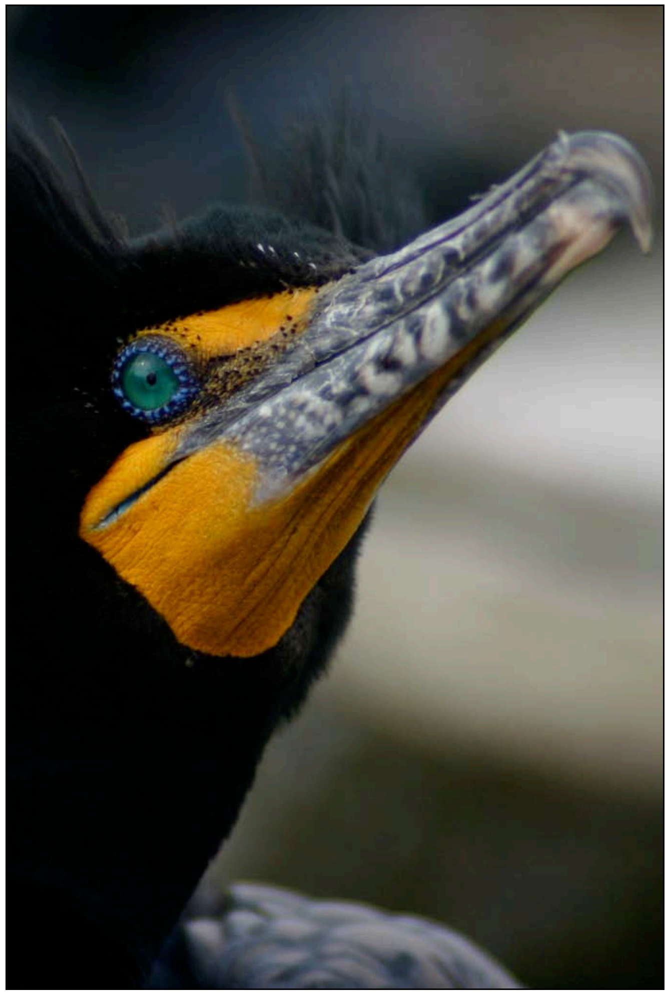
A STATUS ASSESSMENT OF THE DOUBLE-CRESTED CORMORANT (*Phalacrocorax auritus*) IN WESTERN NORTH AMERICA: 1998-2009



Final Report

March 2010

A STATUS ASSESSMENT OF THE DOUBLE-CRESTED CORMORANT (*Phalacrocorax auritus*) IN WESTERN NORTH AMERICA: 1998-2009

Final Report

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31 March 2010

TABLE OF CONTENTS

LIST OF TABLES

Table 9. Numbers of double-crested cormorant breeding pairs at inland sites in California, 1998-2009. Years with few or no data are omitted. A dash indicates no data recorded at that site in that year. Totals in parentheses are incomplete due to missing data because of either (1) a lack of estimates for a large number of sites, (2) no estimate for a site likely to represent a large portion of breeding pairs for the area, or (3) only a visual approximation of breeding pairs was available for a given site(s), rather than a precise count. See Appendix 2 for a complete list of colonies.

Table 10. Numbers of double-crested cormorant breeding pairs in interior states west of the Continental Divide, 1998-2009. Years with few or no data are omitted. A dash indicates no data recorded at that site in that year. Totals in parentheses are incomplete due to missing data because of either (1) a lack of estimates for a large number of sites, (2) no estimate for a site likely to represent a large portion of breeding pairs for the area, or (3) only a visual approximation of breeding pairs was available for a given site(s), rather than a precise count. See Appendix 2 for a complete list of colonies.

Table 11. Summary of the numbers of double-crested cormorant breeding pairs nesting in coastal sub-regions of British Columbia, Washington, Oregon, and California, 1987-1992 and 1998-2009. Years with few or no data are omitted. A dash indicates no data recorded at that site in that year. Totals in parentheses are incomplete due to missing data because of either (1) a lack of estimates for a large number of sites, (2) no estimate for a site likely to represent a large portion of breeding pairs for the area, or (3) only a visual approximation of breeding pairs was available for a given site(s), rather than a precise count. See Appendix 1 for a complete list of colonies.

Table 12. Summary of the numbers of double-crested cormorant breeding pairs in inland sub-regions of British Columbia, Washington, Oregon, and California, 1987-1992 and 1998-2009. A dash indicates no data recorded at that site in that year. Totals in parentheses are incomplete due to missing data because of either (1) a lack of estimates for a large number of sites, (2) no estimate for a site likely to represent a large portion of breeding pairs for the area, or (3) only a visual approximation of breeding pairs was available for a given site(s), rather than a precise count. See Appendix 2 for a complete list of colonies.

Table 13. Numbers of double-crested cormorants in Christmas Bird Counts in British Columbia and the United States west of the Continental Divide, 1997-2008.

LIST OF FIGURES

EXECUTIVE SUMMARY

The first assessment of population size for double-crested cormorants (*Phalacrocorax auritus*) along the Pacific coast of North America summarized data collected prior to 1993 in British Columbia, Washington, Oregon, California, and northwestern Mexico, as well as examining historical trends and conservation issues (Carter et al. 1995). More recent status assessments have been completed for sub-populations in California (Capitolo et al. 2004, Shuford 2010) and in British Columbia (Moul and Gebauer 2002). The breeding distribution of this population has changed dramatically over the past 50 years, with increases at some known colonies and formation of many new colonies; the largest increase has been in the Columbia River estuary, where the number of breeding pairs grew from 6,620 in 1992 to 14,032 in 2007. Fisheries managers have raised concerns over the impact of predation by cormorants from this large breeding assemblage on survival of out-migrating juvenile salmonids (*Oncorhynchus* spp.) from throughout the Columbia Basin, especially those evolutionarily significant units (ESUs) of salmonids that are listed under the U.S. Endangered Species Act.

The geographic area included in this updated status assessment of the Western Population of double-crested cormorants extends from the Pacific Coast east to the Continental Divide, north into southern British Columbia (following the breeding range of the species), and south to the international border with Mexico. The current size of the entire western breeding population is estimated to be about 29,240 breeding pairs. The estimate for the current breeding population in British Columbia, Washington, Oregon, and California, which support the great majority of the Western Population, is approximately 26,390 breeding pairs. This represents an increase of nearly 10,000 breeding pairs (ca. 60% increase) since 1987-1992 (Carter et al. 1995, Moul and Gebauer 2002). Based on the best available data for the three Pacific coastal states and British Columbia during the periods ca. 1992 (Carter et al. 1995, Moul and Gebauer 2002) and ca. 2009, our best estimate of the average annual population growth rate (λ) for this population is 1.03, indicating that the population has grown at an average annual rate of about 3% per year over the last two decades. This overall trend apparently reflects continued recovery of the Western Population due to various statutory and ecological factors during the latter half of the 20th Century, including inclusion of the species in the Migratory Bird Treaty Act, the banning of DDT, and the shift by the species toward increased use of artificial nesting habitats. Most of this population increase, however, can be attributed to increases in the numbers of breeding pairs in the Columbia River estuary and at a few inland sites, which currently account for approximately 41% and 29% of breeding pairs in the Western Population, respectively. Concurrently, numbers of breeding pairs in coastal British Columbia, northern Washington, and southern California have declined since 1987-1992.

The size of the Western Population of double-crested cormorants is still more than an order of magnitude less than the population that inhabits central and eastern North America. Increasing bald eagle (*Haliateeus leucocephalus*) populations, episodic human disturbance, and long-term impacts of certain organochlorine and hydrocarbon pollutants may be important factors causing declines in some portions of the range of the Western Population. Parallel studies on the genetic structure of the Western Population and the post-breeding dispersal of double-crested cormorants nesting in the Columbia River estuary suggest a high degree of population connectivity from southeastern California to southern British Columbia. Alaska, extreme southern California, and areas east of the Continental Divide have more limited connectivity to the Western Population of double-crested cormorants.

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INTRODUCTION

As part of the first status assessment for double-crested cormorants (*Phalacrocorax auritus*) in North America, Carter et al. (1995) summarized available data on the size of breeding colonies for the Pacific Coast Region up to 1992 for both coastal and inland areas of Alaska, British Columbia, Washington, Oregon, California, and northwestern Mexico. An updated status assessment for the species in North America further summarized partial data for the Pacific Coast Region from the mid to late 1990s (Wires et al. 2001, Wires and Cuthbert 2006). In British Columbia, an updated status assessment also was conducted, including survey data up to 2000 (Moul and Gebauer 2002, Chatwin et al. 2002). In 2003, coordinated surveys for double-crested cormorants belonging to the Pacific Coast subspecies, *P. a. albociliatus*, which nests along the Pacific coast from British Columbia, Canada to northwestern Mexico, were initiated by cooperators from federal and state agencies and universities. Estimates of breeding colony sizes were collected from throughout this region; however, inland colonies were not included and the compiled results were not widely disseminated (but see Capitolo et al. 2004; M. Naughton, USFWS, unpubl. data). Consequently, it has been 10-20 years since the status of the double-crested cormorant in western North America has been fully updated.

Wires et al. (2001) followed the geographic "zones" corresponding to the ranges of the five traditional subspecies (Hatch and Weseloh 1999; see the Taxonomy section in this document) in delineating populations in their status assessment of double-crested cormorants across North America. Carter et al. (1995) summarized data for both the subspecies *P. a. cincinatus*, which breeds only in Alaska, and *P. a. albociliatus*, which breeds in British Columbia, Washington, Oregon, California, and northwestern Mexico. For the present status assessment, we accepted the traditional subspecies delineation between Alaska and British Columbia and the conterminous U.S.; this delineation has received strong support from analyses of genetic structure within the species' range (Mercer 2008). Consequently, we did not attempt to collect any current information on the status of double-crested cormorants breeding in Alaska. Similarly, we did not include the area of North America east of the Continental Divide in this assessment because the available information indicated very limited connectivity between the western population and the population of double-crested cormorants in central and eastern North America. Finally, due to genetic evidence suggesting a distinct population of double-crested cormorants in extreme southwestern California and a paucity of recent survey data for northwestern Mexico (Baja California Norte and Sur, Sonora, and Sinaloa) we decided not to include double-crested cormorants nesting in northwestern Mexico in this status assessment (Mercer 2008, see Management Units section below). For the purposes of this status assessment, all breeding colonies of double-crested cormorants within British Columbia, Washington, Oregon, Idaho, California, Nevada, Utah, Arizona, and the portions of Montana, Wyoming, Colorado, and New Mexico that lie west of the Continental Divide (see Figure 1) are considered to belong to the Western Population of the species.

Carter et al. (1995) noted that the population of double-crested cormorants on the Pacific Coast of North America had expanded dramatically since the early 20th century, and was likely to continue to expand. This trend apparently reflects considerable population recovery following a series of enhanced protections afforded the species, including (1) protection of breeding colonies within wildlife refuges, reserves, parks, and other managed areas, especially in the U.S.; (2) protection of double-crested cormorants in the U.S. and Mexico under the Migratory Bird Treaty Act, as amended in 1972, as well as various other legal protections of breeding and foraging habitats from the 1970s to present; and (3) the banning of DDT in 1972, which had severely impacted colonies in southern California and northwestern Baja California Norte since the 1940s. Numbers of double-crested cormorants in certain areas (e.g., coastal British Columbia, coastal Washington, and southern California), however, have experienced less recovery or more recent declines. By 1992, the size of the population of double-crested cormorants west of the Continental Divide was still at least an order of magnitude less than that of the central and eastern North American population, which was estimated to consist of more than 300,000 breeding pairs (Hatch 1995).

The distribution of the Western Population of double-crested cormorants across its breeding range has changed dramatically since 1992, due primarily to the large increase in the number of breeding pairs nesting in the Columbia River estuary, an increase that was first noted in the 1980s (Carter et al. 1992, Anderson et al. 2004). Numbers of double-crested cormorants in the Columbia River estuary grew from an estimated 6,620 pairs in 1992 to an estimated 14,032 pairs in 2007, more than doubling in 15 years (BRNW 2009).

Columbia Basin fisheries managers have raised concerns over the potential impact of predation from the large number of double-crested cormorants nesting in the Columbia River estuary on the survival of juvenile salmonids (*Oncorhynchus* spp.), many of which are listed under the U.S. Endangered Species Act (ESA). In recent years, estimated salmonid smolt consumption by cormorants nesting on East Sand Island near the mouth of the Columbia River has equaled or surpassed consumption by Caspian terns (*Hydroprogne caspia*) nesting in the Columbia River estuary (BRNW 2009). Caspian terns are currently being managed in the Columbia River estuary to reduce their impact on the survival of ESA-listed salmonid smolts. Any management of double-crested cormorants nesting at East Sand Island to reduce smolt mortality in the Columbia River estuary, however, should consider the current status of the Western Population, to which this prominent colony belongs.

Population counts of double-crested cormorants and many other colonial waterbirds are generally conducted during the breeding season, when adults are aggregated at nesting colonies (Bullock and Gomersal 1981, Gaston and Smith 1984), numbers of nests are at or near the seasonal peak, and in the absence of major negative effects from natural or anthropogenic factors. Reliable population counts of double-crested cormorants can be especially challenging because of the potential magnitude of inter-colony movements of individuals between nesting seasons (Hatch and Weseloh 1999, Wires et al. 2001). In some instances, this behavior can result in widely fluctuating counts at particular colonies among years, even in the absence of a net change in regional population size. In the absence of dramatic impacts from bald eagle and human disturbance, pollutants, or other anthropogenic factors, however, fluctuations in the size of particular colonies along the Pacific coast are likely due mainly to changes in oceanographic conditions affecting prey availability (Ainley and Boekelheide 1990, Wilson 1991). Similarly, changes in the size of interior colonies often reflect changes in water levels, which create or destroy potential nesting and foraging habitats (Carter et al. 1995). In addition, major shifts in nesting habitat to artificial nest sites (e.g., bridges in the San Francisco Bay area) have resulted in dramatic short-term changes in colony sizes. Large, short-term inter-colony movements do not occur regularly in all areas along the Pacific coast; however, range-wide census efforts ensure that population trends take into account changes in breeding distribution due to any inter-colony movements. In many cases, trends at individual colonies do not reflect regional trends, especially at small, rapidly-growing colonies or those where nesting habitat is limited. Since the late 1980s, researchers and agency managers along the Pacific coast have recognized that annual surveys of breeding colonies of double-crested cormorants, as well as Brandt's cormorants (*P. penicillatus*) and common murres (*Uria aalge*), can be conducted at relatively low cost and effort using aerial photography, which has led to the development of extensive data sets on these species. Counting birds or nests on aerial photographs, however, has frequently not immediately followed aerial photography surveys due to funding constraints, and many photographs have been archived for later counting (see Carter et al. 2001). Through periodic updates where all colonies are counted in the same years, major changes in Pacific coast populations of double-crested cormorants can be effectively detected and monitored. In the long term, more extensive analyses of all available data from these annual aerial photography surveys, as well as trends at well-studied colonies (e.g., Mandarte Island, BC; East Sand Island, OR; South Farallon Islands, CA; Anacapa Island, CA) will refine those trends detected through periodic updates.

The objectives for this status assessment were five-fold: (1) define management units by incorporating data on population genetic structure from Mercer (2008), who investigated the sub-specific taxonomy of the double-crested cormorant across North America, as well as new data on demographic/migratory connectivity for the species on the Pacific coast; (2) locate and document active colony sites of at least modest size (> 25 breeding pairs) by conducting aerial and ground surveys, as well as through consultation and collaboration with other agencies and individuals; (3) estimate the current size of these breeding colonies; (4) assess the relative demographic/migratory connectivity between the large breeding colony on East Sand Island in the Columbia River estuary and other colony sites, based in part on tracking cormorants using satellite telemetry; and (5) assess demographic trends for the entire Western Population of double-crested cormorants, a management unit that includes the cormorants nesting in the Columbia River estuary, as well as trends in local or regional sub-populations within the management unit.

SPECIES DESCRIPTION

The double-crested cormorant is a large (1.5 – 3.0 kg), dark, sexually monomorphic waterbird with orange-yellow-colored gular and ocular regions year-round. Adults have black or dark brown plumage that can have a greenish cast. The crests over each eye are variable, ranging from all black to all white, and are well-developed only during courtship and sometimes into the incubation period. The buccal cavity and fleshy ring around the eye are bright turquoise, and the irises are bright green. Sub-adults are duller brown and juveniles typically have a pale breast.

TAXONOMY

Five subspecies of double-crested cormorant are currently recognized, four in continental North America and a fifth in the Bahamas. *P*. *a*. *auritus* breeds in central and northeastern North America; *P*. *a*. *cincinatus* breeds in Alaska; *P*. *a*. *albociliatus* breeds from British Columbia, Canada south to at least Sinaloa, Mexico; *P*. *a*. *floridanus* breeds in the southeastern United States; and *P. a. heuretus* breeds on at least San Salvador Island in the Bahamas (Watson et al. 1991, Hatch 1995, Wires et al. 2001). These subspecies have been distinguished based on geographic distribution, body size, and crest characters. There is, however, considerable overlap in geographic range and morphology, and the distribution of crest characters is not well known. Additionally, recent molecular genetics analyses support only two subspecific divisions in continental North America, *P*. *a*. *cincinatus* in Alaska and *P*. *a*. *auritus* across the rest of the species' range (Mercer 2008, see Management Units section below). Mercer (2008) also suggested that the population extending from southwestern California into northwestern Mexico was likely unique; however, further sampling and analyses are necessary to clarify taxonomic status in this region.

LEGAL AND CONSERVATION STATUS

CANADA

The double-crested cormorant was not included in the 1916 Migratory Bird Convention between the US and Canada and so is not protected by the Canadian Federal Government, although the species does receive protection at the provincial level. West of the Continental Divide in British Columbia, the double-crested cormorant is protected by Section 34 of the British Columbia Wildlife Act, which prohibits destruction of individuals, eggs, and nests. The species is currently Blue-listed in British Columbia, a designation that recognizes the double-crested cormorant as a Species of Special Concern (at risk) in the province (BC Conservation Data Centre 2008).

East of the Continental Divide, however, the double-crested cormorant is perceived as a pest species across much of Canada due to increased numbers and their apparent effect on sport fisheries and vegetation, particularly in provincial and national parks. Currently, legal control measures, including organized culls, issuance of take permits, and/or designated hunting seasons, are in effect in most of the central and eastern provinces.

UNITED STATES

In the United States, the double-crested cormorant is federally protected under the Migratory Bird Treaty Act (MBTA) of 1918, as amended in 1972. It is not listed as a species of concern, threatened, or endangered at the federal or state level, with the exception of Kentucky, where it is listed as endangered. Double-crested cormorants were on the 1978 and 1992 lists of bird species of special concern in California, but were not included in the 2008 list, which used a different ranking system (Shuford and Gardali 2008). Double-crested cormorants are considered “not currently at risk” on both the North American Waterbird Conservation Plan (Kushlan et al. 2002) and the U.S. Fish and Wildlife Service’s Seabird Conservation Plan for the Pacific region (USFWS 2005).

Double-crested cormorants have long faced antipathy from humans, particularly the commercial and sport fishing industries (Hatch 1995, Duffy 1995). Populations of double-crested cormorants in the U.S. suffered from the effects of unregulated take and persecution prior to being protected under the MBTA in 1972, and from reproductive impairment from DDT, which was banned in 1972. Since then, the species has become increasingly visible near sport-fishing locations and at the growing number of fish aquaculture facilities, particularly in the southeastern U.S., but also in California. Additionally, concern over the impacts of nesting cormorants on vegetation and other colonial waterbirds has led to increasing conflicts with humans (Wires et al. 2001). These conflicts have been most pronounced east of the Continental Divide; however, concerns are growing in the western U.S., particularly in areas where cormorants forage on juvenile salmonids.

