INTRODUCTION

This catalog is one of a series describing the seabird colonies of the marine shorelines of the United States. The Pacific Coast of North America has been divided into areas following State boundaries. Seabird colonies in Alaska have been documented by Sowls et al. (1978) and in California by Sowls et al. (1980). A catalog of colony sites in Oregon is now in preparation and, with this catalog of Washington colonies, will appear in the Biological Report series (formerly FWS/OBS series), published by the U.S. Fish and Wildlife Service. A similar catalog of British Columbia, Canada, colony sites has been published (Drent and Guiguet 1961) by the British Columbia Provincial Museum, Victoria, and is currently being updated. Thus an inventory of all reported seabird colonies of the Pacific Coast of North America north of Mexico will be available soon. These catalogs establish a historical baseline description of a valuable and interesting marine resource--the breeding seabirds of the eastern North Pacific ocean. A list of published catalogs and atlases is included as Appendix E.

There are several important reasons why the preparation of this catalog was undertaken. First, as mentioned above, it brings together in one source all the most recent information on breeding species, their numbers, and breeding sites in Washington and establishes a baseline in time. In this catalog the baseline period includes the years 1978 through 1982, as a complete census of all sites in the State in 1 or 2 years has never been undertaken, Also, 1978 marked the beginning of intensive efforts to census all colony sites in the State, in part in conjunction with a study of seasonal populations of all marine birds of the northern inland marine waters of Washington (Manuwal et al. 1979; Wahl et al. 1981).

The second objective of this catalog is to present the best possible reconstruction of the history of all breeding marine birds at all known sites in Washington. This includes all historical breeding sites. Original data-points in this catalog span the period from May 1792 through the summer of 1982: 191 nesting seasons.

Third, this catalog is intended as a source document for administrators, regulatory agency personnel, wildlife biologists, researchers, bird-watchers, and others interested in nature. Thus we have documented the source and present location of every reference in this catalog. We have also included an appendix which gives viewpoints from which a number of colonies can be observed without causing disturbance to the birds (Appendix B).

It is our hope that the catalog will aid in the understanding and conservation of this resource, this element of Washington's marine ecosystem. Future study, censusing, and long-term monitoring can be undertaken with a better understanding of the recent and past status of all species and sites. Changes in numbers and sites and species can be understood and placed in a better perspective.

From its beginning, this catalog was destined to be incomplete by

the very nature of its purposes. Without doubt we have overlooked some references, museum holdings of specimens, eggs, field notes, correspondence, historical files and archives, photographs, agency files, observations of innumerable persons, and many other possible sources of information. In a few cases we were unable to track down sources or elicit response from observers in time for publication. Please bring other errors to our attention.

This catalog documents more than 440 nesting areas of 16 species, with a total of more than 300,000 birds within the marine shoreline habitats of Washington. Two more species are also included: one which recently nested in Washington but presumably does not now, and one which does presently nest there but in very small numbers. There are two species of storm-petrels (Fork-tailed and Leach's), three cormorants (Double-crested, Brandt's, and Pelagic), one shorebird (American Black Oystercatcher), three gulls (Western, Glaucous-winged, and Ring-billed), two terns (Arctic and Caspian), and seven alcids (Common Murre, Pigeon Guillemot, Marbled Murrelet, Ancient Murrelet, Cassin's Auklet, Rhinoceros Auklet, and Tufted Puffin). In addition to population information in the maps and tables, species accounts discuss aspects of the natural history of these species, emphasizing status within Washington. Species accounts were modified after Sowls et al. Catalog of California Seabird Colonies (1980), which this catalog parallels.

We point out that this report only documents nesting sites, and only of these species. Large numbers of nonbreeding birds of these species also reside year-round in marine habitats. There are other species not considered "seabirds" which are also resident and which are regularly, significantly involved with the marine ecosystem in Washington. These include Great Blue Heron (Ardea herodias), Bald Eagle (Haliaeetus leucocephalus), Belted Kingfisher (Ceryle alcyon), and American/"Northwestern" Crow (Corvus caurinus).

In addition to these residents, large numbers of non-nesting birds migrate through coastal Washington in spring and fall and many more birds of many species winter along the coast and in protected waters. These include shearwaters from as far away as Tasmania, New Zealand, and Chile; many species of loons; shorebirds and waterfowl from arctic Alaska and Canada; gulls from the Arctic and from Mexico; and inland-nesting species of grebes and gulls. Oil spills and other disturbances could severely affect populations of many species that constitute an international resource and must be managed and protected as such.

METHODS

This catalog summarizes the results of the efforts of numerous investigators and observers over many years. It is not the result of a specifically designed survey project which ultimately led to this report.

Data used in this catalog were obtained from many sources. A nearly complete survey was made of the major ornithological journals as well as regional journals, particularly The Murrelet.

Relevant regional books, monographs, dissertations, and theses were sought out and reviewed. Unpublished manuscripts, field notes, correspondence, surveys, etc., were searched for in several Washington museums, libraries, archives, State and Federal files, and private libraries. Field notes were also obtained from other museums.

Letters of inquiry were sent to most major museums in North America requesting information on specimens and eggs of breeding birds, details of notes on breeding from specimen labels and egg cards, and for field notes from Washington. Correspondence was carried out with the British Museum of Natural History for specimens and notes from the voyage of Vancouver in 1972 to Puget Sound.

Considerable effort was devoted to correspondence with various observers, requesting details of their observations, etc. All sources obtained were checked for other references, both for additional observers and collections, and also for literature citations. Every effort was made to follow any leads which developed.

Data presented in this catalog were acquired through a wide range of survey techniques. Methods of obtaining numbers of breeding birds vary among sites, species, observers, and period of collection. We have judged all the data presented here to be reasonable in that numbers of each species reported breeding at a given site probably did indeed do so. Ultimately it is up to the user of this report to decide whether any given data set is usable for any given project.

In reviewing data collected we eliminated data sets where (1) it was indeterminable whether numbers of a given species were nesting at a reported site, (2) the site was not reported, (3) the site could not be distinguished from others (as in islands reported as a group), (4) the date of the data could not be determined, or (5) there were other problems with the data set which raised serious doubts as to its validity.

Specimen records were assumed to represent birds nesting at the site of collection if this seemed reasonable to us on the basis of knowledge of the species and the site. This was strengthened if there was a history of the species using that site. In some cases, breeding information on specimen tags clarified nesting status. In our request to museums for information we asked that specimen label and egg card comments be sent to us. In many cases this was done, but in others a lack of museum personnel prevented this.

We attempted to reference completely all citations in the catalog, whether from the literature, correspondence, field notes, reports, or museums. We have identified the present location of all data sources as well as possible. For specimens and eggs, the museum holding the specimen(s) is indicated. Literature citations are standard. The present location of correspondence, field notes, and reports is indicated. Several reports and personal communications from various observers are presented

here for the first time, and are otherwise contained only in our personal files, as indicated.

For many sites, species data are outlined in a "box" at the head of the site listing. Data in these boxes represent the best data, usually the latest, for each species at the site, collected from 1978 through 1982. Sites lacking species data outlined in a box have not to our knowledge been censused during this period.

