 1976

there was early nest abandonment followed by later starvation of young on Anacapa Island; this was associated with low anchovy availability (Anderson et al. 1977). In 1977 few pairs nested on Anacapa and widespread nest abandonment again resulted in poor productivity which was associated with a declining anchovy population (Anderson 1977). Breeding success on Anacapa Island in 1978 was the lowest since 1973 (see Table 2) (Gress 1981, Gress et al. ms.). Two subcolonies of about 200 nests were almost completely abandoned (93 percent abandonment rate), and a later third subcolony of apparent renesters had only slightly better success (ibid.). The earlier nest abandonments in 1978 coincided with a decline in anchovy abundance throughout the SCB (in fact, the lowest since surveys began in 1968) (Mais 1978, 1979a). Initiation of a third subcolony was associated with somewhat increased local anchovy availability late in the breeding season (K.F. Mais, pers. comm.). Likewise, breeding success was also poor on Coronado Norte in 1978 (Table 2). The commercial anchovy fishing season in the SCB in 1978 was nearly non-existent during the pelican breeding season (K.F. Mais, pers. comm.).

The number of breeding pelicans greatly increased on both Anacapa and Coronado Norte in 1979 (Table 2). In fact, more pairs (n = 2218) produced more young (n = 1900) in the SCB that year than any previous year since at least 1968 when annual surveys were initiated (Gress 1981, Gress et al. ms.). The increased number of breeding pairs was probably a result of increased recruitment of birds reaching sexual maturity that were produced in the SCB from 1974 through 1976, years

of relatively high reproductive success, as well as from outside recruitment (Anderson and Gress 1983a). Although overall anchovy biomass in the SCB was moderately low in 1979, a local "pocket" comprised primarily of juvenile fish was concentrated in the Santa Barbara Channel just north of Santa Cruz and Anacapa Islands (Mais 1979b, 1980a). These anchovies were for the most part too small to harvest but were of apparent sufficient availability to support the increased number of breeding pelicans of Anacapa (see Gress 1981).

The 1980 breeding effort in the SCB (including Anacapa Island, Santa Barbara Island and Coronado Norte) consisted of nearly 3,000 nesting attempts which produced a total of 1,865 young (Table 2) (Gress 1981, Gress et al. ms., Anderson and Gress 1983a). While the number of nesting attempts was even greater than in 1979, productivity was less, particularly at Coronado Norte. Both colonies were characterized by broadscale nest abandonments and starvation of young (Gress 1981, Gress et al. ms.). Anchovy biomass was relatively high early in the breeding season and was apparently centered in the Santa Barbara Island area (Mais 1980b, 1981a) where aerial surveys also showed much pelican feeding activity (FG, unpublished data). California Department of Fish and Game pelagic fish surveys in February also showed a high anchovy biomass in the area described above (Mais 1980b, 1981a). Consequently, the Santa Barbara Island colony and the early Anacapa cohorts had generally good productivity (Gress 1981, Gress et al. ms.). As in the previous year, the large number of breeding pairs on Anacapa probably resulted from the

recruitment of new breeders previously hatched on Anacapa and also likely from previous breeding stocks from Los Coronados and San Martin which nested on Anacapa and/or Santa Barbara Island because of good local food availability early in the breeding season. Although speculative, the increased number of breeders could also have reflected recruitment from Mexican colonies further south. Anchovy availability declined greatly by May, and the spring commerical harvest eventually ceased before the season's end, far short of the allotted harvest quota (K.F. Mais, pers. comm.). The nest abandonment rate on Anacapa increased to about 50 percent by the end of May; most nests built in April (n = 490) were abandoned (72 percent abandonment rate), and another 114 nests were incompletely built and abandoned prior to egg laying. Mortality of young from starvation greatly increased as well (Gress 1981, Gress et al. ms.). Aerial surveys showed little feeding activity in Anacapa waters during that period (FG, unpublished data). Inadequate food resources at a critical period during the breeding season was the apparent cause of nest abandonment and chick mortality (FG, unpublished data).

The Anacapa Island colony in 1979 and 1980 had the longest breeding seasons on record (Figure 9). The egg-laying period in both years extended to just over 6 months (from 1970-1978 the range was 2.0 to 3.8 months) (Gress 1981, Anderson and Gress 1983a, Gress et al. ms.). The prolonged breeding seasons may have indicated various peaks of local food availability throughout the breeding season.

On Anacapa Island in 1981 an estimated 2946 breeding attempts produced 1805 young that survived to fledging, while on Los Coronados 564 nests produced an estimated 310 young (productivity = 0.61 and 0.55, respectively) (Table 2); there were no other active breeding sites in the SCB (Gress et al. ms.). In summary, 3510 breeding pairs produced 2115 young in the SCB in 1981, and the reproductive rate was 0.60 fledged young per nesting attempt.

The 1981 Anacapa colony, as in 1980, had more breeding pairs and higher productivity than did the Coronados colony (see Table 2 for comparisons). Since 1969, only in 1980 and 1981 has the Anacapa colony had better productivity; shifts of pelican breeding population centers in the SCB are discussed in Anderson and Gress (1983a). The number of nesting attempts and the number of young fledged were the highest recorded in recent years in the SCB. On the other hand, productivity was the lowest since 1978 (see Table 2). The low productivity was largely the result of mid-season nest abandonments and chick mortality (Gress et al. ms.).

The rate of nest abandonment was relatively high on Anacapa in 1981, particularly in April and early May when over 60 percent of the nests built were abandoned; overall abandonment rate was 53 percent (1550 nests) (Gress et al. ms.). Abandonment in April caused high chick mortality. The 1981 mortality rate on Anacapa was 20.5 percent (includes prefledged birds only); most of this mortality was attributed to starvation of young when food shortages likely occurred

in mid-season (ibid.). In comparison, the chick mortality rate in 1980 was 5.8 percent, which at that time was considered higher than usual (Anderson 1977, Gress 1981). Widespread abandonment of nests and high chick mortality were symptoms observed in other years of a rapid reduction in food availability (Anderson et al. 1980, 1982). As in 1979 and 1980, there was a general pattern of good food availability early in the breeding season associated with a large number of breeding pairs, followed by food shortages in mid-season associated with widespread nest abandonment and chick mortality (see Gress 1981). DFG pelagic fish surveys in early February 1981 showed high anchovy abundance in southern California waters, particularly in the northern Channel Islands area, but later surveys in early April indicated greatly reduced anchovy stocks throughout these waters (K.F. Mais, pers. comm.). Brown pelicans nesting on Anacapa reflected the changes in local anchovy abundance; the dispersal of anchovy from the Anacapa area coincided with widespread nest abandonment and starvation of young. Anchovy stocks increased somewhat in June in the northern Channel Islands area, and although abundance was still relatively low (K.F. Mais, per. comm.), it apparently stimulated a late breeding response in pelicans. Thus, as observed in past years (Anderson et al. 1975, 1980, 1982; Gress 1981), 1981 pelican productivity was associated with the abundance and availability of northern anchovy.

Limiting Factors

Yearly variations in historical colony size on both Anacapa and Los Coronados, as well as overall SCB population size, were most likely caused by food availability (Anderson and Gress 1983a and b). Although the SCB pelican colonies are located on relatively inaccessible islands, breeding success was also no doubt affected by occasional human disturbance, particularly on those islands subject to human visitation (Anderson and Keith 1980). With rare exceptions of possible severe storms or natural habitat degradation (such as landslides or fires), there were probably no other significant factors limiting historical populations. Disease, parasites, and predation may have been limiting factors in isolated, local situations but were probably of little consequence to long-term population trends. In recent years, however, the impacts of high levels of DDT residues in these birds literally masked the effects of all other limiting factors. For at least ten years (and perhaps more), the SCB pelican population maintained an extremely low level of productivity. Factors that are potentially limiting to populations of eastern brown pelicans were listed and classified in the Eastern Brown Pelican Recovery Plan (USFWS 1979) and need not be reviewed here. While any of the factors listed there might also limit California brown pelicans if of sufficient magnitude, they do not appear to have contributed significantly to the decline of the SCB population.

While the SCB pelicans have shown great improvement from pollution-related declines since the mid-1970's, there are still chronic signs of reproductive stress, particularly on Anacapa (Anderson et al. 1982, Anderson and Gress 1983a, Gress et al. ms.). Here, overall productivity has not attained that observed in other populations (Anderson and Gress 1983a). Maximum annual productivity in eastern brown pelican populations in Florida (Schreiber 1979) and California brown pelicans breeding in the Gulf of California (DWA, unpublished data) ranged from 1.3 to 1.7 young fledged per nesting attempt, with a long-term mean of about 1.0 in two separate studies of nearly a decade each outside the SCB area (see discussion in Anderson and Gress 1983a). A mean productivity of 1.0 is therefore suggested as a conservative index for a stable, self-sustaining population (see Anderson and Gress 1983a). Anacapa productivity has not reached 1.0 in any given year (let alone a long-term mean of 1.0) since studies began in 1969, although 1.0 was nearly achieved in 1975 (Table 2). When compared to Anacapa, the Los Coronados colony has previously shown somewhat better overall productivity. The large increases in breeding pairs and number of young produced in the SCB in 1979-1981 are encouraging, but productivity has remained relatively low (Table 2) compared to other brown pelican populations.

Historical breeding data for the SCB pelican colonies from which "normal" breeding success can be determined are limited. The only productivity data that exists for pelicans breeding in California prior to 1969 indicate a productivity of about 1.4 young/nest in 1929

on Bird Island near Monterey, California (Williams 1931). Because this was an isolated periperal colony, no productivity inferences relative to SCB colonies can be made based on these data alone. Recent breeding data from these colonies, therefore, must be compared with data available from other populations. There is the remote possibility, of course, that mean historical productivity of the SCB colonies was typically lower than that observed in Florida or the Gulf of California, but this seems unlikely. It is presumed that the SCB colonies have low productivity because of relatively recent environmental change (within approximately the past 25 years). It is not known whether this change can be mitigated through management and protective measures to improve productivity or if this population could sustain itself with perpetually low productivity (see MacCall 1983 for a related discussion). Current management plans are attempting to at least maintain a stable situation so that deleterious environmental changes with potential adverse effects on pelican breeding success will not occur.

Pollution: The primary reason for endangerment of the California brown pelican was the nearly total reproductive failure (in the SCB colonies only) caused by excessive thinning of eggshells, a result of physiological responses to high levels of DDT in the SCB in the late 1960's and early 1970's. Shell thinning in the Anacapa colony occurred several years before it was first observed in 1969; eggs collected in 1962 and measured in 1969 showed a 26 percent reduction in shell thickness from pre-1943 values (Anderson and Hickey 1970).

Analysis of the contents of brown pelican eggs collected from West Coast colonies in 1969 indicated a north-south gradient in both DDE and PCB concentrations from southern California into Mexico (Risebrough 1969, Jehl 1973). This gradient, which peaked in the Los Angeles area, was attributed to effluent discharge into a Los Angeles sewage system from a DDT manufacturing company (Risebrough 1969, Burnett 1971, Schmidt et al. 1971, MacGregor 1974). Similar north-south gradients of DDE concentrations along the West Coast were also observed in the eggs of double-crested cormorants (*Phalacrocorax auritus*) (Gress et al. 1973), in sand crabs (*Emerita analoga*) (Burnett 1971), mussels (*Mytilus californicus*) [Southern California Coastal Water Research Project (SCCWRP) 1973], and northern anchovy and other fish species (Risebrough 1969, MacGregor 1974).

Levels of DDT compounds in the southern California marine environment were among the highest recorded for any coastal ecosystem worldwide (Risebrough et al. 1976). Disposal of liquid wastes from the DDT manufacturing plant to a sanitary landfill, beginning in 1970, resulted in a sharp decline of DDT input into the sea from the sewage system (Carry and Redner 1970, Redner and Payne 1971, MacGregor 1974). Thereafter, residue levels in SCB marine food webs decreased subtantially (see Anderson et al. 1975, 1977; Risebrough et al. 1976, 1979; and Ohlendorf et al. 1978). Input of total DDT compounds from five of southern California's largest municipal wastewater discharges was 21,600 kg/year in 1971, but by 1979 it had steadily declined to 728 kg/year (Schafer 1980).

Concurrent with a decrease of DDE in the SCB, concentrations also declined in pelican egg contents, and mean shell thickness gradually increased (Anderson et al. 1975, 1977). Consequently, pelicans on Anacapa and Los Coronados (Anderson et al. 1975) (see Table 2) and double-crested cormorants on Anacapa (Gress et al. 1973) began showing increased breeding success.

Although the sewage input of DDT into the SCB dramatically decreased by 1971, depressed productivity from eggshell thinning continued through at least 1973. The decline of DDE residues in brown pelicans began leveling off in about 1972, and the rate of improvement in reproductive success began stabilizing in about 1974 (Anderson et al. 1977). Recent analyses indicate DDT levels in the SCB have stabilized to a point where improved pelican reproductive success has also leveled off (Gress, Anderson and Ohlendorf, in preparation). Ecological effects of DDT contamination, however, have not been entirely eliminated, and incidences of eggshell thinning (although greatly reduced since the early 1970's) still occur. Acute contamination of the SCB by DDT compounds has thus been replaced by a low-level, chronic situation (Anderson et al. 1977). Complete recovery of reproductive potential from past contamination may still be many years away.

Studies assessing current pollutant levels in the SCB brown pelicans and possible effects on recent breeding success are underway (Gress, Anderson and Ohlendorf, in preparation). Incidental samples of addled eggs and eggshell fragments were collected during banding

operations in the SCB colonies in 1978-1982. Preliminary analysis of pollutant data from these samples indicate DDE levels comparable to those reported in 1973-1975 by Anderson et al. (1975, 1977). Although these levels are greater than those reported to have caused reproductive impairment in eastern brown pelican colonies in South Carolina (Blus et al. 1974), reproductive problems from eggshell thinning are not occurring on a large scale basis in the SCB colonies, but these results suggest a continuing low-level effect of DDE on breeding success in the SCB (Gress, Anderson, and Ohlendorf, in preparation; see also discussion in Anderson, et al. 1975, 1977).

The primary source of DDT into the SCB has essentially stopped, and environmental contaminants in southern California coastal waters are now well-monitored (see, for example, Risebrough et al. 1979). Natural processes must now be relied upon to reduce DDE levels in the SCB. While DDE-related reproductive problems may still be occurring in SCB brown pelican colonies, detailed in-colony studies on the effects of pollutants that include systematic collecting of fresh eggs, such as those conducted in South Carolina (see Blus et al. 1974), are inadvisable in the SCB colonies. Disturbance caused by collecting fresh eggs from marked nests for monitoring purposes is not worth the risk of substantially reducing reproductive success. Research in the SCB colonies since 1969 has avoided such disturbances to breeding birds (see Jehl 1973, Gress 1981, Gress et al. ms., Anderson and Gress 1983a). Because breeding brown pelicans (and

often-associated double-crested cormorants) are highly sensitive to disturbance, this policy should continue, recognizing that non-disturbing techniques may result in sampling bias and less precise data.

High levels of DDE and stress from restricted food supplies are likely to interact in reducing reproductive success (Keith 1978). Careful management of pelican food resources, therefore, is important in areas of chronic DDE contamination.

Food Availability: Two words are used to define food levels: abundance and availability. They are somewhat interchangeable because of a natural relationship between them (see discussion in Anderson et al. 1982 and Anderson and Gress 1983b). "Abundance" generally refers to the total biomass of a food item or items and "availability" to how much of that abundance might actually be catchable by brown pelicans. Since there is no way to accurately measure availability to pelicans in the field (other than perhaps indirectly through food-delivery rates, growth rates, etc.), most data relating brown pelican population parameters to anchovies more closely approximate abundance (or biomass estimates provided by fishery biologists). When such estimates are refined to more accurately reflect expected availability, the relationships between population parameters and food become stronger (Anderson et al. 1982).

With lessened effects of DDE in the SCB since the early 1970's , other environmental impacts (with regard to effects on pelican populations) were more readily assessed. Since about 1974, food availability has become the most important limiting factor influencing pelican breeding success. As noted previously, fluctuations observed in pelican productivity have been associated with northern anchovy availability and/or abundance (Anderson et al. 1975, 1980, 1982; Anderson and Gress 1983a and b). Studies of food items show breeding pelicans to be almost entirely dependent on northern anchovy (from 1972 through 1979 anchovies comprised 92 percent of the pelican diet during the breeding season; see Table 3) (Gress et al. 1980; Kelly, Gress and Anderson, in preparation).

Historically, pelicans may have had a wider prey base than that present today and perhaps switched to alternate prey when their primary prey was unavailable. It is also possible that the SCB pelican population fed on many different prey items, specializing on no one species. In the Gulf of California more than 40 species of prey are found in the diets of breeding brown pelicans (DWA, unpublished data). There, no single species dominates the diet although some species predominate annually or seasonally. The composition of the fish fauna in the SCB has no doubt been altered from that which was present in historical times. For example, Pacific sardines (Sardinops sagax), a formerly common fish species in the SCB and probably once an important prey item to brown pelicans and other seabirds (see Ainley and Lewis 1974) have greatly declined along the

California coast (see Murphy 1966). Northern anchovies presently dominate the biomass of forage fish species in the SCB (Mais 1974). With the exception of Pacific mackerel (Scomber japonicus), there are few other surface-occurring schooling fish species of sufficient abundance that are available as suitable prey in southern California waters (Gress et al. 1980; Kelly, Gress and Anderson, in preparation).

Because SCB pelicans depend largely on anchovies while breeding, they are likely to be sensitive to anchovy population fluctuations (Anderson et al. 1980, 1982; Anderson and Gress 1983b). It is not known whether anchovies have always been the primary prey species or whether this dependence is a recent phenomenon resulting from the relative absence of other suitable prey items. Factors that limit anchovies and thus affect pelican food resources are complex and will not be discussed here, but these are reviewed in the Northern Anchovy Fishery Management Plan (PFMC 1978).

Studies of pelican/anchovy interactions suggest that brown pelicans breeding in the SCB have better reproductive success in years of higher anchovy abundance (Figure 10) (Anderson et al. 1975, 1980, 1982). For example, the highest productivity of pelicans breeding in the SCB since 1969 occurred in 1974 and 1975 (Table 2), which was concurrent with a correspondingly high abundance of anchovy (Mais 1974, 1980b; Anderson et al. 1975; PFMC 1978). The satellite Scorpion Rock colony was also active during this period of increasing and maximum anchovy abundance.

In 1979-1981 anchovies were abundant regionwide in the SCB during the winter as pelicans began nesting (Gress et al. ms.). Pelicans appear to have responded to this abundance by breeding in large numbers early in the season. Those building nests in January and February were generally more successful (i.e., better productivity, fewer abandoned nests, less chick mortality, and more young per successful nest) than later breeders.

During the breeding season, pelicans are affected by short-term as well as annual changes in anchovy abundance. If food supplies are scarce throughout the breeding season (e.g., in 1978 at Anacapa), then pelican productivity is low. If food becomes scarce after nesting has commenced, nests will be abandoned, and if they contain young, starvation is likely. While pelican reproductive success may be associated with anchovy abundance levels, the situation can be more complicated than that. For example, in 1979 at Anacapa, while overall anchovy availability in the SCB was low, a "local pocket" of anchovies supported a relatively large number of breeding pairs. Peaks of local anchovy availability can stimulate successive breeding efforts and prolong the breeding season. These local events may not necessarily correlate with regional anchovy availability (Anderson et al. 1982, Anderson and Gress 1983b). Pelicans appear to depend ultimately on regional anchovy availability, but proximally on local availability.

Colony Disturbance. Human disturbance, while having the potential for serious disruption to breeding pelicans (see Schreiber 1979, Anderson and Keith 1980), is not the primary cause of

endangerment *per se* of the SCB brown pelican population. Brown pelican colonies on Isla San Martin and Islas Todos Santos, however, were both disturbed to such an extent that they are no longer active (Jehl 1973, Anderson and Keith 1980). Anacapa and Los Coronados are islands of rugged terrain, and despite close proximity to major metropolitan areas, these colony sites are relatively inaccessible. However, fishermen, birders, photographers, educational groups, and in past years, egg collectors, have on occasion disturbed colonies at critical times in the breeding cycle, often with disastrous results to the breeding effort (see, for example, Dawson 1923: 1977).

For adequate reproduction, it is essential that human activities be restricted at and near colony sites. Disturbance can have severe detrimental effects on productivity (Schreiber 1979, Anderson and Keith 1980). The greatest impact from disturbance occurs during the early stages of nesting; brown pelicans will easily abandon nests when disturbed. If disturbance occurs early in the breeding cycle, unattended eggs and young chicks (to about 3 weeks of age) are vulnerable to loss by predation from western gulls (*Larus occidentalis*) and common ravens (*Corvus corax*). Hyper- or hypothermia in young can also occur when nesting adults are away from the disturbed nest site for a prolonged period. Older, more mobile young may suffer injury or be trampled and even impaled on vegetation when panicked. Young may be displaced from their nest sites and can starve if they are incapable of returning. Loss of food through regurgitation in a fright response can also have an effect on the growth of young birds (Schreiber 1976). Young pelicans nearly of

fledging age but not yet fully developed may be forced to fly prematurely and can die from broken limbs or starvation. Even a one-time disturbance, if at a critical time in the breeding cycle, can cause abandonment of a colony or sub-colony. Repeated disturbance over several breeding seasons may cause pelicans to eventually give up colony sites completely (such as occurred on Isla San Martin and Islas Todos Santos).

Not only are nest sites deserted as a result of direct human disturbances, but loud noises (e.g., aircraft, sonic booms, boats, etc.) may also cause desertion (see Evans et al. 1979, Cooper and Jehl 1980, and Jehl and Cooper 1980).

Military and civilian aircraft flying low over the pelican colony at Anacapa and nearby roosting areas are a recurring source of disturbance to pelicans and other seabirds (FG, field notes). Roosting birds flush easily when aircraft fly too low. Birds on nests, on the other hand, are more tenacious and only rarely flush, although agitation and fright-response are noticeable when aircraft (especially helicopters) operate too close to the colony (FG, field notes), There is a great deal of military activity in the Channel Islands area; military helicopters and small private aircraft generally cause the most disturbance. They frequently fly along Anacapa's north shore, occasionally flying too close to the colony. However, the U.S. Navy has cooperated well with Channel Islands National Park requests to divert helicopter flights from colony locations.

Threats to Future Existence

Food availability, disturbance, and oceanic pollution appear to be the major currently operating population limiting factors for the SCB brown pelican population; these topics have been discussed in previous sections. Potential threats related to these limiting factors include commerical fisheries, oil development, recreational fishery, sonic booms and increased tourism (reviewed by Anderson and Gress 1981).

