THE JOURNAL OF RAPTOR RESEARCH

A QUARTERLY PUBLICATION OF THE RAPTOR RESEARCH FOUNDATION, INC.

VOL. 34 | JUNE 2000 | NO. 2

J Raptor Res. 34(2):67–74

© 2000 The Raptor Research Foundation, Inc.

NESTING, POPULATION TREND AND BREEDING SUCCESS OF PEREGRINE FALCONS ON THE WASHINGTON OUTER COAST, 1980–98

ULRICH W. WILSON
U.S. Fish and Wildlife Service, Washington Maritime National Wildlife Refuges, P.O. Box 450, Sequim, WA 98382 U.S.A.

ANITA MCMILLAN
Washington Department of Fish and Wildlife, P.O. Box 1686, Port Angeles, WA 98362 U.S.A.

FREDERICK C. DOBLER
Washington Department of Fish and Wildlife, 2108 Grand Blvd., Vancouver, WA 98661 U.S.A.

ABSTRACT.—We monitored the Peregrine Falcon (*Falco peregrinus*) nesting population of the outer coast of Washington State's Olympic Peninsula during 1980–98. Peregrine Falcon nesting was concentrated in the central portion of the area, where most of Washington's small seabirds nest. During our study, occupied sites increased from 3 to 24, breeding pairs from 2 to 17 and successful pairs from 2 to 13. The mean annual nest site failure rate varied between 0–60%, whereas the mean annual number of young per breeding pair varied from 0.8–2.5 young. Successful pairs produced an average of 1.5–3.0 young annually, increasing significantly ($P < 0.02$) during the study period and approaching that of a reproductively healthy, stable population at Langara Island, British Columbia. This marine peregrine population produced significantly fewer young during El Niño years. Continued close monitoring of Peregrine Falcons is necessary until populations reach their carrying capacity.

KEY WORDS: *Peregrine Falcon;* Falco peregrinus; *breeding success; El Niño; helicopter surveys; population trend; seabird colonies.*

Anidación, tendencia poblacional y éxito reproductivo de halcones peregrinos en la costa de Washington, 1980–98

RESUMEN.—Monitoreamos la población anidante de halcones peregrinos (*Falco peregrinus*) de la costa del Estado de Washington en la Península Olímpica durante 1980–98. Los halcones peregrinos se concentraron en la parte central del área, en donde la mayoría de pequeñas aves marinas de Washington anidan. Durante nuestro estudio, los sitios de nidos ocupados se incrementaron de 3 a 24, las parejas en reproducción de 2 a 17 y las parejas exitosas de 2 a 13. La media anual de la tasa de fracaso de anidación varió de 0.8–2.5 juveniles. Las parejas exitosas produjeron un promedio de 1.5–3.0 juveniles anualmente, lo cual representó un incremeto significativo ($P < 0.02$) durante el período de estudio, aproximándose así a la población estable y exitosa de la isla Langara, British Columbia. Esta población marina de peregrinos produjó significativamente menos juveniles durante los años del Niño. El monitoreo cercano de los halcones peregrinos es necesario hasta que las poblaciones alcancen la capacidad de carga.

[Traducción de César Márquez]

The ecology and population status of the Peregrine Falcon (*Falco peregrinus*) has received much attention in the past several decades, following widespread population declines primarily related to use of DDT (Hickey 1969, Cade et al. 1988) and subsequent recovery (Federal Register 1999) due to restrictions placed on the use of this pesticide (Cade et al. 1988, Enderson et al. 1995), and because of reintroductions of captive-bred birds into their former range (Enderson et al. 1995, Cade et al. 1996). In Washington, a population of peregrines that has not been previously studied inhabits the remote and rugged outer coast of the Olympic Peninsula. The area is of interest not only because of the lack of published information on it, but also because it is a transition zone, resembling the British Columbia coast more closely than the Oregon or California coasts. We report here on the results of long-term monitoring efforts of nesting peregrines in this area.

STUDY AREA AND METHODS

The study area was the outer coast of Washington's Olympic Peninsula (Fig. 1). Between Neah Bay (48°21′N, 124°37′20″W) and Point Grenville (47°18′N, 124°16′45″W), located 5.7 km south of the mouth of the Quinault River, 28 major islands and hundreds of smaller rocks and reefs occur within 3 km of shore. Most of the islands along this 130 km long coastal stretch are typical sea stacks with tall, rugged cliffs, but a few of them support vegetation dominated by salal (*Gaultheria shallon*) and salmonberry (*Rubus spectabilis*). Several also have small stands of Sitka spruce (*Picea sitchensis*). These islands are part of Washington Islands National Wildlife Refuge and support approximately 109 000 breeding pairs of seabirds (Speich and Wahl 1989). The mainland shoreline is characterized by rugged headlands with towering cliffs that rise out of the ocean, separated by beaches and river mouths. Much of this shoreline is part of Olympic National Park, whereas the marine waters surrounding this area are part of the Olympic Coast National Marine Sanctuary.