A Public Resource Depredation Order, first issued in 1998 and amended in 2003, allowed the take of double-crested cormorants without a federal permit in 24 states, all east of the Continental Divide. The depredation order authorizes take of cormorants at aquaculture facilities, at roost sites near aquaculture facilities, and to “protect public resources (fish, wildlife, plants, and their habitats) on private and public lands and freshwaters” (USFWS 2003). In states that are outside the jurisdiction of the depredation order, depredation permits at both the federal and state levels are required for lethal control of double-crested cormorants.

MEXICO

The double-crested cormorant is also protected in Mexico under the 1972 U.S. Convention with Mexico on the Migratory Bird Treaty Act. To our knowledge, however, double-crested cormorants are not protected under any specific legal status at the federal or state level in Mexico, nor are they listed by the IUCN or CITES (InfoNatura 2007).

Cormorants in many parts of Mexico do not face the same level of persecution as they do in parts of the U.S. and Canada, even though major colonies (e.g., San Martin Island; one of the largest colonies in the world in the late 19th century) have been severely reduced by human activities (Carter et al. 1995). However, double-crested cormorants in Mexico do face mounting threats from the growth of the aquaculture and tourism industries in breeding areas, and the resulting habitat loss, increased disturbance, and increased potential for conflicts with humans (Wires et al. 2001, Anderson et al. 2007).

MANAGEMENT UNITS

Molecular genetics analyses of the currently recognized subspecies of double-crested cormorant have been conducted since previous regional or national status assessments were completed (Waits et al. 2003, Green et al. 2006, Mercer 2008). A major conclusion from these studies is the lack of support for delineation below the species level among double-crested cormorants in North America, except for the insular population in Alaska (Waits et al. 2003, Green et al. 2006, Mercer 2008). Waits et al. (2003) and Green et al. (2006) restricted their analyses to the relationship of cormorants in the southeastern versus northeastern U.S. and were limited by small sample sizes of populations and individuals. However, Mercer (2008) included samples from individuals and populations throughout North America and concluded that there was little support for recognition of subspecies within the continental U.S. and Canada, outside of Alaska. Rather than genetically distinct regions, a distribution of genetic variation consistent with a pattern of gradual isolation by distance was observed. This pattern implies that genetic differences across the range are due to geographic distance, rather than discrete subspecific breaks.

Lack of a genetic discontinuity between the traditional geographic subspecies of double-crested cormorant does not necessarily imply strong demographic connectivity and homogenization across the range. Only a few dispersers per generation are necessary to prevent significant genetic differentiation (Wright 1931; Slatkin 1985, 1987; Mills and Allendorf 1996), but the same number of migrants may have no perceptible effect from a demographic standpoint. Further, populations may differ demographically despite gene flow. For example, although the Western Population as a whole has exhibited continued gradual increases in total population size, the rate of increase has been lower and the absolute increase small relative to changes in the Eastern/Central Population (Anderson et al. 2004; USFWS, unpubl. data). Additionally, recent colony declines have been documented in portions of the range of the Western Population (e.g., British Columbia, Washington, and southern California), in contrast to widespread population growth throughout the central and eastern U.S. and Canada (Anderson et al. 2004; Capitolo et al. 2004; Moul and Gebauer 2002; USFWS, unpubl. data).

The life history of double-crested cormorants, as well as regional differences in migratory habits, further distinguish the Western Population as a separate management unit. Double-crested cormorants are colonial nesters with mate selection and pairing occurring at the breeding colony, a system conducive to high natal philopatry in stable colonies (Hatch 1995). Many young birds first breed where they were hatched and new colonies are likely formed by young birds at the closest suitable habitat to the natal colony (Hatch 1995). In fact, recoveries of banded birds have indicated high philopatry and site fidelity to areas near the natal colony (Dolbeer 1991, Clark et al. 2006). An analysis of band records east of the Rocky Mountains found that breeding age birds were recovered at a median and mean distance of only 25 and 232 km, respectively, from their natal colony during the breeding season (Dolbeer 1991). Also, subsequent breeding season recoveries of birds banded in the Columbia River estuary as nestlings were all within 150 km of the natal site (Clark et al. 2006). Clark et al. (2006) noted that movements of cormorants banded in Oregon were almost entirely restricted to the Pacific Northwest, with only rare occurrences east of the Cascade-Sierra Nevada ranges, and likely did not extend to central North America. Ainley and Boekelheide (1990) found that first-year birds banded at the South Farallon Islands, off San Francisco in central California, dispersed as far north as western Vancouver Island and as far south as the Mexico border; for after-first-year birds, however, five of seven recoveries were very near the South Farallon Islands, and two were recovered in southern California. Dolbeer (1991) also noted a pronounced lack of interchange between cormorant colonies east of the Rocky Mountains and colonies in the Pacific states. The apparent low level of interchange across this major mountain range is in part due to the lower density of colonies and breeding individuals within the Intermountain West. In addition, a portion of the double-crested cormorants in the Western Population display a greater tendency to be year-round residents, even in the northern part of their breeding range (e.g., Oregon, Washington, and southern British Columbia), while cormorants from similar or higher latitudes east of the Continental Divide are exclusively migratory, spending the non-breeding season in the lower Mississippi Valley, along the Gulf of Mexico, and in the southeastern U.S. (Hatch 1995).

For the purposes of this status assessment, we defined the Western Population as extending along the Pacific coast from southern British Columbia to the U.S.-Mexico border, and from the Pacific coast eastward to the Continental Divide (Figure 1). This definition excludes the cormorant population in Alaska because of strong evidence for both genetic and demographic discontinuity between the two populations (Mercer 2008). The cormorant population in northwestern Mexico was excluded for three reasons: (1) evidence of some genetic differentiation from the Western Population (Mercer 2008), although some exchange likely occurs between colonies within the U.S. and Mexico portions of the Southern California Bight (Gress and Palacios 2005); (2) the large disparity in both federal and state legal protection afforded the double-crested cormorant in Mexico compared to the U.S. (see the Legal and Conservation Status section above); and (3) the paucity of recent survey data for double-crested cormorants in northwestern Mexico, precluding inferences regarding population trends in this part of the species' range. Considering the major demographic differences observed between the double-crested cormorant populations west and east of the Continental Divide, managing the Western Population as a separate unit from the population in the remaining conterminous U.S. appears warranted.

NATURAL HISTORY

BREEDING

Nesting Chronology

Male double-crested cormorants arrive at the breeding colony site first and begin courtship activities with females at the nest site shortly thereafter (Lewis 1929, Mendall 1936, van Tets 1959, Hatch and Weseloh 1999). In the Strait of Georgia, birds arrive at breeding colonies in early April (Drent et al. 1964, Moul and Gebauer 2002). At East Sand Island in the Columbia River estuary, first arrival varies from late March to early April (BRNW 2009). Both members of a pair participate in nest-building, either building of a new nest or repair of an old nest (Hatch and Weseloh 1999). The nest is typically sufficiently complete for egg-laying within two to four days; however, material may be added to the nest throughout the incubation and chick-rearing periods (Mendall 1936, van Tets 1959, Hatch and Weseloh 1999).

Eggs are first laid approximately two to four weeks after arrival (Hatch and Weseloh 1999). Egg-laying is usually initiated in late April in British Columbia, although the egg-laying period can extend into late summer at some colonies in the Strait of Georgia (Campbell et al. 1990). The first egg at East Sand Island, Oregon is typically laid between mid-April and early May (BRNW 2009). At the South Farallon Islands and in San Francisco Bay in central California, egg-laying begins in late March and extends through late June (Ainley and Boekelhiede 1990, Stenzel et al. 1995). Eggs have been laid as early as late February to early March in Arizona (Corman 2005). At the Salton Sea, eggs have been laid as early as December and January, with young four to five weeks of age present in early March (K. Molina, pers. comm.). Most eggs in a colony are laid within two to three weeks after the first clutch is initiated; however, egg-laying within a colony and between adjacent colonies can be highly asynchronous (Hatch and Weseloh 1999).

Chicks hatch approximately 30 days after eggs are laid (Hatch and Weseloh 1999). Chicks at ground-nesting colonies leave the nest to form crèches when they are three to four weeks old, whereas those at tree- or cliff-nesting colonies may remain in the nest until they are able to fly at six to seven weeks of age (Mendall 1936, Hatch and Weseloh 1999).

Nesting Habits

Anecdotal observations indicate that double-crested cormorants can show high colony-site fidelity; however, the level of nest-site fidelity is unknown (Hatch and Weseloh 1999). Double-crested cormorants nest on the ground, on cliffs, in trees or shrubs, and on human-made structures, such as bridges, navigational markers, and transmission towers. Ground-nesting typically occurs on rocky islands or reefs or on mats of emergent vegetation in marshes. Arboreal nesting is commonly initiated in live trees; however, trees are often killed within 10 years of the initiation of nesting activity (Lemmon et al. 1994).

Both members of a pair participate in nest construction and typically use finger-sized-diameter sticks, as well as other materials, to build the nest (Hatch and Weseloh 1999). Nests must be constantly guarded, as other cormorants will pilfer material from undefended nests until nothing is left. Nests can be lined with grass, rootlets, or seaweed, depending on the location of the colony, and are coated with guano as the season progresses. If not scattered after breeding or destroyed by winter storms, nests may be used in subsequent years.

Diet

The double-crested cormorant is a generalist piscivore and is known to prey on more than 250 species of freshwater and marine fishes ranging in length from 3 cm to 40 cm, with the most common prey size less than 15 cm fork length (Hatch and Weseloh 1999, BRNW unpublished data). While their diet is almost entirely fish, double-crested cormorants also forage on crustaceans and other aquatic animals, including insects and amphibians, although to a much lesser extent (Palmer 1962).

At three sites along the Pacific coast (Mandarte Island, BC, South Farallon Islands, CA, and San Miguel Island, southern CA), double-crested cormorants consumed schooling fish that occurred from the top of the water column down to near bottom (Ainley et al. 1981). Based on analysis of pellet castings and chick regurgitations, sand lance (*Ammodytes hexapterus*), clupeids (herring and sardines), cottids (sculpins), embiotocids (surf perches), engraulids (anchovy), pholids (gunnels), and stichaeids (pricklebacks) were important prey types among these sites.

Diet studies at breeding colonies in the Strait of Georgia and Haro Strait, British Columbia found that gunnels and shiner perch (*Cymatogaster aggregatta*) made up the largest portion of the diet of nestlings at Mandarte Island (Robertson 1974). Sullivan (1998) found that the prey species fed to nestlings at Mandarte Island, Five Fingers Island, and near the mouth of the Fraser River, were nearly identical, although prey composition differed substantially.

The most comprehensive study of double-crested cormorant diet during the breeding season has been conducted in the Columbia River estuary at East Sand Island during 1999-2008 (BRNW 2009). On average, anchovy is the single most prevalent prey type, followed by various marine and freshwater fishes, including clupeids, sculpins, and surfperch. The annual proportion of juvenile salmonids in the diet of double-crested cormorants nesting on East Sand Island has remained relatively stable (ca. 10%) during 2006-2008. The proportion of salmonids in the diet of East Sand Island cormorants was highest in 1999 (about 25%) and lowest in 2005 (about 2%).

The only study known to us of the diet of double-crested cormorants breeding at a location inland from the Pacific coast, but west of the Continental Divide, was from Foundation Island, WA, near the confluence of the Snake and Columbia rivers. Here, limited diet data have been collected from nesting cormorants during 2006-2008 (BRNW 2009). On average, centrarchids (specifically bass and sunfish) are the most prevalent cormorant prey, followed by catfish (ictalurids) and salmonids. In general, the proportion of juvenile salmonids in the diet of Foundation Island cormorants varies widely across the nesting season, ranging from 20-85% in May to 0-7% in June. These diet composition results should be interpreted cautiously, however, because they are based on limited sample sizes.

Predators

Bald eagles (*Haliaeetus leucocephalus*) are the primary predators of nesting double-crested cormorants in the Strait of Georgia, the Puget Sound region, along the Olympic Peninsula, and at the mouth of the Columbia River (Vermeer et al. 1989, Carter et al. 1995, Geisbrecht 2001, Chatwin et al. 2002, Moul and Gebauer 2002, BRNW 2009). Bald eagles prey on adults, nestlings, and occasionally eggs of double-crested cormorants, but also facilitate predation on cormorant eggs and chicks by gulls (*Larus* spp.) and crows (*Corvus* spp.) by disturbing the colony and flushing adult cormorants off nests. The river otter (*Lontra canadensis*) has also been noted as a predator on double-crested cormorants in the Strait of Georgia (Geisbrecht 2001).

Population Limiting Factors

Potential factors that could be limiting to the Western Population of double-crested cormorants include predation (Carter et al. 1995, Moul and Gebauer 2002, BRNW 2009), habitat degradation (Carter et al. 1995), human disturbance (Ellison and Cleary 1978, Verbeek 1982, Henny et al. 1989), food supply (Anderson et al. 2004, Molina and Sturm 2004), climate effects (Wilson 1991, McGowan et al. 1998), environmental contaminants (Gress et al. 1973), and disease (Glaser et al. 1999, Shuford et al. 2002).

Mortality due to oil pollution and fisheries interactions does not appear to be a significant population limiting factor. See the "Status Evaluation" section for a detailed discussion of these factors.

HABITAT REQUIREMENTS

Breeding

Breeding colonies occur at lakes, marshes, rivers, estuaries, and coastlines, on rocky or sandy islands, on emergent vegetation, in trees, on cliffs, and on human-made structures such as bridges, navigational markers, pilings, transmission towers, and abandoned docks. Sites with protection from ground predators and within close proximity (typically less than 10 km; Hatch and Weseloh [1999]) of foraging areas are required. Where tree-nesting occurs, trees are usually in or near water or on islands. Ground-nesting may be the ancestral and preferred nesting habitat for double-crested cormorants, whereas nesting in trees and other elevated structures may be a response to ground predators, human disturbance, and loss of natural breeding habitats (Lewis 1929, Carter et al. 1995, Hatch and Weseloh 1999). Recent increases in double-crested cormorants nesting on cliff-faces in the Strait of Georgia may be a response to avian predators (Chatwin et al. 2002). Daytime loafing areas, such as sandbars, exposed snags, rocks, islands, and pilings in proximity to foraging areas, are used during the breeding season. Non-breeders may roost at a breeding colony site or elsewhere during the night. Off-colony nighttime roost sites may be the same as daytime loafing sites or may be at more remote sites (Hatch and Weseloh 1999).

Non-breeding

Double-crested cormorants require similar characteristics in their foraging, loafing, and roosting sites during the non-breeding or winter season as they do during the breeding season. Individuals breeding along the Pacific Coast are largely resident; however, there is evidence that some individuals nesting on East Sand Island, Oregon move north to the Puget Sound region during the post-breeding season, possibly seeking more weather-protected wintering grounds (see Connectivity Among Colony Sites section).

GEOGRAPHIC DISTRIBUTION IN THE PACIFIC REGION

BREEDING

Along the Pacific Coast, double-crested cormorants breed from southern British Columbia south to at least Sinaloa, Mexico, and east to the Continental Divide.

In British Columbia, double-crested cormorants breed from Mitlenatch Island in the northern Strait of Georgia south to Great Chain Island, off Victoria (Figure 2). Breeding colonies have been observed at two locations inland: at Stum Lake, in the south-central part of the province, and in the Creston Valley Wildlife Management Area, near the southeastern borders with Washington State and Alberta (Figure 2).

In Washington State, colonies are located in the Puget Sound region from the Canadian border south to the mouth of the Snohomish River (Figure 2). Breeding also occurs in the San Juan Islands, the Strait of Juan de Fuca, and along the outer coast of the Olympic Peninsula (Figure 2). Inland colonies are located on the Columbia Plateau along the Columbia, Yakima, and Okanogan rivers, and at Potholes Reservoir (Figure 2).

Breeding in Oregon extends from the Columbia River estuary south along the coast to the California border (Figure 2). Inland colonies are located on the Snake River, the Upper Klamath and Malheur National Wildlife Refuges, and on lakes and reservoirs in Deschutes, Harney, and Lake counties (Figure 2).

In California breeding colonies extend discontinuously along the coast from Oregon to Mexico, including the San Francisco Bay area (Figure 2). The primary inland colonies have been located in northeastern California and on the Salton Sea; however, breeding has also occurred on the Sacramento and San Joaquin rivers and at other inland lakes and reservoirs (Figure 2).

Surveys of breeding double-crested cormorants have been less frequent and less comprehensive in some parts of the interior states within the range of the Western Population (i.e., Idaho, Montana, Wyoming, Nevada, Utah, Colorado, Arizona, and New Mexico), compared to the coastal states and British Columbia. The majority of breeding in the interior states occurs in southeastern Idaho and western Nevada (e.g., about 1,000-2,000 breeding pairs annually; Figure 2 [USFWS, unpubl. data; C. Moulton, pers. comm.]). Breeding also occurs in other parts of Idaho and Nevada and at multiple locations in Utah and Arizona (Figure 2). However, breeding west of the Continental Divide in Montana and Colorado is very limited (Figure 2), and there are no documented breeding colonies west of the Continental Divide in either Wyoming or New Mexico.

NON-BREEDING

The non-breeding or winter distribution of the Western Population of the double-crested cormorant overlaps with its breeding distribution. Most wintering birds occur along the inner-coastal areas of British Columbia and Washington, through the estuaries and some outer-coastal areas of Oregon, and along the California coast. Significant numbers also winter inland in California's Central Valley, at the Salton Sea, and on the lower Colorado River (Wires et al. 2001). Fewer individuals winter inland in other regions, with the exceptions of the lower elevations within the Columbia Basin in Oregon, Washington, and Idaho; southern and western Arizona; and southern Nevada. Double-crested cormorants rarely over-winter in regions with colder winter climates (e.g., high elevations), in Utah, or west of the Continental Divide in Montana, Wyoming, Colorado, and New Mexico.

POPULATION ESTIMATES AND TRENDS FOR THE WESTERN POPULATION

BREEDING

The sub-regional designations used in this section follow Carter et al. (1995), except where noted. The Washington sub-region "Columbia River Mouth" per Carter et al. (1995) has been omitted in this report. The name of the Oregon sub-region "Columbia River Mouth" per Carter et al. (1995) has been changed to "Columbia River Estuary" here. All navigational markers located in the Columbia River estuary or near the mouth of the Columbia River are included here in the Oregon sub-region "Columbia River Estuary".

British Columbia

In 2009, the numbers of double-crested cormorants nesting in coastal British Columbia, including the Strait of Georgia sub-region, the Gulf Islands sub-region, and the Vancouver Area sub-region (a new sub-regional designation in this study), was estimated to be 403 breeding pairs at seven active colonies (Table 1). This is down from 617 breeding pairs at 11 colonies in 2000 and 507 breeding pairs at six colonies in 2007 (Table 1). The numbers of breeding pairs in inland British Columbia, however, has grown from nine breeding pairs at one colony in 1998 to 123 breeding pairs at two colonies in 2008 (Table 2).