Commercial Fisheries. Because brown pelicans breeding in the SCB feed largely on northern anchovies, commercial anchovy harvests have the potential to affect pelican population dynamics (see Anderson et al. 1980, 1982). Pelagic fisheries have interacted with seabird reproduction and population levels elsewhere. For example, seabird declines accompanied large-scale and heavy harvests of the anchoveta (*Engraulis ringus*) in Peru (Idyll 1973); similar events also occurred in the South African pilchard (*Sardinops ocellata*) fishery (Frost et al. 1976, Crawford and Shelton 1978, Cooper 1978). In both situations intensive commercial fishing had adverse effects on seabird populations prior to a crash of the fishery itself (see also Furness 1978). It must be pointed out, however, that each was an essentially unregulated fishery and there was no established "cutoff" (level of estimated biomass in the population below which the harvest quota would be zero), as there has been in the California anchovy fishery.

The Fisheries Conservation and Management Act of 1976 requires agencies to formulate management plans for commercial fish species to ensure optimum yield with guaranteed perpetuation of that resource and minimal impact to the ecosystem of which it is part. Special consideration is also given to endangered species in these management plans. Under this act the Northern Anchovy Fishery Management Plan (AFMP) was prepared by the Pacific Fishery Management Council (PFMC 1978). Several harvest options are provided under this plan (Figure 11). The option chosen and implemented by National Marine Fisheries Service (NMFS) under advisement of PFMC calls for a quota of 33.3 percent of the estimated spawning biomass in excess of 1 million short tons, with no upper limit (Option 2, Figure 11) (PFMC 1978, MacCall 1980). This option was considered "moderate" by PFMC and was chosen over other options with potentially higher harvest quotas primarily because of consideration to the recreational fishery (A.D. MacCall, pers. comm.). In choosing this option, it was not clear how it related to brown pelican needs. The AFMP makes no specific provision for brown pelicans or other wildlife species that utilize anchovies.

The Department of Commerce, in approving the AFMP, adopted the concept of a "forage reserve", which represents a minimum biomass available as forage, below which the commercial fishery must cease operations (the "cutoff"). For the option chosen in the AFMP (PFMC 1978), the forage reserve consists of a million tons of the estimated anchovy spawning biomass plus two-thirds of the estimated biomass above this cutoff (see Figure 11). PFMC is currently revising this

plan; it will include new biomass estimates and new options. The revision will also address needs of pelicans and consider pelican-anchovy interactions in future management measures (DFG News Release, 17 October 1981). The harvest quota set each year has depended upon the estimate of spawning biomass based on larvae census techniques (see PFMC 1978 for summary of methods). There is, however, some discrepancy between this and other estimates (see below), and NMFS has developed a new method based on egg production that is expected to be more reliable.

Since the anchovy fishery management plan has been in effect (1978), there have been natural decreases in anchovy abundance in the SCB through 1981 (A.D. MacCall, pers. comm.; K.F. Mais, pers. comm.; Stauffer and Picquelle, unpubl. obser. for 1980-1982 data only). However, the use of different census techniques to estimate anchovy biomass has given different results and shown different trends. DFG, using acoustical survey techniques (see Mais 1974), has reported lower anchovy biomass estimates than NMFS (Mais 1978, 1979b, 1980b and pers. comm.) and has shown decreasing biomass since 1978. NMFS, using larvae census techniques (see Smith 1972 and PFMC 1978), have shown much higher anchovy biomass estimates than DFG. Furthermore, according to larvae census estimates, anchovy spawning biomass has increased progressively since 1978 (from 1.3 to 2.8 million short tons between 1978 and 1981 respectively), with subsequent increases in the harvest quota (from 58,333 short tons in 1978 to 420,700 short tons in 1981) (Stauffer 1980, Stauffer and Parker 1980, Stauffer and Picquelle 1981, Stauffer and Charter 1981). Using the egg production method

(see Parker 1980), NMFS reports less biomass than the previous estimates based on the larvae census method showed in 1980 through 1982 and also shows biomass decreasing rather than increasing (G.D. Stauffer and S.J. Picquelle, unpubl. obser.; S.J. Picquelle and R. Hewitt, unpubl. obser.) as previously reported.

In any event, the established California quotas were not met in any of those years (see Klingbeil et al. 1980 and Mais 1981b) because of several factors: 1) high fuel costs, 2) increased processing costs, and 3) dwindling markets for fishmeal (A.D. MacCall, pers. comm.). Because of increases in marketing and processing costs, as well as increases in the cost of fuel, the profit margin to fishermen has become too low to encourage expansion of the southern California commercial anchovy fishery. At present, processers are not placing orders for anchovy, and fishermen are not attempting to harvest them in southern California, but fluctuating economic conditions could change this situation. The anchovy reduction fishery has therefore not been fully pursued in recent years (anchovies harvested from the reduction fishery are processed for fishmeal; this is the major use for anchovies, but they are also harvested for live bait). Pacific mackerel populations have been increasing in southern California since 1976 (R.A. Klingbeil, pers. comm.) and have been providing a more profitable harvest than anchovy. As a result, purse seiners are switching from anchovy to mackerel. Possible negative effects of the mackerel fishery on availability of prey for brown pelicans in the SCB is not known.

Because anchovy harvest quotas in California have not yet been met since the AFMP has been in effect, the California commercial anchovy fishery probably has had little impact on pelicans. However, if fishery conditions change so that optimum yield is more fully utilized and the quotas under the current option (Option 2, Figure 11) are realized, there will be an increased probability of interaction between pelicans and the anchovy harvest. At the present time (1982), however, due to factors completely unrelated to either fisheries or seabird management, the waters offshore southern California are effectively a pelican/anchovy "refuge".

Concern has been expressed over the status of SCB anchovy population (see, for example, Fullerton and Odemar 1980, Radovich 1980, and Mais 1981b). Because there has been a steady downward trend in the anchovy catch and a steady deterioration of older age-classes since 1975 (Mais 1981b), a general population decline (at least through 1981) may have occurred. The decline may be the result of the increasing harvest of this resource in Mexico (see Chavez et al. 1977, Sunada and Silva 1980, Mais 1981b), where a less regulated fishery exists. The Mexican anchovy harvest may be having a negative effect on the U.S. fishery. Between 1969 and 1980 Mexico's catch has risen steadily from 4,000 to 340,000 short tons, while the U.S. catch has varied between 11,000 and 156,000 short tons (NMFS 1980, Mais 1981b). The Mexican catch has surpassed and far exceeded the California fishery since 1977. The 1980 harvest in Mexico, for example, was nearly an order of magnitude greater (although some of the Mexican

catch is from a more southern stock not available to U.S. Fishermen) (Mais 1981b). The anchovy harvest is more profitable in Mexico since the Mexican government subsidizes the cost of fuel for fishermen and processers (A.D. MacCall, pers. comm.). The international aspect of this fishery is a complicating factor making it difficult to formulate effective management plans for the anchovy fishery, let alone the marine wildlife dependent upon it (see Anderson and Gress 1981 and 1983b).

Revisions of the anchovy fishery management plan will provide for joint venture fishing and processing with other countries. While it is too early to predict, this would probably allow for higher anchovy harvests in the future (within the limit of optimum yield). It is not possible at this time to assess the potential impact of joint ventures on the anchovy population. Also, because of current economic constraints, anchovies may not even be a major part of this plan. However, if these trends are reversed and the market is stimulated, making it profitable to harvest and process anchovies, the optimum yield as stated in the present management plan could be tested and achieved. In which case, there could be an impact on food availability for pelicans.

Some fish species (when abundant) that could be major brown pelican diet components are showing population increases. After a long period of decline, Pacific mackerel populations in southern California began recovering in 1976; biomass is now higher than at any

time since 1936, the result largely of fishery constraint (A.D. MacCall, pers. comm.). Yearly increases of Pacific mackerel in the SCB are reflected in this species' slightly increased incidence as a brown pelican forage item since 1978 (Gress et al. 1980; Kelly, Gress and Anderson, in preparation). There is at present some indication that Pacific sardines could return as a significant fishery element in southern California waters (A.D. MacCall, pers. comm.). If sardines do return, no substantial fishery should be allowed until the population becomes large by historical standards, not only for the sake of the fishery itself, but also for the needs of marine wildlife. Because of their larger mean size, sardines could be a superior brown pelican food item over anchovies. Any activity that enhances sardine biomass could also benefit pelicans. This, of course, is only speculation, but it points out the need for close coordination between fishery and wildlife management agencies to monitor the situation as it develops.

Oil Development. The Santa Barbara Channel for a number of years has been the site of offshore petroleum drilling. Hazards to marine wildlife (both acute and sublethal) posed by these activities are well documented (see, for example, Holmes and Cronshaw 1977). The potential of oil well blowouts and the effects of resultant oil spillage in the Channel Islands area were observed in the 1969 Santa Barbara oil spill. The spill did not significantly reach Anacapa Island and so had little impact on breeding pelicans (FG, field notes). Offshore petroleum activity in the SCB has increased and will no doubt intensify in the near future. The newly created Minerals

Management Service offered for bid numerous offshore lease tracts in the Southern California Outer Continental Shelf Lease Sale No. 68 in June 1982. None of these tracts are located in the vicinity of Anacapa Island; however, several previously leased tracts are located near Anacapa (Figure 12) and development may pose a potential threat to the brown pelican colony.

Pelicans and their eggs fouled with oil have been observed on numerous occasions in the SCB and Gulf of California (Figure 13) (FG and DWA, field notes). Several studies have shown that small amounts of fresh oil transferred from feathers to eggs can be highly lethal to embryos in a variety of waterbird species (see, for example, Albers 1977, Hoffman 1978, King and Lefever 1979 and White et al. 1979). Data determining the effect of an oil spill on pelican reproductive success or population dynamics are not available, but mortality of pelicans because of oil fouling has been observed in the Gulf of California on at least two occasions (DWA, field notes). As young of the year pelicans fledge, they initially do not range far from the colony and often congregate in large numbers on the water surface near the colony or on rocks along the nearby shore; here they feed, bath, pouch-wash, "practice" dive, and generally spend a great deal of time in the water (FG and DWA, field notes). If an oil spill occurred during this time and washed up on shore, the impact could be detrimental to young pelicans and mortality could certainly occur. The Santa Barbara Channel is well-known for its numerous natural oil seeps, which represent another source of fouling if pelicans land or feed in the vicinity of these seeps.

The risk of oil to pelicans is not limited to the breeding season. In the fall and winter thousands of migrants from Mexico flood the southern California coast and feed extensively in these waters until they return south (Anderson and Anderson 1976, Briggs et al. 1981). They too could be greatly affected by a major oil spill. Many recent studies have documented detrimental sublethal effects of petroleum hydrocarbons (see, for example, Malins 1977), and further review is not needed here.

Several proposed lease tracts are located within the Channel Island Marine Sanctuary boundaries (NOAA 1980; see following discussion for details) (Figure 12) but were withheld when the sanctuary was established. A final determination to restrict oil development in the Channel Islands Sanctuary was made by NOAA (47 Federal Register 18588, April 30, 1982). However, because marine sanctuary regulations can be suspended depending upon policy changes, oil development within the sanctuary could occur.

Space Shuttle. There is a remote possibility of adverse impacts on the Channel Islands' marine resources from Space Shuttle flights (see Dickson 1978 and Sowls et al. 1980). Some launches may leave from Vandenberg Air Force Base; these and some return flights may have a trajectory path over the Channel Islands (Figure 14) (USAF 1978). The primary concern relative to brown pelicans is the potential of breeding disturbance from sonic booms (particularly those generated by launches). Anacapa Island, however, will apparently only be minimally

affected since it lies outside the primary pathway of both launches and returns (Cooper and Jehl 1980, Jehl and Cooper 1980). Few data are available on the effects on wildlife of sonic booms of the magnitude possible from the Space Shuttle launches (Evans et al. 1979); hence, it is difficult to predict the impacts. Monitoring these impacts during space shuttle overflights will therefore be essential, with mitigating measures undertaken when necessary. Early monitoring is essential so that any possible future losses can be anticipated and averted.

Recreational Fisheries. Recreational fishing can have direct effects on brown pelicans primarily through physical injury caused by fishing tackle. Mortality from this source is relatively insignificant to overall population dynamics, but it can be a significant cause of injury, and in some cases mortality, to newly fledged pelicans near colony sites during the summer months when large numbers of migrant and young of the year are present. Newly fledged pelicans are especially susceptible because they are inexperienced in getting food and readily flock around sport fishing (party) boats that regularly anchor near Anacapa and Los Coronados. Since each island group is relatively close to the mainland, there are usually numerous sports fishing boats around the islands, especially during the summer.

Live anchovies are usually used as bait and for "chumming" (the use of live bait to attract game fish). The bait attracts young pelicans and they often swallow baited hooks or get hooks embedded in

their bills or pouches. In some cases, if care is taken, superficially embedded hooks can be removed without damage. However, if the hook is swallowed or if there is substantial injury to the bird from hook removal, mortality is likely. Even relatively small tears in a pouch, for example, will hinder feeding and death from starvation will likely occur. Pelicans may also become ensnared in monofilament fishing line which can cause serious injury, impair movement and flight, prevent feeding, and cause infection from cuts. Entangled birds also generally die from starvation.

People fishing from piers or small boats also occasionally hook pelicans, and it generally is more of a nuisance to fisherman than a serious problem to pelicans. There are some popular coastal fishing areas, however, where a high frequency of hooking pelicans occurs and injury is common. The problem seems more pronounced near the colony sites where young pelicans are usually more concentrated and are attracted to party boats by chumming. Because the problem has not been examined in depth it is difficult to make an accurate assessment.

Past Conservation Efforts

The most significant "conservation measure" taken, not only for the brown pelican but for the entire southern California marine environment, was the cessation of DDT discharges into the Los Angeles County sewage system in April 1970. Input of DDT residues into the SCB has declined sharply since that time (Carry and Redner 1970,

Redner and Payne 1971). With a decrease in DDE levels, brown pelican reproductive success greatly improved (Anderson et al. 1975, 1977).

The designation of the California brown pelican as an endangered species by both the Secretary of Interior and the California Fish and Game Commission was largely responsible for most other protective measures taken since 1969, despite the lack of a formal recovery plan. There was, however, no relationship between the pelican's endangered status and the elimination of the primary cause of its endangerment; the decline of DDT residues in the SCB was independent of the pelican's status. An important benefit of the endangered status has been the immense public interest and sympathetic attitudes concerning the "plight of the pelican". The general public is largely aware of the DDT-related reproductive failures, and because so many people along the California coast see and enjoy brown pelicans, they have become a popular wildlife resource and one of the symbols of an increasing environmental awareness. Public attitude has therefore played a very important role in the protection of pelicans. Endangered status also has been beneficial in providing protection for essential pelican habitat, which also aids other species that would otherwise be unprotected. Endangered status has also required interagency cooperation on potentially conflicting conservation problems.

In this recovery plan we refer to and discuss several types of refuges, sanctuaries, and protection areas in the Anacapa area with varying functions and extent. For clarification, these are summarized below:

1. Anacapa Island Research Natural Area. Located on West Anacapa Island, this area was established by the NPS in 1971 to protect pelican nesting habitat from human intrusion and disturbance.

2. Anacapa Island Ecological Reserve. This includes a "brown pelican fledging area" offshore from the 1979-1982 pelican colony site on West Anacapa Island seaward to 20 fathoms (120 ft.) in depth (see Figure 15); it was established in 1979 by the California Fish and Game Commission to prevent shoreline and nearshore sources of disturbance to breeding pelicans and to provide protection for newly fledged pelicans (see Figure 15). It is enforced jointly by DFG and NPS.

3. Channel Islands Marine Sanctuary. Encompassing a 6-mile zone around the northern Channel Islands and Santa Barbara Island (see Figure 12), this sanctuary was created in 1980 by National Oceanic and Atmospheric Administration (NOAA); it regulates certain human activities that may be potentially damaging to the

marine environment. It does not regulate the natural resources for fishing, or recreational and scientific use of these waters. The Channel Islands National Park jointly administers this sanctuary.

After the 1970 breeding season (when only one young was fledged from 550 nesting attempts), recommendations were made to the NPS (Gress 1970) to prohibit all access to the colony area on West Anacapa Island (with the exception of the tidepool areas at Frenchy's Cove) (see Figure 15). As a result, West Anacapa was declared a "Research Natural Area" to be closed to the public. Large permanent signs were posted on both the east and west ends of West Anacapa prohibiting entry. NPS rangers and DFG marine game wardens have been diligent within their capacity in enforcing the closure.

The public has been well-informed of the closure through numerous media announcements; there have been few known violations to date. To ensure a disturbance-free environment, from 1971 through 1977 there were minimal research activities on West Anacapa, limited mostly to monitoring, data gathering while banding young, and collecting pelican materials for analyses at the end of each breeding season (see Anderson 1977). Detailed and intensive studies of breeding biology and feeding ecology of the Anacapa pelicans began in 1978. This research has been conducted without intrusion into the colony while pelicans are nesting, except to band samples of young that are 4 to 8 weeks old.

In 1979 the California Fish and Game Commission set aside the Anacapa Island Ecological Reserve, which provided for a "Brown Pelican Fledging Area" offshore West Anacapa (California Fish and Game Commission 1981). The regulations restrict all boat and human activity offshore an area that encompasses the colony sites used by pelicans in 1979-1982 seaward to a water depth of 20 fathoms between 1 January and 31 October (Figure 15). The restricted area provides a buffer zone between the colony and the sometimes intense commercial and recreational use of these waters; it also protects newly-fledged young pelicans that often congregate there in large numbers. Initially (1979) the closure was in effect between 31 May and 31 July. These dates were established largely to protect fledglings (although fledging can begin in early May and extend to late October, depending on the onset of breeding). As a result of the expanded breeding effort in 1979, the closure dates were extended in 1980 to the period of 1 March through 31 July. Although protecting newly-fledged young is important, it is even more important for the closure to be in effect at the beginning of the breeding season when pelicans are most sensitive to disturbance (FG and DWA, field notes). In response to this need, the closure dates were extended by the California Fish and Game Commission in September 1981 to include the entire period of time (1 January through 31 October) when breeding pelicans and unfledged young might be present on Anacapa (i.e., from initial nest-building to last fledging). The new closure dates were established by mandate (California Assembly Bill AB 1111) as part of a streamlining measure so that the Fish and Game Commission would not have to make decisions

each year based on annual variability or the timing of pelican breeding (onset of breeding has varied from early January to mid-May; see Figure 9). In actual practice, the closure will probably be enforced within the new closure dates only when pelicans are present in the breeding colonies. The designation of this protection zone as a "fledging area" needs to be redefined both in name and concept.

In principal, the closure as it exists provides necessary protection for essential habitat of breeding pelicans, but the rigidity of the boundaries do not allow for natural year-to-year variability relative to colony location. Pelicans do not always utilize the same areas for nesting on West Anacapa each year. These areas, therefore, cannot be accurately determined from one year to the next. Locations of colony sites on West Anacapa from 1970 through 1981 are shown in Figure 16; nest sites can be located anywhere within this area where suitable conditions exist. Furthermore, during any given year, various sub-colonies may occur at widespread locations (see especially the sub-colony locations of 1970 and 1978 in Figure 15). It is not clear why pelicans shift site locations. Ectoparasite avoidance has been cited as a possible explanation (see King et al. 1977a and b, Duffy 1980), but observations thus far do not indicate this to be an important factor on Anacapa (P.R. Kelly, pers. comm.). There is a presumption in the regulation that the colony will always be located within the present closure (delineated in Figure 15). By coincidence the 1979-1982 colony sites were located within these boundaries; however, colony or sub-colony sites will likely be located elsewhere in the future.

Management recommendations for the protection of pelican nesting and foraging areas on and about Anacapa Island were developed for the NPS in 1980 (Gress 1980). Relative to these recommendations, the NPS has continued to protect pelican breeding areas, but measures proposed to establish a broader offshore protection area surrounding Anacapa Island to protect foraging areas and food supplies were not implemented. Because the recommendations pertaining to protection of offshore zones require interagency agreement and cooperation, the NPS can only initiate and coordinate such actions. There has been little support for this recommendation by other agencies, primarily because there are few data to substantiate the importance of these waters to breeding brown pelicans; furthermore, this area is heavily utilized by both commercial and recreational interests. Consequently, no action was taken to establish a broader offshore protective zone. The Channel Islands National Park Natural and Cultural Resource Management Plan (NPS 1980) contains a number of recommendations to protect brown pelicans. The most important are: continue protection of pelican colony sites from human disturbance, continue cooperative efforts with DFG in maintaining and enforcing the Anacapa Island Ecological Reserve pelican closure, establish restricted airspace corridors, prohibit access to essential roosting habitat, and encourage cooperative agreements with other agencies with regard to management and research activities in adjacent waters.

The Channel Islands Marine Sanctuary was created in 1980 by the National Oceangraphic and Atmospheric Administration under the Marine Protection, Research and Sanctuaries Act of 1972. The sanctuary was established to preserve the marine resources of the waters surrounding the northern Channel Islands and Santa Barbara Island extending 6 nautical miles offshore (see Figure 12). Although it regulates potentially damaging human-related activities, such as sea bed construction, oil and mineral extraction, dumping of contaminants, aircraft intrusion, and the operation of commercial vessels (excluding commercial fishing, kelp, research, and sports fishery vessels), it does not prevent offshore sources of disturbance from the surface, nor does it offer protection for local (i.e. near the breeding colony) food resources.

Conceptually, the sanctuary provides a 6-mile "oil protection zone" within which new petroleum operations are prohibited, but it has little effect on development of the few existing leases within sanctuary boundaries (NOAA 1980). In the event of an oil spill (from either tankers or platforms), this buffer zone presumably would provide time and distance for break-up of oil discharges before reaching nearshore communities, as well as increase available response time for at-sea clean-up and oil spill containment. The 6-mile zone would also provide enough distance to reduce visual and acoustic disturbances of petroleum development which may affect marine wildlife and the aesthetic qualities of the island (NOAA 1980). Although National Marine Sanctuary Regulations prohibit new hydrocarbon

activities within the sanctuary, these regulations were temporarily suspended in 1981. However, following the development and review of an economic impact report, the regulations are again in force. Pending review of the desirability of continuing the regulations, they could again be suspended at a later date.

Marine sanctuary regulations allow cargo-carrying vessels, including oil tankers, to operate to within one nautical mile of the island. While most cargo vessels generally stay within the prescribed sea lanes in the Santa Barbara Channel, their doing so is not mandatory (the southbound sea lane varies from 2.5 to 3.0 miles from Anacapa while the northbound sea lane is about 5.5-6.0 miles away). Because of an apparent greater probability of a spill occurring from a tanker than from a platform (Bureau of Land Management Lease Sale No. 68, Environmental Impact Statement 1981), the possibility of tanker traffic outside the established sea lanes as close as one mile from Anacapa poses a potential threat to pelicans.

