

Methods

The information compiled in this catalog comes from five primary sources:

- U.S. Fish and Wildlife Service (USFWS) surveys:
 - 1989 – 2004, annual aerial photographic surveys of Common Murre and Brandt’s Cormorant colonies (all colonies photographed, with a subset of 31 Common Murre and 25 Brandt’s Cormorant colonies counted each year) (Carter et al. 2001, USFWS unpublished data);
 - 2003 coastwide survey of all Pelagic, Double-crested, and Brandt’s cormorant colonies (USFWS unpublished data);
 - 1988 comprehensive coastwide survey of all seabird species at all colonies (USFWS unpublished data);
 - 1979 comprehensive coastwide survey of all seabird species at all colonies (Varoujean and Pitman 1980, Pitman et al. 1985).
 - 1966 – 1975, annual aerial surveys (visual estimates) of major Common Murre and Double-crested and Brandt’s cormorant colonies (USFWS unpublished data).
- U.S. Geological Survey (USGS) surveys of Caspian Tern, Western/Glaucous-winged and Ring-billed gull, and Double-crested Cormorant colonies in the Columbia River estuary, 1998 – 2004 (Collis et al. 2002, USGS unpublished data).
- Oregon Institute of Marine Biology (OIMB) annual surveys of Pelagic Cormorants at “OIMB Cormorant colony,” near Cape Arago, 1973 – 2004 (Jan Hodder, OIMB unpublished data).
- Historical records from published and unpublished sources.

Survey methods vary by species, location, size of colony, logistics, and personnel/organization conducting the surveys. Surveys were conducted from boats, aircraft, ground surveys from remote vantage points, and ground surveys within the colony. In general, four techniques have been employed: (1) counts of nests, either directly or from aerial photographs; (2) counts of adult birds on or around the colony, either directly or from aerial photographs; (3) sampling to estimate burrow density and occupancy rates, combined with estimates of colony area; and, (4) crude estimates of nests, birds, or burrows.

In this section, methods used during the 1979 and 1988 statewide surveys, and the methods employed by USFWS from 1966 through 2004, are described. Brief summaries of USGS methods employed in the Columbia River estuary and OIMB methods at the Cape Arago cormorant colony are also included. No attempt is made here to provide detailed descriptions of all methods employed to obtain the data presented in this catalog. Readers are referred to the references listed after each data entry in the tables for specific methods.

Boat and Ground Surveys

During both coastwide surveys, boat and mainland surveys were conducted of all rocks and mainland colony sites from West Point (north of Tillamook Head) to Florence, and Coos Bay to the California border (Figure 4). The remaining sections of coast are dominated by sandy beaches, with no offshore rocks, and they were not surveyed by boat. During boat surveys, larger rocks were circumnavigated and, if conditions were favorable, surveyors landed and occasionally camped overnight. Brief descriptions of the rocks and islands were recorded, including approximate height, soil, vegetation, and any other salient features that might aid future workers in accurately relocating the sites (Appendix C).

The majority of the 1979 survey was conducted from a 4 meter (14 foot) inflatable boat (Zodiac) powered by a 25-hp outboard motor. In 1988, surveys were conducted from 4 – 6 meter (14 – 20 foot) inflatable boats with 30-hp outboard motors. Two or three biologists participated in all boat surveys, using 7 – 10 power binoculars. Data were recorded in notebooks and later transcribed to data sheets and entered into an electronic database.

Shore-based Surveys

Use of high power spotting telescopes from high, stable vantage points afforded the best views of some colonies. Counts of Tufted Puffins at Haystack Rock (Clatsop County), Bandon rocks, and miscellaneous observations of puffins at other sites were made from shore. Annual colony counts of Pelagic Cormorants, Western Gulls, and Pigeon Guillemots at Yaquina Head were derived from a combination of shore and



Figure 4. Map of areas surveyed by boat during the 1979 and 1988 coastwide seabird surveys.

boat-based surveys. The long-term monitoring of the Pelagic Cormorant colony at Cape Arago by OIMB was conducted from shore.