Archaeological records show the presence of double-crested cormorants in coastal British Columbia as early as 3,500 years before present (Hobson and Driver 1989). The first published account of nesting was at Mandarte Island in 1927, which had been protected to some degree since 1914 (Munro 1928, Moul and Gebauer 2002). During the late 19th Century and early 20th Century, double-crested cormorants were not known to breed in southern British Columbia, nor in adjacent northern Washington (Drent and Guiguet 1961, Speich and Wahl 1989). Presumably, hunting activities of Coast Salish peoples extirpated breeding colonies long ago and then prevented recolonization at these relatively accessible islands for thousands of years, although the area was still used by wintering or non-breeding birds (Fannin 1891). Activities of early settlers after establishment of Victoria in about 1840 and in many other coastal towns in southern British Columbia and northern Washington shortly thereafter also likely prevented nesting for a period of time, following reduction in numbers of native peoples in the late 19th Century. Nesting at Mandarte Island and the Ballingal Islets eventually led to more widespread nesting throughout the Strait of Georgia and in nearby Washington, which developed from the 1950s to the 1970s (Drent and Guiguet 1961, Carter et al. 1995). Colonists likely originated from the outer coast of the Olympic Peninsula, where nesting was noted during 1906-14 (Speich and Wahl 1989, Carter et al. 1995). Given apparent movements of birds from these colonies to temporarily breed at colonies in inner Washington waters during the severe 1983-84 El Niño (Wilson 1991), it is possible that breeding in 1927 at Mandarte Island was prompted by movements related to severe El Niño conditions in 1925-26, coupled with protection from human disturbance at Mandarte Island where birds likely had roosted in the non-breeding season. Inland breeding was first documented in British Columbia in 1993, when four pairs were observed nesting among American white pelicans (*Pelecanus erythrorhynchos*) at a colony on Stum Lake (Moul and Gebauer 2002). The numbers of inland breeding pairs have increased primarily due to a second colony located in the Creston Valley Wildlife Management Area, which formed within a great blue heron (*Ardea herodias*) rookery around 1999 (Van Damme 2004). The majority of inland-breeding cormorants in British Columbia have nested at the Creston Valley colony during the last several years (Table 2).

The current estimate of numbers of double-crested cormorants nesting in coastal British Columbia is down ca. 80% from the peak of 1,981 breeding pairs in 1987 (Moul and Gebauer 2002). Population trends in this region have been driven in large part by patterns at breeding colonies on three islands: Mandarte Island, Five Fingers Island, and Great Chain Island, which collectively supported 82% of the coastal breeding pairs in 1987 (Moul and Gebauer 2002). Within the last 11 years, Five Fingers and Great Chain islands have clearly declined, and no nesting was observed at either site in 2009 (Table 1, Figure 3). The trend at Mandarte Island during the same time period is not as clear; however, the numbers of breeding pairs at this colony over the last few years are a fraction of what they were in 1987 (Table 1, Figure 3; Moul and Gebauer 2002).

While numbers of breeding pairs at many of the ground-nesting island colonies are down, colonies located on cliffs and artificial (human-made) structures appear to be increasing in both size and number (Table 1). These types of breeding habitats are perhaps being used more frequently and by greater numbers of cormorants because they may provide some refuge from bald eagle harassment and human disturbance (Chatwin et al. 2002, Moul and Gebauer 2002).

Washington

As noted under the above section on British Columbia, nesting occurred only on the outer coast of the Olympic Peninsula in the early 20th Century. The first record of nesting in Washington inner-coastal waters was noted in 1937, after initial breeding in adjacent British Columbia, with subsequent growth at many colonies in the San Juan Islands and Strait of Juan de Fuca between the 1940s and 1970s; however, since the 1960s, many colonies in the San Juan Islands were abandoned, with only one colony (Bird Rocks) remaining in this sub-region during 1993-94 (Carter et al. 1995). Numbers in the Strait of Juan de Fuca, however, continued to increase into the early 1990s. In interior Washington on the Columbia River, double-crested cormorants were known to breed prior to 1932; however, nesting habitat was lost and numbers of nesting birds declined as a result of impoundment of the river behind McNary Dam beginning in 1954 (Hanson 1968). Double-crested cormorants were also known to nest on the Snake River upstream of Clarkston, WA prior to dam impoundments (Weber and Larrison 1977, Smith et al. 1997).

In 2009, numbers breeding in coastal Washington, including the San Juan Islands, the Eastern Strait of Juan de Fuca, the Olympic Peninsula Outer Coast, and the Grays Harbor sub-regions, were estimated to be 788 breeding pairs (Table 3). It is difficult to make direct comparisons between 2009 counts and counts from any of the previous 12 years because not all coastal Washington colony sites were surveyed in any one year. Instead, we attempted to make direct comparisons within sub-regions with a qualified discussion of trends in numbers for all of coastal Washington.

In 2009, 595 breeding pairs were estimated to have nested at four colony sites in the San Juan Islands sub-region (Table 3, Table 11). Missing data makes direct comparisons to previous years problematic, even within this sub-region. A colony at the mouth of the Snohomish River, active but of unrecorded size in 1998 and 1999, was the largest colony in the San Juan Islands in both 2003 and 2009, with 529 and 249 breeding pairs, respectively (Table 3). Additionally, in 2003, there was no estimate of breeding pairs recorded for the cormorant colony in Drayton Harbor, which has become a significant breeding colony in recent years (134 breeding pairs in 2008 and 142 breeding pairs in 2009, Table 3). Based on observations from employees of the Port of Bellingham working in the area at the time, it is likely the Drayton Harbor colony was active in 2003 (P. Taft, pers. comm.). Given that the estimate for the San Juan Island sub-region in 2003 was 718 breeding pairs at five colony sites and did not include all known colonies, the 2009 estimate for this sub-region is at least 17% smaller (Table 3).

It is difficult to establish a clear trend for the number of double-crested cormorants breeding in the San Juan Islands sub-region during 1998-2009. Considering that Carter et al. (1995) reported that only 25 breeding pairs nested at one colony in this sub-region in 1992, it appears that numbers of double-crested cormorant breeding pairs in the San Juan Islands have increased dramatically since the early 1990s, but are currently relatively stable. The potential for the Snohomish River mouth colony to continue to support ≥ 250 breeding pairs is uncertain, however, as this colony is located among old creosote pilings, some of which were removed in 2008 and replaced with fewer steel pilings intended for osprey (*Pandion haliaetus*) nesting habitat. More pilings may be slated for removal and/or replacement in the future as part of a creosote removal project (T. Cyra, pers. comm.).

In the Eastern Strait of Juan de Fuca sub-region in 2009, about 28 breeding pairs nested at one colony site, Smith Island. A second colony site in this sub-region, Protection Island, was active as recently as 2008, when 11 breeding pairs nested on the island (Table 4). Overall, these colonies had a greater number of breeding pairs in 1998 and 2003 compared to 1999, 2008, and 2009 (Table 3, Figure 4). Both colonies have experienced variable nesting success in the past. An estimated 528 breeding pairs nested at these colonies in 1992; however, complete nest failure for this and the preceding two years was attributed to human and bald eagle disturbances (Carter et al. 1995). At this time, boat disturbances commonly flushed birds from nests (U. Wilson, pers. comm. to H. Carter) and bald eagle disturbances were extensive; both factors likely contributed to the small colonies remaining at these sites (Carter et al. 1995). During our 2009 aerial survey, we observed ≥15 bald eagles in the vicinity of Smith Island and five bald eagles around Protection Island. Double-crested cormorants at Smith Island, which had nested on the ground in the past, have restricted their nesting to one or two navigation towers on the island during the last few years. Boat disturbances are rarely noted during brief aerial surveys; more work is needed to evaluate current levels of boat or other human disturbances.

A total of 75 breeding pairs nested at three colony sites in the Olympic Peninsula Outer Coast sub-region in 2009. This is down from 210 breeding pairs at 10 colonies in 1998 and 101 breeding pairs at five colonies in 1999 (Table 3). While it is difficult to establish a trend of declining numbers due to missing data in the intervening years, numbers of breeding pairs and colony sites for all three years are down from those in 1992, when 571 breeding pairs nested at 16 colony sites (Carter et al. 1995). Several factors could be affecting the number of breeding pairs and nesting sites in this sub-region. Wilson (1991) documented that nesting seabirds may move away from the outer coast during El Niño years. Common murres, Brandt's cormorants, and gulls nest at many of the former double-crested cormorant colony sites and may provide some competition for nesting habitat. However, common murre numbers are much reduced from population levels in the 1970s and 1980s, due mainly to limited recovery from mortality due to oil spills and gill-nets and from bald eagle disturbances (Carter et al. 2001). During our 2009 aerial survey we observed numerous bald eagles in the vicinity of the seabird colonies along the coast, as well as two incidents of bald eagles actively disturbing colonies. Similar to the Eastern Strait of Juan de Fuca sites, bald eagles may currently be the main factor limiting numbers of double-crested cormorants nesting in the Olympic Peninsula Outer Coast sub-region, although changes in prey availability may also be a factor.

In 2009, 90 breeding pairs of double-crested cormorants nested on channel markers in Grays Harbor. Since 2000, all cormorants breeding in Grays Harbor have nested on channel markers, but there is no clear trend in the number of breeding pairs during this period (Table 3). Numbers peaked in 2004, when 185 breeding pairs were estimated to nest in Grays Harbor (OSU/RTR/USGS, unpubl. data). In 2008, 52 breeding pairs were estimated to be nesting, the lowest number since 2000 (OSU/RTR/USGS, unpubl. data). Larger numbers nested in the Grays Harbor sub-region in 1992, with 191 breeding pairs at Goose Island and 249 breeding pairs at Unnamed Sand Island (Carter et al. 1995). Goose Island has since washed away, and Unnamed Sand Island has not supported nesting double-crested cormorants since five pairs nested there in 1999 (Table 3).

It is difficult to establish a clear trend in numbers nesting along coastal Washington within the last 12 years (Table 3). However, the numbers of breeding pairs during 1998-2009 are down from 1,618 breeding pairs in 1992 (Carter et al. 1995). Our 2009 estimate of 788 breeding pairs in coastal Washington is a 51% decrease from 1992.

In 2009, 1,196 breeding pairs were estimated to have nested at four sites in inland Washington (Table 4). This is the lowest breeding pair estimate since regular data collection began at the three main eastern Washington colonies in 2005 (Table 4). Breeding colonies at Foundation Island and Potholes Reservoir were approximately 13% and 19% smaller in 2009 compared to 2008 (Table 4). The number of breeding cormorants in this region, although currently stable, has grown from 425 breeding pairs in 1991 (Carter et al. 1995).

Oregon

Small numbers of double-crested cormorants bred along the Oregon coast in the early 20th Century but increased to about 2,000 nests at 15 sites by 1979-1980 (Carter et al. 1995). A major change began when birds colonized artificial habitats (pilings and other structures) in the Columbia River estuary in 1980 and then moved to two artificial islands (East Sand Island and Rice Island) in 1987-88, where 2,026 and 1,211 breeding pairs, respectively, occurred during 1991-1992 (Carter et al. 1995). During the 1980s, a rapid increase also occurred at other Oregon coastal colonies. Immigration of birds from other regions, reduced persecution in coastal areas, and protection of nesting habitat may have been contributing factors associated with this increase (Carter et al. 1995).

In 2009, 12,346 breeding pairs were estimated to have nested at four sites in the Columbia River Estuary sub-region (Table 5). The number of breeding pairs in this sub-region approximately doubled in 10 years, from an estimated 7,270 breeding pairs in 1998 to an estimated 14,032 breeding pairs in 2007 (Table 5). This is up from the 1990-1992 estimate of 3,364 breeding pairs at six sites (Carter et al. 1995). This growth was almost exclusively due to the increase in size of the breeding colony on East Sand Island, which grew from approximately 6,285 breeding pairs in 1998 to 13,771 breeding pairs in 2007. The number of breeding colony sites in the Columbia River Estuary sub-region has remained relatively stable during 1998-2009 (Table 5). The estimated size of the East Sand Island colony declined by approximately 20% in 2008 to 10,950 breeding pairs, driving down the overall total for the Columbia River Estuary, then increased to 12,090 pairs in 2009 (Table 5).

In 2009, an estimated 2,384 breeding pairs of double-crested cormorants nested at 22 colony sites along the Oregon coast (Table 6). This is a modest increase from the 2003 and 2006 estimates of 2,216 and 1,903 breeding pairs at 24 and 21 colony sites, respectively (Table 6). Overall, breeding numbers during 2003-2009 in coastal Oregon are lower than the 1988-1992 estimate of 2,939 breeding pairs at 19 colony sites (Carter et al. 1995, Naughton et al. 2007). There was a shift in the use of the different sub-regions of the Oregon coast between 1988-1992 and 2003-2009. In 1988-1992, 20% of all breeding pairs nested at colonies in the Central Coast sub-region, compared to only 1-2% of breeding pairs in 2003-2009.

The breeding colony dataset for inland Oregon is problematic, with some missing data in most years. In 2009, when a comprehensive aerial survey was conducted, an estimated 1,041 breeding pairs nested at seven colony sites (Table 7). The suite of subcolonies in the Upper Klamath NWR constituted 82% of all breeding pairs in inland Oregon in 2009. This has been the dominant nesting site in inland Oregon since at least 1999 (USFWS, unpubl. data; Shuford et al. 2006). The 2009 estimate of breeding pairs in Upper Klamath NWR is up from 1999 and 1992 estimates of 500 and 485 breeding pairs, respectively (Table 7; Carter et al. (1995). The 1992 estimate was considered to be low compared to earlier years, likely due to changing water levels (Carter et al. 1995). A second previously important nesting site on Malheur Lake in Malheur NWR was last documented as active in 1999, when 259 breeding pairs nested at this site (M. Naughton, USFWS, unpubl. data). Double-crested cormorants have not nested at the Malheur Lake site for several years, as there are no longer trees or emergent vegetation available for nesting habitat (T. Bodeen, pers. comm.). Cormorants in inland Oregon are subjected to variable water levels, due to water management in some areas and severe drought years, which can have a dramatic effect on availability of nesting and foraging habitat. Climate and irrigation-based agriculture likely influence the numbers of nesting cormorants and availability of nesting sites in inland Oregon from year to year.

California

In the mid 19th Century, large numbers of double-crested cormorants bred on the South Farallon Islands and smaller colonies occurred on the Channel Islands off southern California, although colonies were reduced dramatically by human disturbance by the late 19th Century (Ainley and Lewis 1974). In the 1960s, a new population became established in northern California; in the 1960s to 1989, populations in central and northern California grew substantially, reflecting colony and other protections (Carter et al. 1995). Colonization of artificial habitats in San Francisco Bay in the late 1970s and early 1980s also reflected reduced human disturbance in these areas, although pollutants likely affected breeding success. Historical nesting in this area has been suggested through archaeological remains of cormorant chicks in middens (Sher 1994), but no nesting was reported for at least two centuries during extensive use and development first by Mexicans (from the late 18th Century to 1848) and subsequently by Americans. In the early to mid 20th Century, colonies declined in southern California and northwestern Baja California Norte due to human disturbance and organochlorine pollutants that caused significant eggshell thinning and reproductive failures (Gress et al. 1973). With the banning of DDT in 1972, numbers in southern California began to increase in the late 1970s, with additional growth in the 1980s; growth likely included some immigration from Mexican or interior colonies. In the mid 19th Century, large populations bred in interior California but were reduced dramatically in the late 19th and early 20th centuries by large-scale agricultural developments (Carter et al. 1995). However, interior populations survived and began increasing in the 1980s.

In 2008, an estimated 4,994 breeding pairs nested at 48 colony sites along the California coast (Table 8). This number is down from the 2001-2003 estimate for this same region, when 6,575 breeding pairs were counted at 45 colony sites (Table 8; Capitolo et al. 2004). The greatest declines were in the Northern Coast – North Section sub-region (ca. 41% decline) and the Central Coast – San Francisco Bay sub-region (ca. 34% decline). The 2008 estimate is similar to the 1989-1991 estimate (Carter et al. 1995). During this time period, a total of 4,405 breeding pairs nested at 39 colony sites along the California coast.

Although overall numbers breeding in California in 2008 were similar to 1989-1991, the relative distribution of breeding cormorants shifted among the different sub-regions of the California coast. A greater proportion of cormorants nested in the Central Coast sub-regions in 2008 (ca. 52%) compared to 1989-1991 (ca. 43%), and a smaller proportion nested in the Southern Coast sub-region in 2008 (ca. 15.5%) than in 1991 (ca. 25%). By contrast, the proportion of cormorants that nested in the Northern Coast sub-regions was ca. 32-33% in both time periods. Within the Central Coast sub-regions, the greatest change was in the Outer Coast South, where the number of breeding cormorants increased by ca. 256% between the two time periods despite the number of colony sites remaining at six. Within the Southern Coast sub-region during both 2008 and 1991, the majority of colony sites were located in the Channel Islands (seven of nine sites and five of six sites, respectively). Overall, the number of double-crested cormorants breeding in the Channel Islands declined by ca. 35% between 1991 and 2008, despite lowered pollutant levels and little human disturbance during this period. In contrast, numbers of nesting brown pelicans (*P. occidentalis*) at the same islands, which also had been greatly affected by earlier organochlorine pollution, increased during this time period.

The most comprehensive recent estimates for numbers of double-crested cormorants breeding in inland California are currently available only for the northeastern part of the state. In 2009, about 259 breeding pairs nested at five colony sites in this sub-region. This is down from the 1992, 1999, 2003, and 2004 estimates when 540, 574, 521, and 604 breeding pairs, respectively, nested at three surveyed sites in 1992, 2003, and 2004 and at six surveyed sites in 1999 (Table 9; Carter et al. 1995). Estimates for 1992, 1999, 2003, and 2004 should be considered minimums, however, as data were missing for some sites in all years. The greatest difference between 2009 and the previous years was in the number of breeding pairs that nested at Sheepy Lake in Lower Klamath NWR and at Sump 1A and Sump 1B in Tule Lake NWR (Table 9). In general, fewer cormorants nested at these three sites in 2009 than in previous years.

The Salton Sea has been at least an intermittent breeding site for double-crested cormorants in inland southern California since soon after its formation in 1906-1907 (Molina and Sturm 2004). Nesting at this site has been sporadic over the last two decades, however, and perhaps since its formation. No more than 57 breeding pairs nested there in 1988 (Carter et al. 1995) and no nesting by double-crested cormorants occurred during 1989-1994 (Molina and Sturm 2004). Forty-eight breeding pairs nested at the Salton Sea in 1995 and by 1999 the breeding population had increased rapidly to an estimated 5,425 breeding pairs, primarily on Mullet Island (Shuford et al. 2002, Molina and Sturm 2004). This period was followed by a severe drop in nesting numbers, when no cormorant nesting was observed at Mullet Island in 2001 and 2002 (Molina and Sturm 2004). No data are currently available for the intervening years; however, available visual assessments suggested that a minimum of 2,000 breeding pairs nested on Mullet Island in 2009 (Table 9; K. Molina, pers. comm.). Because nesting habitat remained constant from 1995 to 1999, and this period of rapid growth in the number of breeding cormorants coincided with a population explosion of tilapia (*Oreochromis mossambicus*) in the sea, Molina and Sturm (2004) suggested that food availability is a likely factor driving the population dynamics of breeding double-crested cormorants at the Salton Sea.

Interior States

Data on double-crested cormorant breeding colonies in the interior states portion of the range of the Western Population are limited because colonies are not typically surveyed on an annual basis, as they are at many coastal sites. Consequently, these data are not sufficient for assessing population trends for this portion of the range of the Western Population. No known breeding colonies are located west of the Continental Divide in either New Mexico or Wyoming (Wires et al. 2001; A. Orabona, pers. comm.).