At present, it is not known how the sanctuary will eventually affect brown pelicans and other marine wildlife, but it is hoped that it will at least help in preventing aircraft disturbances and, most importantly, that it will protect the Anacapa colony from oil industry accidents. If, however, oil extraction or increased tanker traffic occurs within the sanctuary boundaries, much of the value of the sanctuary to wildlife resources would be nullified.

In summary, conservation efforts taken to date appear to assure the continued long-term protection of brown pelican breeding sites in those areas in which the National Park Service has jurisdiction. This protection, however, does not extend to Los Coronados or Scorpion Rock; both areas are subject to human disturbance. More conservation efforts are needed for protection of brown pelican food resources; these must be given high priority in management plans. Essential roosting areas also have little protection other than incidentally under other actions, even though USFWS recognizes the importance of endangered status in justifying protection of coastal wildlife habitat (USFWS 1980a). Most roosting areas pertaining specifically to pelicans are still ill-defined, but pelican roosts are most likely areas already defined as important for other coastal wildlife species.

This recovery plan will address each of the above issues and make recommendations accordingly. The plan does not, of course, initiate the recovery effort; steps taken to protect this population began in 1969. Protection of the breeding birds and their nesting grounds and the establishment of monitoring programs for both pollutants and pelican breeding success were early accomplishments. There has been considerable research effort since 1969 investigating and elucidating pelican problems, while continually monitoring its status. Once reproduction began showing improvement and pollutants no longer appeared to be the major factor limiting productivity, further research indicated that variable food supplies were associated with fluctations in pelican productivity. Conservation of pelican food

supplies and protection of foraging and breeding habitat have largely replaced DDT/pelican relationships, the original cause of endangerment, as the focus of management measures to ensure recovery. For full recovery, brown pelicans must have adequate food supplies but also must be allowed to nest, feed, and raise their young in an undisturbed environment. The intent of this plan, therefore, is to formalize past conservation efforts and plans already in effect, to establish further steps toward recovery, and to remove any threats on the recovery itself.

PART II

RECOVERY

OBJECTIVES

The primary objective of the California Brown Pelican Recovery Plan is to restore and maintain stable, self-sustaining populations throughout the subspecies' range. The accomplishment of this goal will require achievement of the following criteria:

1) Maintain existing populations in Mexico.

2) Assure long-term protection of adequate food supplies and essential nesting, roosting and offshore habitat throughout the range.

3) Restore population size and productivity to self-sustaining levels in the SCB (both Anacapa and Los Coronados).

To fulfill 3), the following specific criteria should be achieved for the SCB population in addition to 1) and 2), for consideration of reclassification or delisting:

(a) When any 5-year mean productivity for the SCB population reaches at least 0.7 young fledged per nesting attempt from a breeding population of at least 3000 pairs, the California brown pelican should be considered for reclassification to threatened status.

(b) When any 5-year mean productivity for the SCB population reaches at least 0.9 young fledged per nesting attempt from a breeding population of at least 3000 pairs, the California brown pelican should be considered for delisting.

Thus, consideration for reclassification to threatened status would require a total production averaging at least 2100 fledglings per year over any five year period. Consideration for delisting would require an average of at least 2700 fledglings per year over any five year period.

Attaining the above goals would probably be indicative of stable, self-sustaining populations of P. o. californicus throughout its range. At any point that additional population or reproductive data become available to further refine the estimates upon which these criteria are based, the criteria can be adjusted. It can be seen from Table 2 that SCB populations are approaching these criteria.

Specific criteria regarding population performance indicative of "recovery" are difficult to precisely identify because of inherent variability. Natural history data (such as productivity, breeding population size, and number of young fledged) prescribed as recovery goals are nonetheless important to estimate because of their use by resource managers, but it must be emphasized that these data can only be approximations. The development of more specific management criteria (based on models developed from field data) to better assess brown pelican populations and breeding performances, and continual

monitoring necessarily accompany any decisions based on the above criteria. Population monitoring can be extended to other seabird species simultaneously, particularly in the SCB. Because many seabird populations are severely reduced from historical numbers in the SCB (Hunt et al. 1979, 1980), the conservation of the California brown pelican is important to the conservation of marine avifauna in general.

To maintain self-sustaining populations, brown pelicans need an undisturbed breeding area, ample food supplies, a pollution-free environment and adequate roosting areas. To restore and maintain the SCB population, each of these limiting factors must be addressed. Habitat protection, including both nesting and foraging habitat, and conservation of food resources are essential. Although variability in food is probably the major limiting factor of the California brown pelican, food supplies have no formal protection other than the establishment of a "forage reserve" under the Northern Anchovy Fishery Management Plan.

In complex ecosystems food resources are difficult to identify, let alone manage. One of the greatest problems in brown pelican management now is the lack of precise data on food and feeding ecology (studies are in progress). Protection of food supplies is much more difficult and complex than affording protection to nesting sites; the latter is a fairly straight forward task and the course of action recommended in most management plans. The problems are manifold: how does one protect a mobile food source? How does one establish

management policies for pelicans when few related data exist from the fishery? How does one reconcile economic factors of the fishery with biological necessities of an endangered species to the agencies charged with managing the fishery? This component of the recovery plan is the most difficult to deal with, yet from the pelican point-of-view it is perhaps the most critical.

Data showing cause-and-effect relationships of marine birds and mammals with their food resources are generally few and extremely difficult to obtain, and because of this, relationships to commercial fisheries cannot easily be determined. Thus, based primarily on the "potential" of a negative environmental impact occurring, agencies managing the fisheries are reluctant to establish policies that may further restrict harvests of commercially valuable fish. Despite considerable research effort, it is often difficult to give specific information or data to justify recommendations or to show that certain actions may adversely affect a species and/or its habitat. The data required to give these precise answers may never become available. Yet, if California brown pelican populations are to be maintained, decisions must be made on the best data available. Thus, a more conservative approach favoring the pelicans should be taken in areas where the information is imprecise and open to interpretation.

It is doubtful that pelicans can be induced to increase their population size or to improve productivity over that which environmental conditions would allow. If conditions are right, pelicans will reestablish themselves at former colony sites. These

conditions include recentness of past nesting, nearby availability of food, the habitual use of the area as a roost, and freedom from disturbance and predation. There is no present need, therefore, for habitat rehabilitation or reestablishment of former colonies through propagation programs such as restocking and captive breeding. If habitat and food supplies are managed properly, brown pelicans are quite capable of making it on their own.

CALIFORNIA BROWN PELICAN RECOVERY PLAN STEP-DOWN OUTLINE

OBJECTIVE: To restore and maintain stable, self-sustaining populations of the California brown pelican throughout its range by: 1) maintaining existing populations in Mexico; 2) assuring long-term protection of adequate food supplies and essential nesting, roosting, and offshore habitat throughout the range; and 3) restoring population size and productivity to a self-sustaining level in the Southern California Bight so that the subspecies can be delisted.

1. Establish international conservation program with the Mexican government to protect brown pelican populations and their colony sites in Mexico.

    11. Develop and implement joint USFWS-Fauna Silvestre management plan to protect Mexican pelican populations and colony sites.

        111. Develop and implement a plan to protect colony sites from human disturbance.

        112. Determine essential habitat and provide protection.

        113. Develop and implement plan to provide protection for post-breeding migrants off U.S. coast and in Mexico.

114. Coordinate protection of pelican food supplies in Mexican waters with other Mexican agencies.

12. Encourage research and monitoring programs of breeding populations in Mexico by Mexican universities and authorities.

121. Continue basic research on pelican biology in Gulf of California.

122. Continue banding and color-marking program.

123. Develop and implement long-term monitoring plan for Medican populations and establish methodology for consistent monitoring.

1231. Monitor breeding and non-breeding pelicans to assess population status.

1232. Assess and monitor environmental impacts that may adversely affect pelican populations.

13. Develop and implement plans for public information and conservation education in Mexico.

131. Develop bilingual pamphlets and distribute to fishermen, tourists, and local community.

132. Study feasibility of establishing public viewing areas of colony sites on select islands.

133. Aid in design, construction and placement of bilingual signs warning of presence of pelican and seabird colonies.

14. Promote and expand international aspects and agreements for island conservation programs through international conservation organizations.

15. Establish committee for coordination of conservation efforts in Mexico.

16. Encourage Mexican government to manage fishery resources to ensure availability of prey (see also 114).

2. Maintain self-sustaining brown pelican breeding populations in the Southern California Bight including northwestern Baja California coast.

21. Prevent human disturbance and interference at colony sites.

211. Protect colony site on Anacapa Island.

2111. Continue restriction of human access to West Anacapa during pelican breeding season, including research-related activities and non-scientific visitation.

2112. Continue offshore protection of waters from colony site seaward to 20 fathoms depth.

21121. Evaluate and revise current regulations as written in Title 14, California Administrative Code, pertaining to fledging zone closure.

21122. Develop effective means for patrolling and enforcing regulations, with periodic review.

21123. Develop and implement public information program to help ensure compliance with regulations.

2113. Restrict airspace under 3000 feet elevation over Anacapa Island and one nautical mile over the waters around Anacapa.

21131. Revise current Fish and Game Code and NOAA regulations.

21132. Develop and implement public information program to help ensure compliance with regulations.

2114. Delineate essential habitat for breeding.

2115. Study feasibility of requiring cargo-carrying vessels to operate only in established sea lanes within the Channel Islands Marine Sanctuary.

212. Encourage Mexican government to grant sanctuary status to Los Coronados.

213. Develop contingency plans to protect infrequently used historical colony sites as nesting occurs.

214. Afford protection to Scorpion Rock.

2141. Determine ownership of Scorpion Rock.

2142. Secure Scorpion Rock or otherwise afford protection.

2143. Restrict access and enforce closure.

2144. Post signs.

215. Develop and implement measures to minimize injury to foraging pelicans resulting from recreational fishing (see also 265).

2151. Contact boat operators to advise them of methods to disperse pelicans, handle hooked pelicans and remove hooks and lines.

2152. Develop and distribute written material to boat operators and issue press releases with above information.

2153. Discourage chumming during summer months near the colony sites when young pelicans are present.

22. Protect pelican food resources and feeding habitat.

221. Determine offshore essential habitat.

222. Study feasibility of establishing a one nautical mile protection area surrounding Anacapa Island to minimize impact of commerical fisheries.

223. Protect pelican food supplies.

2231. Initiate Section 7 consultation with NMFS when revised Anchovy Fishery Management Plan becomes available.

2232. Consider use of anchovies by brown pelicans and other marine wildlife in revision of AFMP.

22321. Study feasibility of establishing a lower anchovy fishery quota, and modify if deemed necessary.

22322. Study feasibility of increasing anchovy forage reserve.

2233. Develop contingency plans for pelican utilization of sardines and Pacific mackeral.

2234. Consider appointing a marine wildlife representative to anchovy plan development team and advisory panel of Pacific Fishery Management Council.

224. Encourage efforts for international cooperation with Mexico on anchovy harvest quotas and fishing regulations through cooperative agreements.

23. Protect major roosting areas.

231. Identify and assess essential roosting sites.

232. Develop management plan for each essential site.

233. Secure and protect important roosting sites as needed.

234. Limit human access on public lands where needed.

235. Determine essential habitat for roosting areas.

24. Monitor pelican population to determine success of management, status of population, and environmental impacts.

241. Develop and implement long-term monitoring plan for California brown pelican population and establish methodology for consistent monitoring.

242. Conduct long-term monitoring of SCB population.

2421. Continue annual breeding surveys and determine annual production.

2422. Continue surveys of non-breeding pelicans.

243. Monitor pelican dietary components.

244. Monitor environmental impacts that have potential to affect reproductive success.

2441. Issue collecting permits for monitoring purposes only after disturbance and other possible effects are carefully evaluated by involved agencies.

2442. Collect addled eggs and crushed eggshells incidentally at conculsion of breeding seasons; collect fresh eggs only if disturbance to the colony has a low probability of significantly affecting productivity.

24421. Analyze for organochlorine pollutants.

24422. Determine eggshell thicknesses.

2443. Monitor exposure of pelicans to oil.

2444. Monitor impact of Space Shuttle sonic booms if flights over Channel Islands occur.

2445. Maintain surveillance for other potential environmental problems which may adversely affect pelican populations.

25. Continue research programs to gather information for management and conservation of brown pelican populations.

251. Continue resource utilization studies in the Southern California Bight.

2511. Continue studies of pelican feeding ecology.

2512. Determine major pelican foraging areas during the breeding season.

252. Continue studies investigating pelican/anchovy relationships.

2521. Continue examining potential impacts of commercial fisheries on food availability for pelicans.

2522. Continue studies of relationships between prey abundance and/or availability and pelican productivity.

2523. Continue studies of pelicans as indicators of fishery stocks.

2524. Conduct studies of relationship of fishing activities on fish behavior and subsequent effect on prey availability to pelicans.

253. Conduct studies of population estimates, genetic variation, disease, distribution, and daily activities.

2531. Conduct routine aerial and shipboard surveys in colony areas during breeding season.

2532. Continue banding and color-marking program.

2533. Continue analysis of band sightings and recoveries.

2534. Carry out plans for radiotelemetry studies.

2535. Carry out plans for a genetic study.

2536. Develop assessment techniques relating pelican populations to carrying capacity and population parameters.

2537. Conduct shoreline and/or aerial surveys during non-breeding period along the coasts of California, Oregon and Washington.

2538. Carry out disease and parasite assessment study.

254. Develop management models.

2541. Develop model to examine management alternatives.

2542. Develop model of pelican reproductive effort and success.

2543. Develop model of forage availability.

2544. Develop integrated life-history model of brown pelican popualtion dynamics.

2545. Develop model relating pelican life-history parameters to oceanographic data.

255. Establish advisory committee to coordinate and recommend guidelines for research, monitoring, and management activities for brown pelicans.

26. Conduct a public information and conservation education program.

261. Develop educational and interpretive program.

262. Provide current information to news media.

263. Develop information sheets and posters describing restrictions and regulations to pelican breeding areas and closures to be posted and/or handed out at marinas and harbors between Santa Barbara and San Diego.

264. Notify commercial users of waters near colony sites of restrictions and closures pertaining to pelicans.

265. Develop and distribute information advising sports fishing boat operators of methods to minimize injury to pelicans from recreational fishing (see also 2151-2153).

27. Enforce existing state and federal regulations.

Narrative

1. Protect Pelican Populations in Mexico

The central populations of the California brown pelican (primarily in the Gulf of California and southern Baja California) have not experienced the impacts of massive and persistent reproductive failures and resultant declines that affected the SCB populations. There is little DDE contamination in this area and eggshell thinning is uncommon (Anderson 1972; DWA, unpublished data). One of the greatest threats to these colonies is disturbance from tourists, fishermen, boaters and educational groups. Colony sites are generally accessible by boat, and productivity in some has been significantly reduced by human disturbance (Anderson and Keith 1980; DWA, field notes). USFWS and Fauna Silvestre should develop a joint management plan to protect these colonies (1, 11, 111). Management plans also need to address the determination of essential habitat (112) and protection of post-breeding migrants along the Pacific coast of the U.S. and Mexico (113). USFWS should also coordinate protection of pelican food supplies in Mexican waters with appropriate Mexican agencies (114).

Research and monitoring programs of breeding populations in Mexico by Mexican universities and authorities should be encouraged (12), including a continuation of non-disturbing studies on various aspects

of pelican biology (such as feeding ecology, distribution, and population estimates) (121) and banding and color-marking programs (122). Long-term monitoring plans should be developed and implemented for Mexican pelican populations and methodology established for consistent monitoring (123) of both breeding and non-breeding birds (1231). An assessment of potential adverse environmental impacts on pelican populations in Mexico should be conducted and a monitoring program developed (1232). The major goal in applying the objectives of this plan to brown pelican populations outside U.S. borders is to promote management, monitoring, and research by Mexican agencies and universities and also to promote an interest and means in Mexico for international conservation programs.

Public information and conservation education programs as a joint venture between Fauna Silvestre and USFWS (and possibly including conservation organizations such as the National Audubon Society and The Nature Conservancy) need to be developed and implemented (13). With increased tourism in Baja California and the Gulf of California, there is great potential for colony disturbances. Well-meaning visitors to these areas have little concept of the extent of disruption that their visits may cause to nesting pelicans and other seabirds. Bilingual information and educational pamphlets should be distributed to fishermen and tourists (131); bilingual signs should be placed on islands warning of the presence of pelican and seabird colonies (133); and public viewing areas of colony sites might be constructed on some islands (132). These measures would perhaps help promote public awareness and reduce colony disturbances.

International agreements regarding island conservation programs should be promoted and expanded by international conservation organizations (14). A committee comprising Mexican and U.S. conservation interests and expertise should be established to initiate, develop and coordinate actions proposed for the protection of brown pelicans and other seabirds, their habitat, and food resources in Mexican waters (15). Since the majority of *P. o. californicus* breed in Mexico, managing fishery resources there to assure availability of food to pelicans should be encouraged (16).

2. Maintain self-sustaining brown pelican breeding populations in the Southern California Bight including northwestern Baja California Coast

The following steps for the recovery of SCB populations are more specific and detailed than those outlined for Mexico (other than the Mexican portion of the SCB). The reasons are multiple: 1) the demonstrated immediate problems and the need for immediate recovery are in the SCB; 2) most of the SCB is within U.S. authority; 3) conservation and research programs are already underway in the U.S. portion of the SCB; and 4) Mexican agencies need to detail their own specifics in Mexican waters.

Human disturbance and interference at colony sites should be prevented to help maximize reproductive success (21). Such protection should be afforded every colony site.

Injuries to pelicans from being hooked, swallowing baited hooks, or becoming entangled in monofilament fishing line used by sports fisherman must be minimized (215). Personal contacts should be made with party boat operators whenever possible advising them of the problems and possible ways of dispersing pelicans from around a boat (such as spraying water from a hose); they should also be instructed in how to handle pelicans that have been hooked and least damaging methods of removing hooks and lines (2151). Individuals on party boats need to be advised of these methods by operators. Fishermen must be made aware that a torn pouch or entanglement in monofilament line most often results in the death of the bird. News releases should be issued to the press to bring public attention to this problem. Written material containing this information should be developed and distributed to all party boat operators and posted or made available to the public at marinas and harbors between Santa Barbara and San Diego (2152). Newly fledged pelicans would be hooked far less frequently in colony areas if they were not attracted to party boats by chumming. This practice should therefore be strongly discouraged near the breeding colonies (Anacapa Island in particular) during the summer months when young pelicans are usually present in large numbers (2153).

Anacapa Island. The establishment by NPS of West Anacapa Island as a research natural area has assured protection for the colony there (211). The Channel Islands National Park staff since 1974 (when W. H. Ehorn became superintendent) has treated West

Anacapa as a wilderness island, in large part to protect the island habitat as well as the pelicans. The restrictions prohibiting access to the colony area have been well-enforced. The closed area and current NPS policies to protect the colony should be continued (2111). In this regard, the NPS is to be commended for the protection given the Anacapa pelican colony.

Low-level civilian and military flights over or near the Anacapa Island pelican colony are frequent and can cause disturbance to nesting pelicans. Existing DFG regulations (Fish and Game Code 10501.5) prohibit overflights below 1000 feet elevation over Anacapa, Channel Islands Marine Sanctuary regulations also prohibit overflights below 1000 feet elevation within one nautical mile over the waters around Anacapa. These regulations, however, are frequently violated. Airspace under 3000 feet elevation over Anacapa and at least one nautical mile over the waters around Anacapa should be considered essential habitat and all aircraft prohibited, with the exception of rescue or other emergency operations, those flights essential for national defense, and NPS and military helicopter landings on East Anacapa (2113). These exceptions noted above, whenever possible, should also avoid low flight or flight close to the pelican colony on West Anacapa during the nesting season. Exceptions should also be made for aerial surveys needed to assess the pelican population, but these flights should be approved by DFG and NPS and all efforts made to minimize disturbance to breeding pelicans. Regulations need better enforcement and known violators warned

and/or prosecuted. Because West Anacapa is a wilderness island, few persons witness possible violations, thereby making it difficult to enforce airspace restrictions. A public information campaign, therefore, is needed to inform the public (particularly private pilots and the military) of the restrictions, the importance of complicance, and consequences of non-compliance (21132). Section 7 consultations should be initiated with the Federal Aviation Administration (FAA) and the military (U.S. Coast Guard and U.S. Navy). The Fish and Game Code should be revised to extend the restricted airspace over Anacapa to 3000 feet elevation; revision would require legislative action (21131). NOAA is similarly urged to ammend their regulations for the waters one nautical mile around Anacapa (21131). The revised restrictions should then be designated on civilian and military flight charts (21131). It is important to also note that pelicans and gulls soar over the nesting islands in excess of 1000' altitude and pose a potential aircraft collision hazard.

Cargo carrying vessels can operate to within one nautical mile of any of the Channel Islands within the Channel Islands Marine Sanctuary. Because of the threat to pelicans of a potential oil spill from tankers this close to the islands, cargo vessels should be required to operate only within the established sea lanes (2115).

Anacapa Island Ecological Reserve. Protection of the offshore area adjacent to the Anacapa colony site should continue (2112). While the basic idea of a closure as part of the Anacapa

Island Ecological Reserve is a good one and has worked well, there needs to be more flexibility to account for yearly breeding variations. The regulations as stated in Title 14, California Administrative Code (California Fish and Game Commission 1981) pertaining to the closure boundaries are in need of revision (21121). Several alternatives are possible: 1) Maintain the boundaries as presently written in the regulations until the colony shifts elsewhere, at which time the closure boundaries would be redefined and new regulations considered. 2) Extend the closure boundaries to include all known nesting sites (as delineated on Figure 17) and enforce the entire area as a protection zone during the established closure dates; this would result in a permanent closure. 3) Establish the closure boundaries as indicated on Figure 17, recognizing this area as one where pelican nesting can occur anywhere. Once the colony site(s) has (have) been determined for that particular breeding season, the actual closure would be set to include only the active areas. 4) The closure would be defined each year based on the breeding area location.