Aerial Surveys

The most significant changes in survey methods over the past 40 years have been improvements and refinements of aerial survey protocols. From 1966 to 1975, USFWS conducted annual aerial surveys of Common Murre and cormorant (species not identified) colonies along the entire Oregon coast using fixed-winged aircraft. These surveys generally targeted only the larger concentrations of Common Murres, and Brandt's and Double-crested cormorants, and were not designed to be comprehensive. Visual estimates of colony size were made by a single observer during a one day survey of the entire coast. In 1979, several aerial surveys were conducted (Pitman et al. 1985). On 19 April, 1979, all major colony sites along the coast were photographed from a single-engine Cessna aircraft. Although too early in the season for maximum seabird attendance at colonies, the flight served as an orientation flight to identify colonies. Later in the season four aerial surveys were made from U.S. Coast Guard Sikorsky helicopters. All major colonies, including nearly every Common Murre and Brandt's Cormorant colony, were photographed on at least two occasions. Photographs were taken using 35 mm SLR cameras equipped with 200 mm and 300 mm focal length lenses and ASA 64 and 400 color slide film.

Beginning in 1988, the timing of aerial photographic surveys was standardized to facilitate comparison between years (Carter et al. 2001). Small, quiet helicopters (Hughes 500, models D & E) with the doors removed were used to minimize disturbance to the colonies and improve the quality of the photographs. Colony photographs were taken by two photographers using 35 mm cameras. Common Murres, Brandt's and Double-crested cormorants, and Western/Glaucous-winged gulls have been counted from these photographs.

Aerial photographic surveys of islands in the Columbia River estuary have been conducted by USGS since 1997. See Collis et. al. (2002) for a detailed description of survey methods at these colonies.

Methods of Estimation

Colony estimates based on direct nest counts provide the most accurate information, and this method was used whenever possible. Virtually all Double-crested, Brandt's, and Pelagic cormorant estimates were obtained using this method. Western/Glaucous-winged

gull estimates (except in the Columbia River estuary) were also derived from nest counts. These species build conspicuous nests which are relatively easy to detect. Direct nest counts were also employed whenever possible to estimate Tufted Puffin breeding numbers, but their burrow-nesting habit made the results less reliable.

Estimates based on the total number of adults present on the colony were used for those species whose nests are difficult to find and for species that nest in dense colonies, where it is difficult, or impossible, to distinguish breeding from nonbreeding individuals. Pigeon Guillemots and Black Oystercatchers are often quite conspicuous around nesting colonies, but their actual nest sites are difficult to locate. Estimates presented in this catalog for these two species represent the number of adult birds seen in the vicinity of appropriate nesting habitat, unless otherwise noted. Common Murres and Caspian Terns nest in large, dense colonies. Estimates of colony size for these species were based on counts of adult birds on the colony (from aerial photographs), adjusted by a correction factor, to account for breeding birds away from the colony and non-breeding birds in attendance.

Burrow-nesting species were the most difficult to estimate. When possible, colonies were directly sampled to estimate burrow density and occupancy rates. The total area of the colony was then estimated in the field or from aerial photographs. Density of active burrows was combined with estimates of colony area to generate colony estimates.

Species-Specific Methods

Cormorants

Pelagic Cormorants typically nest in small colonies on steep cliffs or artificial structures. Boat- or ground-based surveys were the best means to survey these colonies. The longest time series data set for Pelagic Cormorants in Oregon is from the OIMB Cormorant Colony at Cape Arago. Surveys of this colony have been conducted from shore since 1973 by staff and students from Oregon Institute of Marine Biology (J. Hodder, pers. comm.).

Double-crested and Brandt's cormorants typically nest on broader cliff ledges or the tops of islands or headlands where they can be effectively surveyed using high quality aerial photography. Nests are easily identified and counted from projected slides. Double-crested Cormorants also nest in trees, channel markers, bridges, and other structures where new or small colonies can go undetected, especially during aerial surveys. In some colonies (e.g., Three Arch

Rocks, Cape Lookout, and Island Rock), Double-crested and Brandt's cormorants intermix. Distinction between species can be difficult at these colonies if aerial photographs are not high quality. Combining aerial surveys with ground or boat surveys is often necessary to determine the species composition at these sites.