In 2009, west of the Continental Divide, one active breeding colony was documented in Colorado and three active breeding colonies were documented in Montana (Appendix 2). The single western Colorado colony has been known since 2005, when 21 breeding pairs were present, compared to 41 breeding pairs in 2009 (Table 10). In 2009, a total of 32 breeding pairs nested at two of the three documented colony sites in western Montana (Appendix 2). Breeding was confirmed at the third colony site, but no estimate of colony size was recorded. In 2006, however, breeding at this third site was limited to a single pair. It is likely that < 50 breeding pairs nested in western Montana during 2009.

In 2009, 1,613 breeding pairs were estimated to have nested at 11 colony sites in Idaho (Table 10, Appendix 2). Since 2006, between 1,000 and 1,600 breeding pairs have nested at up to 11 colony sites in Idaho, with the majority breeding at the Blackfoot and American Falls Reservoirs and at Minidoka NWR in southeastern Idaho (Table 10, Appendix 2).

In 2009, an estimated 660 breeding pairs of double-crested cormorants nested at six colony sites in Nevada (Table 10, Appendix 2). This is lower than the 1,677 breeding pairs estimated to have nested at four colony sites in 1999 (Table 10). This is due in part to fewer cormorants nesting at Anaho Island on Pyramid Lake in recent years (D. Withers, pers. comm.). Additionally, the Humboldt Sink colony can account for ca. 50% of all breeding pairs in the state in years when this site is inundated with water, which occurs once or twice every five years (J. Jeffers, pers. comm.). No cormorants nest at the Humboldt Sink in years when there is little to no water (i.e., 2009).

In 2009, 177 breeding pairs were estimated to have nested at five colony sites in Utah (Table 10, Appendix 2). Data from previous years are not currently available for this state.

In 2009, numbers of double-crested cormorants breeding in Arizona were estimated at 325 breeding pairs nesting at six colony sites (Table 10, Appendix 2). This was the greatest number of breeding pairs estimated in the state during the last four years; however, more sites were surveyed in 2009 than in any previous year.

Western Population of Double-crested Cormorants

The estimate for the entire Western Population (British Columbia and all US states west of the Continental Divide), based on 2009 data, where available, and substituting the most recent available data when 2009 data were not available[1], is approximately 29,240 breeding pairs (see numbers in bold in Tables 9-12). Of this current estimate, approximately 41% nest at East Sand Island in the Columbia River estuary, approximately 30% nest at coastal colony sites other than East Sand Island, and approximately 29% nest at inland colony sites. Of the approximately 29% of breeding pairs nesting at inland colony sites, only 10% nest in the interior states (Idaho, Montana, Nevada, Utah, Colorado, and Arizona).

Using the same methods, the estimate for the current number of breeding double-crested cormorants at both inland and coastal sites in the Pacific Region coastal states (British Columbia, Washington, Oregon, and California), is approximately 26,390 breeding pairs (see numbers in bold in Tables 9, 11, and 12). This estimate is about 60% greater than the comparable estimate from the late 1980s/early 1990s (Carter et al. 1995, Mould and Gebauer 2002) of about 16,465 breeding pairs. Of this current estimate of 26,390 breeding pairs in the coastal states, approximately 46% nest at East Sand Island in the Columbia River estuary.

Based on the best available data for the Pacific Region coastal states for the periods ca. 1992 (Carter et al. 1995, Moul and Gebauer 2002) and ca. 2009, our best estimate of the average annual population growth rate (λ) for this population is 1.03 (3% annual increase). This compares to a likely composite λ of approximately 1.07 for the population in central and eastern North America during the 1960s to the 1990s (Sauer et al. 1997, Hatch and Weseloh 1999). While the Western Population of double-crested cormorant is currently growing, it appears to be growing at a slower rate than when exponential

[1]2008 estimates used for all of coastal California

population expansion was observed for double-crested cormorants in regions east of the Continental Divide.

NON-BREEDING

Christmas Bird Count Data

Christmas Bird Count (CBC) data for the period 1997-2008 have not been statistically analyzed and the raw data presented here should be interpreted cautiously. CBCs are useful as an index of winter population trends, as well as providing important information on winter occurrence. However, certain aspects of CBC data collection, such as observer skill level and number of counts, can vary within count localities, states and provinces, and from year to year, and therefore should be treated as a qualitative assessment.

Based on raw data for the period 1997-2008, there was no apparent directional trend in the numbers of double-crested cormorants wintering in the Pacific Region coastal states and British Columbia (Table 13). The data, however, suggest that the number of double-crested cormorants wintering in some portions of interior states west of the Continental Divide may have increased in recent years (Table 13).

CONNECTIVITY AMONG COLONY SITES

Research on the inter-colony movement and post-breeding dispersal of double-crested cormorants breeding west of the Continental Divide has been limited to two studies using leg band recoveries, Clark et al. (2006) and Dolbeer (1991), although the latter study was primarily focused on the cormorant population east of the Continental Divide. In order to further understand the connectivity among cormorant breeding colony sites, Oregon State University in cooperation with the USGS – Oregon Cooperative Fish and Wildlife Research Unit and Real Time Research, conducted a satellite-tracking study to observe the post-breeding season movements and dispersal of double-crested cormorants from East Sand Island, the largest breeding colony on the Pacific Coast.

RANGE

Breeding adult double-crested cormorants were tagged at East Sand Island, Oregon during the 2008 and 2009 breeding seasons with satellite-transmitters programmed to collect nighttime roosting locations once weekly. Tracked cormorants dispersed during the non-breeding season to use roost sites near the northern and southern extremes of the range of the Western Population (n = 51; 2008: n = 14, 2009: n = 37). Tracking data collected through January 2010 revealed that tagged individuals traveled to roosting locations as far north as the mouth of the Powell River in the northern Strait of Georgia, British Columbia, Canada and as far south as the mouth of the Colorado River, Baja California Norte, Mexico (Fig. 5). More than 75 roost sites in British Columbia, Washington, Oregon, California, and Baja California Norte were used by tagged cormorants during the non-breeding season, including at least 12 current or historical nesting sites (Figure 5). Satellite-tagged cormorants did not travel to interior states and only one individual was recorded east of the Cascade-Sierra Nevada ranges (Fig. 5).

MOVEMENTS

Cormorants began to disperse from the Columbia River estuary in mid-August. All tagged cormorants had left the region by mid-December, with the exception of only two individuals that remained resident in the estuary. The most commonly used roost sites outside of the Columbia River estuary were two estuaries less than 75 km north of East Sand Island in southwestern Washington, Willapa Bay and Grays Harbor. At least 76% (39/51) of tracked cormorants used one of these two estuaries as a stopover location for up to 10 weeks before dispersing to other locations. Approximately half of tracked cormorants (47%) used inland roost sites in addition to coastal sites.   The majority of cormorants (95%) tracked through the winter (n = 39; 2008: n = 6, 2009: n = 33) traveled to a region and made only local movements (< 20 km) within that region for three or more months during September through January. Cormorants arrived at these overwintering areas between mid-September and early November. A small proportion of individuals (2/39 [5%]) remained transitory throughout the winter period. One transitory individual roosted at multiple locations in the Salish Sea region, including the northernmost identified roosting location (Powell River mouth in the northern Strait of Georgia). The second transitory individual traveled south to multiple roost sites in California and Baja California Norte, including the southernmost roosting location of any tagged cormorant (Colorado River mouth in Baja California Norte, Mexico).

OVERWINTERING

Double-crested cormorants tagged at East Sand Island largely overwintered in one of two regions; (1) the Salish Sea region in northern Washington and southwestern British Columbia that encompasses the coastal areas and islands from the northern Strait of Georgia to western Strait of Juan de Fuca to southern Puget Sound, and (2) inland Oregon and Washington west of the Cascade Mountains, primarily near Portland, Oregon along the Columbia and Willamette Rivers. The Salish Sea and inland regions were used by 41% (16/39) and 28% (11/39) of overwintering cormorants, respectively. In 2009, one cormorant (2.5%) overwintered at Tenmile Lake on the southern Oregon coast. In northern California, inland and coastal regions were used by 8% and 5% of overwintering birds, respectively. Two individuals (5%) remained resident in the Columbia River estuary and one individual (2.5%) overwintered in Willapa Bay, in southwestern Washington. One cormorant (2.5%) arrived at Mullet Island on the Salton Sea in inland southern California in late October and overwintered there. Mullet Island is a somewhat unusual overwintering site where nesting activity has been documented in all months of the year, though no nesting occurs in some years. A site visit on 23 February 2010 confirmed that some cormorants were breeding (3-4 week old chicks present in some nests) during the winter residency of this tagged individual.

LOCATIONS UTILIZED

For double-crested cormorants satellite-tagged in 2008 and 2009, the most commonly used roost site, outside of the two southwestern Washington estuaries, was Sauvie Island in Portland, Oregon; at least 14% (7/51) of individuals utilized this inland location (which is not a known breeding site) for one or more nights. Regionally, however, the Salish Sea was used by the greatest number of cormorants, at least 41% (21/51) of birds roosted at sites throughout this region during dispersal or overwintering. Cormorants that utilized the Salish Sea region roosted at Bird Rocks (n = 4), Mandarte Island (n = 1), and Drayton Harbor (n = 1), sites that were active breeding colonies during 2008 and 2009, in addition to roosting at historical breeding colony locations, such as Viti Rocks (n = 5) and Westshore Terminal (n = 3). Before reaching the Salish Sea region, one individual roosted near Dahodaalah [rock] and Seal Rock and a second individual roosted at Gunsight Rock, all historical breeding colonies on the outer coast of the Olympic Peninsula, Washington. Tenmile Lake, used by one overwintering cormorant in 2009, was the only coastal Oregon location to be identified as a roost site utilized by cormorants dispersing from East Sand Island. In northern California, active breeding sites in San Francisco and Arcata Bays were utilized by dispersing and overwintering cormorants. Additionally, Clear Lake (Lake County) in inland California, an active breeding site when last surveyed in 1999, was used by two individuals. In inland southern California, Mullet Island at the Salton Sea was visited by at least two individuals, one of which overwintered at this location and the other which continued southward to roost at multiple sites along the Colorado River in Baja California Norte, Mexico.

CONCLUSIONS

These tracking data demonstrate direct connectivity between the double-crested cormorant colony at East Sand Island, which has experienced tremendous growth over the last two decades, and colonies to the north (e.g., outer-coastal Washington and Puget Sound, WA colonies) and to the south (e.g., San Francisco Bay, CA and Mullet Island, Salton Sea, CA colonies) that have experienced declines over the same time period. Based on the observed dispersal of satellite-tagged individuals following the 2008 and 2009 breeding seasons, double-crested cormorants from East Sand Island have the greatest connectivity with active and historical colony sites to the north in the Salish Sea region, followed by colonies to the south in northern California. Similar to our satellite-tracking observations, Clark et al. (2006) found the greatest concentration of band recoveries during the migration-winter period in the greater Puget Sound region. These tracking results support the suggestion by Clark et al. (2006) that double-crested cormorants from the Columbia River estuary infrequently travel beyond the Cascade-Sierra Nevada ranges, resulting in minimal intermixing with interior North America populations. These data also support the hypothesis that some double-crested cormorants nesting on East Sand Island originated from breeding colonies to the north, immigration from which is thought to have contributed to the rapid growth of the double-crested cormorant colony at East Sand Island early in colony formation (Carter et al. 1995, Anderson et al. 2004).

STATUS EVALUATION

THREATS

Predation

Bald eagles, gulls, and crows are the most common predators on double-crested cormorants, their eggs, and young in the Pacific Coast Region (Vermeer et al. 1989, Carter et al. 1995, Giesbrecht 2001, Chatwin et al. 2002, Moul and Gebauer 2002, BRNW 2009). Bald eagles prey directly on adult cormorants, nestlings, and occasionally eggs. Gulls and crows prey on eggs and nestlings primarily during colony disturbances, usually initiated by bald eagles or humans, which cause adult cormorants to flush off of nests. Mammalian predators, such as river otters, have been observed at accessible ground-nesting colonies (Giesbrecht 2001).

There is evidence that bald eagles negatively affect cormorant nesting success at some colonies. Carter et al. (1995) noted that disturbance by bald eagles at colonies in the eastern Strait of Juan de Fuca caused complete nesting failure during 1990-1992. We also observed small colony sizes or absence of nesting altogether at these colonies (Protection and Smith islands) in 2008 and 2009, concurrent with observations of bald eagles during aerial surveys. Moul and Gebauer (2002) and Chatwin et al. (2002) observed similar effects at colonies in the Strait of Georgia, where double-crested cormorants appear to be increasing their use of cliff-face and human-made structures for colony sites, apparently due to the improved protection these types of habits provide from bald eagles. Parrish (1995) and Parrish et al. (2001) observed that bald eagles directly and indirectly negatively affected the common murre breeding colony at Tatoosh Island on the northern outer coast of Washington. Disturbance and predation pressure from bald eagles apparently caused double-crested cormorants at the large East Sand Island colony to use a smaller area and to nest in higher densities during 2005-2008 than in previous years (BRNW 2009). Based on the observed habitat preferences of cormorants nesting at East Sand Island, there is currently ample unoccupied habitat available at this site. Despite the availability of habitat to support the continued growth of this colony, however, bald eagle predation and the associated disturbance and nest predation by gulls may limit the size of this colony in the future.

Human Disturbance

While the impact of direct human harassment and disturbance on double-crested cormorant populations in the U.S. has declined substantially since they were protected in 1972 under the Migratory Bird Treaty Act, nesting cormorants remain sensitive to human disturbance, particularly during the early incubation and early nestling-rearing stages (Ellison and Cleary 1978, Hatch and Weseloh 1999). The effects of human disturbance have been well documented at colonies in British Columbia (Verbeek 1982, Rodway 1991, Moul and Gebauer 2002, Chatwin et al. 2002) and are thought to have contributed to nesting failure and colony abandonment at sites in the eastern Strait of Juan de Fuca and the San Juan Islands in the recent past (Henny et al. 1989, Carter et al. 1995). Human presence at active breeding colonies and the resulting disturbance has been documented recently at colonies in northern California (P. Capitolo et al., unpubl. data); construction and maintenance activities of human-made structures, such as bridges, navigational markers, and transmission towers, have also been a source of disturbance for cormorants in California (Stenzel et al. 1995, Rauzon et al. 2001, Capitolo et al. 2004). Many current colony sites are located in federal, state, and provincial protected areas, where access by the public is technically prohibited or restricted. East Sand Island is owned by the U.S. Army Corps of Engineers and is closed to the public during the breeding season. However, with expanding human populations along the coast and the increasing perception that double-crested cormorants represent a threat to sport and commercial fisheries throughout the range of the Western Population, human disturbance could pose a significant threat to this population in the future, especially in the absence of new rules and restrictions. Nesting colonies on artificial habitats (e.g., bridges, dredge spoil islands, navigational markers, power towers) used by humans or accessed for maintenance may be particularly vulnerable.

Environmental Contaminants

Extensive reproductive failures due to eggshell thinning occurred along the coasts of southern California and northwestern Baja California Norte prior to the ban on DDT established in the U.S. during 1972 (Gress et al. 1973). In 1992, contaminant levels were found to be much lower, but some cormorant eggs from Anacapa Island, California still exhibited higher levels, which were likely affecting hatching success (Fry 1994). Lower levels of DDT contamination were also found in eggs from central California and British Columbia in 1992 and relatively high PCB contamination was found in eggs from British Columbia in the same year (Fry 1994). Although eggs were later found to be highly contaminated, reproductive success in San Francisco Bay in 1988-1990 was not affected to a great degree (Stenzel et al. 1995, Carter et al. 1995). Since then, research on contaminant effects has been concentrated on the cormorant population east of the Continental Divide; however, several studies have considered the Pacific Coast population.

Although there was widespread nesting failure and colony abandonment in the eastern Strait of Juan de Fuca and the San Juan Islands in the 1980s, Henny et al. (1989) did not find elevated contaminant levels in cormorant eggs from these areas and attributed these failures to human disturbance. Other recent studies demonstrate that contaminants remain an issue for cormorants in some regions of the west. Fledglings foraging in the Lower Carson River System in western Nevada in the late 1990s were found to have toxic levels of mercury and experienced some degree of neurological and histological damage (Henny et al. 2002). The effects of mercury released into this system more than 100 years ago (associated with gold and silver mining in the 1800s) may currently be affecting post-fledgling survival and could potentially have population-level consequences (Henny et al. 2002).

Double-crested cormorants nesting at East Sand Island and at other sites in the Columbia River estuary are exposed to numerous environmental contaminants. The Columbia River drains an area encompassing 260,000 square miles and receives contaminants from multiple sources (Buck and Sproul 1999). Buck and Sproul (1999) found that eggs from cormorants nesting in the estuary in 1993 and 1994 had elevated levels of DDE, PCBs, and dioxins compared to a reference colony from the southern Oregon coast, and showed some eggshell thinning. While their results did not predict population-level effects, they did indicate the potential for impacts on developing embryos or egg mortality in some individuals.

Oil Pollution

Since the early 20th Century, oil pollution from ships, tankers, and barges has regularly occurred along the Pacific coast, particularly in California (Carter 2003, USFWS 2005). Until the late 1960s, little effort was directed at assessing the impacts to seabirds from oil spills. In 1969, a major spill occurred near Santa Barbara, California, when an offshore oil well ruptured. A total of 395 oiled cormorants and pelicans were recovered on beaches from February to May (CDFG 1969a, b), including many double-crested cormorants (Drinkwater et al. 1971); however, overall numbers of seabirds killed were not well documented. This mortality likely contributed to lower numbers of double-crested cormorants at colonies on nearby Anacapa Island in the early 1970s, even though extensive DDT contamination was the main factor depressing this colony (Gress et al. 1973). In general, double-crested cormorants have not been killed in large numbers by oil spills on the Pacific coast (usually 0-10 birds per spill) because; (1) most oil spills have occurred in winter when double-crested cormorants occur in relatively small numbers in a scattered distribution along the coast, (2) their estuarine foraging habits spare them from offshore oil spills, (3) double-crested cormorants were much less numerous in the past, and (4) oil spills have declined in frequency since the early 1990s (USFWS 2005, Helm et al. 2006). In the November 2007 *Cosco Busan* oil spill in San Francisco Bay, however, 66 double-crested cormorants were oiled and recovered (S. Hampton, unpubl. data). These higher numbers reflected the increased number of breeding and wintering cormorants in this area since the early 1980s (Carter et al. 1995). Only 21 double-crested and Brandt's cormorants were recovered after the much larger 1971 San Francisco oil spill in the same general area (Smail et al. 1972), when no breeding colonies of double-crested cormorants were known in San Francisco Bay and the species was much less common in the Bay area.

Disease

Newcastle disease is the most common disease threat to double-crested cormorants and can cause high mortality rates in juvenile cormorants. The disease was first recognized in double-crested cormorants from eastern Canada in 1975 (Kuiken 1999). Prior to 1997, symptomatic Newcastle disease had only been recognized in cormorants from east of the Continental Divide; however, in that year approximately 1,600 dead cormorant nestlings and fledglings were found at the Salton Sea, and a sample were diagnosed with Newcastle disease (Wildlife Health Centre Newsletter 1997, Kuiken 1999). Newcastle disease was also first diagnosed in juvenile double-crested cormorants from colonies in the Columbia River estuary and the Great Salt Lake in Utah in 1997 (Wildlife Health Centre Newsletter 1997, Kuiken

1999); however, cormorant fledglings from East Sand Island have since been diagnosed with the disease in multiple years (2003, 2005, 2007, 2009). While Newcastle disease has not caused a major epidemic among double-crested cormorants nesting at marine or estuarine colony sites on the Pacific coast, more widespread epizootics have occurred in cormorants east of the Continental Divide, most notably in 1992 when the disease spread across the interior population killing thousands of juvenile cormorants (Glaser 1999, Kuiken 1999). Considering the concentration of double-crested cormorants breeding in the Columbia River estuary and the presence of disease in the population, the potential for Newcastle disease to cause high juvenile mortality could pose a threat to this colony.