None of the alternatives given is a completely satisfactory solution to protecting breeding pelicans and their habitat on Anacapa while still allowing multiple use of these waters. Option 1 is, of course, a temporary, no-action alternative that postpones a decision until it becomes necessary to act. This option works well as long as pelicans continue nesting in the same area. Frequent users of these waters have become familiar with the

regulations as they now exist. Option 2 offers the best protection to pelicans, but is probably unworkable and impractical because of the heavy recreational use of the waters along the north shore of West Anacapa. This option would create a permanent sanctuary and close off a wide area for most of the year. Because Option 2 is highly restrictive and would greatly affect the many users of this area, it would no doubt be unacceptable to recreational interests, and would cause many enforcement problems. Option 3, or some variation, is probably the best alternative from the most practical viewpoint. It has the advantage of allowing flexibility to the agencies, while still permitting recreational use. It suffers from the problem of not knowing when the pelicans will start nesting; if they nested late, the problems of Option 2 would occur. Also, when the narrower boundaries conforming to the current year's colony site are set, this could lead to confusion by the public as to where the actual boundaries are located. Option 4 could ideally be the best solution, but because the closure boundaries would have to be determined and approved by the Fish and Game Commission each year, the administrative procedures are such that a considerable period of time could elapse in which pelicans would not be protected before the Commission could make a final determination. There is also the possibility that the Commission would not approve a closure in some years. In Option 4 the possible ephemeral nature of the closure's boundaries would no doubt create much public confusion and enforcement difficulties.

Within present legal and administrative limitations these options appear to be the main alternatives available; perhaps other, more workable solutions are possible if special consideration or exceptions in current policy can be modified. These possibilities should be explored by the agencies. Option 3, at present, is the best alternative and is the choice of this plan. DFG needs to consider the ramifications of each alternative and establish a workable formula in consultation with USFWS and NPS.

Because of the difficulty in determining the boundary of the closure by depth, most users of these waters are uncertain where the boundary of the protection zone lies (most recreational vessels lack fathometers to determine depth). The regulations should therefore be revised to include an approximate linear measure of the distance from the shoreline to where the water depth is 20 fathoms (21121).

NPS rangers and DFG marine game wardens are responsible for enforcing regulations protecting brown pelicans; a periodic review of enforcement problems between the agencies is needed for more effective control of enforcement procedures and to review difficulties and problems encountered in enforcing the regulations (21122). Enforcement personnel need to be kept up-to-date regarding the status of the pelican population and recovery efforts.

More effective public information programs are needed so that the regulations become public knowledge (21123). News releases should be sent out to the media by DFG and/or NPS, notifications sent to all commercial operators of these waters (DFG), and regulations posted via attractive posters and/or handouts at harbors and marinas along the coast from Santa Barbara to San Diego (DFG).

Other Colony Sites in California. Future possible breeding efforts on Santa Barbara Island seem assured of receiving adequate protection from the NPS. Scorpion Rock, on the other hand, is essential habitat and is in need of protection (214). Ownership of the island is uncertain and access is not restricted. Until recently, Scorpion Rock was assumed to be privately owned by Mr. Pier Ghrerini, owner of the eastern end of Santa Cruz Island. However, the islet may be State of California property or it may be under Bureau of Land Management jurisdiction. The area is a popular one for boating, fishing and diving, and is near a well-known anchorage; access to the island is not difficult, and people have been seen climbing on it. In 1974, Mr. Ghrerini cooperated with DFG in posting the island, but in subsequent years the signs were vandalized and disappeared. Pelicans have not nested there since 1975, and interest in its protection as a breeding site has waned.

Regardless of ownership, access to Scorpion Rock should be permanently restricted (2143), but restrictions of the water around the island are not recommended at this time. If the island could be kept disturbance-free, pelicans might breed there once again. Even with no pelicans nesting there, the island is an important roosting area for pelicans and other seabirds in both breeding and non-breeding periods. Since ownership is uncertain, it should be ascertained through a title search (2141) or some other means. If it is determined that Scorpion Rock is State owned, DFG should take lead responsibility to ensure its protection (214). If it is Federally owned, the agencies involved should implement cooperative agreements with DFG regarding its protection (214). If the islet is privately owned, the various options available to secure it as a permanent sanctuary should be explored (2142), which is perhaps the surest way of providing long-term reliable protection. In the latter case, a joint venture between The Nature Conservancy (operator of the Santa Cruz Island Preserve), NPS, and DFG would seem appropriate in initiating steps to secure the property. Alternatively, securing Scorpion Rock might be accomplished through a long-term cooperative agreement with the owner to restrict access. NPS and DFG would have joint enforcement responsibilities (2143). Posting with prominent and more permanent signs, such as those used by the NPS on West Anacapa Island, should be a minimum step taken to protect the island (2144).

Since brown pelican breeding in other areas of southern California is a rare and unpredictable event, giving permanent protection to these areas at this time is not practical. Some former breeding areas, such as Prince Island, Middle Anacapa Island, and Bird Rock near Point Lobos, are already reasonably protected with policies of restricted access. Protection for other seabird species is nonetheless an essential agency responsibility, although not part of the brown pelican recovery plan. If infrequently used colony sites become active pelican nesting areas, ad hoc contingency plans need to be developed and put into effect without delay (the first few weeks of a new breeding effort are the most critical in terms of disturbance), as was the case with the Santa Barbara Island colony in 1980 (213). Such cooperation is possible in the Channel Islands through existing NPS and DFG agreements. In any case, if the appropriate agencies take cooperative steps to acquire and/or protect all offshore seabird nesting and essential roosting sites, pelican protection would be greatly enhanced.

Los Coronados. USFWS should initiate contact with Fauna Silvestre in Mexico with regard to granting sanctuary status and limiting human access to Los Coronados (212), although this could be a function of the joint coordinating committee recommended previously (15). Although technically Los Coronados access is already prohibited for reasons other than pelican protection, the restrictions are rarely enforced and colony disturbances have

occurred, including the presence of seasonal fishing camps on Coronado Norte shores. The Mexican government has created island wildlife sanctuaries in the Gulf of California (see Anderson and Keith 1980). Expanding the process may be all that is required to provide adequate protection at Los Coronados, but there has been little action to date. Providing protection to Los Coronados is certainly as important to the SCB pelican population as protecting Anacapa. University groups in Ensenada, La Paz, Mazatlan, Puerto Vallarta and Mexico City are pursuing studies of and developing conservation efforts for brown pelicans and other seabirds. There will be an eventual need to contact and coordinate this recovery plan with organizations and agencies in Mexico (15).

3. Protect Pelican Food Resources and Feeding Habitat (22).

The status of the anchovy population in the SCB is important to the well-being of the SCB pelican population. Food resources have probably become the brown pelican's primary limiting factor and should be protected (223); in years when anchovies are more abundant, pelicans appear to have higher reproductive performance. The needs of brown pelicans and other marine wildlife should specifically be considered in the revision of the anchovy management plan (2232). In light of heavy wildlife dependence on this resource in the SCB, any expansion of the anchovy fishery in southern California should be viewed with caution. If the anchovy catch had reached the higher quota limits set in recent years,

pelicans (and other marine wildlife) might well have experienced food shortages and, hence, lower productivity. Unless other appropriate fish species become abundant enough to be significant pelican prey items, a more conservative anchovy harvest should be proposed to ensure adequate food supplies for optimum pelican reproduction (22321). Another option to consider is a larger forage reserve (22322). A major need in managing and monitoring this fishery is a good estimate of anchovy biomass. There is also a great need for significantly more data on predator use of anchovy by both fish and wildife. Monitoring the interactions of commercial fisheries and brown pelicans is also important in understanding these relationships.

National Marine Fisheries Service makes the final decision on the type of anchovy fishery management program that is adopted. Because anchovy harvest quotas have potential for adverse effects on a species that is considered endangered, NMFS is required to initiate formal Section 7 consultation with USFWS with regard to the Northern Anchovy Fishery Management Plan. NMFS initiated consultation on 17 April 1978. The resultant biological opinion of USFWS discussed the pelican/anchovy interaction in relation to current information; a determination that brown pelicans were not jeopardized by these activities was made subject to a number of conditions. Among these conditions was "the maximum annual harvest of anchovies should not exceed 450,000 short tons when the anchovy biomass is in excess of one million tons" (Option 1 Figure 11); this would allow for "increased production of pelicans in

years of anchovy abundance" (USFWS, files) (although the combined annual U.S.-Mexico harvest has not yet exceeded this amount). NMFS did not agree with this recommendation, as well as some of the others. A series of meetings followed in which the pelican/anchovy interaction was discussed. As these dialogues continued, it became apparent that new data and additional information were being assembled and that NMFS would likely reinitiate consultation on the issue. A NMFS fishery biologist analyzed available data on the relationship of pelican breeding success and anchovy biomass, as well as the potential effects of increased anchovy harvests (Lenarz 1980); the results, however, were inconclusive. The report indicated that more data were needed before any conclusions could be determined. Consultation will probably be reinitiated on this subject in view of the current revision of the anchovy management plan (2231).

Establishing an offshore "sanctuary" for pelicans breeding on Anacapa solely on the basis of food resource protection probably cannot be justified at this time because of the variability, patchiness and mobility of surface fish. Such a concept may also be impractical from a management and enforcement viewpoint. Yet, given sufficient data there should exist parameters of fish and pelican behavior that are predictable. If so, adequate protection might involve areas that have a high probability of containing sufficient food supplies during the breeding season. At present, however, no such data are available. Continual monitoring through entire breeding seasons over several years is needed to quantify

the importance of potential refuge areas for food supply protection or to determine if such area designation would be feasible or practical. There is, though, justification for establishing offshore protection areas to prevent recreational, aircraft, and fishery-related sources of disturbance to breeding brown pelicans.

Since pelicans are dependent upon local food supplies during the breeding season (especially when raising young), establishing an offshore protection zone closed to commercial fishing would offer protection to offshore habitat and could perhaps minimize possible adverse pelican and commercial fishery interactions. A study of the feasibility of designating a protection area one nautical mile around Anacapa Island to minimize the possible effects of commercial fisheries on pelicans should be undertaken (222). This study would examine the extent of pelican/commercial fishery interactions to determine if such a zone is justified. The proposed zone would be workable within existing management units discussed in a previous section (Channel Islands Marine Sanctuary and the present NPS jurisdiction of resources on Anacapa). It would prevent, for example, certain commercial fishing activities and fishery-related disturbances in waters near pelican colony areas. This protection area would have little probable effect on the total commercial catch, yet is a conservative approach for providing protection to offshore habitat for brown pelicans and other marine wildlife.

A contingency plan should be developed for potential utilization of sardines and Pacific mackerel by pelicans in the event that future fishery mangement plans are developed and implemented for these species (2233).

To assess more adequately the needs of the California brown pelican and other marine wildlife in fishery management plans, a marine wildlife representative should be appointed to development teams and/or advisory panels of the Pacific Fishery Management Council (PFMC), the multi-agency group that prepared the anchovy management plan and recommends harvest options and other regulations to the U.S. Department of Commerce and the California Fish and Game Commission for implementation (2234). In addition, a marine wildlife scientist might be considered for appointment to the Scientific and Statistical Committee of PFMC. In light of the multiple use aspect of the resource, the proposed action may be the best means of providing direct input into the fishery management plans from a wildlife perspective.

Management and conservation needs of wildlife species (such as brown pelicans) require a different outlook and add a new dimension to the management of commercially valuable resources such as anchovies; compromises must therefore be made to satisfy both "users". This recovery plan addresses the potential conflict and strongly recommends that some parameters of the anchovy management plan be reexamined from a perspective of wildlife needs. To ensure continued recovery, needs of the California

brown pelican must be given consideration. It is therefore strongly recommended that the revised AFMP address the issue of specific needs of pelicans and other offshore wildlife dependent on this fishery resource.

A further complication in anchovy management plans (which may make everything else a moot point) is the Mexican harvest along the northwestern Baja California coast. Since 1974, the Mexican fishery has been much larger than that of the U.S. (see Mais 1981b). Because of inconsistencies in Mexico's anchovy fishery relating to the U.S. plan, it is difficult to develop sound optimum yield management plans of the same population in the U.S. The anchovy fishery and brown pelicans in the SCB may both be affected by distant events in which U.S. interests have little or no control. Recent disputes regarding fisheries have caused Mexico to withdraw from several aspects of bilateral fishing treaties with the U.S. (as of December 1980). Complications involving the Mexican fishery may be one of the most pressing issues in anchovy fishery management in the near future (see, for example, Fullerton and Odemar 1981). Despite a somewhat pessimistic outlook, efforts for international cooperation with Mexico and joint management decisions must be encouraged (224) for the sake of the anchovy fishery and ultimately for the well-being of the California brown pelican.

4. Protect Major Roosting Areas (23)

Important roosting sites, both for breeding and non-breeding birds during the breeding season and for wintering migrants, need to be identified and an assessment made of each (231). Management plans should then be developed for those sites considered essential (232); some sites may be secured and protected only by acquisition (233), but most occur on public lands and access can probably be restricted where needed (234). Essential roosting habitat should be delineated (235). Roosts associated with breeding colonies should have highest priority.

There are currently no data on the importance of undisturbed roosting sites. Presently, there appear to be no critical areas of immediate concern, but the problem needs further study. There are certainly some areas, particularly along the mainland coast, that are near enough to human activities to be frequently disturbed. Roosts, like nesting areas, are no doubt selected to maximize the possibilities of successful foraging with minimum energy expended. Other criteria for roosting areas might be the suitability of physical structure, convenience in terms of location, isolation from potential disturbance, and lack of predation. The most important roosting areas are probably those used during the breeding season close to the island colony sites, on nearby islands, and perhaps to a lesser degree, along the mainland coast closest to the colony.

With regard to the Anacapa colony, there are a number of traditional roosts located on the Anacapa group itself (Arch Rock, Cat Rock, Rat Rock, West Anacapa's north slopes, etc.), Santa Cruz Island (including Scorpion Rock and Gull Island), Santa Barbara Island (including Sutil Island) and along the mainland coast (particularly the area from Santa Barbara south to Point Dume, including numerous man-made structures) (FG, field notes). Occasional disturbance of breeding birds at traditional roosts would probably have little effect on the breeding population. On the other hand, frequent disturbance (especially if conditions were intolerable and breeding pelicans could no longer roost in an essential area) or the destruction of a major roost might have adverse population effects.

5. Delineate Essential Habitat (2114, 221, 235)

"Essential habitat" for the California brown pelican, has not yet been delineated. Those areas considered as "essential habitat" are colony sites, air-space over colony sites, offshore protection zones adjacent to colony sites, feeding habitat, and roosting sites. These areas should be analyzed so that "essential habitat" can be delineated.

6. Monitor Pelican Population (24)

Monitoring the pelican population is essential and should be continued in order to determine the success of management plans, status of the population, and effects of environmental impacts. A long-term

monitoring plan, such as that included in the Eastern Brown Pelican Recovery Plan (USFWS 1979), should be developed and implemented for the California brown pelican throughout its range (241), particularly in the SCB (242). The NPS has initiated a study for monitoring seabirds in the Channel Islands National Park; that agency has taken the lead in establishing the necessary routine data acquisition (i.e., year-to-year status) needed by resource managers on a continual basis. Monitoring colony areas to determine the extent of each year's breeding effort and the annual production of young should continue in a consistent manner (2421), using techniques and methodology established in previous years (described in Gress et al. 1980; Gress et al. ms.; Anderson and Gress 1983a) and those that will be recommended as a result of the NPS study. Accurate survey data on breeding birds will be especially important if changes occur in the anchovy fishery or if other fish species increase significantly as important pelican prey species. Former colony sites need to be monitored annually, as do major roosting areas near the colonies. Coastal and island surveys in the SCB are also needed during the fall and winter (2422). Data collected should be compatible with those collected from previous and current studies.

Pelican dietary components should be monitored (243) to detect changes in diet that might reflect changes in anchovy populations. Food analysis would also detect the relative importance of other fish species in the diet and indicate if other species are increasing significantly as prey items (methods for collection and analysis are described in Gress et al. 1980 and Kelly, Gress and Anderson, in

preparation). It is proposed that DFG continue analyzing food samples as they are routinely collected each year. Brown pelican food samples have also been suggested as a means of monitoring anchovy population age group structure (Sunada et al. 1981) (2523).

Environmental impacts having the potential to affect reproductive success should also be monitored (244). At the conclusion of the breeding season, addled eggs or eggshell fragments that remain in the colony should be collected (2442); chlorinated hydrocarbon residues (24421) and shell thicknesses (24422) can thus be monitored. For reasons given in a previous section, systematic collections of fresh eggs from marked nests is not recommended because of the probability of substantially reducing reproductive success through inevitable disturbance of breeding birds. Only if, perchance, a relatively isolated group or cohort could be sampled with no effects or at worst only minor effects on the rest of the colony, collecting fresh eggs might be justified (2442). Before any such collecting is allowed, a thorough and careful evaluation is strongly recommended before the necessary permits (WSFWS, DFG, and NPS) are issued (2441).

Observations of oiled birds should be noted to give at least a rough index of the degree of exposure to surface oil (2443). In the event of an oil spill to which pelicans might be exposed, or during Space Shuttle flights, specific monitoring programs will be required to determine possible adverse impacts (2444). Surveillance for other potential environmental problems that may adversely affect pelican populations should also be part of a routine monitoring program (2445).

7. Research Activities (25)

Concurrent research programs providing data essential for the recovery effort, which also aid in developing brown pelican management and conservation measures, should be continued. These studies are necessary to provide for future management actions ensuring that brown pelican recovery will be maintained. Continuing studies include the following:

a. Studies on resource utilization (251).

(1) Studies of feeding ecology and diet composition (2511).

(2) Determination of major foraging areas during the breeding season (2512).

b. Studies investigating pelican/anchovy relationships (252).

(1) Studies of potential impacts of commercial fisheries on pelican food supplies (2521).

(2) Studies of the relationship of prey abundance and/or availability and pelican productivity (2522).

(3) Study of pelicans as indicators of fishery stocks (2523).

c. Studies investigating population estimates, distribution, and daily activities (253).

(1) Routine aerial and shipboard surveys in colony areas during the breeding season (2531).

(2) Banding and color-marking throughout the range of the subspecies (2532).

(3) Analysis of band sightings and recoveries (2533).

(4) Shoreline and/or aerial surveys during the non-breeding period along the coasts of California, Oregon, and Washington (2537).

Some of the above studies are presently conducted on a near-routine basis each year at relatively low cost; these studies have a large data-base spanning several years (since 1971). Banding and color-marking young have provided a great deal of information on movements and relative mortality rates (2532). Data analysis from sightings, and recoveries from the past ten years of banding will require supplemental funding (2533). There is need for further investigation of pelican/anchovy interactions (252) to more thoroughly analyze predator-prey relationships and the potential impact of commercial fisheries; lack of funding has been an obstacle in generating the kinds of data needed.

Shipboard and shoreline surveys provide further data on age structure, distribution, and feeding activities (2536). Aerial and shipboard surveys are essential in examining distributional patterns, dispersal, density, and foraging areas; these surveys also require specific funding.

Other studies that are planned but have not yet been funded or implemented will give considerably more information in formulating management and conservation measures and thus have high priority:

a. A radiotelemetry study will provide more specific and detailed data on daily time budgets, roost site selection, and feeding activities. This project is of top priority; it has great potential to yield useful management information (2534).

b. A study of genetic diversity between various breeding groups within the subspecies range may provide information on rate and extent of interchange between colonies, origin of SCB recruitment, and possible genetic differences of various breeding groups. This study, too, has high priority, given that the information would have direct management implications (2535).

c. A study should be implemented to develop a formula or technique that relates desired pelican population levels (or indices) to carrying capacity and population parameters in the varying environment of the SCB (2537).

d. Develop management models (254) as follows: 1) model to examine management alternatives (2541); 2) model of pelican reproductive effort and success (2542); 3) model of forage availability, especially with respect to fishery influences (2543); 4) integrated life-history model of brown pelican population dynamics (2544); and 5) model relating pelican life history parameters (e.g., reproduction and distribution) to oceanographic data (2545).

e. Develop and conduct studies to assess the relationship of commercial fishing activities on fish behavior and subsequent effect on prey availability to pelicans (2524).

f. Undertake study assessing the role of disease and/or parasites in affecting brown pelican population dynamics, including possible effects on reproductive success. Field sampling supported by appropriate laboratory assays should be undertaken to provide a data base for disease and parasite evaluation (2538).

While research should be encouraged, priority should be given to studies that will promote management and conservation goals enhancing recovery efforts. Research requiring in-colony visits while nests contain eggs or small young, manipulations (such as marking eggs and nests, routine weighing of young, etc.) or any other activity that may cause a reduction in pelican productivity should be discouraged; pelicans are too sensitive to disturbance to allow these kinds of studies. Any studies at the colony site should follow precautions and tactics such as those outlined by Anderson and Gress (1983a) and Gress et al. (ms.). Guidelines and criteria should be established regarding the impact of research activities on pelicans and scientific/educational visitation to colony sites. This might best be accomplished through the establishment of an advisory committee that, in addition to recommending guidelines for research, monitoring and management, would also coordinate these activities with the agencies (255).

Colony visitation for studies of brown pelicans which are not clearly related to recovery goals and projects proposed by inexperienced or otherwise scientifically unqualified persons (e.g., cinematographers, photographers, amateur researchers, birders, writers, etc.) should be prohibited. Similarly, visits to the colony site or other protected areas by tour groups, extension-type educational courses, and school or university classes, no matter how well-intentioned their purpose is, should also be prohibited. The educational benefits of observing brown pelicans can be just as effective from a boat outside those areas considered as essential habitat.

8. Public Information and Conservation Education

Public information and conservation education have played important roles in increasing public awareness of the relationship between oceanic pollutants and brown pelican reproductive failures. Public concern over marine pollution has played a role in seeking solutions to reduce pollutant levels in the marine environment. Furthermore, public information has greatly heightened perceptions of marine ecosystems and their vulnerability to technological wastes. As problems experienced by pelicans and the role of pollutants became public knowledge, a protective attitude towards pelicans (and marine wildlife in general) developed.

While experiencing severe reproductive problems, the need to protect and preserve brown pelicans became a public priority. For example, since measures protecting the pelican population have been in effect, there have been few incidences of disturbance or vandalism in the Channel Island colonies (none very serious that we know of). Most visitors to the Channel Islands are cognizant of the pelican colony on Anacapa and the need for maintaining a disturbance-free environment. In general, there has been excellent public cooperation from people who have a specific or vested interest in visiting the colonies, such as birders, educational and school groups, and photographers/filmmakers. Most people have a sympathetic attitude toward pelicans. There is perhaps more public interest and concern about the pelican than almost any other wildlife species along the California coast. The brown pelican has received a great deal of media attention and though it has been 13 years since the reproductive failures were first publicized, interest in the welfare of Anacapa's pelican population seems just as keen today. This media attention has created a public protectiveness and an awareness of problems that marine wildlife face. There are few wildlife species that have illicited the type of public response which the California brown pelican has received.