From 1966 to 1975, USFWS conducted annual aerial surveys of the major Brandt's and Double-crested cormorant colonies along the entire Oregon coast, using fixed-winged aircraft. These surveys, conducted in June or July, were completed in one day and the visual estimates did not identify cormorants to species. Beginning in 1979, aerial photographs were utilized in conjunction with ground and boat-based surveys. Since 1988, timing of the surveys has been standardized to coincide with the two-day aerial survey of Common Murres flown annually in early June. (See Common Murre methods for specifics regarding aircraft and photography.)

Statewide surveys of all Double-crested, Brandt's, and Pelagic cormorant colonies were conducted in 1979, 1988, and 2003. Between 1988 and 2003 (except 1995), almost all Brandt's and Double-crested cormorant colonies were photographed annually, and a sample of 25 colonies was counted each year. Photographs of the other colonies were labeled and archived, but not counted.

Brandt's and Double-crested cormorants exhibit relatively low site fidelity. For surveys of the entire coast, this was not an issue since all colonies were counted and most movement between colonies was captured. However, monitoring trends of single colonies, or small groups of colonies, can lead to erroneous conclusions if birds move between sampled and un-sampled colonies.

Common Murre

In Oregon, Common Murres nest on the tops of islands or on mainland cliffs in large, dense colonies. Common Murres do not build nests, and colony estimates are based on counts of adult birds on the colony. From 1966 to 1979, Common Murre colonies were surveyed by visual estimates of breeding birds from a fixed wing airplane. Given the high densities and large size of Oregon Common Murre colonies, these estimates were generally very poor quality. Counts from aerial photographs were first used in 1979 (Pitman et al. 1985), however; biologists had limited control over the timing of the surveys and many of the photographs were taken too late in the season to accurately census breeding murres.

Since 1988, single annual aerial photographic surveys of all major Common Murre colonies in Oregon have been conducted (except 1995) using standardized techniques. Surveys were flown in early June to coincide with late incubation and hatching (after Takekawa et al. 1990), using a Hughes 500 helicopter (models C, D and E) or a Bell helicopter at altitudes of 260 – 330 m with side doors removed. Colony photographs were taken by two photographers using 35-mm cameras with 100 – 400 or 300 mm lenses for close-up photographs (front-seat photographer) using ASA 400 color slide film and shutter speeds less than 1/1000 per second, and 55- or 70 – 210-mm lenses for colony overviews (back-seat photographer) (Carter et al. 2001). Overlapping colony slides were projected onto large sheets of paper, simultaneously using 3 – 4 projectors, and individual birds were counted. These data were transferred to data sheets and computerized. A general *k*-correction factor of 1.67 (based on California data) was applied to all count data to estimate the number of breeding adults at colonies in Oregon (Carter et al. 2001). A specific *k*-correction value for Oregon colonies has not been researched.

All Common Murre colonies were photographed annually between 1988 and 2004, and a subsample of 31 colonies was counted annually. Photographs of the other colonies were labeled and archived. In the data tables of this catalog, the actual counts of Common Murre adults and the estimated number of breeding birds (bird count x 1.67) are both reported.

Pigeon Guillemot

Pigeon Guillemots nest in rock crevices and burrows, and nests are extremely difficult to locate and count. Pigeon Guillemots are social birds and they gather on the rocks and in the water adjacent to nesting areas early in the season. Repeated counts of Pigeon Guillemots on the water during early morning or evening in late April and May show little daily variation and presumably represent an index of the nesting population (Ainley et al. 1990). Counts generally decrease by late morning and are lower through the middle of the day (Carter et al. 1992). Counts also tend to be lower later in the season, since one pair member is incubating or both members are foraging more actively during the chick-rearing period. Counts presented in this catalog were not standardized for time of season or time of day, so colony sizes were likely underestimated. Counts of Pigeon Guillemots during El Niño years might be higher than expected if few birds are nesting and more are visible on the water near the colony (Jaques and Strong 2001).

Tufted Puffin

Tufted Puffins can be counted outside nesting burrows early in the season, particularly during the morning hours. Unlike Pigeon Guillemots, Tufted Puffins engage in frequent flights, entries and departures from burrows, and exhibit variable activity levels through the day, confounding any attempt to get an index of the breeding population based on a count of adults. Estimates were typically derived from a ground count of appropriately sized burrows (often obtained after the nesting season on islands with nesting Common Murres). At some colonies, the presence of Tufted Puffins was noted and a rough estimate was generated based on the number of sightings and the amount of suitable nesting habitat.