The user of this catalog should be aware that the totals given for burrowing species, especially those entering and leaving burrows nocturnally, are not usually the result of direct counts. These totals are often the result of grid samples extrapolated to cover the entire suitable habitat at the site. This procedure in itself introduces tremendous potential variance in reported totals. In addition, burrow samples signify different things to different investigators, or even the same investigator at different times or locations. In some cases the estimated total of nocturnal, burrowing species may represent all burrows observed. In other cases it may represent active burrows, burrows with eggs, burrows with chicks, or even just burrows that produce young. Some serious users of this catalog will undoubtedly want to review personally the original source documents.

THE NATURE OF SEABIRDS

Seabirds have relatively long lifespans, low adult mortality rates, relatively late sexual maturity, and small clutch sizes. Lifespans of seabirds are imperfectly known, but they are certainly long in comparison to most terrestrial birds. There are records of several species of seabirds reaching 20 and even 30 years of age in the wild. Glaucous-winged Gulls banded as chicks in the San Juan Islands in Washington have been seen on the nesting colonies up to 25 years later (T. Wahl, unpubl. obs.). Long lifespans in a species imply a low annual rate of adult mortality, and annual mortality rates below 20% are common in seabirds (Ashmole 1971; Henny 1972). Some albatrosses may have annual mortality rates of as low as 3% (Lack 1954) whereas many passerines, at the other extreme, have annual mortality rates from 40 to 70% (Lack 1954; Henny 1972). If mortality rates remain constant with increasing age, large seabirds with very low annual mortality rates may attain a breeding life of 50 years or more (Ashmole 1971). In addition, recruitment of birds into the breeding population is often slow and delayed. Before attaining maturity, many seabirds spend at least 2 years, and more commonly 3-5, and up to 9 years as non-breeders (Ashmole 1971; Speich and Manuwal 1974). Long breeding lives, low recruitment rates, and delayed maturity could delay the detection of effects on successive breeding populations for several years.

The clutch size of seabirds is usually low. Storm-petrels and other Procellariiformes lay one egg, alcids lay one or two eggs, and pelicans and gulls lay one to three eggs. Cormorants may lay up to seven eggs, though clutches of four or five are more common. By contrast, species of land birds

lay from 7 to 15 eggs per clutch, and many produce two or more broods each year.

Because seabirds reproduce at a slow rate but over a long lifetime, the effects of an oil spill or other disaster and the potentially more dangerous effects of long-term, chronic pollution, habitat loss, and other disturbances demand careful and frequent monitoring of seabird populations.

Seabirds tend to be of two types: those which spend most of their time near shore and usually roost on shore (including cormorants, pelicans, and gulls), and those which come to land only during the breeding season or sometimes intermittently during other times of the year (including storm-petrels and alcids). Of the truly pelagic seabirds, several are nocturnal on the breeding grounds, entering or leaving colonies only at night. In Washington the storm-petrels, Marbled Murrelet, Cassin's and Rhinoceros auklets are nocturnal in their visits to nest sites.

The colony site is a very critical habitat for seabirds because reproduction and thus continuation of species depend on these sites. Here the population will reach its annual low, just before young are hatched, and its annual high, just after hatching. At other times of the year, seabirds may be able to avoid problems, such as disruption of food supplies and perhaps even large oil spills, simply by flying somewhere else, but for successful reproduction they are limited to the area around the colony.

In following sections, we point out some of the problems which face seabirds. We hope an awareness of these will alert coastal planners and, indeed, all others to the kinds of problems that may be encountered.

THREATS TO SEABIRDS

DISTURBANCE

In Washington, especially in the areas east of Cape Flattery, in Puget Sound and the San Juan Islands, disturbance-induced stress and mortality are probably the most important long-term factors affecting marine bird populations. The effects of disturbance are often subtle and easily overlooked by the casual observer, but are often devastating to the birds. Impacts range from slight disruption of courtship behavior, incubation, and feeding of nestlings by adults, to outright mortality of nestlings from exposure to heat or cold, and induced predation by conspecific adults or by other species.

The effects of a disturbance event depend on many factors, including the species involved, stage of nesting, type and time of disturbance and its duration and intensity. The long-term summation of all disturbance events is of great concern. Although individual events may appear innocuous separately, together they may be sufficient to lower the mean success of the species' population in the area. Each species is vulnerable in different ways, and each species has its own tolerance to disturbance events below a level significantly affecting its reproduction. Our view is that

the continued existence, especially of many of the birds nesting in Puget Sound and the San Juan Islands, is already being seriously jeopardized by disturbance.

Major forms of disturbance and their potentially detrimental effects on breeding marine birds in Washington include the following:

Recreation

Boating. The spring and summer are popular boating periods which, of course, coincide with the greatest nesting activity and vulnerability to disturbance of nesting seabirds. Our observations indicate that most disturbance occurs indirectly with water recreation and is unintentional and unknown to the persons involved. Only when boats are taken near colony sites is disturbance likely to result. Many boaters usually stay far from rocks, islands, and shorelines, but others seek out such areas as a matter of curiosity or as a place to spend the day or night. The waters immediately adjacent to colonies are often good fishing spots. These close visits near colonies constitute the problem with boating. Often, even when islands are posted as U.S. Fish and Wildlife Refuges, persons land on colonies, walk about, sunbathe, picnic, or run dogs. These activities can be extremely detrimental to nesting birds, disrupting their breeding biology.

The presence of humans or dogs in colonies causes adult birds to leave nests, exposing eggs and young to the weather and predatory species. Boats and their occupants brought close to colonies can also result in adults leaving their nests unprotected. Exposed eggs and small young are often eaten whole by gulls which boldly approach unprotected nests during disturbances. Crows can break and carry off eggs and remove small young. Eggs and young left unprotected may expire from exposure to the sun's heat or chill on cold days. When young are larger and able to move about, disturbance can cause young birds to leave nest sites or territories in panic. Young gulls may be killed by neighboring adults or fall off cliffs into the water and be unable to return to the nest. Young cormorants may be eaten by gulls and crows or be frightened into the water prematurely.

The problems of disturbance are not unique to Washington and are recognized from many other areas; e.g., Baja California, Mexico (Anderson and Keith 1980); and California colonies (S. Speich pers. obs.).

Boating in foraging areas, although perhaps less disturbing to marine birds, can affect nesting birds by reducing foraging opportunities and efficiency. This is thus far undocumented for Washington, but it may prove to be significant in the future, particularly in inland marine waters.

Scuba Diving. Diving is an increasingly popular sport in Washington's inland marine waters. Dive boats operating in the San Juan Islands often anchor near seabird colonies. The proximity of the boat, its occupants, and their activities cause cormorants especially to desert nests, leaving young or eggs unattended. Tufted Puffins are also easily

disturbed. Activity near the colony for long periods can be fatal to eggs and young birds due to exposure or predation. Divers often leave the water and land on the islands, compounding the disturbance and its effects.

Search and Rescue

Although there is no question as to the need for search and rescue operations by United States and Canadian Coast Guard units in Washington, these nevertheless can affect seabirds. These operations often bring vessels, air-cushion craft, and helicopters very near colonies. Helicopters and air-cushion craft are noisy and scare large numbers of birds from nests. Night operations combine noise with powerful searchlights that sweep the colonies, causing great confusion and panic among adults and nestlings. Adults frightened from colonies may not return for hours. Conventional Coast Guard search-and-rescue vessels pose similar disturbance threats as pleasure craft do during daylight hours. The potential impacts on seabird colonies of searchlights at night, especially when employed by air-cushion vessels and helicopters, can be extreme.