Despite the publicity, there is still a need to disseminate information and educate the public further about the brown pelican and its needs for recovery and maintaining stable populations (26). We have already discussed several public information needs relative to other proposed actions of the recovery plan (e.g., educational

material concerning pelican colonies in Mexico and publicity about closures and injuries from fishing tackle). Information dissemination with regard to the brown pelican and this plan should also address issues concerning marine wildlife in general.

The Channel Islands National Park has a new visitor center. This seems like a good opportunity to develop an educational and interpretative program which would inform the public not only of the brown pelican natural history, but also about its past decline, its continuing recovery, and its needs for full recovery (261). This would also be an opportunity to inform the public of the importance of island refuges and offshore sanctuaries and the need for protection zones, as well as to illustrate the conflicts between marine wildlife resource utilization and man's.

Current information concerning the status of brown pelicans has been disseminated each year in press releases from DFG. There is great value in this service and it should continue (262). It is important, however, that the press releases from the agencies be technically accurate; incorrect information reported by the press has often led to problems and misinterpretations. Prepared news releases should be reviewed by technical personnel before being distributed.

Information sheets and posters outlining the restrictions and regulations regarding pelican breeding areas and closures should be printed and posted or handed out at appropriate marinas and harbors between Santa Barbara and San Diego (263). This publicity should aid

in the law enforcement effort to protect pelicans from disturbance or injury. Commercial users of waters near colony sites should also be notified of the restrictions and closures (264). Most violations of the offshore protection area at West Anacapa, for example, occur from lack of knowledge concerning closures and restrictions. Notification might be best accomplished with a flyer mailed to commercial license holders, along with other materials mailed annually by DFG, informing them of the regulations.

The above procedures might also be used to distribute information to sports fishery boat operators advising them of the problems of pelicans hooked by fishing tackle or entangled in monofilament line, and outlining methods for minimizing or avoiding injury (265) as discussed in a previous section.

9. Enforce Existing Laws and Regulations. Enforcement of the state and Federal regulations pertaining to brown pelicans is essential to the recovery effort. Coordination and mutual cooperation by the agencies involved (DFG, USFWS, and NPS in particular) are needed to effectively enforce the regulations (27).

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PART III

IMPLEMENTATION SCHEDULE

Table I, which follows, is a summary of scheduled actions and costs for the California Brown Pelican Recovery Program. It is a guide to meet the objectives of the California Brown Pelican Recovery Plan, as elaborated upon in Part II, Action Narrative Section. This table indicates the priority in scheduling tasks to meet the objectives, which agencies are responsible to perform these tasks, a time-table for accomplishing these tasks, and lastly, the estimated costs to perform them. Implementing Part III is the action of the recovery plan, that when accomplished, will bring about the recovery of this endangered species.

GENERAL CATEGORIES FOR IMPLEMENTATION SCHEDULES

Information Gathering - I or R (research)

1. Population status
2. Habitat status
3. Habitat requirements
4. Management techniques
5. Taxonomic studies
6. Demographic studies
7. Propagation
8. Migration
9. Predation
10. Competition
11. Disease
12. Environmental contaminant
13. Reintroduction
14. Other information

Acquisition - A

1. Lease
2. Easement
3. Management agreement
4. Exchange
5. Withdrawal
6. Fee title
7. Other

Management - M

1. Propagation
2. Reintroduction
3. Habitat maintenance and manipulation
4. Predator and competitor control
5. Depredation control
6. Disease control
7. Other management

Other - O

1. Information and education
2. Law Enforcement
3. Regulations
4. Administration

RECOVERY ACTION PRIORITIES

1 = An action that must be taken to prevent extinction or to prevent the species from declining irreversibly.
2 = An action that must be taken to prevent a significant decline in species population/habitat quality, or some other significant negative impact short of extinction.
3 = All other actions necessary to provide for full recovery of the species.

ABBREVIATIONS

CDFG - California Dept. of Fish and Game
DPR - California Dept. of Parks & Recreation
FAA - Federal Aviation Administration
FWS - Fish and Wildlife Service
IA - International Affairs Office
MFS - Fauna Silvestre (Mexico)
NMFS - National Marine Fisheries Service
ODFW - Oregon Department of Fish and Wildlife
PFMC - Pacific Fishery Management Council
USAF - U.S. Air Force
USCG - U.S. Coast Guard
USN - U.S. Navy
WDG - Washington Department of Game
WO - Washington Office

TBD - To be determined
An "X" in Fiscal Year Costs/Year column indicated desired starting date.
* - Denotes agency with lead responsibility

PART III
IMPLEMENTATION SCHEDULE

General Category	Plan Task	Task No.	Priority	Task Duration (Yrs.)	Responsible Agency: FWS Region	Responsible Agency: FWS Program	Responsible Agency: Other Agencies	Fiscal Year Costs (in $1,000's) 1	2	3	Comments
	LANDS										
A6	Secure and protect Scorpion Rock	2142	2	2			NPS, CDFG*	TO BE DETERMINED			
A6	Secure and protect important roosting areas***	233	2	2	1	SE*	CDFG, NPS	TO BE DETERMINED			
	INVESTIGATIONS										
I1	Conduct breeding surveys; determine productivity in SCB	2421	1	ongoing	1	SE		5	5	5	
							CDFG*	10	10	10	
I1	Continue banding and color marking program	2532	1	ongoing	1	SE*		1	1	1	
							CDFG	1	1	1	
I1	Research and monitoring of Mexican populations	12	1	ongoing	9	Research*		TO BE DETERMINED			Includes 121, 122, 123, 1231, 1232
							MFS				
I2	Conduct feeding ecology studies; determine foraging areas	251	1	4			CDFG*	5	5	5	Includes 2511, 2512
I2	Conduct radio-telemetry studies	2534	1	2			CDFG	25	5		
I2	Conduct genetic studies	2535	2	3	9	Research*		5	5	5	

							CDFG	5	5	5	

General Category	Plan Task	Task No.	Priority	Task Duration (Yrs.)	Responsible Agency: FWS Region	Responsible Agency: FWS Program	Responsible Agency: Other Agencies	Fiscal Year Costs (in $1,000's) 1	2	3	Comments
R1	Develop assessment techniques relating pelican populations to carrying capacity and population parameters	2536	2	2			CDFG*	5	5		
R1	Conduct studies of pelican/anchovy relationships, pelicans as indicators of fishery stocks	252	2	4	1	SE*		10	10	10	Includes 2521-2524
							NMFS	5	5	5	
							CDFG	5	5	5	
RI	Develop management models	254	2	3	1	SE*		3	3	4	Includes 2541-2545
							DFG	2	2	2	
							NMFS	2	2	2	
I2	Identify essential roosting areas	231	2	2			CDFG*	2	3	-	
							NPS	1	1	-	
							DPR	1	1	-	
R4	Implement and develop a long-term monitoring plan and establish methodology for consistent monitoring in SCB	241	2	2			CDFG	2	2	-	
							NPS	5	5	-	
RI	Analysis of band recoveries	2533	2	2			CDFG*	2.5	2.5	-	

General Category	Plan Task	Task No.	Priority	Task Duration (Yrs.)	Responsible Agency: FWS Region	FWS Program	Other Agencies	Fiscal Year Costs (in $1,000's) 1	2	3	Comments
I1	Conduct studies of population estimates, movement, and distribution during breeding season	2531	2	4			CDFG	5	5	5	Includes 2536
I1	Monitor distribution and numbers along Calif., Oregon, and Washington coasts during non-breeding period	2537	3	ongoing	1	SE	ODFW* WDG* CDFG*	TO BE DETERMINED			
I1	Carry out disease impact study	2538	3	3	9	Research	CDFG	TO BE DETERMINED			
I1	Monitor pelican dietary components	243	2	ongoing			CDFG	3	3	3	
I12	Analyze eggs for organochlorine pollutants	24421	2	ongoing	1	SE*	 CDFG	3 3	3 3	3 3	
I12	Measure shell thickness	24422	2	ongoing			CDFG	1.0	1.0	1.0	
I12	Monitor exposure of pelicans to oil	2443	2	as needed	1	SE	CDFG*, USCG, NPS	TO BE DETERMINED			
I12	Monitor impact of space shuttle sonic booms if flights occur over Channel Islands	2444	2	as needed	1	SE	USAF*, CDFG, NPS	TO BE DETERMINED			

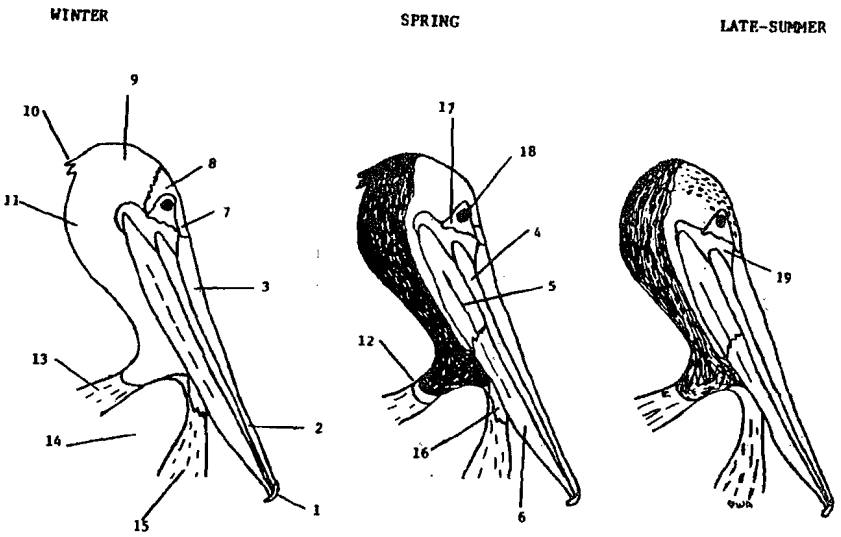
General Category	Plan Task	Task No.	Priority	Task Duration (Yrs.)	Responsible Agency: FWS Region	Responsible Agency: FWS Program	Responsible Agency: Other Agencies	Fiscal Year Costs (in $1,000's) 1	2	3	Comments
I12	Maintain surveillance for potential environmental problems	2445	2	as needed	1	SE	CDFG*, NPS	TO BE DETERMINED			
I1	Conduct nonbreeding surveys	2422	2	ongoing	1	SE		-	-	-	
							CDFG*	2	2	2	
							NPS	1	1	1	
	ADMINISTRATION										
03	Study feasibility of requiring cargo vessels to operate only in Santa Barbara Channel	2115	2	1	1	SE*	USCG	-	-	-	
							NPS	-	-	-	
							CDFG	-	-	-	
M7	Establish protection area area one nautical mile around Anacapa Island	222	2	TBD	1	SE	NPS, CDFG*	XTBD			
M7	Consider feasibility of a lower fishery quota option	22321	2	1	1	SE	NMFS*, CDFG, PFMC	TO BE DETERMINED			
M7	Study feasibility of increasing anchovy forage reserve	22322	2	1	1	SE	NMFS*, PFMC	XTBD			
M7	Develop contingency plans for use of sardines and Pacific mackerel	2233	2	1	1	SE	NMFS*, PFMC	XTBD			

General Category	Plan Task	Task No.	Priority	Task Duration (Yrs.)	Responsible Agency: FWS Region	Responsible Agency: FWS Program	Responsible Agency: Other Agencies	Fiscal Year Costs (in $1,000's) 1	2	3	Comments
02	Enforce State and Federal regulations	27	1	ongoing	1	LE*					
							CDFG	TO BE DETERMINED			
							NPS	TO BE DETERMINED			
							NMFS	TO BE DETERMINED			
							USCG	TO BE DETERMINED			
M7	Encourage efforts for regulated anchovy harvest in Mexico	224	1	TBD	WO	IA	MFS,CDFG, NMFS*	XTBD			
M7	Encourage sanctuary status for Los Coronados	212	3	1	WO	IA*		TO BE DETERMINED			
							MFS				
							CDFG				
M7	Develop joint U.S. Mexico plan to protect populations in Mexico	11	2	1	WO	IA*		TO BE DETERMINED			Includes 111-114
							MFS				
							CDFG				
A7	Determine ownership of Scorpion Rock	2141	3	1			CDFG	0.3			
M7	Restrict access to Scorpion Rock	2143	3	1			CDFG*	2			
A7	Post signs on Scorpion Rock	2144	3	1			CDFG	0.3			
M7	Minimize damage to foraging pelicans from fishing tackle	215	2	ongoing			CDFG*	TO BE DETERMINED			Includes 2151, 2152, See also 265
							NPS				

General Category	Plan Task	Task No.	Priority	Task Duration (Yrs.)	Responsible Agency: FWS Region	Responsible Agency: FWS Program	Responsible Agency: Other Agencies	Fiscal Year Costs (in $1,000's) 1	2	3	Comments
M3	Develop plans for essential roosting sites	232	2	2	1	SE		2.5	2.5		
							CDFG*	2	3		
							NPS	TO BE DETERMINED			
							DPR	TO BE DETERMINED			
02	Limit access to roosting areas where needed	234	2	ongoing once started			CDFG	TO BE DETERMINED			
							NPS	TO BE DETERMINED			
							DPR	TO BE DETERMINED			
04	Promote international island conservation agreements	14	3	ongoing once started	WO	IA	MFS	TO BE DETERMINED			
04	Establish committee for coordination with Mexico	15	2	1	WO	IA	MFS, CDFG	TO BE DETERMINED			
04	Promote management of fishery resources in Mexico	16	1	ongoing once started			NMFS*, MFS	TO BE DETERMINED			
M7	Establish advisory committee to coordinate research monitoring, and management activity	255	3	ongoing	1	SE*		2	2	2	
							CDFG	1	1	1	
							NPS	1	1	1	
M7	Determine essential habitat for breeding foraging, and roosting	2114	2	1	1	SE*		3			Includes 221,235

General Category	Plan Task	Task No.	Priority	Task Duration (Yrs.)	Responsible Agency: FWS Region	Responsible Agency: FWS Program	Responsible Agency: Other Agencies	Fiscal Year Costs (in $1,000's) 1	2	3	Comments
M3	Develop contingency plans to protect infrequently used colony sites	213	3	1			NPS		1		
PUBLIC INFORMATION											
01	Develop and distribute bilingual pamphlets re: Mexican and U.S. colonies	131	3	2	WO	IA	MFS*	TO BE DETERMINED	TO BE DETERMINED		
01	Study feasibility of establishing public viewing areas of colony sites in Mexico	132	3	1	WO	IA	MFS*	TO BE DETERMINED			
01	Design, construct, and post bilingual signs to protect colonies in Mexico	133	3	1	WO	IA	MFS*	TO BE DETERMINED			
01	Develop educational and interpretive program at new C.I.N.P. visitor's center	261	3	1			NPS*	5			
01	Provide current pelican information to media	262	2	ongoing	1	SE	CDFG*, NPS	TO BE DETERMINED			

General Category	Plan Task	Task No.	Priority	Task Duration (Yrs.)	Responsible Agency: FWS Region	Responsible Agency: FWS Program	Responsible Agency: Other Agencies	Fiscal Year Costs (in $1,000's) 1	2	3	Comments
01	Develop information sheets and posters concerning pelican closures	263	2	ongoing			CDFG*	3	3	3	
01	Notify commercial users of waters near colony sites of closures	264	2	ongoing			CDFG* NPS NMFS	2 .5 .5	2 .5 .5	2 .5 .5	See also 225, 265
01	Inform fishing boat operators of best methods to remove hooks and monofilament line from young pelicans	265	2	ongoing			CDFG* NPS	1 1	1 1	1 1	See also 215



	Winter (pre-breeding)	Spring (breeding)		Late-summer (post-breeding)	
Area--Description	Appearance	Appearance	Change	Appearance	Change
1---nail	yellow	bright yellow	hormonal	yellow	hormonal
2---upper mandible (distal)	yellow/some orange	yellow/orange pink/red	hormonal	yellow/some orange	hormonal
3---upper mandible (proximal)	light blue	light blue/ pinkish	hormonal	grey-blue	hormonal, sheding
4---lower mandible	light blue	light blue	hormonal	grey-blue	same
5---gular pouch (proximal)	reddish orange	bright red	hormonal	yellow-grey	hormonal
6---gular pouch (distal)	grey-green	deep green	hormonal	grey	hormonal
7---forehead	yellow	yellow	molting	salt & pepper	molt
8---lower crown	yellow	white	molt	salt & pepper	molt
9---upper crown	white	white	none	salt & pepper	molt
10--crest	white	dark brown	molt	reddish brown (if present)	wear
11--occiput & nape	white	dark brown	molt	medium brown	wear
12--upper back	white	to dark brown	molt	medium brown	wear
13--mid-back	silver-grey	silver-grey	none	dull brown	wear, molt
14--wing coverts	silver-grey	silver-grey	none	dull brown	wear, molt
15--upper breast	grey-brown	dark brown	wear	scruffy, flecked, dull brown	wear, molt
16--jugulum	yellow	yellow	wear	very faded	molt, wear
17--eye-ring	grey	pink	hormonal	grey	hormonal
18--iris	light blue	light blue	none	brownish	hormonal
19--lore	grey	grey-pink	hormonal	dark grey	hormonal, shedding

Figure 1. Complex changes in the appearance of the adult California brown pelican through one annual cycle, as related to various factors (molt, feather wear, physiological condition). Various zones in the head region are numbered and changes in those zones are outlined on the following table. Intensity of colors, especially in the fleshy parts, is greatest in adult and older-adult pelicans; the greater intensities tend to remain once they are acquired. There is much age-related variation in the younger birds tending toward more brown feathers and less intense colors. Taken from Anderson (1981).

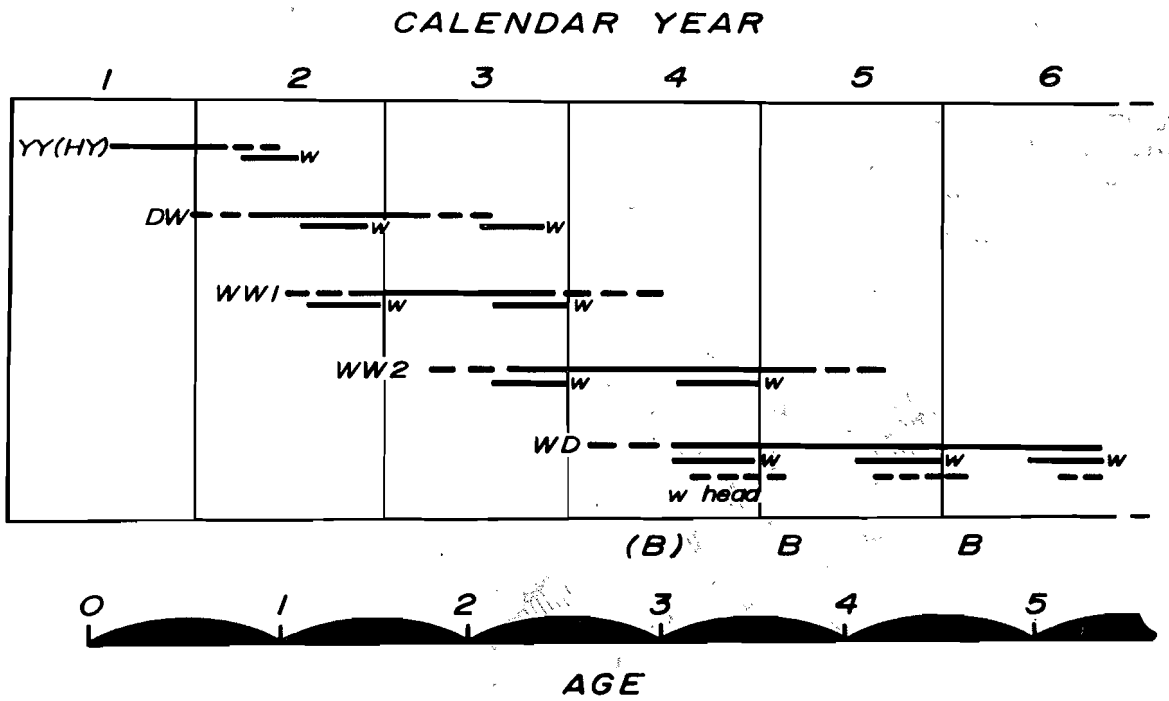


Figure 2. Year-class changes in the California brown pelican (from Anderson 1981 and DWA unpublished field notes). Abbreviations are as follows: YY = young-of-the-year (brown head, white belly; all soft parts on head grey without color; feet yellowish; line between dark and light on sides appears hazy).

DW = second-year bird (dark head, white belly; feet greyish; yellow bill tip; line between dark and light on sides more distinct).

WW1 = early-stage third-year bird or late-stage second-year bird (white head, white belly; head has appearance of faded adult; this is an intermediate stage plumage that is quite variable, and may last longer in males than females).

WW2 = third or fourth-year bird (white head, white belly; distinctly adult type head with patch of white remaining on belly).

WD = full adult (white head, dark belly; completely dark belly; typical adult head).