In terms of other disease threats, large die-offs of American white pelicans and brown pelicans from avian botulism have occurred at the Salton Sea (Rocke et al. 2004), avian cholera has caused large die-offs of hatch year cormorants in the Canadian provinces of Alberta and Saskatchewan (Wildlife Health Centre Newsletter 1998 and 2005), and the West Nile virus has been diagnosed in a double-crested cormorant wintering in Florida (Allison et al. 2005), as well as an American white pelican at the Summer Lake Wildlife Area in south-central Oregon (ODFW 2007). It is conceivable that cormorants in the Western Population could be at risk from these diseases in the future, as well.

Forage Base

Double-crested cormorants are large birds that typically exhibit high fecundity. Not only must they forage for themselves, but usually also for multiple young over the course of the chick-rearing period. As a colonial-nesting waterbird, double-crested cormorants congregate in areas with ample food resources and are dependent on the stability and predictability of those resources for successful breeding.

Studies have documented changes in seabird population dynamics, including for coastal double-crested cormorants, in relation to changes in ocean conditions and climatic shifts off the Pacific coast (Ainley and Boekelheide 1990, Wilson 1991, Veit et al. 1996, Sydeman et al. 2001, Jahncke et al. 2008). Other studies have documented the effects that these changes in ocean conditions have on forage fish communities on which coastal cormorants rely (Emmett and Brodeur 2000, Chavez et al. 2003, Emmett et al. 2006). Because the coastal community of forage fishes is directly affected by these changes, such as the onset of upwelling winds and its influence on primary productivity (Barth et al. 2007), variation in climate and ocean conditions can have a profound effect on coastal-breeding cormorants. For example, in 2005 there was a record late onset of upwelling that corresponded with massive seabird mortality events and breeding failures along the coasts of Washington, Oregon, and California (Sydeman et al. 2006, Parrish et al. 2007). Double-crested cormorants nesting at East Sand Island, however, appeared to be buffered to a certain extent, possibly by more stable food resources associated with the Columbia River estuary (Anderson et al. 2004). While the prior consistent growth of the East Sand Island cormorant colony was abated and there was reduced breeding success in 2005, no unusual mortality events were observed.

Double-crested cormorants breeding at inland sites may also face a lack of stable and predictable food resources due to severe drought in some years (Carter et al. 1995). Nesting at the Salton Sea, the largest inland California breeding colony for cormorants in some years, is likely driven by the tilapia population in the lake (Molina and Sturm 2004), which in turn is susceptible to temperature and high salinity levels (Sardella et al. 2007). So far, the large colony of cormorants nesting at East Sand Island does not appear to be limited by food availability in most years, and is buffered from the most pronounced declines in their marine forage base. For the remainder of the Western Population of double-crested cormorants, however, changes in the forage base could pose a threat to the persistence of some colonies, especially at inland sites.

HABITAT STATUS

The availability of suitable nesting substrate does not appear to be a limiting factor for double-crested cormorants in most parts of the range of the Western Population, particularly along the coast, and especially where natural nesting habitats are augmented with artificial habitats. Certain coastal colony sites have been abandoned in some years or over longer periods due to predation and human disturbance (e.g., Protection Island in the eastern Strait of Juan de Fuca and Great Chain Island near Victoria, BC). When colony abandonment occurs, suitable nesting substrates usually remain. At many islands that support larger colonies, such as Mandarte Island near Sidney, British Columbia, Bird Rocks in the San Juan Islands, and East Sand Island, Oregon, all available nesting substrates have not been occupied, although parts of islands may be disturbed by humans (e.g., Mandarte Island). Additionally, many of the coastal colony sites are in protected areas (e.g., the San Juan Islands NWR, Protection Island NWR, Farallon Islands NWR, Olympic Coast National Marine Sanctuary, Channel Islands National Park). Different factors (see the Threats section above) appear to be limiting the persistence and size of at least some of these colonies. In the Columbia River estuary, San Francisco Bay, and certain other areas, use of artificial habitats with relatively low human disturbance and predation over the past few decades has been critical to the development of large nesting colonies in areas where none nested previously (Carter et al. 1995). Available habitat may, however, be limiting for inland-breeding cormorants (Carter et al. 1995). Intentional water manipulation for agricultural and other purposes, as well as natural drought and flood events, can cause drastic reductions or increases in available nesting and foraging habitat. Areas inundated with water that provide secure tree- and island-nesting habitat may become dry in some years, allowing access by mammalian predators.

RESEARCH NEEDS AND INFORMATION GAPS

Many gaps remain in our knowledge of the Western Population of double-crested cormorants, because much of the research has been focused on a few colonies (e.g., Mandarte Island, BC; East Sand Island, OR; Foundation Island, WA; South Farallon Islands, CA; San Francisco Bay bridges, CA; Anacapa Island, CA).

Double-crested cormorants breed and winter in a diversity of habitats, making generalizations about what they eat difficult; however, little is known about the current diet composition of cormorants nesting outside the Columbia River estuary. Inter-annual variation in diet composition is not unusual in cormorants nesting at East Sand Island, and some knowledge of the variability in cormorant diet composition at nesting colonies in other regions (e.g., Mandarte Island, BC, South Farallon Island, CA, Prince Island, CA; see Ainley et al. 1981) would be useful, especially for predicting colony responses to changes in climate conditions.

Double-crested cormorants in some areas west of the Continental Divide, particularly near the coast, are thought to be largely non-migratory residents; however, we are just beginning to explore the post-breeding dispersal and movements of cormorants nesting in the Columbia River estuary through satellite-tracking. Learning where cormorants from other colonies spend the post-breeding and winter seasons will aid in our understanding of how winter conditions influence demographic dynamics at the population level. Little is known about many other aspects of the demography of the Western Population of double-crested cormorants. Initiating or reviving efforts to mark adults and fledglings with leg bands at the breeding colonies, where feasible, would help to improve our knowledge base in this area.

Many double-crested cormorant breeding colonies, particularly inland colonies, are ephemeral in nature, existing in one season and absent the next, and many colonies are not surveyed on an annual basis. Increasing the frequency of breeding colony surveys between years as well as better coordinating the timing and methodology of surveys, would help to refine population estimates and better understand colony dynamics. Additionally, it can be difficult to interpret survey data across years and from multiple agencies and institutions with different priorities for data collection.

Predation pressure by bald eagles is apparently a limiting factor at some colonies in the Strait of Georgia, the San Juan Islands, and the Olympic Peninsula outer coast, and likely has impeded the growth of the East Sand Island colony in the Columbia River estuary. However, the effects of eagles on the size and productivity of cormorant colonies have not been quantified at most sites. It would be useful to investigate how bald eagles are influencing individual double-crested cormorant colonies and if they could become a limiting factor at the population level.

CONCLUSIONS

The current size of the Western Population of double-crested cormorants is approximately 29,240 breeding pairs. The size of the population in the Pacific Region coastal states has increased by about 60% since ca. 1992 (Carter et al. 1995, Moul and Gebauer 2002). Based on the best available data for the periods ca. 1992 and ca. 2009, the average annual population growth rate for the breeding population in the Pacific coastal states plus British Columbia is 1.03, indicating that this population is growing, but at a slower rate than that observed in central and eastern North America in recent decades. Most of the increase in the Western Population, however, can be attributed to increases in the size of the nesting colony at East Sand Island in the Columbia River estuary, which currently accounts for approximately 41% of all breeding pairs in the Western Population. Numbers of breeding pairs in coastal British Columbia, Washington, and parts of California have declined. The size of the Western Population is still more than an order of magnitude less than the cormorant population that inhabits central and eastern North America. Bald eagles and human disturbance likely constitute the greatest constraints to the growth of the Western Population of double-crested cormorants. Based on molecular genetics analyses, satellite-tracking results, and leg band recoveries, there is apparently a high degree of population connectivity among colonies from central and northern California to southern British Columbia. The connectivity of the Western Population of double-crested cormorants with populations in Alaska, southwestern California, and east of the Continental Divide is more limited. Considering the major demographic differences observed between the populations west and east of the Continental Divide, treating the Western Population of double-crested cormorants as a separate management unit from the population in the remaining conterminous U.S. is warranted.

Table 1. Numbers of double-crested cormorant breeding pairs at marine and estuarine sites in British Columbia, 1998-2009. Years with few or no data are omitted. A dash indicates no data recorded at that site in that year. Totals in parentheses are incomplete due to missing data because of either (1) a lack of estimates for a large number of sites, (2) no estimate for a site likely to represent a large portion of breeding pairs for the area, or (3) only a visual approximation of breeding pairs was available for a given site(s), rather than a precise count. See Appendix 1 for a complete list of colonies.

Colony	1998 [a]	1999 [a]	2000 [a]	2007 [b]	2009 [d]
Mitlenatch Island	46	47	70	34	20 [b]
McRae Islets	-	-	1	-	-
Pam Rock & Christie Islet	-	-	42	-	4
Northern Strait of Georgia Subtotal	*(46)*	*(47)*	*113*	*(34)*	*24*
Five Fingers Island	43	42	15 [c]	0	0 [b]
Gabriola Island cliffs	-	-	-	95	43
Rose Islets	-	6	15	0	0 [b]
Bare Point	19	11	0	0	0
Galiano Island cliffs	0 [b]	0 [b]	14	90	47
Crofton log crane and dolphins	-	83	104	95	83
Mandarte Island	178	43	215	167	143
Great Chain Island	300	100	95	26	0
Gulf Islands Subtotal	*(540)*	*285*	*458*	*473*	*316*
Sand Heads	-	-	35	-	0
Westshore Terminal	-	-	11	-	0
Second Narrows Bridge Power Tower	-	-	-	-	63 [e]
Vancouver Area Subtotal	*-*	*-*	*46*	*-*	*63*
COASTAL BRITISH COLUMBIA TOTAL	***(586)***	***(332)***	***617***	***(507)***	***403***

[a] Moul and Gebauer (2002) unless otherwise noted
[b] T. Chatwin, pers. comm.
[c] Chatwin et al. (2001)
[d] Oregon State University/Real Time Research/Bird Research Northwest (OSU/RTR/BRNW) unless otherwise noted
[e] H. Carter, pers. comm.

Table 2. Numbers of double-crested cormorant breeding pairs at inland sites in British Columbia, 1998-2008. A dash indicates no data recorded at that site in that year; PB indicates possible breeding.

Colony	1998	1999	2000	2001	2002	2003	2005	2006	2007	2008
Stum Lake [a]	9 [b]	10 [b]	11 [b]	12	13	22	23	25	25	25
Creston Valley WMA [c]	-	PB	PB	PB	10 [d]	3	36 [d]	92 [d]	74 [d]	98 [e]
INTERIOR BRITISH COLUMBIA TOTAL	***9***	***10***	***11***	***12***	***23***	***25***	***59***	***117***	***99***	***123***

[a] J. Steciw, pers. comm. unless otherwise noted
[b] Moul and Gebauer (2002)
[c] Van Damme (2004) unless otherwise noted
[d] BC Conservation Data Centre (2008)
[e] M. Machmer, pers. comm.

Table 3. Numbers of double-crested cormorant breeding pairs at marine and estuarine sites in Washington, 1998-2009. Years with few or no data are omitted. A dash indicates no data recorded at that site in that year; B indicates breeding; PB indicates possible breeding; name in brackets indicates an alternate name. Totals in parentheses are incomplete due to missing data because of either (1) a lack of estimates for a large number of sites, (2) no estimate for a site likely to represent a large portion of breeding pairs for the area, or (3) only a visual approximation of breeding pairs was available for a given site(s), rather than a precise count. See Appendix 1 for a complete list of colonies.

Colony	1998 [a]	1999 [a]	2003 [a]	2008 [b]	2009 [b]
Drayton Harbor	0	0	PB	134	142
Viti Rocks	43	17	47	0	0
Bird Rocks	25	15	0	132	148
Williamson Rocks	52	63	44	0	0
Goose Island [Cattle Pass]	-	-	84	-	56
Hall Island	0	0	14	0	0
Snohomish River Mouth	B	B	529	B	249
San Juan Islands Subtotal	*(120)*	*(95)*	*718*	*(266)*	*595*
Smith Island	95	33	70	34	28
Protection Island	71	49	86	11	0
Eastern Strait of Juan de Fuca Subtotal	*166*	*82*	*156*	*45*	*28*
Bodelteh Islands	3	0	-	-	0
White Rock	7	0	-	-	0
Carroll Island	65	0	-	-	1
Petrel Island [Kohchaa]	11	11	-	-	3
Gunsight Rock	4	0	-	-	0
Ghost Rock	1	0	-	-	0
Hoh Head Mainland	68	0	-	-	0
North Rock	31	10	-	-	0
Tunnel Islands	17	40	-	-	0
Little Hogsback Island	-	-	-	-	71
Willoughby Rock	0	1	-	-	0
Point Grenville Islands	3	39	-	-	0
Olympic Peninsula Outer Coast Subtotal	*210*	*101*	*-*	*-*	*75*
Unnamed Sand Island	-	5	0	0	0
Grays Harbor Channel Markers	-	-	80 [b]	52	90
Grays Harbor Subtotal	*-*	*(5)*	*80*	*52*	*90*
COASTAL WASHINGTON TOTAL	***(496)***	***(283)***	***(954)***	***(363)***	***788***

[a] U.S. Fish and Wildlife Service (USFWS), unpubl. data, M. Naughton unless otherwise noted
[b] OSU/RTR/BRNW

Table 4. Numbers of double-crested cormorant breeding pairs at inland sites in Washington, 2003-2009. A dash indicates no data recorded at that site in that year; B indicates breeding. Totals in parentheses are incomplete due to missing data because of either (1) a lack of estimates for a large number of sites, (2) no estimate for a site likely to represent a large portion of breeding pairs for the area, or (3) only a visual approximation of breeding pairs was available for a given site(s), rather than a precise count. See Appendix 2 for a complete list of sites. [a]

Colony	2003	2004	2005	2006	2007	2008	2009
Mouth of Okanogan River	-	-	38	32	10	33	36
Sprague Lake, Harper Island	-	-	0	0	0	38	42
North Potholes	B	B	865	1156	1015	1000	809
Hanford Reach	-	-	-	-	8	0	0
Lions Ferry Railroad Trestle	-	-	-	2	0	0	0
Foundation Island	250	300	315	359	334	357	309
Miller Rocks	-	-	0	5	0	0	0
INTERIOR WASHINGTON TOTAL	***(250)***	***(300)***	***1,218***	***1,554***	***1,367***	***1,428***	***1,196***

[a] All data from OSU/RTR/BRNW

Table 5. Numbers of double-crested cormorant breeding pairs nesting in the Columbia River Estuary, Oregon, 1998-2009. A dash indicates no data recorded at that site in that year. See Appendix 1 for a complete list of sites. [a]

Colony	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
East Sand Island	6,285	6,561	7,162	8,120	10,230	10,646	12,480	12,287	13,738	13,771	10,950	12,087
Rice Island	795	0	0	150	53	211	0	0	35	0	0	0
Miller Sands Spit	0	0	0	12	0	0	0	0	41	90	129	0
Miller Sands Navigational Aids	70	-	150	75	129	183	194	208	150	160	174	162
Upper Estuary Navigational Aids	-	-	-	-	-	-	-	-	12	-	42	73
Desdemona Sands Pilings	120 [b]	-	61	0	0	0	0	0	0	0	0	0
Astoria-Megler Bridge	-	0	0	0	0	0	6	14	7	11	20	24
COLUMBIA RIVER ESTUARY TOTAL	***7,270***	***6,561***	***7,373***	***8,357***	***10,412***	***11,040***	***12,680***	***12,509***	***13,983***	***14,032***	***11,315***	***12,346***

[a] Data from OSU/RTR/BRNW unless otherwise noted

[b] USFWS, unpubl. data, M. Naughton

Table 6. Numbers of double-crested cormorant breeding pairs at marine and estuarine sites in Oregon, excluding the Columbia River Estuary, 2003-2009. Years with few or no data are omitted. A dash indicates no data recorded at that site in that year; name in brackets indicates an alternate name. See Appendix 1 for a complete list of colonies.

Colony	2003 [a]	2006 [b]	2009 [c]
Unnamed Colony [Oswald West]	219	122	95
Three Arch Rocks – Finley Rock [East]	359	169	417
Three Arch Rocks – Middle Rock	0	0	22
Unnamed Colony [Cape Lookout]	103	132	128
Haystack Rock	107	86	75
Northern Coast Subtotal	*788*	*509*	*737*
Yaquina Bay Bridge	-	2	-
Blast Rock	50	25	12
Parrot Rock	2	0	19
Central Coast Subtotal	*52*	*27*	*31*
Siuslaw River Trees	75	144	0
Bolon Island	326	324	763
Unnamed Colony	163	109	0
Unnamed Colony	145	48	56
Unnamed Colony	114	82	183
Chiefs Island [Gregory Point]	0	8	0
Unnamed Colony	16	40	88
Qochyax [Squaw] Island	107	57	26
Table Rock	2	48	125
Elephant Rock	1	0	0
Castle Rock	141	129	15
Gull Rock	-	1	27
Redfish Rocks, East Central	-	-	6
Sisters Rocks Island, South	40	48	49
Hunters Island	197	297	222
Unnamed Colony [Unnamed Rock]	1	0	1
North Crook Point Rock	8	0	0
Unnamed Colony [Mack Reef]	14	16	24
Unnamed Colony [Mack Reef]	8	0	14
Whaleshead Cove, East Rock	0	16	17
Whaleshead Cove, West Rock	17	-	0
Rainbow Island	1	0	-
Southern Coast Subtotal	*1,376*	*1,367*	*1,616*
COASTAL OREGON TOTAL (excluding Columbia River Estuary)	***2,216***	***1,903***	***2,384***

[a] Naughton et al. (2007)

[b] USFWS, unpubl. data, S. Stephensen

[c] USFWS/OSU, unpubl. data

Table 7. Numbers of double-crested cormorant breeding pairs at inland sites in Oregon, 1998-2009. Years with few or no data are omitted. A dash indicates no data recorded at that site in that year. Totals in parentheses are incomplete due to missing data because of either (1) a lack of estimates for a large number of sites, (2) no estimate for a site likely to represent a large portion of breeding pairs for the area, or (3) only a visual approximation of breeding pairs was available for a given site(s), rather than a precise count. See Appendix 2 for a complete list of colonies.

Colony	1998 [a]	1999 [a]	2003 [b]	2004 [b]	2008 [c]	2009 [c]
Snake River, Unnamed Sand Island	-	-	-	-	-	27 [d]
Snake River, Unnamed Sand Island	-	-	-	-	-	63 [d]
Crane Prairie Reservoir	53	61	-	-	3	20
Malheur NWR, Malheur Lake	153	259	-	-	0	0
Malheur NWR, Sodhouse Ranch	-	-	-	-	10	29
Summer Lake WA, Gold Dike Pond	36	33	-	-	7	0
Upper Klamath NWR	-	500 [e]	840	999	-	850 [f]
Swan Lake	-	60	43	38	-	0
Lake Abert, Rivers End	-	-	-	-	-	16
Crump Lake, Tern Island	-	-	-	-	10	0
Pelican Lake, Pelican Island	-	-	-	-	18	36
Gerber Reservoir	-	-	0	6	-	0
INTERIOR OREGON TOTAL	***(242)***	***(913)***	***(883)***	***(1,043)***	***(48)***	***1,041***

[a] USFWS, unpubl. data, M. Naughton
[b] Shuford et al. (2006)
[c] OSU/RTR/BRNW unless otherwise noted
[d] P. Milburn pers. comm.
[e] Approximate estimate
[f] Shuford and Henderson (2010); OSU/RTR/BRNW estimate was 1,270 breeding pairs, Shuford and Henderson (2010) estimate used because it was directly comparable to previous years

Table 8. Numbers of double-crested cormorant breeding pairs at marine and estuarine sites in California, 1998-2009. Years with few or no data are omitted. A dash indicates no data recorded at that site in that year. See Appendix 1 for a complete list of colonies.