Military Operations

Several islands along the outer coast of Washington, as well as islands in Rosario Strait, have been used as bombing targets in the past. Fortunately these activities have been halted in the inland marine waters and are very limited on the outer coast.

Another source of disturbance is close overflights of seabird colonies by a variety of military aircraft. Sudden loud noise panics nesting birds from nest sites: Common Murres often figuratively explode from the cliffs and loss of eggs (held between the legs of incubating birds) may be extremely high.

The use of strobe lights and high-powered searchlights on or near nesting colonies accompanied by engine noise and the firing of cannon constitutes another disturbance hazard to nesting seabirds.

Cormorants, Common Murres, and Tufted Puffins are the species probably most affected by these activities.

Domestic Animals

The introduction of domestic animals into a nesting colony can be disastrous. Dogs especially are extremely disruptive of nesting birds. They not only disrupt nesting activities, but a single dog can easily kill many nestlings and even adult nocturnal birds such as the Rhinoceros Auklet (see Manuwal 1978).

The Pigeon Guillemot is now probably being excluded from many beach areas because of the presence of free-running dogs. Guillemot nests under beach logs and other objects are easily found by dogs.

Many intertidal areas are important foraging areas for gulls, crows, and herons at lower tide stages. Dogs can effectively eliminate these areas from use by foraging nesting birds, as we have observed on numerous occasions. This pressure may be effective in

essentially eliminating foraging areas in heavily populated regions or at recreation sites.

LOSS OF HABITAT

Loss of habitat can take many forms. Some have already been noted above, as where habitat is rendered unsuitable due to disturbance. When discussing nesting marine birds, we tend to think generally of only the actual nesting site and give little attention to the birds' habitat requirements throughout the year and their life cycles.

Nesting Sites

It is of course critical that nesting sites be preserved. In Washington nearly all colony sites are now in public ownership, and there is presently little threat of loss due to development. However, as discussed above, disturbance has the potential to render sites unusable for some species of birds. Pigeon Guillemots and Glaucous-winged Gulls are now probably excluded from some shoreline areas due to disturbance from people and dogs. Marbled Murrelets, if they indeed nest exclusively in trees in Washington, may now have less nesting habitat available than in pre-logging days, but we have no way to evaluate historical population changes or current levels.

Foraging Areas

It is important that foraging areas be preserved and prey species populations maintained at levels which will in turn support marine bird populations (see Commercial Fishing). Each species has habitat preferences, and individuals within species have favored localities in which they tend to forage. The outright alteration of these habitats can eliminate or reduce the support capability, the "carrying capacity," of the habitat. The filling of inter-tidal areas and destruction of bottom and infaunal communities through dredging, filling, and pollution are examples of drastic alteration. And, of course, constant disturbance from people, boating traffic, and domestic animals can also effectively eliminate a site as a foraging area.

Roosting Sites

All birds require sites to rest, and different species have different site requirements. Some species use upland sites to roost while others use water sites, or both. Roosting sites are important for resting and preening. For cormorants, roost sites, both during daytime and nighttime hours, are critically important for the essential drying of the birds' plumage.

Roost sites, like nesting and foraging areas, must be free from disturbance and secure from predators or perceived predators such as domestic dogs. These sites are important throughout the year.

During winter storms, periods of high stress and energy consumption, secure roosting sites become even more important as places of safety and shelter. Breeding seabirds must be considered on an annual basis: survival requirements must be met throughout the year.

Wintering Areas

There are very few data on the actual wintering areas of marine birds that breed in Washington, though some general patterns are known. These wintering areas need to be identified and preserved where necessary. Storm-petrels remain at sea during the winter. Tufted Puffins disperse over the North Pacific at this time, with young birds remaining there until old enough to breed. Presumably cormorants breeding in Washington stay in Washington waters; at least, many individuals of each species are present in winter. American Black Oystercatchers probably remain in Washington and are often found in large flocks. Rhinoceros Auklets appear to go south along the coast to winter off California. Cassin's Auklets are present offshore from Washington during the winter, but most birds may go farther south; we simply do not know. Large numbers of Marbled Murrelets are present during the winter, but we have no information on their origin. At least some Common Murres breeding in Washington may leave the outer coastal waters and enter the inland marine waters during the winter. Although young Glaucous-winged Gulls may disperse up and down the Pacific Coast, adults probably stay in the area during the winter. Caspian Terns probably move south to the waters off Central and South America.

It is essential for the survival of the breeding populations that wintering areas continue to be adequate. Many of the birds breeding in Washington probably leave and winter at sea or along the coasts of Oregon, California, and farther south, but more definite evidence on winter areas is needed. Within Washington we can only directly ensure that winter habitats for roosting and foraging are maintained for local wintering birds.

COMMERCIAL FISHING

There are two major ways that commercial fishing operations can affect marine birds. First, and the most obvious, is the direct mortality of birds caught in fishing nets. In Washington mortality occurs primarily during gill net operations. This mortality from gill nets is poorly documented, but observations and reports from fishermen indicate it occurs locally and in some cases involves many birds. Much gill-netting is done in the shallower bays and estuaries where bird densities are usually highest. Western Grebes (Aechmorphorus occidentalis) are the chief victims observed; however, Common Murres and Marbled Murrelets are also reported to be frequently drowned in nets. A large gill net fishery is in the middle of the Strait of Juan de Fuca, and its impact on the annual large influx of Common Murres in late summer should be investigated. Gill nets staked across rivers may also kill numbers of birds. Lost gill nets have killed large numbers of seabirds on the high seas (see DeGange and Newby 1980), but the mortality from lost nets in Washington is unknown. Gill-netting occurs primarily at night, and the elimination of seabird mortality appears very difficult under many circumstances.

Purse-seining is the other primary type of commercial fishing which affects bird populations. It is conducted during daylight

and, as it can be considered an "active" type of netting which attempts to select fish schools, would appear to catch fewer birds. However, we have observed Western Grebes and Common Murres caught in nets, and numbers of dead birds are occasionally seen floating or beached near locations where purse-seining is extensive. Our observations lead to the suggestion that mortality from purse-seining may be reduced by modifications of net design or fishing strategy.

A second way fishing may affect bird populations is in overfishing or reducing fish to a level where stocks of predators, including seabirds and mammals, may also be reduced. Some bird species may not be able to switch to alternative prey items because of specializations in behavior or diet requirements. In Washington, overfishing could happen, particularly in the case of herring-roe fisheries or other extremely localized and intensive fisheries. Overfishing is a concern for both summer breeding populations and populations of marine birds wintering in Washington.

OIL POLLUTION

There are several ways that petroleum (e.g., solvents, gasoline, fuel oil, lubricating oils, bunker oil, and crude oil) arrives in the marine environment. These include at one extreme massive oil spills, such as when an oil tanker is wrecked. Less catastrophic petroleum events include small local spills such as occur at fuel docks, both commercial and recreational, during fueling of vessels. Fuel may be spilled during transfer between barges or vessels and shore facilities. Crude oil may be spilled during transfer at refineries, by accidents within refineries, or through damage or failure of oil pipelines. Small quantities of petroleum products are lost daily through bilge pumping, small spills at fuel docks, and other accidents. And of significance in the large urban areas are petroleum products, i.e., various oils and greases, which are flushed into storm drains from roadways and into marine waters during rains.