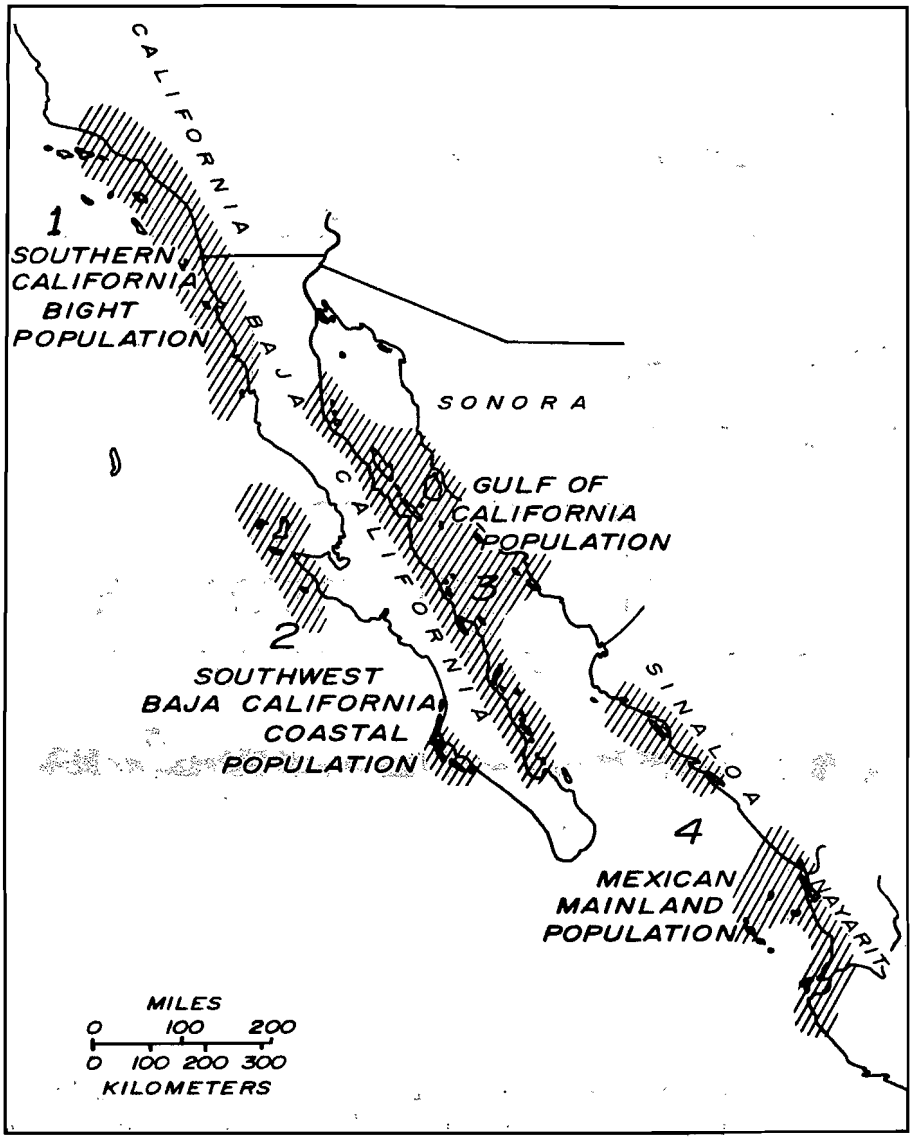


Figure 3. Map showing the breeding populations and range of the California brown pelican, as discussed in the text. Data were obtained from aerial surveys in 1974 and 1977; details of these surveys are being prepared for publication (DWA, unpublished data).

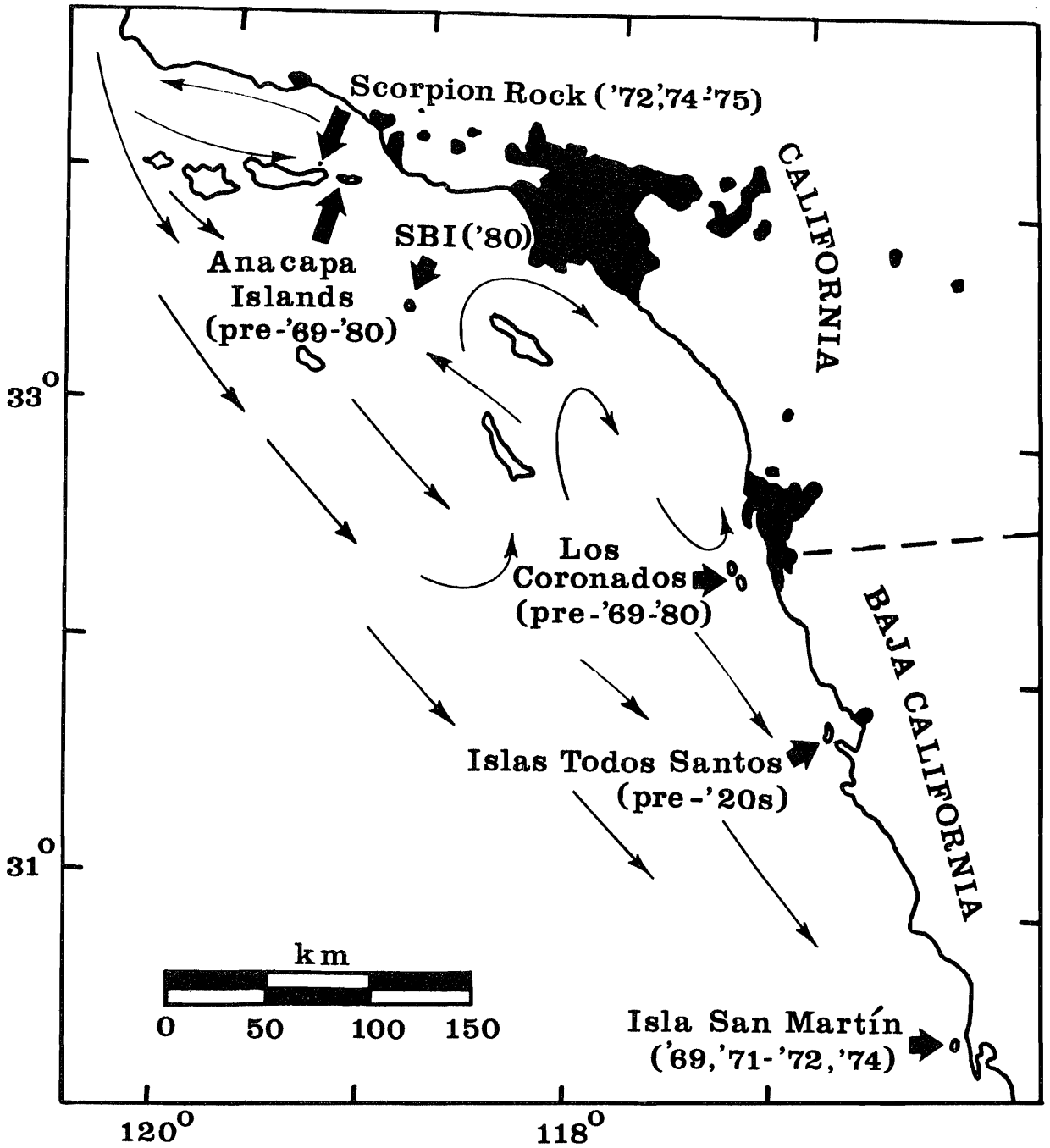


Figure 4. Map of the Southern California Bight area showing the locations of present and past brown pelican nesting colonies. Dates in parentheses below each location are the years when these colonies have been active. Santa Barbara Island is abbreviated as "SBI." Narrow arrows indicate major water circulation patterns in the Southern California Bight. Taken from Anderson and Gress (1982a).

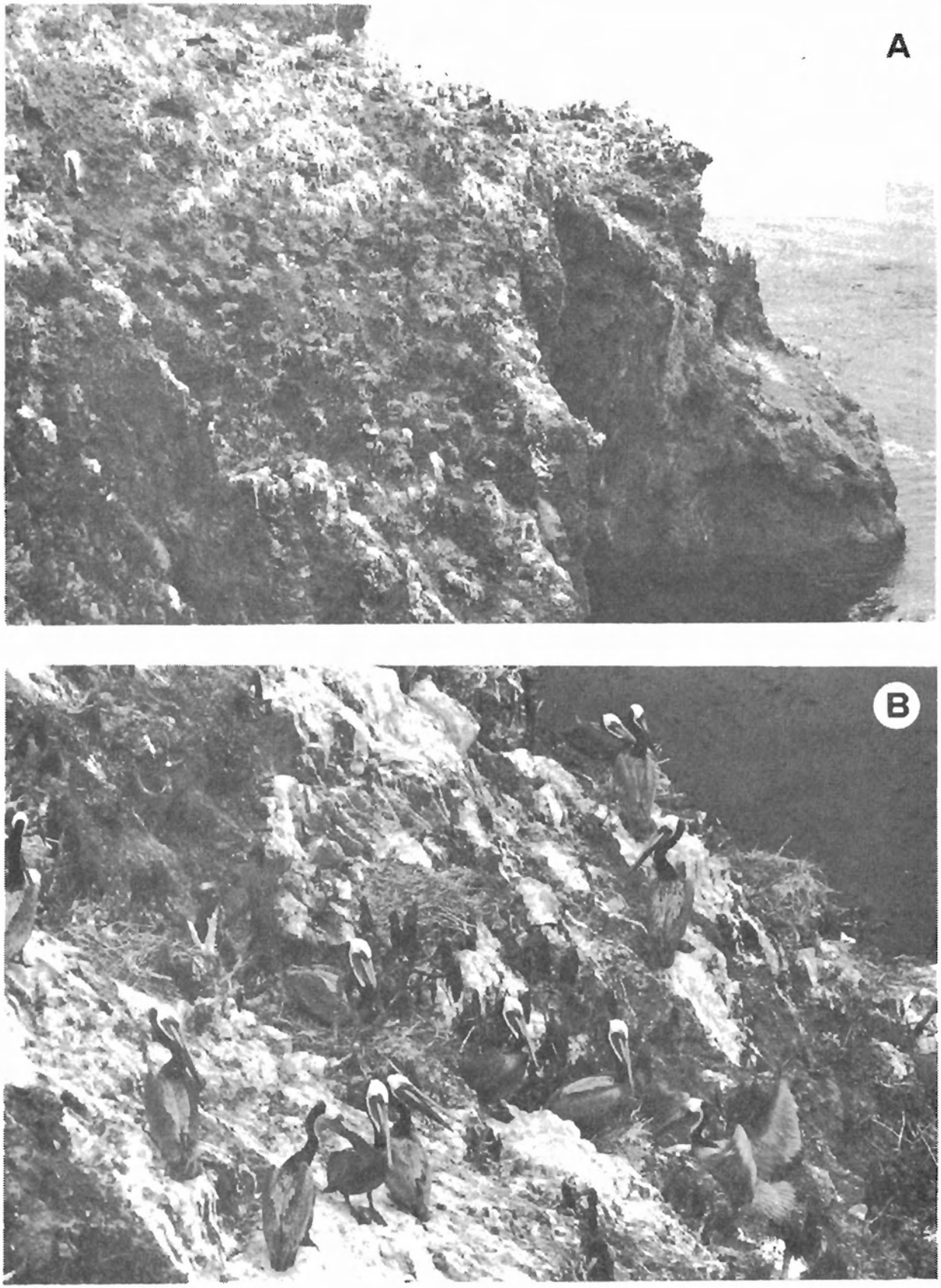


Figure 5. Photographs of brown pelican colony on West Anacapa Island:
A. 5 June 1970--Rocky slope nesting habitat on north side of island.
B. 5 June 1970--Closeup of rocky slope habitat. F. Gress.

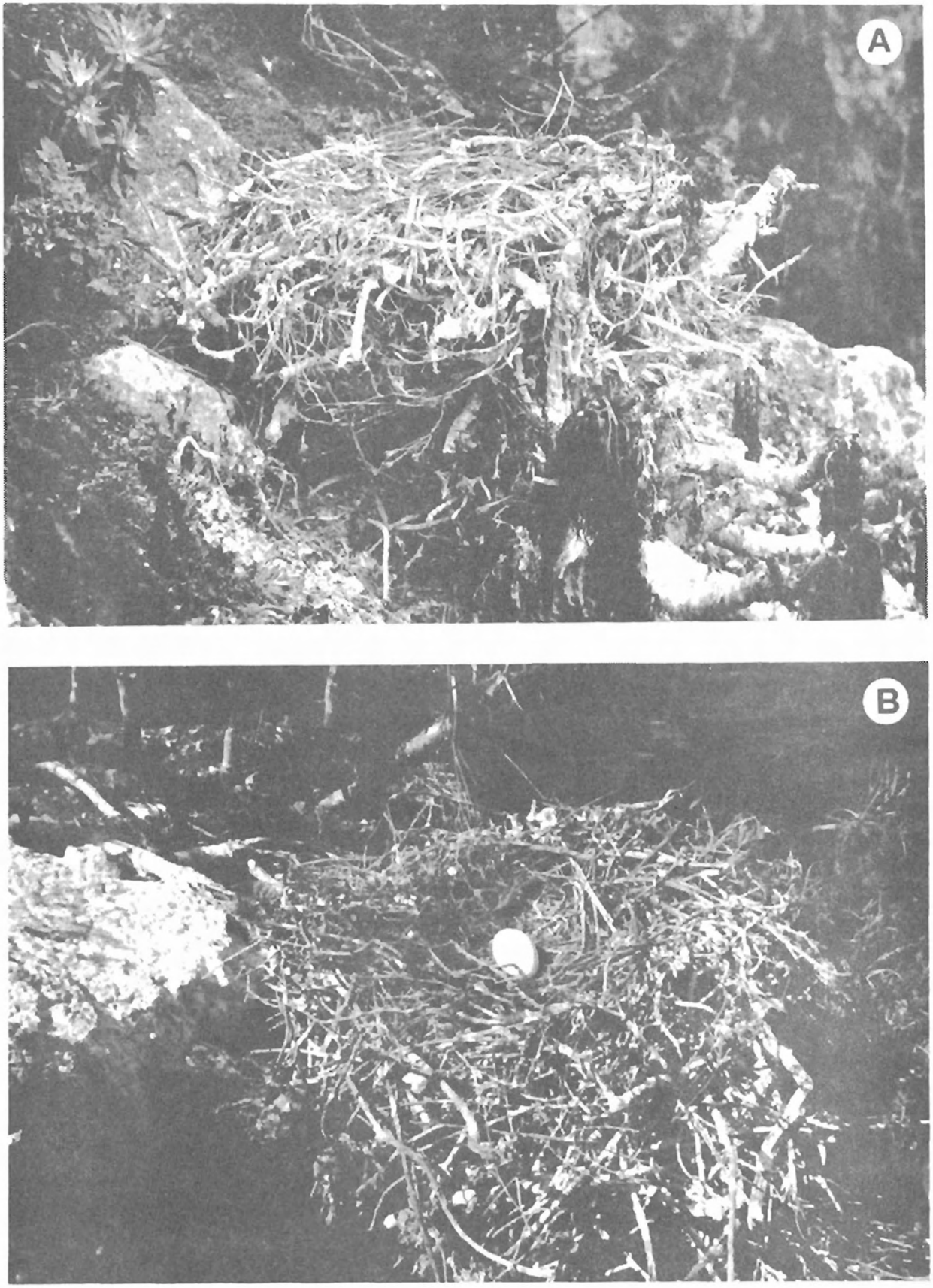
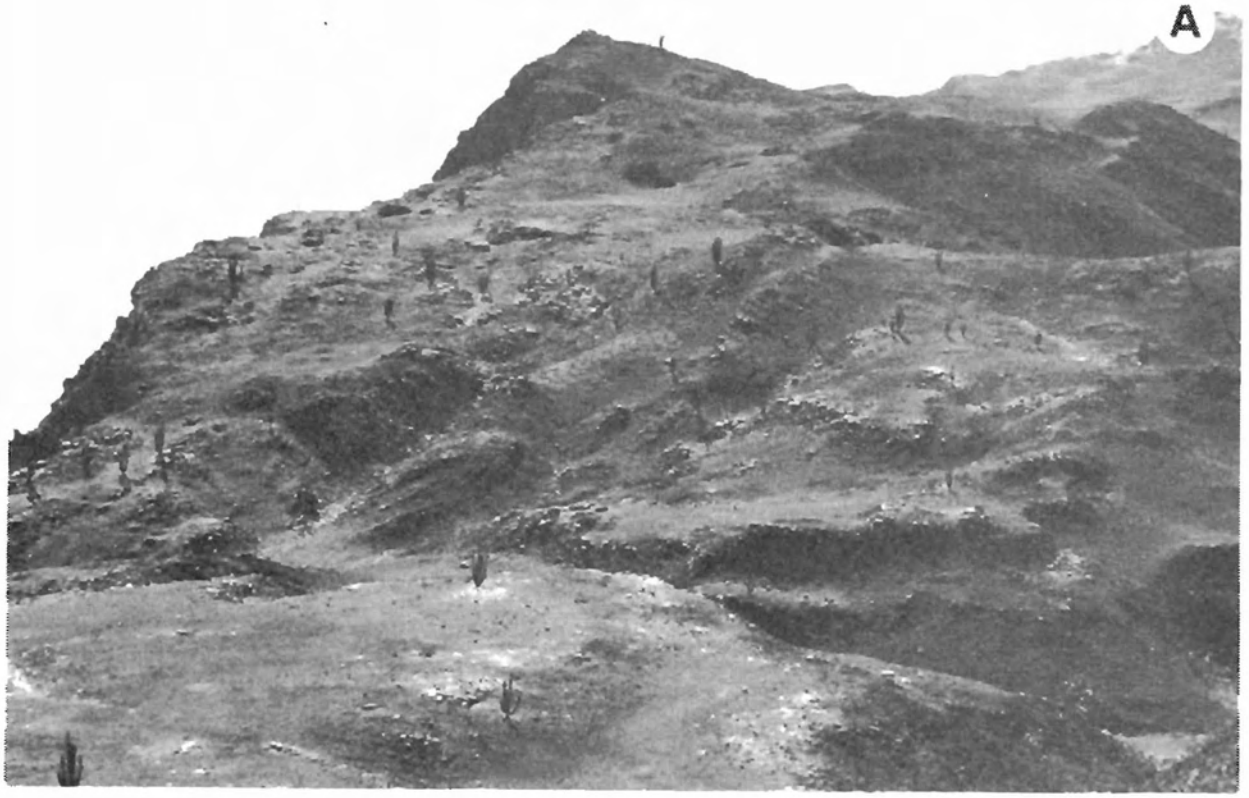
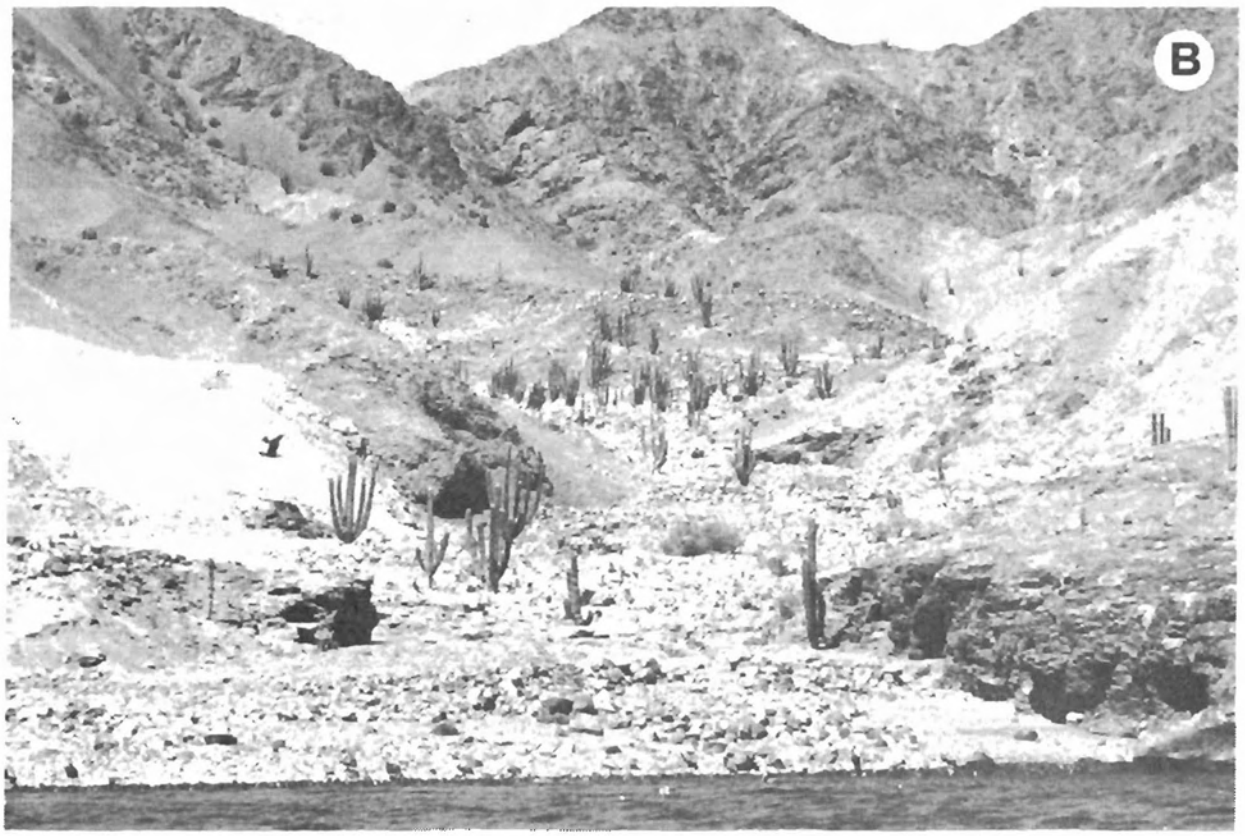


Figure 6. Photographs of brown pelican nests on West Anacapa Island; these are typical of nests built in the Southern California Bight colonies.
A. Nest built on steep slopes using Coreopsis gigantea as anchor.
B. Contents of nest, showing grass lining. F. Gress.


A


B

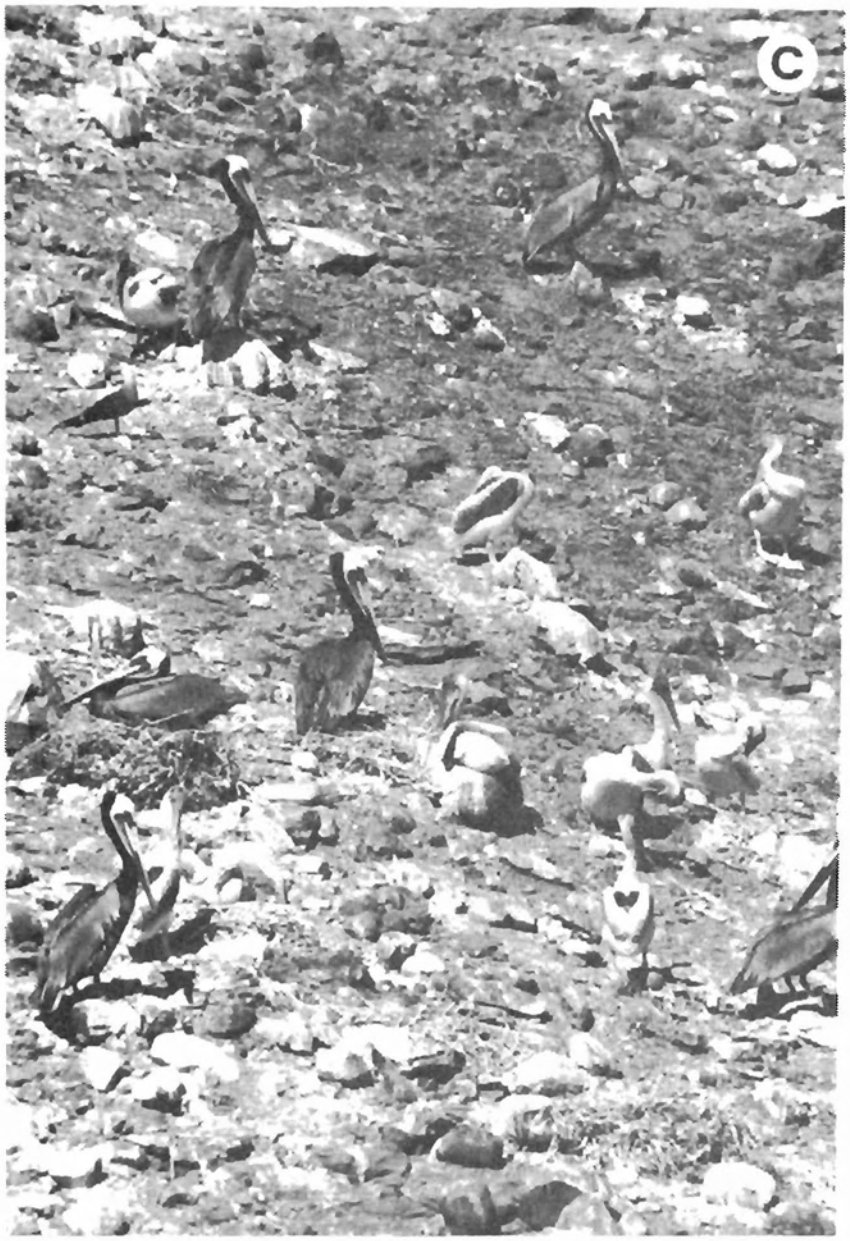


Figure 7. Photographs of brown pelican colony areas on desert islands in the Gulf of California: A. 23 May 1980--Upland nesting habitat on Isla San Lorenzo Norte, the largest brown pelican colony in North America. B. 20 May 1980--Canyon and upland nesting habitat on Isla San Lorenzo Sur. C. 21 May 1980--Closeup of pelican nesting habitat on Isla San Lorenzo Norte. D.W. Anderson.