Colony	2003 [a]	2008 [b]
Prince Island	323	220
Castle Rock	84	35
False Klamath Rock	68	48
Radar Station Rocks	72	57
White Rock	33	6
Big Lagoon	0	42
Sea Gull Rock	21	13
Sea Lion Rock	20	0
Trinidad Bay Rocks	0	5
Little River Rock	141	100
Arcata Bay Sand Islands	809	103
Old Arcata Wharf	70	51
Teal Island	365	485
False Cape Rocks	52	1
Sugarloaf Island	53	69
Northern Coast – North Section Subtotal	*2,111*	*1,235*
Russian Gulch	40	50
Russian River Rocks	108	25
Gull Rock	34	0
Shell-Wright Beach Rocks	16	30
Dillon Beach Rocks	16	0
Hog Island	112	285
Northern Coast – South Section Subtotal	*326*	*390*
South Farallon Islands	439	334
Lake Merced	142 [c]	226 [c]
Central Coast – Outer Coast North Subtotal	*581*	*560*
Russ Island	2 [d]	38
Knight Island	200	37
N. San Pablo Bay Radar Target	15	6
N.E. San Pablo Bay Beacon	4 [e]	2
Wheeler Island	126	55
Richmond-San Rafael Bridge	632	266 [f]
San Francisco-Oakland Bay Bridge	745	310 [f]
Lake Merritt	103 [c]	93 [c]
Alviso Plant, Pond Nos. A9 & A10	49 [c]	46
Dumbarton Bridge Power Towers	0	160
Bair Island/Steinberger Slough Power Towers	220	294
Moffett Power Towers	0 [c]	65 [c]
San Mateo Bridge & PG&E Towers	105	78 [g]
Central Coast – San Francisco Bay Subtotal	*2,201*	*1,450*
Schwan Lake	59 [h]	93 [h]
Pinto Lake	7 [h]	38 [h]
San Lorenzo River Mouth	0 [h]	10 [h]
Rockland Landing North	9	0
Morro Rock & Pillar Rock	41	14
Fairbank Point	406	225
Shell Beach Rocks	130	204

Central Coast – Outer Coast South Subtotal	*652*	*584*
Goleta Slough	-	11
Prince Island	140 [i]	98
Sierra Pablo Area	-	16
Anacapa Island – West	330 [i]	335 [j]
Anacapa Island – Middle	-	47 [j]
Santa Barbara Island	119 [e, i]	89
Sutil Island	66 [i]	51
Seal Cove Area	17 [i]	73
S. San Diego Bay Saltworks	32 [i]	55
Southern Coast Subtotal	*704* [i]	*775*
COASTAL CALIFORNIA TOTAL	*6,575* [k]	*4,994*

[a] Capitolo et al. (2004) unless otherwise noted
[b] University of California, Santa Cruz/USFWS/OSU unless otherwise noted
[c] C. Robinson-Nilsen, pers. comm.
[d] Incomplete data
[e] P. Capitolo, pers. comm.
[f] M. Elliott, pers. comm.
[g] 2005 estimate
[h] Santa Cruz Bird Club county records, D. Suddjian compiler
[i] 2001 estimate
[j] Minimum estimate; L. Harvey, unpubl. data
[k] 2001 and 2003 data used to calculate estimate

Table 9. Numbers of double-crested cormorant breeding pairs at inland sites in California, 1998-2009. Years with few or no data are omitted. A dash indicates no data recorded at that site in that year. Totals in parentheses are incomplete due to missing data because of either (1) a lack of estimates for a large number of sites, (2) no estimate for a site likely to represent a large portion of breeding pairs for the area, or (3) only a visual approximation of breeding pairs was available for a given site(s), rather than a precise count. See Appendix 2 for a complete list of colonies.

Colony	1998 [a]	1999 [a]	2003 [b]	2004 [b]	2009 [c]
Lake Shastina	8	-	-	-	**41**
Butte Valley WA, Meiss Lake,	20	84	0	0	**0**
Lower Klamath NWR, Sheepy Lake	80	62	371	458	**79**
Tule Lake NWR, Sump 1A	0	0	56	0	**0**
Tule Lake NWR, Sump 1B	120	172	0	30	**0**
Clear Lake NWR	37	114	94	116	**126**
Eagle Lake, unnamed island	-	0	-	-	**2**
Eagle Lake, Pelican Point	-	118	-	-	**0**
Butt Valley Reservoir	15	24	-	-	**11**
Northeastern California Subtotal	*(280)*	*574*	*(521)*	*(604)*	*259*
Sacramento River East, Llanco Seco Rancho	61	**15**	-	-	-
Sacramento River West, NNE Grimes	1	**0**	-	-	-
Butte Sink, North Butte Country Club	109	**65**	-	-	-
Sutter Bypass West	7	**12**	-	-	-
Sacramento River West, Beaver Lake	16	**16**	-	-	-
Port of Sacramento	5	**0**	-	-	-
Stone Lakes NWR, North Stone Lake	180	**154**	-	-	-
Cosumnes River Reservoir, Valensin Ranch	0	**3**	-	-	-
Pellandini Ranch	38	**29**	-	-	-
Venice Tip	-	**9**	-	-	-
Clear Lake, Lake County	175	**97**	-	-	-
Petaluma Waste Water Treatment Plant	4	**6**	-	-	-
Laguna de Santa Rosa	55	**59**	-	-	-
Arroyo del Valle, Shadow Cliffs Park	1	0 [d]	6 [d]	8 [d]	**14** [d]
San Luis NWR	57	22 [e]	2 [e]	31 [e]	**14** [e]
San Joaquin River NWR, Christman Is.	34	12	0 [e]	0 [e]	**0** [e]
Merced NWR, East Side Bypass	1	**0**	-	-	-
San Felipe Lake	11	**-**	-	-	-
San Joaquin River Ecological Reserve, Milburn	3	**9**	-	-	-
South Wilbur Flood Area	95	**119**	-	-	-
East Hacienda Ranch	63	**6**	-	-	-
Central Valley and Central Coast Ranges Area Subtotal	*916*	*633*	*-*	*-*	*(28)*
San Gabriel River, Pico Rivera	6	**6**	-	-	-
Anaheim Lakes	-	**105**	-	-	-
Sweetwater Reservoir	27	**28**	-	-	-
Prado Basin near dam	40	**30**	-	-	-
Mystic Lake	-	**64**	-	-	-
Salton Sea North, Johnson St.	2	2 [f]	-	-	-
Salton Sea South, East Poe Rd.	-	13 [f]	-	-	-
Salton Sea South, New River mouth,	500	30 [f]	-	-	-
Salton Sea South, Alamo River mouth	75	106 [f]	-	-	-
Salton Sea South, Mullet Island	2,700 [g]	5,425	-	-	**2,000** [g, h]
Imperial WA, Ramer Lake	7	18 [f]	-	-	-
Southern Interior Subtotal	*(3,357)*	*5,658*	*-*	*-*	*(2,000)*
INTERIOR CALIFORNIA TOTAL	*(4,553)*	*6,865*			*(2,287)*

[a] Shuford (2010)

[b] Shuford et al. (2006) unless otherwise noted

[c] Shuford and Henderson (2010) unless otherwise noted

[d] C. Robinson-Nilsen, pers. comm.

[e] D. Woolington, pers. comm.
[f] Not included in total; likely failed breeders from Mullet Island renesting after peak on Mullet Island
[g] Visual approximation, minimum estimate
[h] K. Molina, pers. comm.

Table 10. Numbers of double-crested cormorant breeding pairs in interior states west of the Continental Divide, 1998-2009. Years with few or no data are omitted. A dash indicates no data recorded at that site in that year. Totals in parentheses are incomplete due to missing data because of either (1) a lack of estimates for a large number of sites, (2) no estimate for a site likely to represent a large portion of breeding pairs for the area, or (3) only a visual approximation of breeding pairs was available for a given site(s), rather than a precise count. See Appendix 2 for a complete list of colonies.

Colony	1998	1999	2005	2006	2007	2008	2009
Idaho [a]	-	-	-	1,008	1,180 [h]	1,418 [h]	**1,613**
Montana [b]	-	-	-	17 [h]	-	-	**32**
Nevada [c]	911	1,677 [g]	269 [h]	720 [h]	872 [h]	165 [h]	**660**
Utah [d]	-	-	-	-	-	-	**177**
Colorado [e]	-	-	21	18	19	29	**41**
Arizona [f]	-	-	-	-	-	-	**325**
INTERIOR STATES TOTAL	*(908)*	*(1,677)*	*(290)*	*(1,763)*	*(2,071)*	*(1,612)*	*2,848*

[a] C. Moulton, pers. comm.
[b] C. Wightman, pers. comm.
[c] D. Withers, J. Jeffers, and P. Bradley, pers. comm.
[d] S. Jones, J. Neill, and J. Cavitt, pers. comm.
[e] J. Beason, pers. comm.
[f] T. Corman, pers. comm.
[g] Includes USFWS, M. Naughton, unpubl. data
[h] Incomplete data

Table 11. Summary of the numbers of double-crested cormorant breeding pairs nesting in coastal sub-regions of British Columbia, Washington, Oregon, and California, 1987-1992 and 1998-2009. Years with few or no data are omitted. A dash indicates no data recorded at that site in that year. Totals in parentheses are incomplete due to missing data because of either (1) a lack of estimates for a large number of sites, (2) no estimate for a site likely to represent a large portion of breeding pairs for the area, or (3) only a visual approximation of breeding pairs was available for a given site(s), rather than a precise count. See Appendix 1 for a complete list of colonies. [a]

Location	1987-1992 [b]	1998	1999	2000	2001	2003	2006	2008	2009
BRITISH COLUMBIA									
Northern Strait of Georgia	124	46	47	113	-	-	-	-	**24**
Gulf Island	1,729	540	285	458	-	-	-	-	**316**
Vancouver Area	128	-	-	46	-	-	-	-	**63**
Coastal British Columbia Total	*1,981*	*(586)*	*(332)*	*617*	-	-	-	-	*403*
WASHINGTON									
San Juan Islands	25	120	95	-	-	718	-	-	**595**
Juan de Fuca Strait East	528	166	82	-	-	156	-	-	**28**
Olympic Peninsula Outer Coast	571	210	101	-	-	-	-	-	**75**
Grays Harbor Bay	440	0	5	-	-	80	-	-	**90**
Coastal Washington Total	*1,564*	*496*	*283*	-	-	*(954)*	-	-	*788*
OREGON									
Columbia River Estuary	3,364	7,270	6,561	7,373	8,357	11,040	13,983	11,315	**12,346**
Northern Coast	983	-	-	-	-	788	509	-	**737**
Central Coast	599	-	-	-	-	52	27	-	**31**
Southern Coast	1,357	-	-	-	-	1,376	1,367	-	**1,616**
Coastal Oregon Total	*6,303*	-	-	-	-	*13,256*	*15,886*	-	*14,730*
CALIFORNIA									
Northern Coast – North Section	1,210	-	-	-	-	2,111	-	**1,235**	-
Northern Coast – South Section	182	-	-	-	-	326	-	**390**	-
Central Coast – Outer Coast North	475	-	-	-	-	581	-	**560**	-
Central Coast – San Francisco Bay	1,261	-	-	-	-	2,201	-	**1,450**	-
Central Coast – Outer Coast South	164	-	-	-	-	652	-	**584**	-
Southern Coast	1,113	-	-	-	704	-	-	**775**	-
Coastal California Total	*4,405*	-	-	-	-	*6,575* [c]	-	*4,994*	-

[a] See Tables 1, 3, 5, 6, and 8 for data sources

[b] British Columbia data from Moul and Gebauer (2002); all other data from Carter et al. (1995), but see Capitolo et al. (2004) for revised California numbers and detailed estimation methods; see text for years in which particular sub-regions were surveyed

[c] Total calculated using 2001 data for Southern Coast

Table 12. Summary of the numbers of double-crested cormorant breeding pairs in inland sub-regions of British Columbia, Washington, Oregon, and California, 1987-1992 and 1998-2009. A dash indicates no data recorded at that site in that year. Totals in parentheses are incomplete due to missing data because of either (1) a lack of estimates for a large number of sites, (2) no estimate for a site likely to represent a large portion of breeding pairs for the area, or (3) only a visual approximation of breeding pairs was available for a given site(s), rather than a precise count. See Appendix 2 for a complete list of colonies. [a]

Location	1987-1992 [b]	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
British Columbia													
Inland Total	4 [c]	9	10	11	12	23	25	-	59	117	99	**123**	-
Washington													
Inland Total	(425)	-	-	-	-	-	(250)	(300)	1,218	1,554	1,367	1,428	**1,196**
Oregon													
Inland Total	(725)	-	913	-	-	-	(883)	(1,043)	-	-	-	-	**1,041**
California													
Northeastern California	680	-	574	-	-	-	-	-	-	-	-	-	259
Central Valley Area	317	781	633	-	-	-	-	-	-	-	-	-	(28)
Southern Interior	62	(3,359)	5,658	-	-	-	-	-	-	-	-	-	(2,000)
Inland Total	(1,059)	(4,140)	6,865	-	-	-	-	-	-	-	-	-	(2,287)

[a] See Tables 2, 4, 7, and 9 for data sources
[b] Carter et al. (1995) unless otherwise noted
[c] Moul and Gebauer (2002), 1983 estimate

Table 13. Numbers of double-crested cormorants in Christmas Bird Counts in British Columbia and the United States west of the Continental Divide, 1997-2008.[a]

Location	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
British Columbia	1,859	2,547	2,474	3,201	4,144	4,471	3,737	6,241	4,982	5,066	4,074	2,451
Washington	4,597	4,039	6,931	7,344	8,406	9,194	9,130	9,912	7,822	9,749	10,222	6,084
Oregon	1,775	1,733	2,264	2,914	2,017	3,156	2,330	2,730	2,931	3,218	3,000	2,430
California	35,969	27,272	33,928	26,121	25,309	20,621	33,282	34,857	28,294	44,310	38,965	46,636
Idaho	97	108	131	78	75	100	106	148	167	198	243	182
Montana	4	4	1	4	18	0	0	4	1	0	0	0
Nevada	53	89	204	159	68	102	167	134	136	67	89	41
Arizona	639	591	863	581	1,384	960	1,341	1,470	1,197	1,516	1,946	1,753
Colorado	4	4	0	0	1	1	0	0	2	5	0	1
Utah	1	1	2	0	1	1	4	9	13	16	15	38
New Mexico	0	0	0	0	0	0	0	0	0	0	0	0
Wyoming	0	0	0	0	0	0	0	0	0	0	0	0
Subtotal Coastal States & BC	44,200	35,591	45,597	39,580	39,876	37,442	48,479	53,740	44,029	62,343	56,261	57,601
Subtotal Interior States	798	797	1,201	822	1,547	1,164	1,618	1,765	1,516	1,802	2,293	2,015
TOTAL	**44,998**	**36,388**	**46,798**	**40,402**	**41,423**	**38,606**	**50,097**	**55,505**	**45,545**	**64,145**	**58,554**	**59,616**

[a] Numbers are raw counts for all CBCs within a state for a given year. Numbers are not corrected for the number of counts conducted or for party hours or miles. Data from National Audubon Society, http://www.audubon.org/bird/cbc (accessed 03 August 2009).

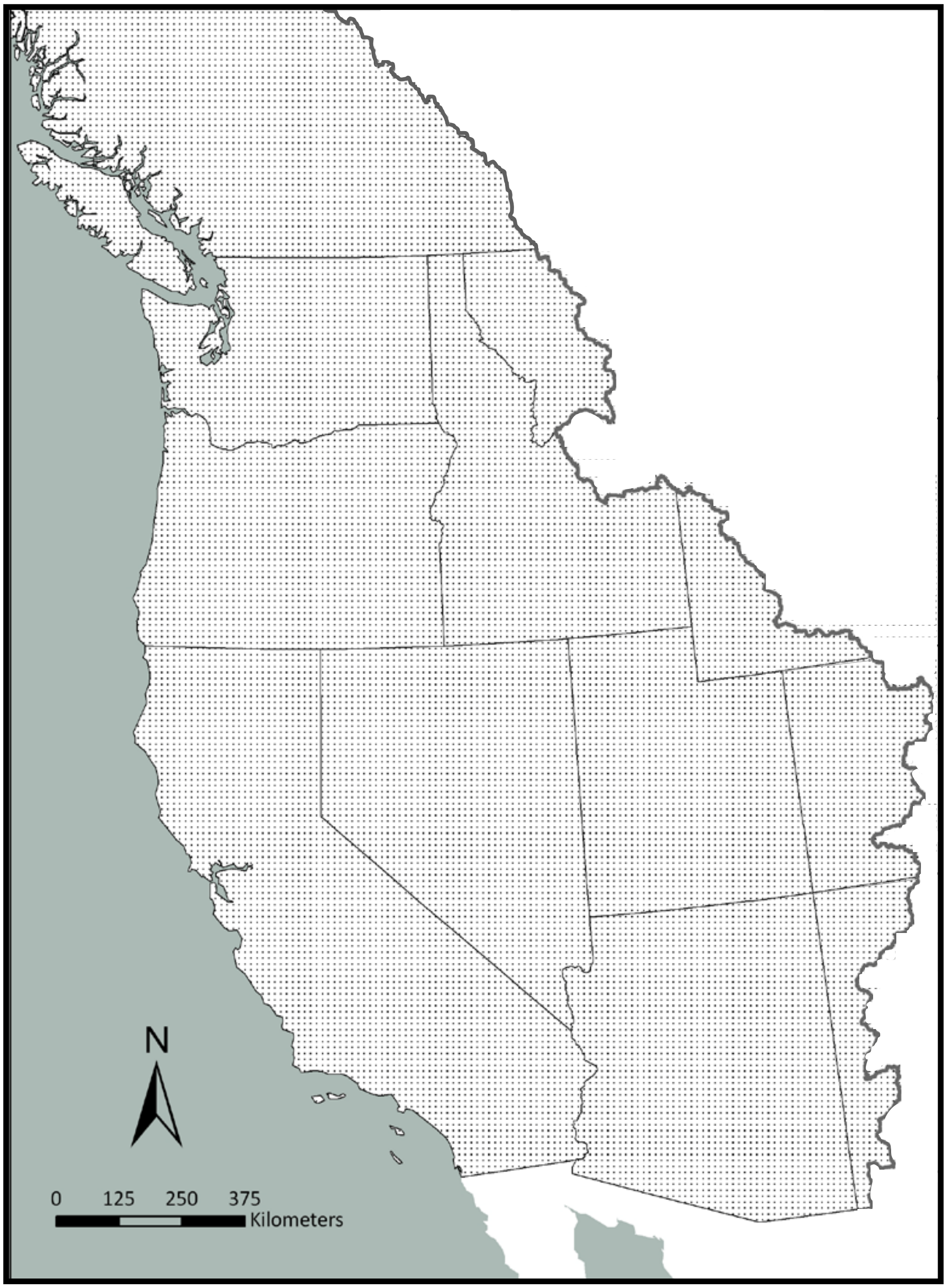

Figure 1. Geographic boundary of the area included in this status assessment corresponding to the breeding range of the Western Population of the double-crested cormorant.