In Washington, it is fortunate that no large oil spills, such as an oil tanker wreck, have occurred to date. The wreck of the freighter Seagate on the outer coast of Washington on September 6, 1956, released fuel that led to the death of several thousand White-winged Scoters (Melanitta fusca) and Common Murres (Richardson 1956). There is a potential, however, for large oil spills in Washington. There is regular and frequent tanker traffic offshore along the outer coast between Alaska and California and ports in Central America. There is traffic also in the Strait of Juan de Fuca and through Rosario Strait to major refineries at Cherry Point in Whatcom County and March Point in Skagit County. These tanker routes pass almost all the major seabird colonies in the State, with ships passing particularly close to several colonies in Rosario Strait.

Chronic, low-level introduction of petroleum products into the marine environment is a serious concern. However, to date, little evidence indicates significant impact on marine bird populations

in Washington. Surveys of beaches in areas east of Cape Flattery in 1978 and 1979 revealed few dead birds that were obviously marked with oil (Speich and Wahl 1986). Nevertheless, the potential effects of chronic low-level oil pollution should not be underestimated. Only a small fraction of actual numbers of dead birds, oiled or unoiled, may reach shore (Hope Jones et al. 1970), leading to underestimates of mortality.

Oil in the marine environment can affect marine birds in several ways and at varying magnitudes. Marine oil spills leave the most obvious effects, easily visible in the form of oiled birds. Because of the habits particular to each species, such as sites and methods of roosting, feeding, and nesting, different species are affected differently. Generally the species most severely impacted are those divers that spend nearly all their time, including hours of darkness, on the water surface. After oil spills in other areas, species of loons, grebes, and alcids occur at high rates on beaches, often heavily oiled and beyond rescue (Smail et al. 1972; Powers and Rumage 1978; Mead and Baillie 1981). These swimming birds are more likely to encounter and be fouled by oil and to be more heavily oiled than species that fly more frequently or roost ashore at night (Powers and Rumage 1978). Gulls observed after the Argo Merchant oil spill tended to have less surface area oiled than did alcids (Powers and Rumage 1978; see also Levy 1980).

Crude oil and crude oil derivatives can affect birds several ways. The most direct is through oiling of feathers which reduces the buoyancy and insulation of the plumage. This increases body heat loss and decreases the swimming and foraging efficiency of affected birds, leading to a greater energy demand and decreased ability to meet that demand. This combination can be fatal, particularly during times of environmental stress. Gulls that were oiled only slightly following the wreck of the Argo Merchant apparently died from being weakened due to oiling and to environmental stress (Levy 1980). Clearly birds that are extensively oiled, especially in cases where oil-matted feathers allow direct contact of the body surface with cold water, have very much reduced chances of survival.

When oil adheres to feathers of a bird, its reaction is to preen and restore the feathers to their natural state. The process of preening can result in the ingestion of oil. Oil can also enter the digestive system by ingestion of contaminated food items. Oil fractions are differentially absorbed within the bird and can cause severe, even fatal physiological disruptions (Hartung and Hunt 1966; Powers and Rumage 1978; see also Stickel and Dieter 1979). Hemolytic anemia in marine birds is a primary toxic effect of the ingestion of crude oil (Leighton et al. 1983).

Ingestion of oil, especially during critical periods of egg formation, can cause depression of laying and rates of hatching, as shown in studies of Cassin's Auklet (Ainley et al. 1981; see also Stickel and Dieter 1979). This can reduce the reproductive efficiency of the population as late nesting birds are less likely

to be successful in fledging their young than birds reproducing on a normal schedule. If birds produce infertile eggs due to physiological disruption caused by ingestion of oil, results on the population may be severe. Birds attempting to incubate eggs that fail to hatch may be effectively eliminated from reproducing that season.

Oil on the feathers of adult birds can be a threat not only to them, but in the case of nesting birds, to their eggs and young. Laboratory studies which simulated the oiling of eggs by oiled parents returning to a nest showed marked decreases in hatching and fledging rates. Treatment of the eggs of nesting Great Black-backed Gulls (Larus marinus) confirmed this in the field. Free-ranging, incubating Laughing Gulls (L. atricilla) were captured and 2.5 ml of No. 2 fuel oil was applied to their feathers around the brood patch. After 5 days of incubation, embryo death was significantly greater in the experimental groups (Stickel and Dieter 1979). These experiments demonstrate that even small amounts of oil on a bird's plumage can seriously reduce productivity. Chronic low-level petroleum pollution of the marine environment potentially can, and may be already, reducing reproductive output. In the long-term, chronic low-level pollution by petroleum products may be more significant in impacting populations than less frequent and yet more obvious and dramatic pollution events like major spills.

Several species of alcids nest in Washington in large numbers; included are two important colonies of Rhinoceros Auklets. In the event of a major spill in foraging or staging areas, especially during the summer breeding period, there could be very high mortality. During late summer there are perhaps as many as one-quarter million Common Murres, including flightless adults and chicks, in the Strait of Juan de Fuca moving from nesting sites in Washington, Oregon, and perhaps northern California to wintering areas in inland marine waters of the State. An oil spill then and there could result in the loss of huge numbers of birds.

There is little information on the response in general of birds to the presence of oil in foraging areas. Some species are more easily oiled than others. But it is not known with certainty whether birds will effectively shift to new foraging areas free from oil (and unexploited by other populations or species). Observations of oiled birds suggest that in at least some cases habitat or location shifts do not occur. However, following the IXTOC I spill along the Texas coastline, part of the shorebird populations left polluted beaches and returned only after the oil was gone (Getter et al. 1981).

TOXIC SUBSTANCES

There has been a general perception by the public that the waters of Washington, including Puget Sound, are "clean." Huge quantities of marine organisms are taken annually for human consumption within the region. However, recent studies of Puget Sound revealed that heavy metals, aromatic hydrocarbons, and synthetic organic compounds occur

throughout the area. Highest concentrations were recorded in samples of marine organisms and sediments from bays near urban areas. These areas include the bays and waterways of the industrial areas of Seattle and Tacoma, particularly, and Bremerton and Bellingham. These findings have led the U.S. Environmental Protection Agency to include the nearshore and tideflat areas of Commencement Bay (Tacoma) within the list of the top ten priority toxic waste dump sites in the country requiring remedial action. Contaminants recently found in high concentrations include chlorobiphenyls (PCB's), chlorobutadienes (CBD's), various aromatic hydrocarbons, and metals such as mercury, lead, arsenic, and cadmium (see Long 1982 for a review of recent findings).

Recent studies have shown that certain sites within Puget Sound are significantly contaminated (Long 1982; Malins et al. 1982). Apparently areas outside of Puget Sound are relatively "clean"; however, none of the parts of Puget Sound studied thus far have been found to be contaminant free (Malins et al. 1982). Parts of the outer coast of Washington are the most removed from sources of contamination, but there are apparently few or no data available from the area for comparisons with other regions.