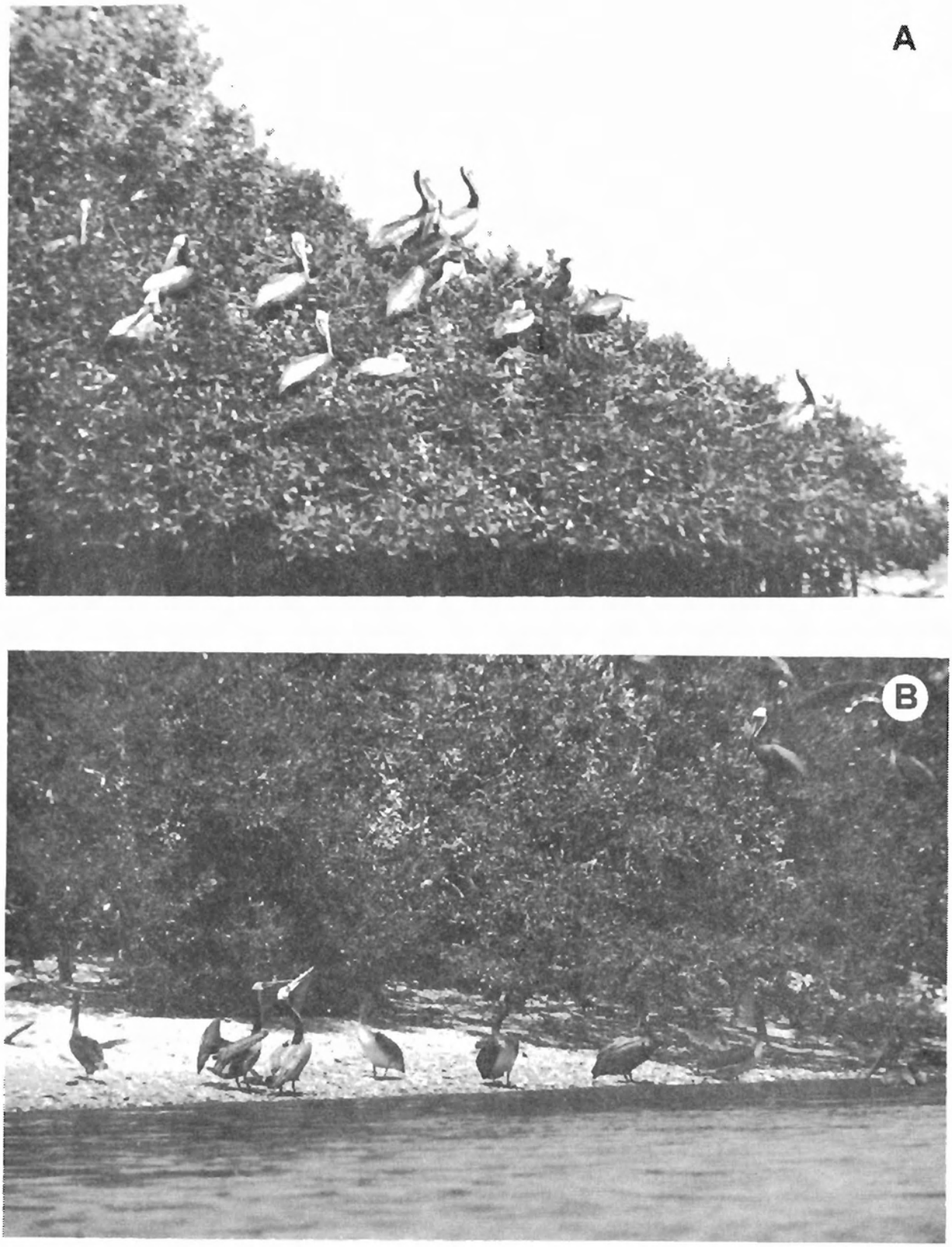


Figure 8. Photographs of brown pelican colony areas in mangrove habitat along the west coast of mainland Mexico: A. 8 May 1974--Nesting pelicans perched in mangrove trees on Sinaloa coast. B. 25 April 1976--Loafing and nesting pelicans on a mangrove island along Sinaloa coast. D. W. Anderson.

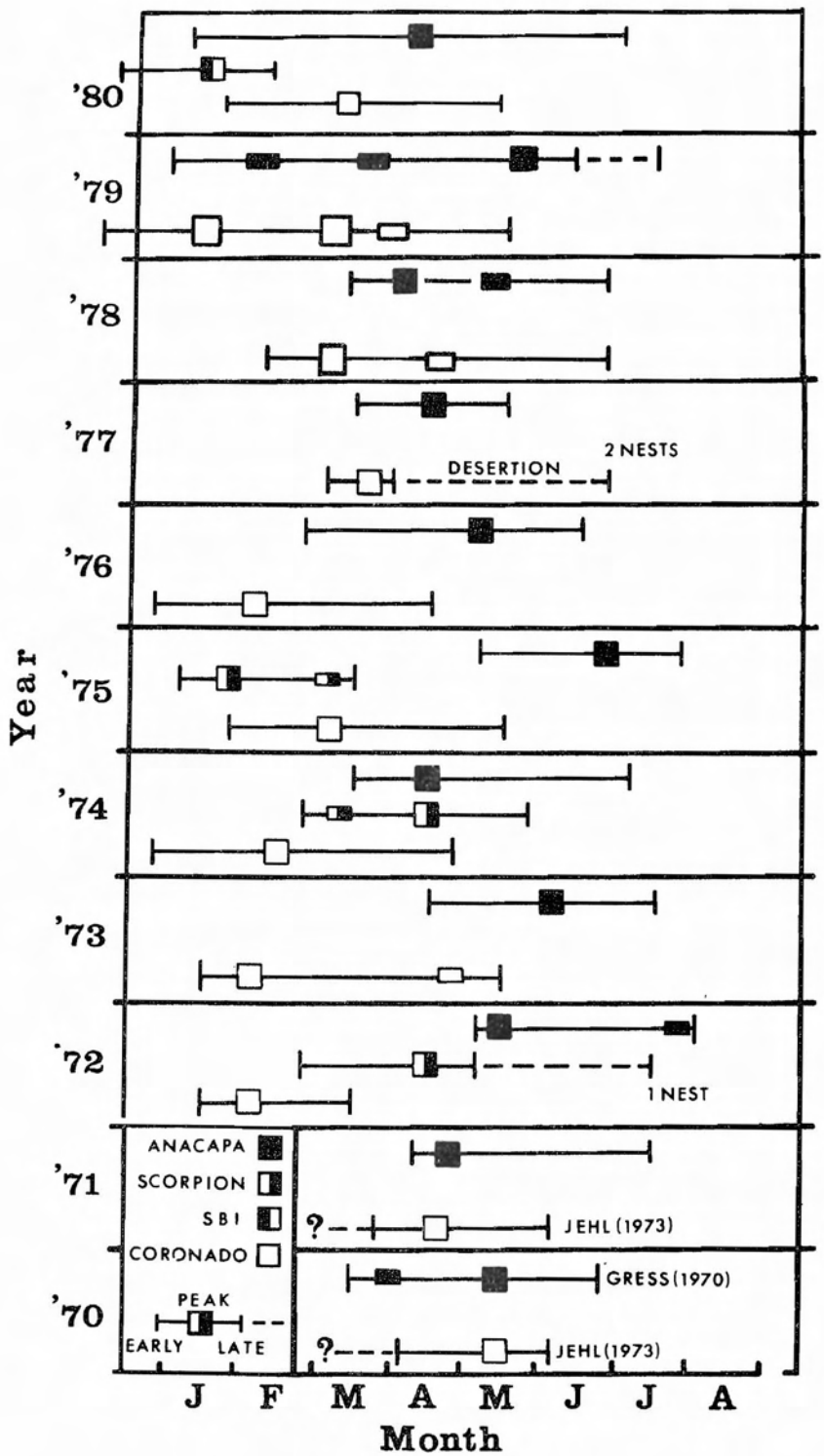


Figure 9. Condensed nesting phenology (egg-laying dates) of brown pelicans in the Southern California Bight colonies, 1970 through 1980. Because of early potential failures in 1970 and 1971 from effects of pollution, it is unknown if peaks actually represent second nestings or first attempts during those years at Los Coronados (? on figure). After Anderson and Gress (1982a).

Figure 10. A. Changes in anchovy biomass estimates (abundance) from 1971-1980 (km^2 of school surface area) as related to changes in brown pelican productivity (feldging rates) in the Southern California Bight (Anacapa and Los Coronados). Estimates to 1979 are from DFG surveys using acoustic methods (K. F. Mais 1974, and pers. comm.). Biomass estimates in 1979 and 1980 are from California Cooperative Oceanic Fisheries Investigations (CalCOFI)(see Stouffer 1980; Stouffer and Parker 1980; and Stouffer and Picquelle 1981) using larvae survey methods converted to equivalent units based on 1978 comparisons. Previous to 1979, CalCOFI estimates were not available on a yearly basis. The relationship between biomass and area as measures of anchovy abundance is discussed in Anderson et at. 1982.
B. Reduction fishery harvest of anchovies by U.S. fishermen from 1971-1980 expressed in metric tons x 10^3 (from Mais 1981).
C. Relationship of Southern California Bight overall estimates of anchovy abundance (using same units as above) and brown pelican productivity; the curve was fitted by eye. Regional comparisons like this are more imprecise than local ones (see Anderson et al. 1982), but as presented here they are most comparable to the units of anchovy management (see Anderson et al. 1980). The "x" represents an anomalous year (1972-1973)(see explanations in Anderson et al. 1980, 1982, and Anderson and Gress 1982a).

Taken from Anderson and Gress (1982b).

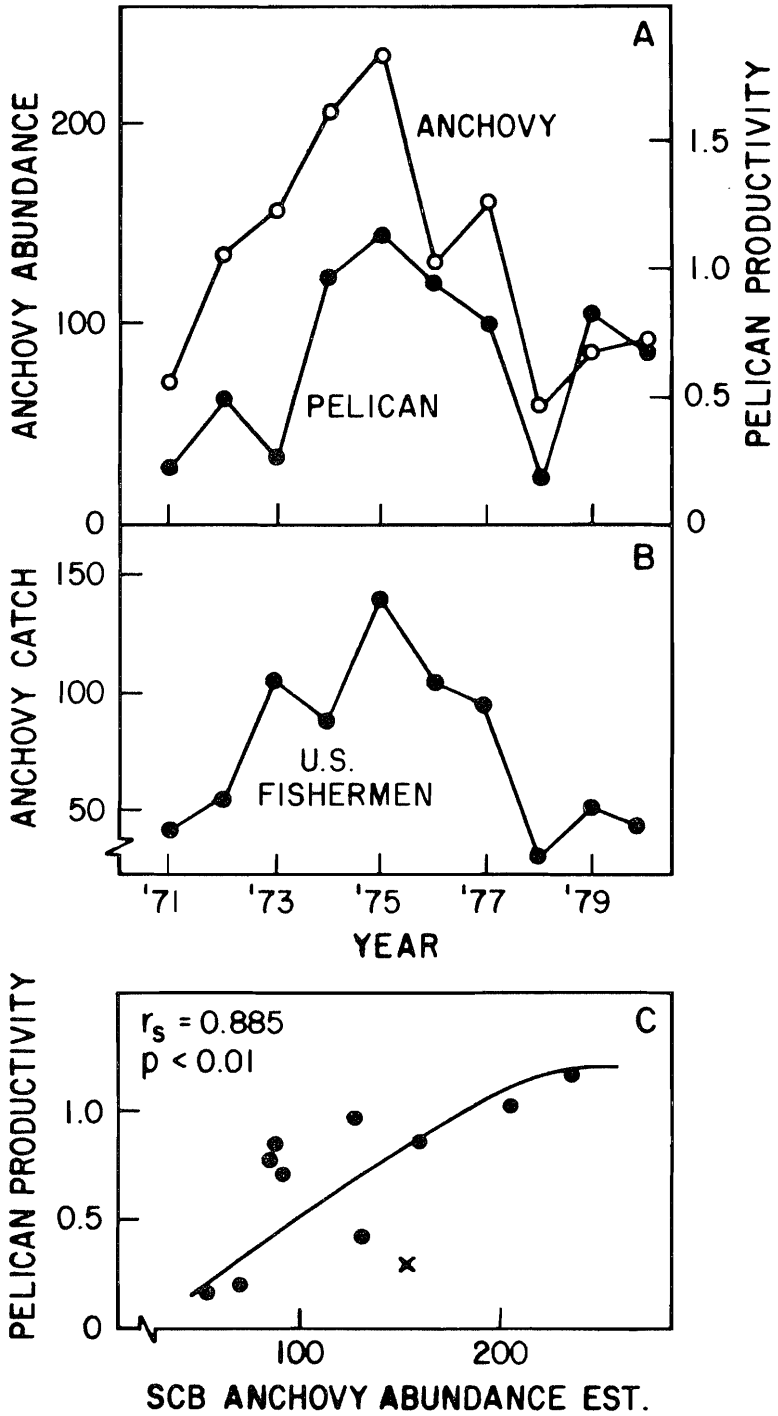

A
ANCHOVY
PELICAN
ANCHOVY ABUNDANCE
PELICAN PRODUCTIVITY
200
100
0
1.5
1.0
0.5
0
B
ANCHOVY CATCH
150
100
50
U.S.
FISHERMEN
'71
'73
'75
'77
'79
YEAR
C
r_s = 0.885
p < 0.01
PELICAN PRODUCTIVITY
1.0
0.5
0
100
200
SCB ANCHOVY ABUNDANCE EST.

Figure 11. Optimal harvest quota options described in the Northern Anchovy Management Plan, illustrating each of the harvest formulas for the anchovy reduction fishery. The solid line represents quota as a function of biomass; the dashed line represents estimated surplus production. Each formula can be described in terms of a cutoff below which biomass the quota would be zero; a slope which is the fraction of the biomass in excess of the cutoff which is to be harvested; and in the case of Option 1, a limit which is the maximum value the quota can assume. The following summarizes each harvest option:

Option 1--Quota is 33.3% of the spawning biomass in excess of 1 million tons, with an upper quota limit of 450,000 tons.

Option 2--Quota is 33.3% of the spawning biomass in excess of 1 million tons.

Option 3--Quota is 20% of the spawning biomass in excess of 0.5 million tons.

Option 4--Quota is 10% of the spawning biomass, but is zero if the spawning biomass is less than 1 million tons (quota is 0.1 at cutoff).

Option 5--Quota is 25% of the spawning biomass, but is zero when the spawning biomass is less than 1 million tons (quota is 0.25 at cutoff).

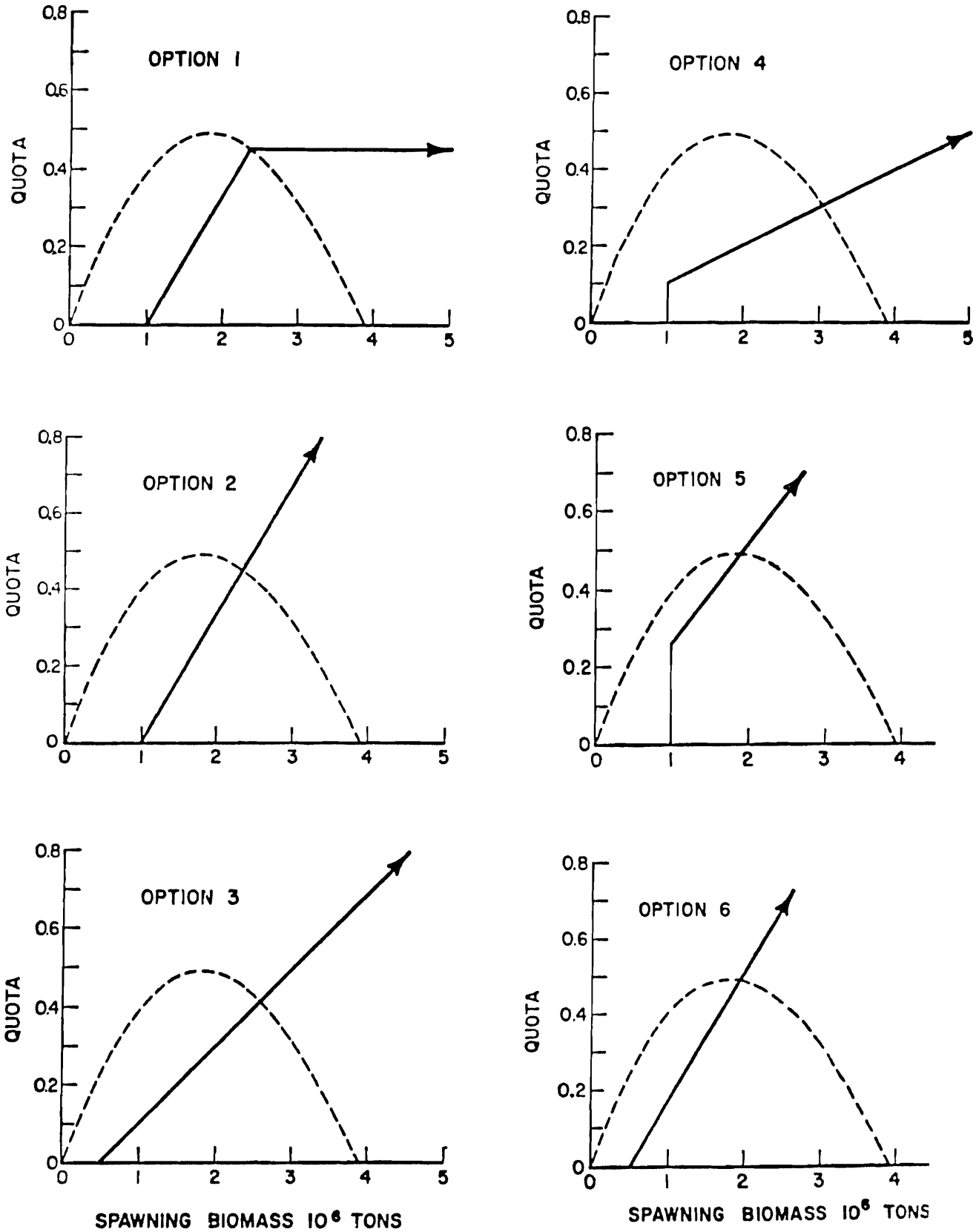
Option 6--Quota is 33.3% of the spawning biomass in excess of 0.5 million tons.

Option 2 is the harvest formula adopted by the Pacific Fishery Management Council in the U.S. Fishery Conservation Zone for the anchovies in the central subpopulation (which includes southern California waters).

Option 1 and 4 maintain the highest levels of median biomass, while yielding the smallest average catches. Options 3 and 6 have relatively high average catches and will result in fishery shutdowns in the fewest number of years. Option 5 gives the highest average catch, while having the highest probability of fishery shutdown. Option 2 provides almost as much average annual yield as Options 5 and 6 and also is expected to maintain a reasonably large biomass of anchovies.

The Northern Anchovy Fishery Management Plan was implemented in 1978. It is currently under review and is expected to be revised during 1983; new options are proposed.

From Pacific Fishery Management Council (1978).