Small Nocturnal Burrow-Nesting Species

Fork-tailed and Leach's storm-petrels, and Rhinoceros and Cassin's auklets are nocturnal burrow nesters, and estimates of colony size are particularly difficult to obtain. Estimates of colony size are of poor quality; far less precise than for surface nesters, and may only be accurate within an order of magnitude except where intensive surveys were conducted. Only a few Oregon islands have soil of sufficient depth to support burrow nesting. Observations from a remote vantage point are not possible, even for Rhinoceros Auklets that are active at dusk. The rugged nature of Oregon's islands and the presence of breeding murres at many sites precludes ground surveys of most of the islands. Estimates of Cassin's and Rhinoceros auklet colonies were based on observations of birds close to the colony (often "staging" at dusk) or the availability of suitable nesting habitat. Only a few estimates were based on visits to the colonies during the nesting season.

In 1979 and 1988, estimates of Leach's Storm-Petrel numbers at Goat Island, Hunters Island, and Saddle Rock were derived from density estimates of burrows in specific nesting habitat types, coupled with an estimate of the total area of each habitat type. In 1979, rough estimates of breeding Leach's Storm-Petrels were also generated for islands where breeding was known to occur, but which were surveyed only briefly or not at all. At these islands, the area of potential nesting habitat was visually estimated and density estimates from Goat Island (2.4 breeding birds/m²) were applied to calculate a rough estimate of the potential Leach's Storm-Petrel breeding population. In 1988, presence or absence of Leach's Storm-Petrels was noted for colonies that could not be surveyed on the ground, but numerical estimates of colony size were not made for these colonies. Thousands of Leach's Storm-Petrels have been banded at Saddle Rock in southern Oregon between 1979 and 2004, and

mark-recapture techniques are being investigated as a monitoring tool at this colony.

Western and Glaucous-winged Gulls and Hybrids

Western/Glaucous-winged gulls are opportunistic in selection of nesting substrate and habitats. They nest on a variety of structures (roof tops, pilings, bridges, islets) and small colonies can be missed. A combination of boat, ground, and aerial surveys were used to count Western/Glaucous-winged gull nests at various sites during the two statewide surveys. Annual aerial photographic surveys were conducted by USGS at the East Sand Island colony in the Columbia River in 1997 and 1998 (Collis et al. 2002). Since 1999, aerial photographs have been taken and archived (D. Roby, pers. comm.). Counts of nests were the basis for colony estimates at all sites except colonies in the Columbia River estuary, where adults were counted from aerial photographs. A specific *k*-correction factor has not been researched for the estuary colonies (the largest concentration of nesting gulls in Oregon), so the *k*-value of 1.4, calculated for Western Gulls in California (Carter et al. 1992), was substituted. Both the actual count of birds and the estimated number of breeding birds at these colonies are presented in the data tables.

Oregon is in the zone of hybridization between Western and Glaucous-winged gulls (Scott 1971, Hoffman 1978, Bell 1996). While hybridization between these species occurs as far south as central California, most nesting gulls on the southern and central Oregon coast are Western Gulls (Bell 1996, D. Pitkin, pers. comm.). In 1989, Bell (1996) found that approximately half of the gulls nesting in the Columbia River estuary were Glaucous-winged or hybrids. These Columbia River colonies have increased in size by an order of magnitude since 1989, and the proportion of hybrids appears to have increased also. Determination of hybrid status is impossible from the air. All estimates in this catalog are reported as Western/Glaucous-winged gull, but the proportion of Western Gulls, Glaucous-winged Gulls, and hybrids varies at each site.

Caspian Tern

Aerial photographic surveys of Caspian Tern colonies in the Columbia River estuary have been conducted annually by USGS since 1997 (Collis et al. 2002). Intensive ground surveys of Caspian Tern plots were conducted each year in conjunction with the aerial surveys to generate *k*-correction factors which were then applied to bird counts to estimate the number of breeding birds. See Collis et al. (2002) for a more detailed description of survey methods at these colonies.