There are several examples of the effects of metals and man-made chemicals on the survival of adult birds and their ability to reproduce successfully. Effects include physiological disorders and egg-shell thinning (Peakall 1970 and 1975; Hays and Riseborough 1972) that have been observed in several species. The pattern of reproductive failure and its apparent reversal in the case of the Brown Pelican (Pelecanus occidentalis) in California is well known and documented (Gress et al. 1973; Anderson et al. 1975). Double-crested Cormorants also experienced depressed reproductive success during the same period (Gress et al. 1973). The thinning of eggshells of the Ashy Storm-Petrel (Oceanodroma homochroa) and Common Murre on the Farallon Islands has been linked to contaminants (Coulter and Riseborough 1973; Gress et al. 1973), as was the case of the Western Gull in southern California (Hunt and Hunt 1973). For a discussion of egg-shell thinning patterns in Oregon seabirds, see Henny et al. (1982).

Samples of birds collected in 1982 from the Seattle and Tacoma marine water areas contained metals and high concentrations of PCB's (Riley et al. 1983). Birds tend to accumulate mercury and organic contaminants, but not others. The egg of one Pigeon Guillemot contained PCB concentrations at a level known to be lethal to chicken embryos, but apparently little is known of the interactive pathways of PCB's. Samples away from Tacoma and Seattle contained lower levels of pollutants. Although there are high levels of contaminants near these cities, few marine birds breed in the area. Fewer than 1% of the total of all marine birds nesting in Washington breed in the inland waters south of Admiralty Inlet. However, this apparent remoteness of major breeding populations does not necessarily mean remoteness of these birds from contaminants. Birds breeding in relatively clean areas may winter in contaminated areas, as

in the case of Common Murres wintering in Puget Sound. A Fork-tailed Storm-Petrel egg collected in coastal Oregon contained high levels of DDE and PCB's (Henny et al. 1982). This species generally feeds offshore, over deep water. Birds can pick up contaminants at any time of the year at any location. But we must point out that we do not yet have any evidence that Puget Sound marine birds are suffering from exposure to or the uptake of contaminants.

LIMITATIONS OF THE DATA BASE

There are many variables that limit the accuracy and reliability of the data that are available and presented in this catalog of the breeding marine birds of Washington. These limits are of two kinds and must be considered when using data from the catalog. There are, first, the reliability and accuracy of the data available from the viewpoint of observer shortcomings in collecting and recording the data. Second, intrinsic in the nesting habits of each species is great variability in the species' observability and the researcher's ability to obtain a number that reflects the actual number of individuals of a species nesting at any given site.

RELIABILITY AND ACCURACY OF DATA

All data presented are affected by the reliability and accuracy of the observer. Factors range from the observer's ability to identify a species accurately and determine whether it is nesting, to the recording of observations in a clear, complete, and concise format. Other important factors include the observer's competence in knowing and recording the exact location of observation.

Unfortunately, most recorded observations are incomplete and a considerable number cannot be used because of ambiguity or lack of data on location, species identification, or species nesting status. Insufficient documentation and recording of observations has occurred since the first explorations of this region in the 1780's and 1790's, and continues to this day. It is distressing to consider the amount of time and resources spent by numerous individuals, various agency personnel, persons associated with colleges and universities, etc., and the poor quality of recorded observations that have often resulted from their efforts. And, in almost all cases, apparently little thought was given and little effort expended to insure the availability of recorded observations to later workers. There is an almost universal lack of recording of observations in formal field notes in the format of or even vaguely similar to that of the late Joseph Grinnell of the Museum of Vertebrate Zoology (Herman 1980). Most recorded data are fragmentary, often on scraps of paper, in letters, recorded in tables without comments, or contained in the literature in brief form. A lack of maps depicting locations of observations has been particularly limiting in many cases.

Specimens and egg sets are known from many colony sites in Washington. In using these specimens, it is necessary to "trust" the accuracy of the collectors, particularly in regard

to locations. With egg sets it is virtually certain the species was nesting. However, unless specimens are of pre-fledgling young, we can only assume the individual was nesting at the site of collection. This assumption is reinforced if there is a recorded history of nesting at the site by the species, or if the collector has made notes on the tag indicating the specimen or species was nesting.

SPECIES-SPECIFIC PROBLEMS IN COLLECTING DATA

Although species treated in this catalog are breeding marine birds, their natural history, including their manner of nesting, varies considerably. Because of this, different methods must be used to determine numbers nesting of each species, and even for the same species at different sites (i.e., see Nettleship 1976). The confidence a user can put in the numbers recorded as nesting is thus varied. This is in part reflected in the Data Quality codes, a code system based upon the proportion of actual nests counted. But the Data Quality code is thus limited, as it may be possible to obtain a very accurate determination by counting, for example, the individual birds at a site.

NUMBERS OF BREEDING WASHINGTON SEABIRDS--SUMMARY

Eighteen species of marine birds, with minimum total populations of about 303,000 breeding birds, are discussed in this catalog. It is likely that all major colonies within the State are presently known, though the actual sizes of populations of some species using these colonies are very imperfectly known. Although most minor colonies or nest sites are also likely known, there are almost certainly many more locations where species that nest as single pairs, particularly hole-nesters, are breeding. Species accounts (below) give totals for these species breeding along the marine shorelines of the State, but do not include populations of any which might breed on fresh water, particularly east of the Cascade Mountains. Ring-billed Gulls and California Gulls (*Larus californicus*), in particular, nest in colonies in eastern Washington. The species accounts point out which species population totals are believed to be accurate. For those species that we consider existing data to be inadequate, we include estimates of actual numbers breeding in the marine habitats. We feel these estimates are reasonable and realistically conservative, and consequently we estimate a total of about 423,000 marine birds may be nesting within the area covered by this catalog.

The species accounts also indicate that the lack of sufficient historical data for virtually all species precludes any assessment of long-term population changes within the State. Only in the cases of relatively late-arriving species such as Ring-billed Gull and Caspian Tern is there information to show changes, though informed speculation can be made on populations of a number of other species.

Seven species constitute 81% of the breeding marine birds covered in this catalog. Cassin's and

Rhinoceros auklets, Leach's Storm-Petrel, Glaucous-winged and Western gulls (numbers combined--see species accounts), Common Murre and Tufted Puffin make up this group (Figure 1). This proportion is not uniform, however, throughout the various regions of the State. Four of these species breed predominantly on the outer coast, often in a few large colonies, and these species are absent or scarce east of Cape Flattery; therefore, a number of the remaining nine species become relatively much more important as nesting birds in the inland marine waters.

Figure 2 indicates where colonies of the more populous species are concentrated. Over 72% of the total estimated birds breed along the outer coast north from about Point Grenville to Seal and Sail Rocks near Neah Bay.

There are a number of colonies throughout the area generally known as the San Juan Islands and adjacent waters, and in total these form an important nesting area and are, indeed for several species, the primary known nesting area within the State.

The major nesting site in the inland waters is Protection Island, where 16% of all birds in the catalog area nest. The importance of this site (species totals are shown separately in Species Accounts Figures and in Figure 3) is evident in species accounts and the site descriptions below.

The shoreline south of Point Grenville on the outer coast has limited nesting habitat available except for accreted sand islands in Grays Harbor and Willapa Bay and the rock cliff face at the mouth of the Columbia River.

The inland waters south of Admiralty Inlet, including Puget Sound and Hood Canal, have relatively few breeding marine birds, and these are concentrated in a few sites which were unintentionally provided as a result of human activities. Nest sites, except for Pigeon Guillemots, are limited here, though factors of marine productivity and disturbance may also explain low numbers of nesting seabirds in this most highly developed and densely populated part of the State.