OPTION 1
OPTION 2
OPTION 3
OPTION 4
OPTION 5
OPTION 6
QUOTA
0.8
0.6
0.4
0.2
0
0
1
2
3
4
5
SPAWNING BIOMASS 10⁶ TONS

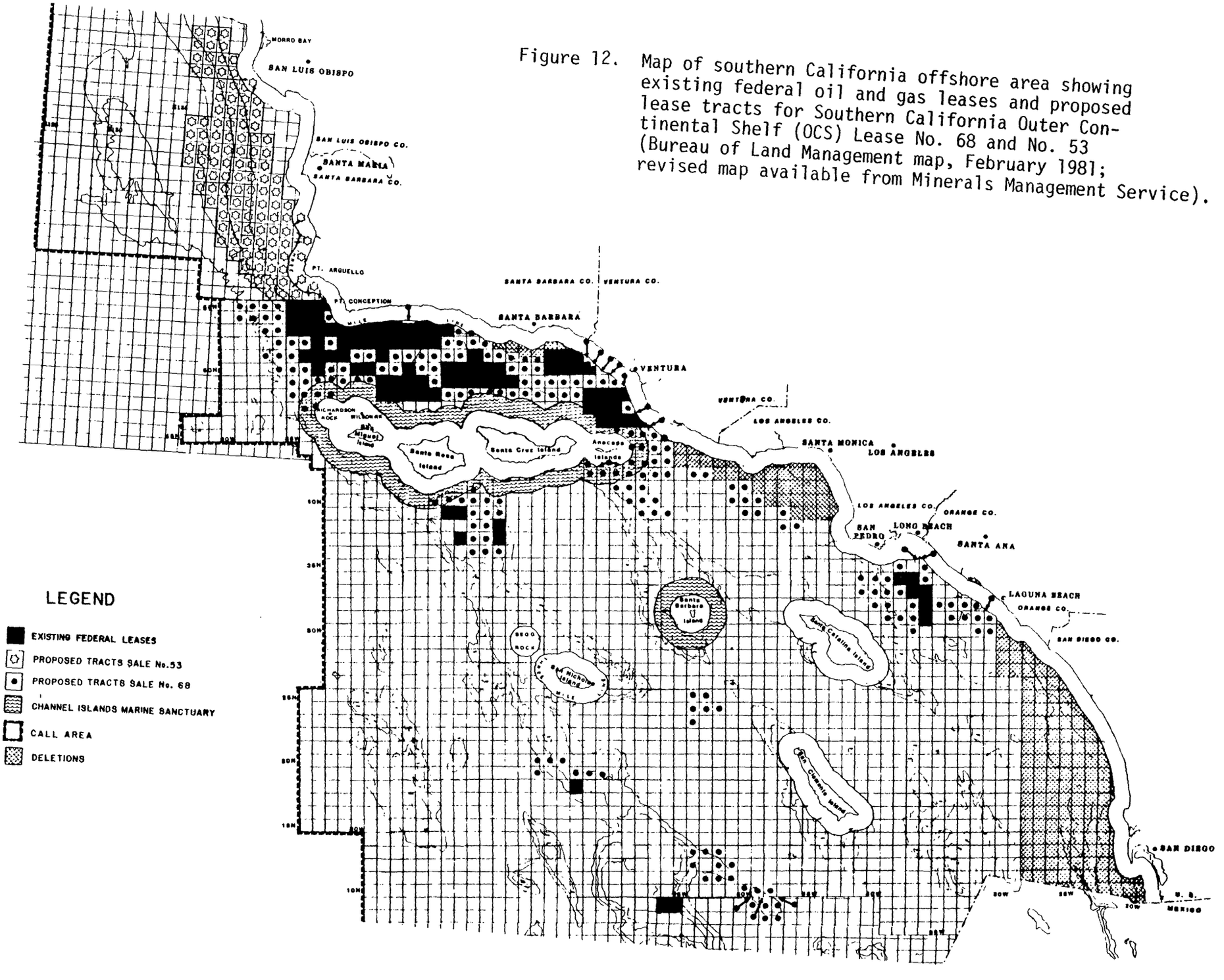


Figure 12. Map of southern California offshore area showing existing federal oil and gas leases and proposed lease tracts for Southern California Outer Continental Shelf (OCS) Lease No. 68 and No. 53 (Bureau of Land Management map, February 1981; revised map available from Minerals Management Service).

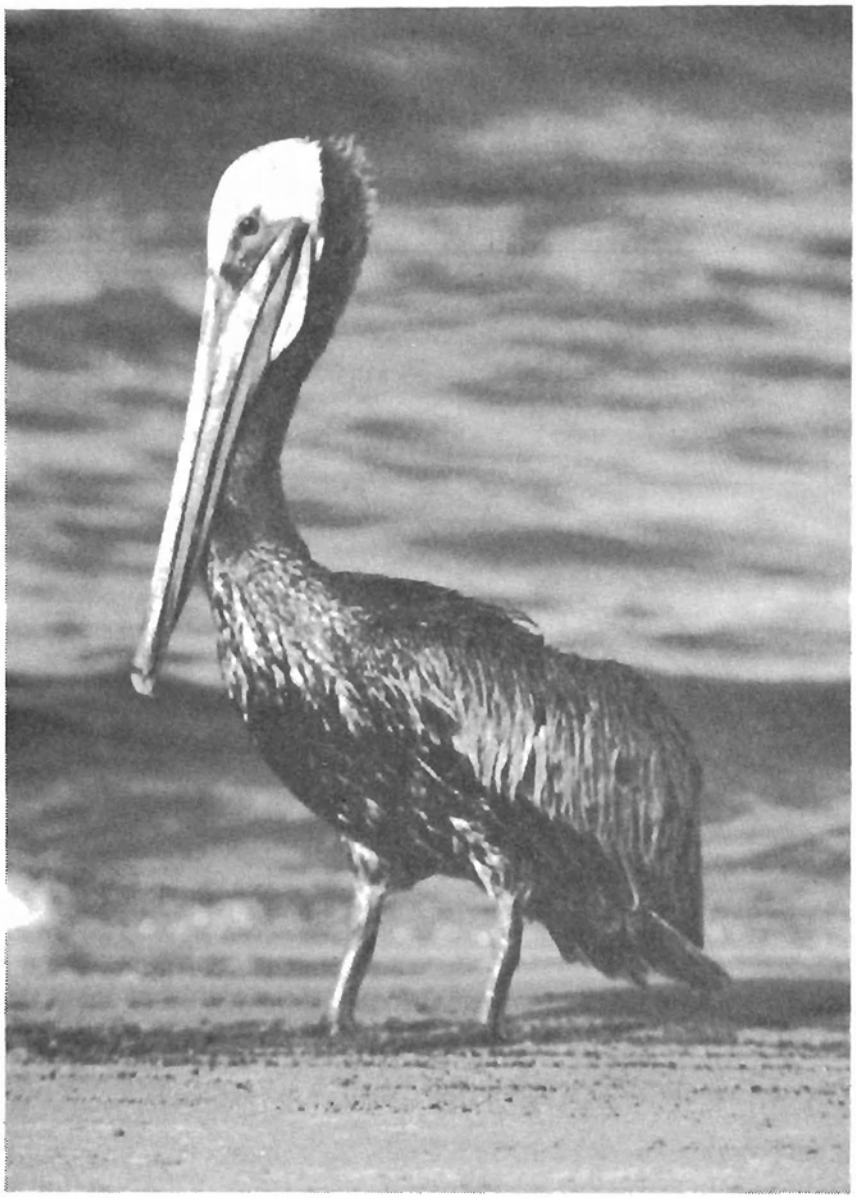


Figure 13. Adult brown pelican fouled with oil, 20 July 1978, Bahía de Los Angeles, Baja California. D. W. Anderson.

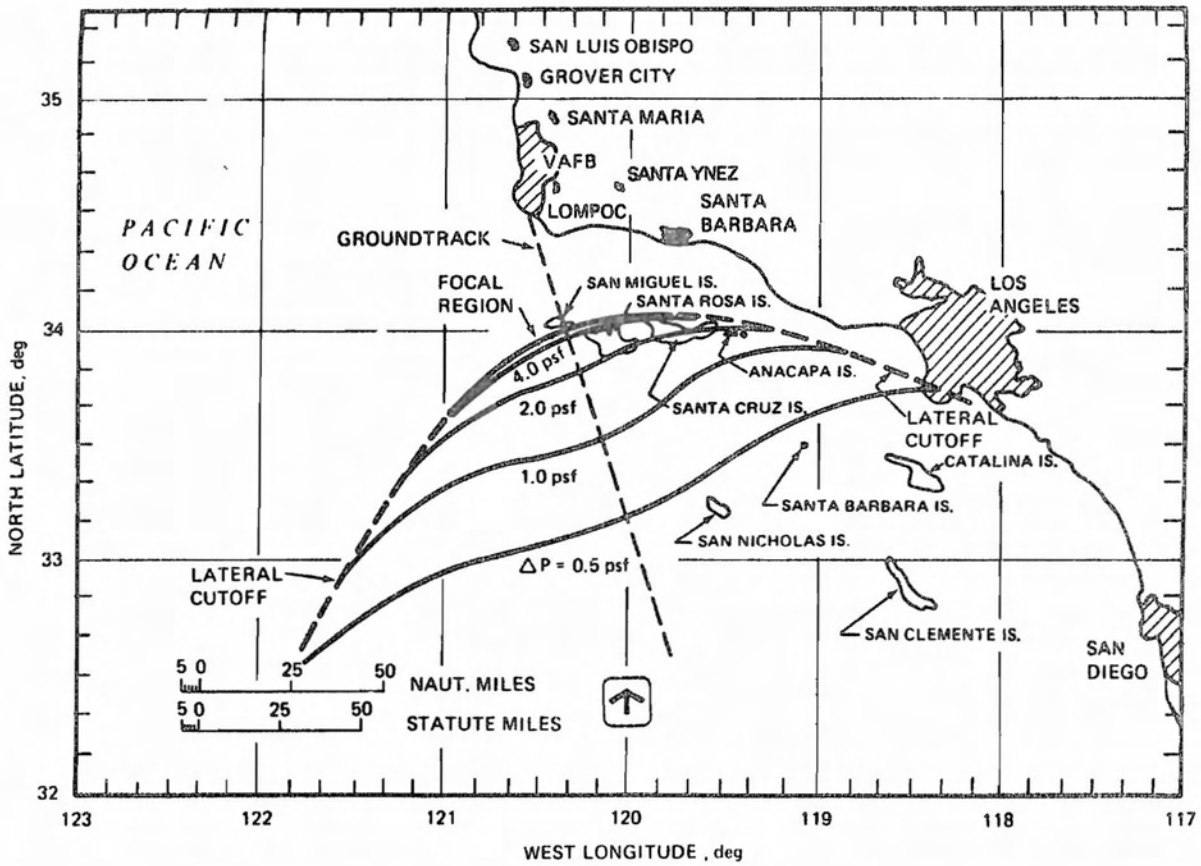


Figure 14. Launch pattern of the Space Shuttle over the Channel Islands with its predicted sealevel "footprint" of sonic boom overpressures that could potentially affect nesting brown pelicans. From U. S. Air Force (1978).

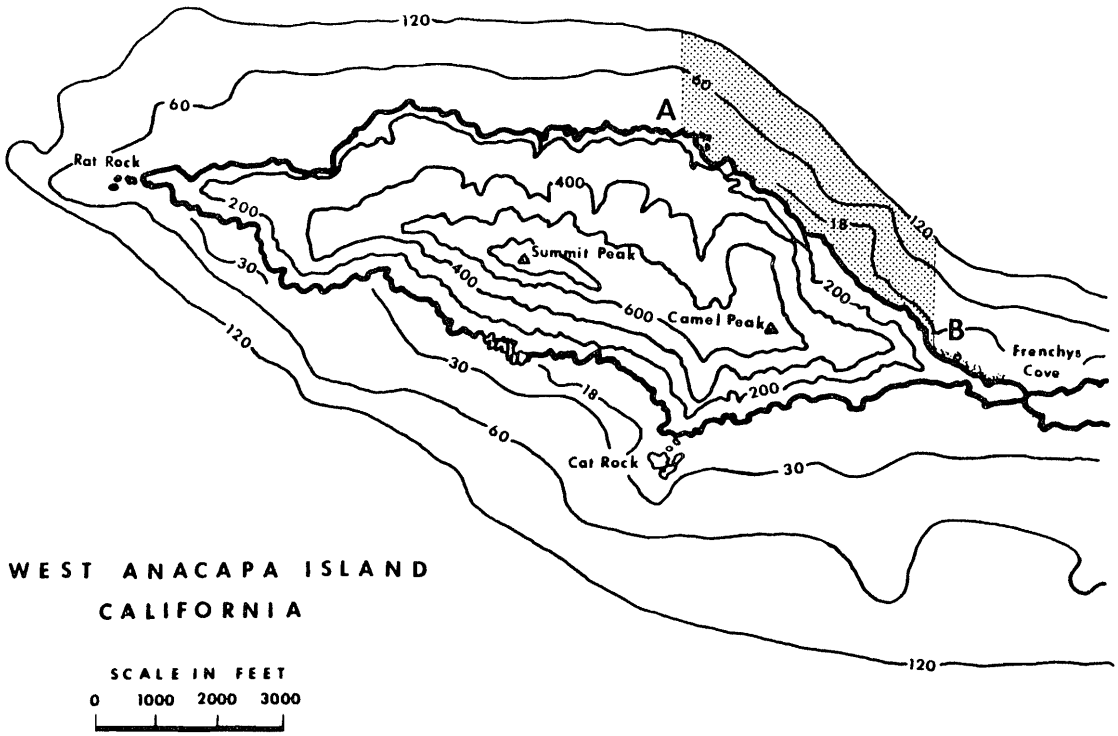


Figure 15. Map of West Anacapa Island showing the brown pelican protection zone, which is part of the Anacapa Island Ecological Reserve. The closure area is designated from the mean high tide mark seaward to a water depth of 20 fathoms (120 feet) on the north side of the west island, between a line extending 345° magnetic off Portuguese Rock (A) to a line extending 345° magnetic off the western edge of Frenchy's Cove (B), a distance of approximately 4,000 feet (boundary description from California Fish and Game Commission 1981). The closure is in effect while pelicans are breeding in this area from 1 January through 31 October.

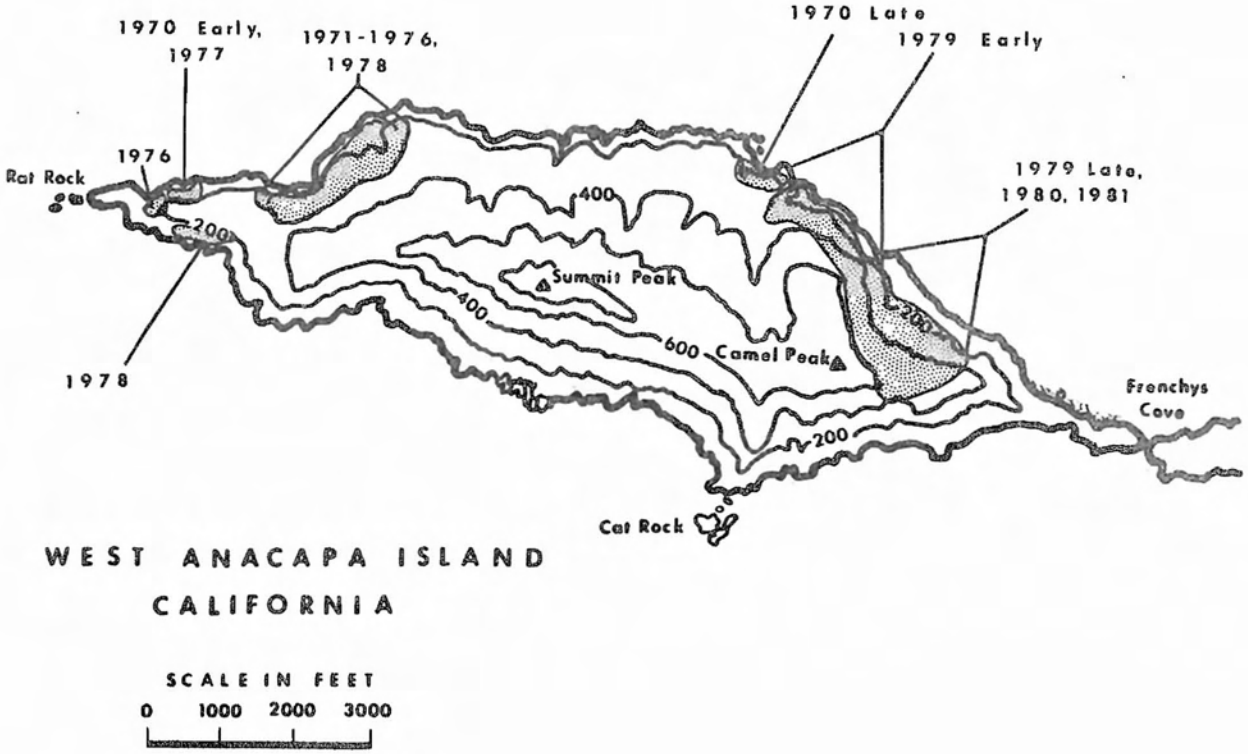


Figure 16. Map of West Anacapa Island showing brown pelican nesting sites from 1970 through 1981.

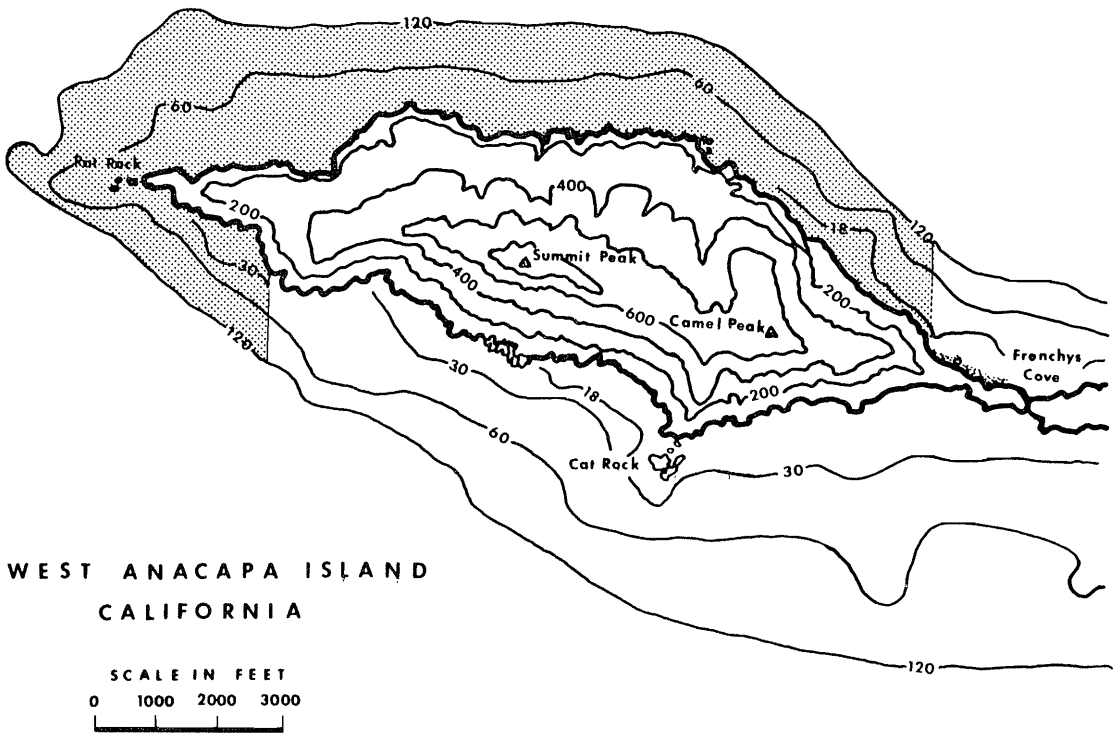


Figure 17. Map of West Anacapa Island showing the offshore zone seaward to 20 fathoms contiguous to known brown pelican breeding areas.

Table 1. Estimated annual number of breeding pairs of the California brown pelican throughout its range in western North America. Approximate numbers of nesting pairs for "poor years" and "good years" (with respect to number of pairs breeding) and average number of pairs that nested in "usual years" are given. Percent total population is based on usual years. [1]

Geographic unit	Estimated yearly average of nesting pairs			Percent total population
	Poor years	Good years	Usual years	
Southern California Bight	1,500	5,000	3,000	6.2
Southwest Baja California	1,200	8,500	5,000	10.3
Gulf of California	20,000	36,000	33,000	68.0
Mexican Mainland	6,000	9,000	7,500	15.5
Total	28,700	58,500	48,500	

[1] Estimates are based on published records, personal observations and field notes of past observers, and personal observations of DWA and FG. Because historical records are scant, these are gross estimates only. This is a tentative analysis for comparative purposes only and is subject to reinterpretation as further data become available.

Table 2. Yearly mean population data for brown pelicans nesting in the Anacapa Island area (West Anacapa Island, Scorpion Rock, and Santa Barbara Island) and on Isla Coronado Norte from 1969 through 1981.

	Anacapa Area			Los Coronados		
Year	Est. No. Pairs[1]	No. Yng. Fledged	Product-ivity[2]	Est. No. pairs[1]	No. Yng. fledged	Product-ivity[2]
1969	750	4	0.005	375	0	0
1970	552	1	0.002	175	4	0.02
1971	540	7	0.013	110	35	0.32
1972[3]	261	57	0.22	250	150	0.60
1973	247	34	0.14	350	100	0.29
1974[3]	416	305	0.73	870	880	1.01
1975[3]	292	256	0.88	339	407	1.20
1976	417	279	0.67	473	487	1.01
1977	76	39	0.51	263	216	0.82
1978[4]	210	37	0.18	265	62	0.23
1979	1258	980	0.78	960	920	0.96
1980[3]	2244	1515	0.68	758	350	0.46
1981	2946	1805	0.61	564	310	0.55

[1] Estimates represent a compromise between maximum numbers present, numbers of nests constructed, reproductive behavior, and appearances of secondary sexual characteristics.

[2] Expressed as number of young fledged per pair. Data for years 1969-1974 are from Anderson et al. (1975), for 1975-1980 from Anderson and Gress (1982a)and Gress and Anderson (1982).

[3] Nesting occurred on Scorpion Rock in 1972 (112 nests; 31 young), 1974 (105 nests; 75 young), and 1975 (80 nests; 74 young) and on Santa Barbara Island in 1980 (97 nests; 77 young).

[4] Probable renesting occurred on Anacapa in 1978; 210 pairs built 340 nests.

Table 3. Diet composition of brown pelicans breeding in the Southern California Bight, 1972-1979, as determined from field identification and otolith analysis of fish species found in nestling regurgitations.[1] Number of individual fish and percent total of each species are given.[2]

Fish Species	Number of Fish	Percent total
Engraulis mordax (Northern anchovy)	2,028	92.4
Cololabis saira (Pacific saury)	68	3.1
Sebastes spp. (juv.) (Rockfish)	44	2.0
Scomber japonicus (Pacific mackerel)	36	1.6
Atherinops affinis (Topsmelt)	13	0.6
Genyonemus lineatus (White croaker)	4	0.2
Embiotocidae (Surf perches)	1	0.05
Chromis punctipinnis (Blacksmith)	1	0.05
TOTAL	2,195	

[1] In 1972-1978, 70 regurgitations were examined in the field; northern anchovy comprised 88.0 percent of 761 individual fish identifications.

In 1979, 39 regurgitations were examined in the field; also, 58 samples containing well-digested and unrecognizable material were collected and fish species identified by otolith analysis. The combined set of samples yielded 94.7 percent northern anchovy from 1,434 individual fish identified.

[2] n = 167 regurgitation samples examined.

From Gress et al. 1980.

CALIFORNIA BROWN PELICAN RECOVERY PLAN - AGENCY REVIEW

National Park Service
San Francisco, CA

National Park Service
Seattle, WA

California Department of Fish and Game
Sacramento, CA

Washington Department of Game
Olympia, WA

Oregon Department of Fish and Wildlife
Portland, OR

National Marine Fisheries Service, Northwest Region
Seattle, WA

National Marine Fisheries Service, Southwest Region
Terminal Island, CA

Minerals Management Service
Los Angeles, CA

California Department of Parks and Recreation
Sacramento, CA

Pacific Fishery Management Council
Portland, OR