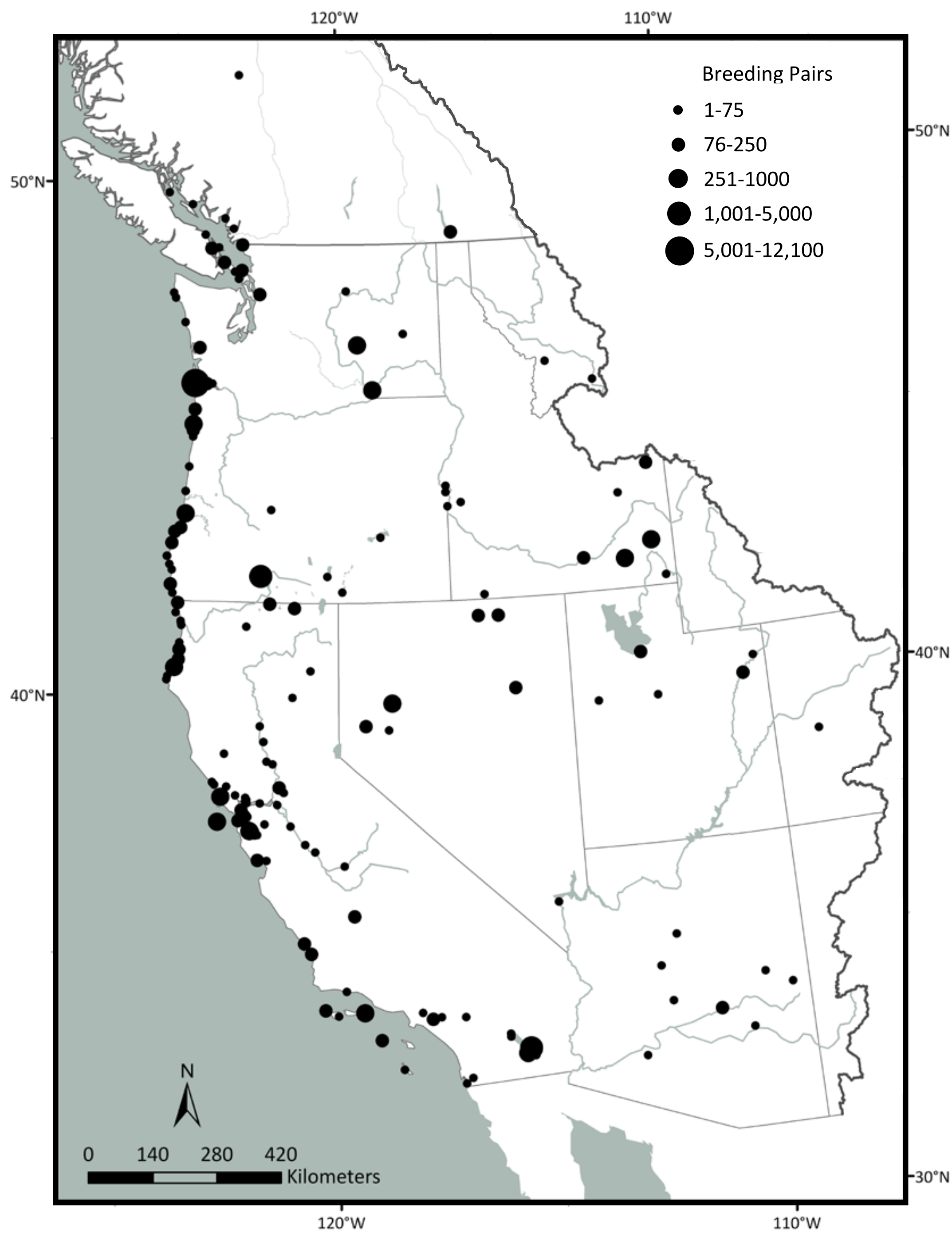

Figure 2. Distribution and relative size of double-crested cormorant breeding colonies in the Western Population at the time of most recent surveys (1998-2009; Appendices 1 and 2).

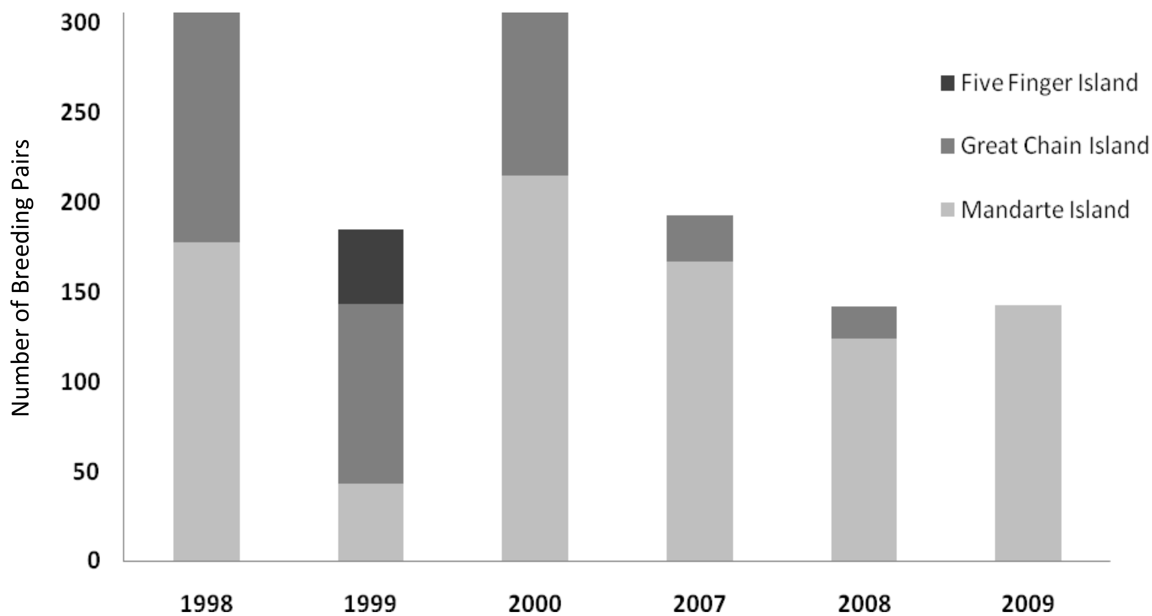

Figure 3. Numbers of double-crested cormorant breeding pairs nesting at Five Finger, Great Chain, and Mandarte islands, Gulf Islands sub-region, British Columbia, 1998-2009.

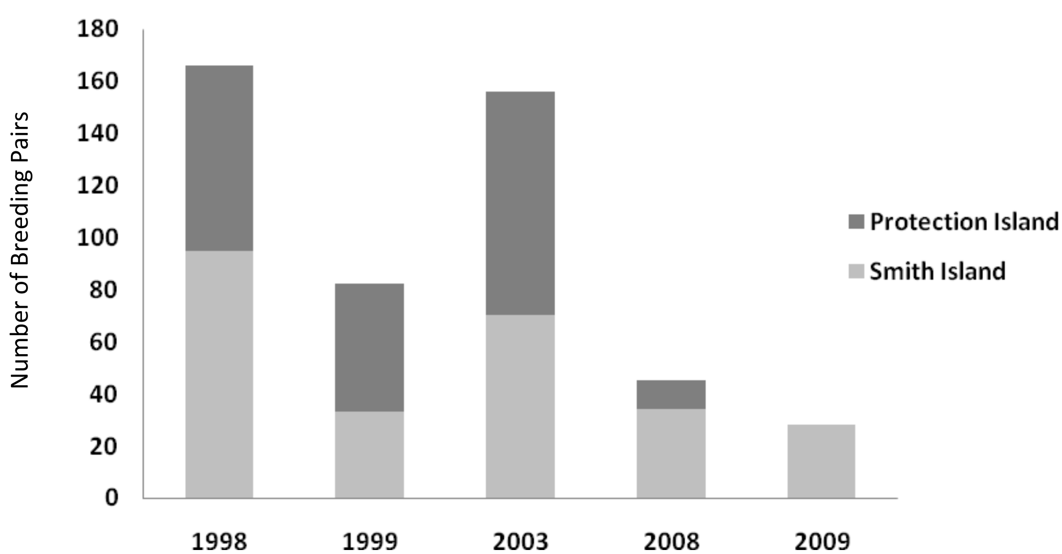

Figure 4. Numbers of double-crested cormorant breeding pairs nesting at Protection and Smith islands, Eastern Strait of Juan de Fuca sub-region, Washington, 1998-2009.

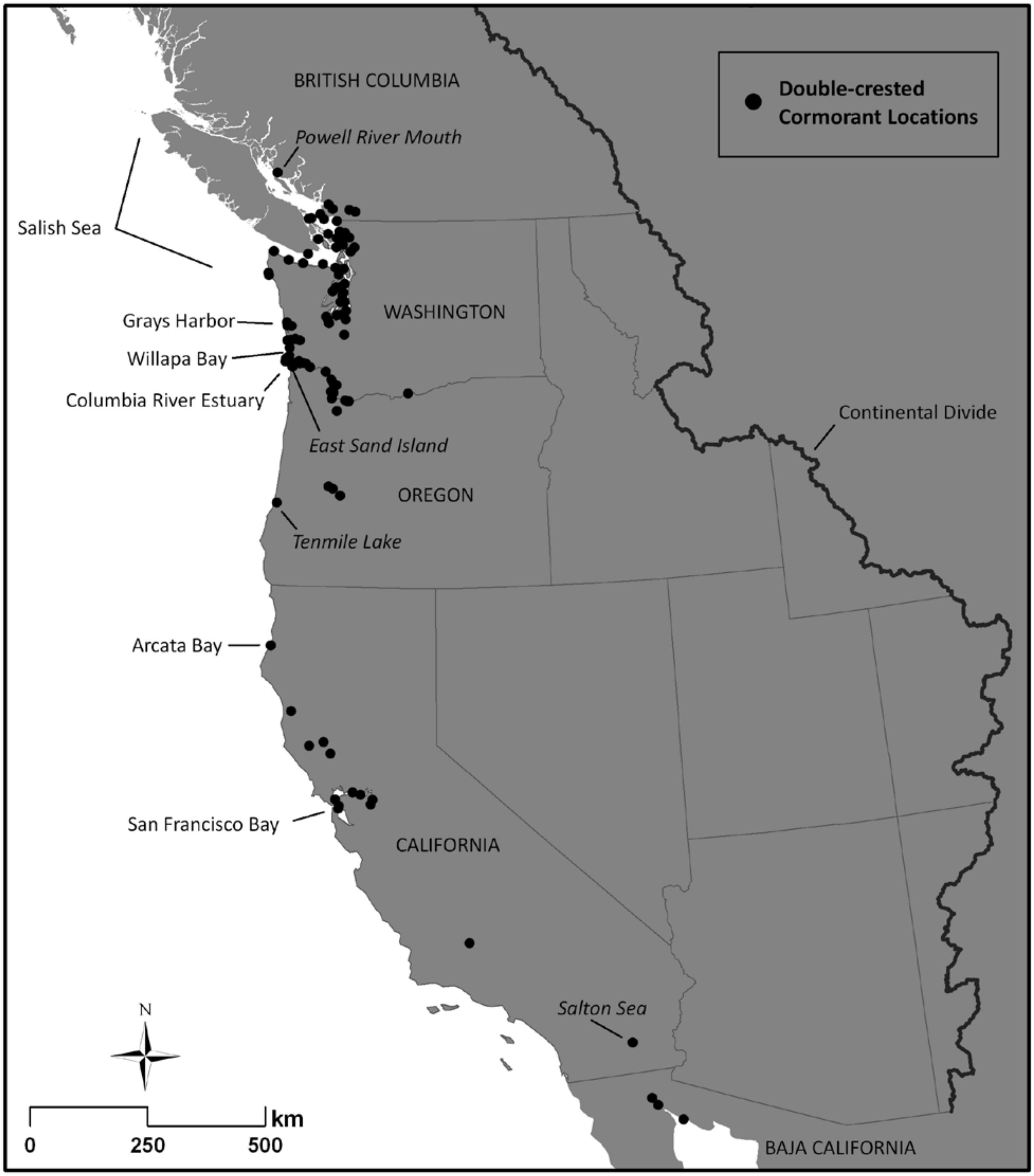

Figure 5. Post-breeding season (August - March) roosting locations of 51 double-crested cormorants satellite-tagged while nesting (June- July) at East Sand Island, Oregon in 2008 & 2009.

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Appendix 1. Locality coordinates, date of most recent census, most recent number of nests (i.e., breeding pairs), and data reference for double-crested cormorant colonies at marine and estuarine sites from southern British Columbia to the U.S.-Mexico border through 2009. B indicates breeding.

Colony Name	Latitude (decimal degrees)	Longitude (decimal degrees)	Most Recent Census	Number of Nests	Reference[a]
BRITISH COLUMBIA					
Northern Strait of Georgia					
Mitlenatch Island	49.95	-125	2009	20	1
McRae Islets	49.7395	-124.288833	2000	1	2
Christie Islet	49.492667	-123.301	2009	0	3
Pam Rock	49.486	-123.292333	2009	4	3
Franklin Rock/Merry Island	49.466667	-123.916667	2000	0	2
Gulf Islands					
Five Fingers Island	49.225667	-123.909	2009	0	1
Hudson Rocks	49.221667	-123.921667	2009	0	1
Gabriola Cliffs	49.160595	-123.86249	2009	43	3
Canoe Islet	49.023667	-123.585833	2009	0	1
Rose Islets	49.005	-123.638333	2009	0	1
Ladysmith Harbor	48.996294	-123.811594	2009	0	3
Bare Point	48.923333	-123.703	2009	0	3
Galiano Island cliffs	48.918667	-123.45	2009	47	3
Ballingal Islets	48.904167	-123.455	2009	0	3
Charles Island	48.900833	-123.433333			
Shoal Island (Crofton)	48.9	-123.666667	2009	83	3
Second Sister Islet	48.838333	-123.453333	2009	0	3
Annette Inlet	48.821667	-123.388333	2009	0	3
Red Islets	48.809333	-123.352	2009	0	3
Channel Islands	48.801167	-123.375333	2009	0	3
Mandarte Island	48.633333	-123.283333	2009	143	3
Chain Islets	48.419167	-123.266667	2009	0	3
Great Chain Island	48.418833	-123.272	2009	0	3
Vancouver Area					
Queen's Reach	49.235667	-122.85	1987	0	2
Sand Heads	49.105333	-123.290333	2009	0	3
Westshore Terminal	49.018333	-123.155	2009	0	3
Second Narrows Bridge Power Tower	49.294776	-123.032421	2009	63	4
WASHINGTON					
San Juan Islands					
Drayton Harbor	48.9875	-122.757833	2009	142	3
Puffin Island	48.740333	-122.818667	2009	0	3
Little Sister Island	48.687167	-122.755	2009	0	3
Viti Rocks	48.633333	-122.6195	2009	0	3
Bare Island	48.724667	-123.007833	2009	0	3
Waldron Island	48.700833	-123.024667	2009	0	3
White Rock	48.667333	-123.069	2009	0	3
Gull Rock	48.650667	-123.086333	2009	0	3
Flattop Island	48.641833	-123.075333	2009	0	3
Bird Rocks	48.484667	-122.757167	2009	148	3
Williamson Rocks	48.4505	-122.702833	2009	0	3
Goose Island (Cattle Pass)	48.457787	-122.957016	2009	56	3

Hall Island	48.434333	-122.906167	2009	0	3
Castle Island	48.42	-122.818833	2009	0	3
Colville Islands	48.409667	-122.8195	2009	0	3
Snohomish River Mouth	48.022833	-122.217	2009	249	3
<u>Eastern Strait of Juan de Fuca</u>					
Smith Island	48.318	-122.838667	2009	28	3
Protection Island	48.123333	-122.925	2009	0	3
Point No Point	47.909167	-122.521667	2009	0	3
<u>Olympic Peninsula Outer Coast</u>					
Seal Rock	48.3575	-124.541667	2009	0	3
No Name 061	48.369333	-124.725333	2009	0	3
Point of the Arches	48.241667	-124.693	2009	0	3
Father and Son	48.222667	-124.706833	2009	0	3
Bodelteh Islands	48.172	-124.755	2009	0	3
White Rock	48.134167	-124.733333	2009	0	3
Carroll Island	48.003333	-124.719333	2009	1	3
Jagged Islands	47.991333	-124.69	2009	0	3
No Name 303	47.9525	-124.670667	2009	0	3
Dahodaalah	47.950833	-124.668833	2009	0	3
Dahdayla	47.934667	-124.666833	2009	0	3
Petrel Island (Kohchaa)	47.906333	-124.65	2009	3	3
Gunsight Rock	47.904833	-124.650333	2009	0	3
Quillayute Needles	47.905167	-124.64	2009	0	3
Ghost Rock	47.853667	-124.5675	2009	0	3
Rounded Island	47.825833	-124.552167	2009	0	3
Half Round Rocks	47.809333	-124.504833	2009	0	3
Alexander Island	47.792	-124.502667	2009	0	3
Hoh Head Mainland	47.768667	-124.471667	2009	0	3
North Rock	47.75	-124.471667	2009	0	3
Middle Rock	47.742333	-124.442333	2009	0	3
South Rock	47.692833	-124.421667	2009	0	3
Abbey Island	47.709667	-124.418333	2009	0	3
Tunnel Islands	47.458333	-124.34	2009	0	3
Little Hogsback Island	47.435167	-124.3385	2009	71	3
Willoughby Rock	47.407	-124.352833	2009	0	3
Split Rock	47.404833	-124.357667	2009	0	3
No Name 535	47.3925	-124.3575	2009	0	3
Point Grenville Islands	47.3	-124.274167	2009	0	3
<u>Grays Harbor</u>					
Goose Island	46.973333	-124.068333	2009	0	3
Unnamed Sand Island	46.9575	-124.054167	2009	0	3
Grays Harbor Channel Markers	46.9545	-123.9005	2009	90	3
OREGON					
<u>Columbia River Mouth</u>					
East Sand Island	46.258	-123.986833	2009	12,087	3
Rice Island	46.258333	-123.758333	2009	0	3
Miller Sands Spit	46.244651	-123.682977	2009	0	3
Miller Sands Navigational Aids	46.253333	-123.658	2009	162	3
Other Upper Estuary Navigational Aids	46.256993	-123.501669	2009	73	3
Trestle Bay	46.218667	-123.987833	2009	0	3
Desdemona Sands Pilings	46.206167	-123.8725	2009	0	3
Astoria-Megler Bridge	46.200333	-123.8525	2009	24	3
<u>Northern Coast</u>					