Although a number of species essentially nest throughout the State in suitable habitats, several species are confined to the outer coast exclusively, and this gives the State a "split personality" as far as its marine birds are concerned. Seven species breed along the coast but not in inland habitats, while none breed exclusively in the inland waters area. Some species are likely restricted to outer coast sites because suitable nesting habitat is unavailable elsewhere, but some also likely require nest sites near pelagic foraging areas.

Six species, including the least abundant species breeding in the area, Ring-billed Gull, and the most abundant nesting bird, Cassin's Auklet, are known to nest at fewer than ten locations. Fork-tailed Storm-Petrel, Brandt's Cormorant, Caspian Tern, and Rhinoceros Auklet (the second-most abundant species) are also restricted to very few nesting sites. At the other extreme, the Pigeon Guillemot is the most

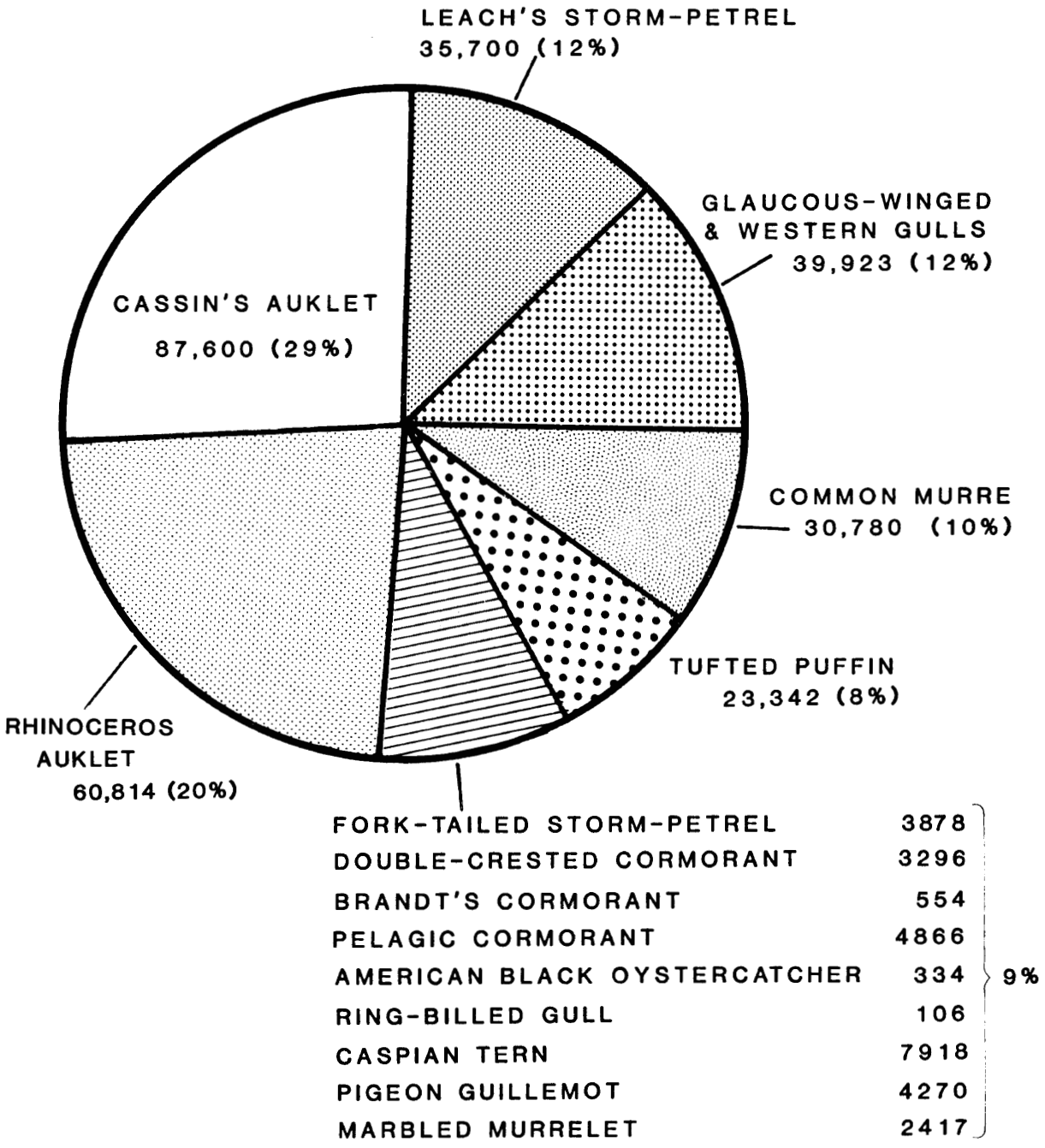

Figure 1. Populations of breeding seabirds and percentages of total aggregate population in Washington.

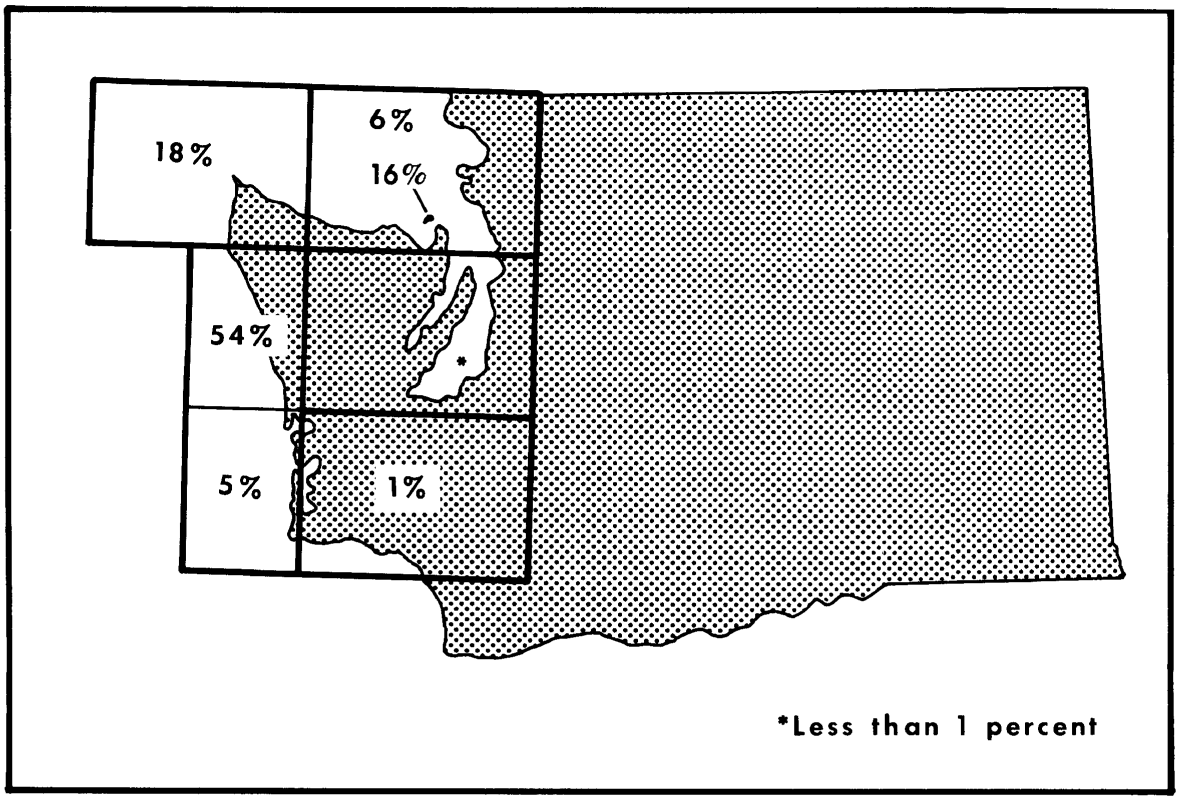

Figure 2. Percentage of breeding seabirds along the marine shorelines of Washington.

widespread nesting species, being recorded here in 148 locations but possibly actually nesting in 200 or more. Other relatively widespread species are Pelagic Cormorant, American Black Oystercatcher (with one of the lowest total nesting populations in the State for the species considered in this study), Glaucous-winged and Western gulls, and presumably, Marbled Murrelet.

If Glaucous-winged and Western gulls are considered one species or closely related species (see species account), and exceptions are made for Ring-billed Gull (essentially an inland-nesting species) and Caspian Tern (of southern origin), species breeding in Washington's marine habitats also nest along the Pacific coast of North America from approximately northern California to Alaska. This species composition reflects similarities in climate and habitats within this long stretch of coastline.

Although breeding distribution of different species of seabirds has been related to oceanography and biological productivity in various parts of the world (e.g., Sowls et al. 1980), little attention has

been given to these relationships in Washington. The associations between great variations in breeding success and variations in oceanographic and climatic conditions also have to date received little attention in Washington.

Thus far, most long-term changes in breeding seabird populations in Washington have been attributed to factors such as land use and human activity patterns and waste disposal. The species accounts below will suggest some possible associations. Additionally, studies are required on effects of pollution and fishing activities on seabird populations and implications for bird reproduction in the State.

Although historical data are minimal, there is evidence that a number of nesting sites in Washington have changed in vegetative cover over time, likely affecting nesting birds. Burrow-nesting birds can accelerate soil erosion and make a site unsuitable over time. Removal or loss of trees or shrub cover can eliminate soil by erosion and thus make an island unusable by burrow-nesting species while possibly benefiting species which nest on bare rock. Fire, whether from lightning strikes or human-caused accidents, can transform nesting habitat within a brief period of time. Erosion by the sea itself is continually occurring, and a number of islands used by nesting birds in Washington have shown significant changes during recent years.

Knowledge of nesting marine bird populations in Washington, particularly in any areas other than nest sites and species composition, is in early stages and there is much to learn. However, with many of the nesting sites in the State now under State or Federal ownership and management, with public interest in protecting and preserving our natural heritage highly evident, and with enforcement of regulations regarding shoreline use and discharge of pollutants, there is reason for optimism regarding the future of marine birds here. With proper concern and public education and judicious use of other resources that the birds may also require, we can meet the basic needs of the birds for food and foraging areas, sufficient nesting and roosting habitat, freedom from disturbance, and a clean environment. Populations of breeding seabirds can thus be maintained.

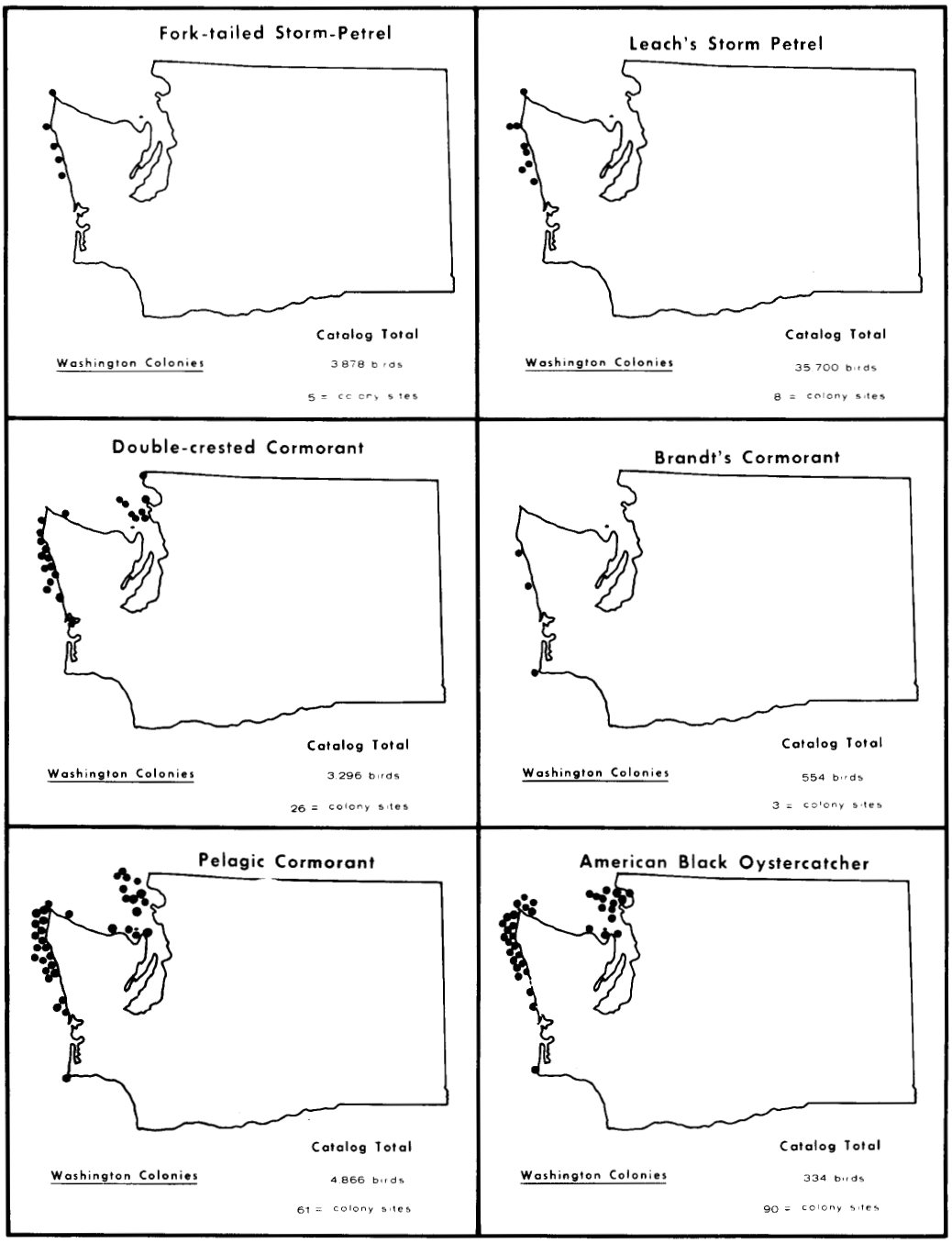

Figure 3. Distribution of nesting sites of the Washington species of seabirds.