Bird Rocks - North	45.905667	-123.97	2009	0	5
Unnamed Colony (Oswald West)	45.742333	-123.959667	2009	95	5
Three Arch Rocks - Finley Rock (East)	45.458667	-123.9845	2009	417	5
Three Arch Rocks - Middle Rock (Middle)	45.458333	-123.986167	2009	22	5
Three Arch Rocks - Shag Rock (West)	45.457	-123.9875	2009	0	5
Unnamed Colony (Unnamed Rock)	45.342333	-123.984	2009	0	5
Unnamed Colony (Cape Lookout)	45.335833	-123.989	2009	128	5
Haystack Rock	45.207	-123.9855	2009	75	5
Central Coast					
Yaquina Bay Bridge	44.619667	-124.0535	2006	2	6
Unnamed Colony	44.588833	-124.019	2006	0	6
Heceta Head	44.136833	-124.123167	2009	0	5
Conical Rock	44.137167	-124.122	2009	0	5
Blast Rock	44.135	-124.123667	2009	12	5
Parrot Rock	44.1345	-124.123833	2009	19	5
Sea Lion Caves	44.119333	-124.121333	2009	0	5
Southern Coast					
Siuslaw River Trees	43.959	-124.090833	2009	0	5
Bolon Island	43.707	-124.1015	2009	763	5
Unnamed Colony	43.688667	-124.167167	2009	0	5
Unnamed Colony	43.4385	-124.216833	2009	56	5
Unnamed Colony	43.422333	-124.220167	2009	183	5
Chiefs Island (Gregory Point)	43.339	-124.372333	2009	0	5
Unnamed Colony	43.337333	-124.371667	2009	88	5
Qochyax (Squaw) Island	43.336	-124.373333	2009	26	5
Table Rock	43.1175	-124.435833	2009	125	5
Middle Coquille Point Rock	43.108667	-124.436667	2009	0	5
Elephant Rock	43.107667	-124.436167	2009	0	5
Castle Rock	42.853833	-124.541833	2009	15	5
Gull Rock	42.850333	-124.5545	2009	27	5
Redfish Rocks (East Central)	42.692666	-124.470667	2009	6	5
Sisters Rocks Island (South)	42.587667	-124.405167	2009	49	5
Hunters Island	42.308333	-124.422167	2009	222	5
Unnamed Colony (Unnamed Rock)	42.2545	-124.409333	2009	1	5
North Crook Point Rock	42.254	-124.408167	2009	0	5
Unnamed Colony (Mack Reef)	42.242167	-124.407333	2009	24	5
Unnamed Colony (Mack Reef)	42.2405	-124.406167	2009	14	5
Unnamed Colony (Mack Reef)	42.234833	-124.408333	2009	0	5
Unnamed Colony	42.1695	-124.359167	2006	0	6
Whaleshead Cove (East Rock)	42.137167	-124.356667	2009	17	5
Whaleshead Cove (West Rock)	21.46	42.1365	2009	0	5
Rainbow Island	42.084333	-124.335667	2006	0	6
CALIFORNIA					
Northern Coast – North Section					
Prince Island	41.950667	-124.206833	2008	220	7
Castle Rock	41.756167	-124.25	2008	35	7
Tolowa Rocks	41.7525	-124.233333	2008	0	7
Unnamed Small Rocks	41.7	-124.133333	2008	0	7
Last Chance Rock	41.634167	-124.121667	2008	0	7
False Klamath Rock	41.59	-124.106	2008	48	7
Radar Station Rocks	41.555	-124.1	2008	57	7
Flint Rock Head	41.521833	-124.083333	2008	0	7
White Rock (DN)	41.509333	-124.084333	2008	6	7

High Bluff South	N/A	N/A	2008	0	7
Big Lagoon	41.168135	-124.113886	2008	42	7
Sea Gull Rock	41.086833	-124.151167	2008	13	7
Sea Lion Rock	41.09	-124.158167	2008	0	7
White Rock (HU)	41.0855	-124.1555	2008	0	7
Pilot Rock	41.051	-124.1515	2008	0	7
Trinidad Bay Rocks	41.05	-124.133333	2008	5	7
Little River Rock	41.034667	-124.119333	2008	100	7
Arcata Bay Sand Islands	40.840381	-124.124112	2008	103	7
Old Arcata Wharf	40.8405	-124.105333	2008	51	7
Humboldt Bay Platforms	40.717167	-124.234333	2008	0	7
Teal Island	40.6911	-124.224	2008	485	7
False Cape Rocks	40.506333	-124.39	2008	1	7
Sugarloaf Island	40.436333	-124.406833	2008	69	7
<u>Northern Coast – South Section</u>					
Kibesillah Rock	39.574833	-123.775167	2008	0	7
Russian Gulch	38.466667	-123.156	2008	50	7
Russian River Rocks	38.452333	-123.139	2008	25	7
Gull Rock	38.421667	-123.118333	2008	0	7
Shell-Wright Beach Rocks	38.416667	-123.1	2008	30	7
Dillon Beach Rocks	38.271	-122.985167	2008	0	7
Hog Island	38.1915	-122.9345	2008	285	7
<u>Central Coast – Outer Coast North</u>					
Point Resistance	37.9925	-122.823333	2008	0	7
South Farallon Islands	37.7	-123	2008	334	7
Seal Rocks	37.773667	-122.508833	2008	0	7
Lake Merced	37.719167	-122.490333	2009	99	8
Pillar Point	37.488333	-122.4925	2008	0	7
<u>Central Coast – San Francisco Bay</u>					
Russ Island	38.176167	-122.3195	2008	38	7
Knight Island	38.136	-122.293	2008	37	7
N. San Pablo Bay Radar Target	38.100667	-122.323333	2008	15	7
N.E. San Pablo Bay Beacon	38.0695	-122.286167	2008	2	7
Wheeler Island	38.072833	-121.957833	2008	126	7
Donlon Island	38.024167	-121.775	2008	0	7
Richmond-San Rafael Bridge	37.9335	-122.421	2009	169	9
San Francisco-Oakland Bay Bridge	37.818333	-122.3385	2009	83	9
Lake Merritt	37.803667	-122.252667	2009	68	8
Alviso Plant, Pond Nos. A9 & A10	37.452833	-122.006667	2009	0	8
Dumbarton Bridge Power Towers	37.505846	-122.120919	2008	160	7
Bair Island Power Towers (incl. Steinberger Slough)	37.523833	-122.2175	2008	294	7
Moffett Power Towers	37.444585	-122.065958	2009	31	8
San Mateo Bridge & PG&E Towers	37.587333	-122.24	2005	78	7
<u>Central Coast – Outer Coast South</u>					
Schwan Lake	36.965273	-121.994564	2009	142	10
Pinto Lake	36.955489	-121.771631	2009	66	10
San Lorenzo River Mouth	36.964483	-122.012621	2009	4	10
Partington Ridge North	36.167667	-121.685667	2008	0	7
Anderson Canyon Rocks	36.151167	-121.658833	2008	0	7
Rockland Landing North	36.0095	-121.538333	2008	0	7
Cape San Martin	35.886167	-121.459167	2008	0	7
Morro Rock & Pillar Rock	35.352167	-120.868	2008	14	7
Fairbank Point	35.350833	-120.839667	2008	225	7

Shell Beach Rocks	35.151	-120.6685	2008	204	7
Southern Coast					
Goleta Slough	34.421063	-119.842585	2008	11	7
Prince Island	34.054833	-120.333333	2008	98	7
Hoffman Point Area	34.040333	-120.358667	2008	0	7
Sierra Pablo Area	33.94295	-120.028425	2008	16	7
Scorpion Rocks	34.042	-119.541167	2008	0	7
Anacapa Island - West	34.006833	-119.419833	2008	335	11
Anacapa Island - Middle	34.00454	-119.393078	2008	47	11
Shag Rock	33.485833	-119.034167	2008	0	7
Santa Barbara Island	33.472833	-119.033833	2008	89	7
Sutil Island	33.475	-119.041667	2008	51	7
Cormorant Rock Area	33.238833	-119.552833	2008	0	7
Seal Cove Area	32.901667	-118.526333	2008	73	7
Ship Rock	33.457833	-118.487833	2008	0	7
La Jolla	32.8425	-117.259333	2008	0	7
South San Diego Bay Saltworks	32.6	-117.116667	2008	55	7

[a] References: 1 (T. Chatwin, pers. comm.); 2 (Moul & Gebauer 2002); 3 (Oregon State University/Real Time Research/Bird Research Northwest, unpubl. data); 4 (H. Carter, pers. comm.); 5 (U.S. Fish & Wildlife Service/Oregon State University, unpubl. data); 6 (U.S. Fish & Wildlife Service, unpubl. data); 7 (University of California, Santa Cruz/U.S. Fish & Wildlife Service/Oregon State University, unpubl. data); 8 (C. Robinson-Nilsen, pers. comm.); 9 (M. Elliott, pers. comm.) ; 10 (Santa Cruz Bird Club county records, D. Suddjian compiler); 11 (L. Harvey, unpubl. data).

Appendix 2. Locality coordinates, dates of most recent census dates, most recent numbers of nests (i.e., breeding pairs), and data references for double-crested cormorant colonies at inland sites in British Columbia, Washington, Oregon, California, Idaho, Nevada, Arizona, and the portions of Montana, Wyoming, Utah, Colorado, and New Mexico west of the Continental Divide, through 2009. B indicates breeding; PB indicates possible breeding.

	Colony Name	Latitude	Longitude	Most Recent Census	Number of Nests	Reference[a]
BRITISH COLUMBIA						
	Stum Lake	52.275	-123.02567	2008	25	1
	Creston Valley Wildlife Management Area	49.2	-116.58	2008	98	2
WASHINGTON						
	Mouth of Okanogan River	48.0925	-119.70983	2009	36	3
	Sprague Lake, Harper Island	47.241	-118.08383	2009	42	3
	North Potholes	47.0406667	-119.40283	2009	809	3
	Selah, WA	46.658	-120.49217	2006	B	3
	Hanford Reach	46.6548333	-119.41667	2009	0	3
	Lions Ferry Railroad Trestle	46.5893333	-118.22383	2009	0	3
	Goat Island	46.2353333	-119.19283	2009	0	3
	Foundation Island	46.1593333	-118.99117	2009	309	3
	Vancouver Lake	45.673	-122.7175	1936	4	4
	Miller Rocks	45.657	-120.87183	2009	0	3
OREGON						
	Snake River Unnamed Island	43.8417083	-117.00853	2009	27	5
	Snake River Unnamed Island	44.241948	-117.04232	2009	63	5
	Crane Prairie Reservoir	43.8116667	-121.78833	2009	20	3
	Malheur Lake	43.330591	-118.78816	2009	0	3
	Sodhouse Ranch (Malheur NWR)	43.263857	-118.84297	2009	29	3
	Summer Lake, Unnamed Island	42.9075	-120.76983	2009	0	3
	Upper Klamath Lake	42.509639	-122.03903	2009	850, 1,270	6, 3
	Swan Lake	42.323774	-121.60807	2009	0	3
	Anderson Lake	42.502744	-119.81705	2009	0	3
	Rivers End (Lake Abert)	42.51	-120.26833	2009	16	3
	Crump Lake, Tern Island	42.2838333	-119.83967	2009	0	3
	Pelican Lake, Pelican Island	42.2013333	-119.8765	2009	36	3
	Gerber Reservoir	42.205018	-121.10474	2009	0	3
	Drews Reservoir	42.171287	-120.66331	2009	0	3
CALIFORNIA						
	Lake Shastina	41.5181667	-122.38833	2009	41	7
	Meiss Lake, Butte Valley WA	41.8535	-122.05717	2009	0	3
	Sheepy Lake, Lower Klamath NWR	41.9683333	-121.78833	2009	79	7
	Trout Lake	41.6845	-122.47233	1992	40	4
	Iron Gate Reservoir - Copco Lake	41.9518333	-122.43367	1980	PB	4
	Tule Lake NWR, Sump 1A	41.896743	-121.52973	2009	0	3
	Tule Lake NWR, Sump 1B	41.837	-121.442	2009	0	3
	Clear Lake NWR	41.8885	-121.13717	2009	126	7
	Goose Lake	41.8036667	-120.42017	2009	0	3
	Big Sage Reservoir	41.5925	-120.6425	2009	0	3
	Reservoir F	41.5711667	-120.87367	1970's	13	4

Modoc NWR	41.4573333	-120.5195	1977	16	8
Eagle Lake, unnamed island	40.65946	-120.7148	2009	2	7
Eagle Lake, Pelican Point	40.6266667	-120.74083	2009	0	7
Hartson Reservoir	40.29	-120.37267	1990	50	4
Butt Valley Reservoir	40.1383333	-121.17167	2009	11	7
Llanco Seco Rancho (Sac. River E)	39.5761667	-121.98883	1999	15	6
NNE Grimes (Sac. River W)	39.1063333	-121.903	1999	0	6
North Butte Country Club, Butte Sink	39.2703333	-121.89117	1999	65	6
Sutter Bypass West	38.837	-121.65467	1999	12	6
Beaver Lake (Sac. River W)	38.8865	-121.807	1999	16	6
Port of Sacramento	38.5583333	-121.55367	1999	0	6
North Stone Lake, Stone Lakes NWR	38.384	-121.486	1999	154	6
Valensin Ranch, Cosumnes R. Reservoir	38.3038333	-121.39167	1999	3	6
Pellandini Ranch	38.284	-121.367	1999	29	6
Cut-off Slough, Solano Co.	38.1866667	-122.006	1920	40	4
Venice Tip	38.0416667	-121.52533	1999	9	6
Clear Lake (Lake Co.)	39.0238333	-122.87467	1999	97	6
Petaluma Waste Water Treatment Plant	38.2193333	-122.57283	1999	6	6
Laguna de Santa Rosa	38.3865	-122.80067	1999	59	6
Arroyo del Valle, Shadow Cliffs Park	37.6586667	-121.83633	2008	14	9
San Luis NWR	37.126393	-120.58761	2009	14	10
San Joaquin River NWR	37.626	-121.193	2009	0	9
Merced NWR (East Side Bypass)	37.1673333	-120.62667	1999	0	6
San Felipe Lake	36.97566667	121.4561667	1998	11	6
Milburn, San Joaquin River Eco. Res.	36.8521667	-119.87067	1999	9	6
South Wilbur Flood Area	35.8723333	-119.64067	1999	119	6
East Hacienda Ranch	N/A	N/A	1999	6	6
Tulare Lake	36.0675	-119.75217	1907	100's	4
Corcoran Irrigation District Ponds	36.171	-119.5855	1980	6	4
Buena Vista Lake, Kern Co.	35.2206667	-119.25867	1912	300	4
Bridgeport Reservoir, Mono Co.	38.2903333	-119.22667	1974	6	4
San Gabriel River, Pico Rivera	33.9838333	-118.07383	1999	6	6
Santa Ana River Ponds	33.8528333	-117.8255	1999	0	8
Anaheim Lakes	33.8576667	-117.842	1999	105	6
Sweetwater Reservoir	32.7045	-116.97233	1999	28	6
Lake Henshaw, San Diego Co.	33.2356667	-116.74133	1932	B	4
Prado Basin near dam	33.8895	-117.63833	1999	30	6
Mystic Lake	33.8751667	-117.07417	1999	64	6
Johnson St., Salton Sea (No.)	33.4575	-116.0565	1999	2	6
East Poe Rd., Salton Sea (So.)	33.1003333	-115.73383	1999	13	6
New River mouth, Salton Sea (So.)	33.1335	-115.69017	1999	30	6
Alamo River mouth, Salton Sea (So.)	33.205	-115.61683	1999	106	6
Mullet Is., Salton Sea (So.)	33.222	-115.60517	2009	2,000	11
Ramer Lake, Imperial WA	33.0731667	-115.507	1998	18	6

IDAHO

Gull Island - Minidoka NWR	42.662828	-113.45054	2009	61	12
Pelican Island - Minidoka NWR	42.662514	-113.45439	2009	87	12
American Falls Reservoir	42.59	-112.36	2009	500	12
Blackfoot Reservoir	42.898034	-111.61359	2009	634	12
Mud Lake WMA	43.877617	-112.37937	2009	26	12
Bear Lake NWR	42.188552	-111.31998	2009	58	12
Mormon Reservoir	43.255969	-114.82903	2008	0	12
Island Park Reservoir	44.405801	-111.54254	2009	136	12

	Lake Lowell Sector - Deer Flat NWR	43.4	-116.45	2009	0	12
	Gosling Island, Snake River Sector - Deer Flat NWR	44.12	-117.05	2009	25	12
	Stork Island	42.5	-116.1	2009	0	12
	Foreman Reservoir	43.024156	-116.3326	2009	0	12
	Henry's Lake	44.639291	-111.40265	2009	0	12
	Palisades Reservoir	43.262017	-111.12894	2009	0	12
	Boise River - Hop Road	N/A	N/A	2009	0	12
	Boise River - Wagner 2	N/A	N/A	2009	50	12
	Boise River - Lemp Lane	N/A	N/A	2009	20	12
	Payette River - Letha	43.907952	-116.64736	2009	16	12
	Magic Reservoir	43.258535	-114.36619	2009	0	12
	Old Castle Rookery A	N/A	N/A	2004	13	12
	Old Castle Rookery B	N/A	N/A	2004	14	12
	Emmett Rookery	N/A	N/A	2009	0	12
MONTANA						
	Warm Springs Ponds WMA	46.14264	-112.78429	2009	29	13
	Lee Metcalf NWR	46.56965	-114.07844	2009	3	13
	Ninepipes NWR	47.4317	-114.1171	2009	B	13
NEVADA						
	Ruby Lake NWR	N/A	N/A	2009	100	14
	Borderline, East Fork Owyhee River	N/A	N/A	2009	40	14
	Wildhorse Reservoir	N/A	N/A	2009	200	14
	Wilson Reservoir	N/A	N/A	2009	100	14
	Kirch WMA	38.419866	-115.08274	1994	40	8
	S-Line Reservoir	39.297	-118.433	2009	20	15
	Lahontan Reservoir	39.264	-119.404	1996	18	8
	Humboldt WMA	39.594	-118.365	2007	500	15
	Anaho Island	39.576	-119.308	2009	200	16
	Carson Sink	39.815282	-118.76644	1987	B	8
UTAH	Pelican Lake	N/A	N/A	2009	0	17
	Green River	N/A	N/A	2009	4	17
	Mona Reservoir	N/A	N/A	2009	13	17
	Fish Springs NWR, Mallard Pond	N/A	N/A	2009	2	17
	Ouray NWR	N/A	N/A	2009	76	17
	Great Salt Lake	N/A	N/A	2009	82	17
COLORADO						
	Fruitgrowers Reservoir	38.828613	-107.9519	2009	41	18
ARIZONA						
	Painted Rock Dam	33.0791667	-113.02083	1996	5	19
	Painted Rock Road Exit	32.9096047	-112.9568	2001	8	19
	San Carlos Lake	33.2552392	-110.4383	2008	50	19
	Roosevelt Lake	33.675	-111.14167	2009	147	19
	Lake Pleasant	33.9166667	-112.24167	2009	18	19
	River Reservoir	34.0301665	-109.43586	2006	30	19
	Scholz Lake	35.1916667	-112.01667	2009	31	19
	Willow Creek Reservoir	34.6083333	-112.45	2009	52	19
	Telephone Lake	34.2916667	-110.04167	2009	26	19
	Lake Mead, below Hoover Dam	36.0096723	-114.74271	2009	51	20

[a]References: 1 (J. Steciw, pers. comm.); 2 (M. Machmer, pers. comm.); 3 (Oregon State University/Real Time Research/Bird Research Northwest, unpubl. data); 4 (Carter et al. 1995); 5 (P. Milburn, pers. comm.); 6 (Shuford and Henderson 2010); 7 (Shuford 2010); 8 (U.S. Fish & Wildlife Service, unpubl. data); 9 (C. Robinson-Nilsen, pers. comm.); 10 (D. Woolington, pers. comm.); 11 (K. Molina, pers. comm.); 12 (C. Moulton, pers. comm.); 13 (C. Wightman, pers. comm.); 14 (P. Bradley, pers. comm.); 15 (J. Jeffers, pers. comm.); 16 (D. Withers, pers. comm.); 17 (S. Jones/J. Neill/J. Cavitt, pers. comm.); 18 (J. Beason, pers. comm.); 19 (T. Corman, pers. comm.); 20 (T. Corman/J. Barnes, pers. comm.).

Appendix 3. Data and personal communication sources and affiliations.

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