(Continued)

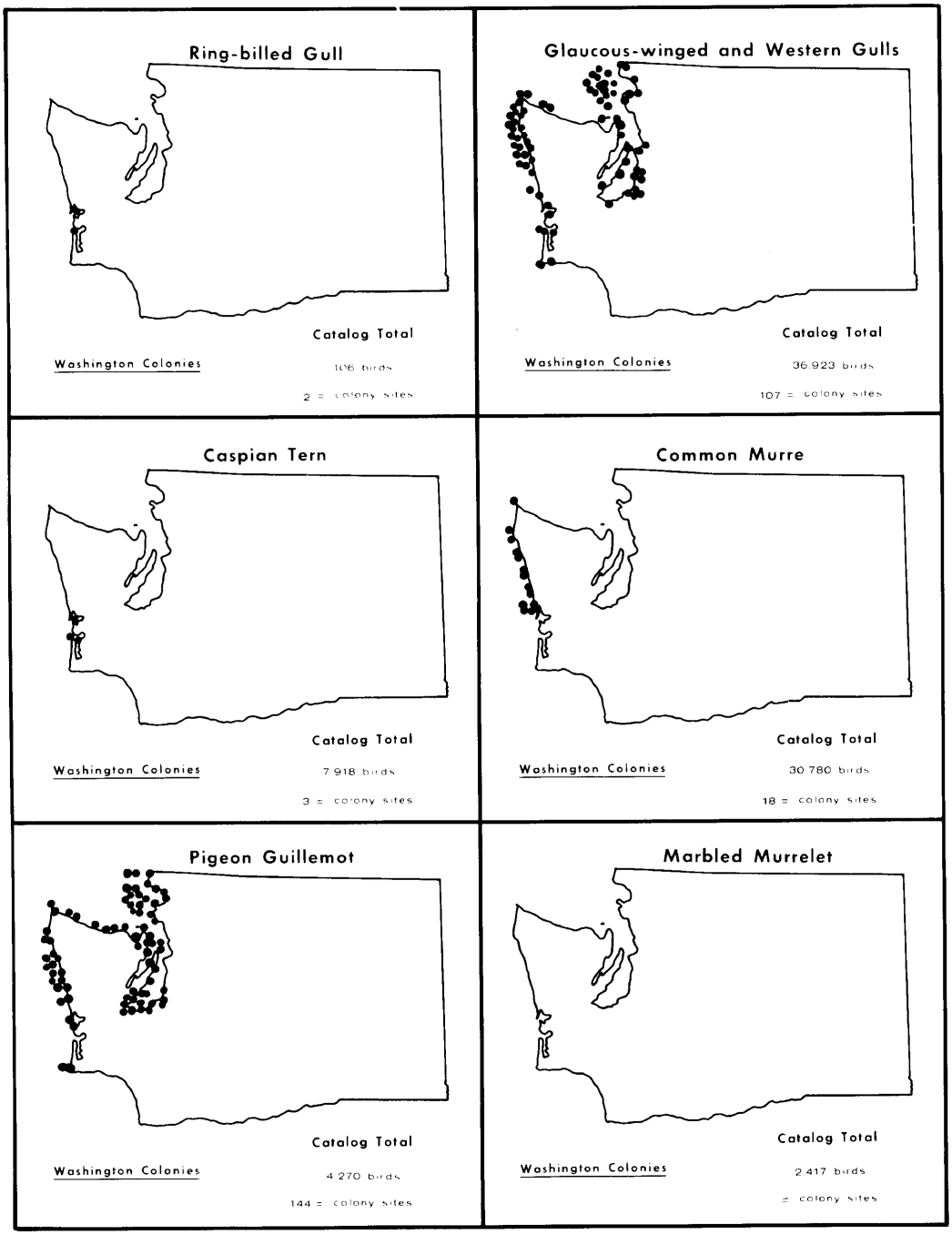

Figure 3. (Continued)

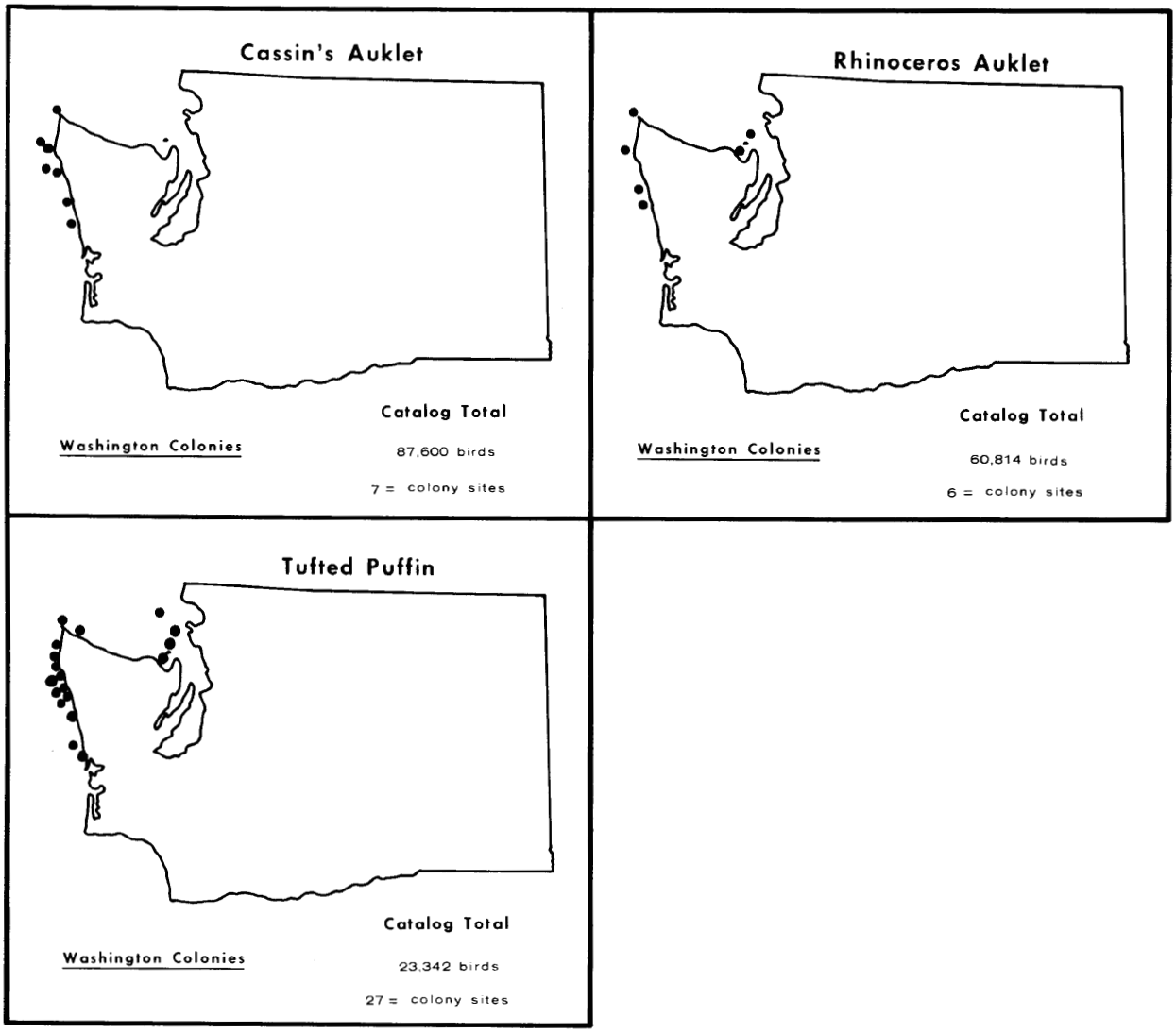

Figure 3. (Concluded)