From 1980–98, we monitored the area's peregrine population annually by determining the number of occupied sites (at least one adult present), breeding pairs (adult seen in incubating posture or eggs observed), successful pairs (young produced) and the number of young produced by each successful pair. We searched for nest sites during April and May of each year, and revisited the sites with incubating birds until the breeding outcome could be determined.

Because little was known about the area's peregrines prior to this study, we initially used a combination of methods to search for nest sites and to determine the number of young produced. During 1980–88, data were collected by walking accessible beaches and making observations from headland overlooks. Islands and mainland cliffs also were frequently surveyed from an inflatable boat. Occasionally, we surveyed areas and nest sites with a Hughes 500D helicopter. Annual helicopter seabird surveys of all islands, rocks, sea stacks and mainland cliffs of the entire study area were conducted from 1984–98 and contributed to our overall peregrine monitoring efforts.

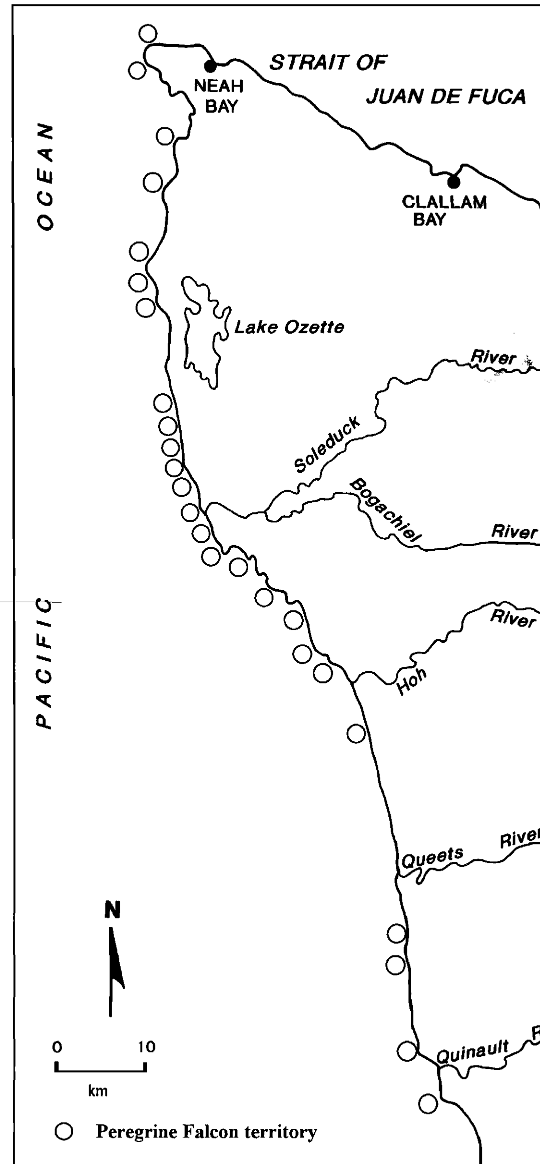

Figure 1. Locations of known Peregrine Falcon breeding territories on the outer coast of the Olympic Peninsula, Washington during 1980–98.

Because of the apparent increase in peregrine nesting and the difficulties in surveying the remote outer coast of Washington, we decided to monitor the species exclusively by helicopter starting in 1989. These surveys were conducted with a Hughes 500D or Bell 206 Jet Ranger with the passenger door removed. We generally conducted two activity surveys during April and May when all known sites where peregrines had occurred previously were checked for incubating birds. During these flights, new areas with potential for peregrine breeding, but where birds had not been observed, also were searched. When peregrines were found, we classified the sites as being either occupied or having breeding pairs. In most cases, we could not confirm whether the birds were actually incubating eggs, because the checks were brief in order to minimize disturbance. The activity surveys were followed up with two or more surveys during late May to July when the sites were checked for the number of young produced. Once the number of young was determined, the sites were not checked again. Because the ages of the young varied during these final checks, our production estimates were not based on the number of young fledged, but on whether the breeding attempt had been successful. The surveys were flown on fair weather days. Observations were made with 7× binoculars and we took photographs of all nesting ledges. Photos were later enlarged and marked with the nest locations and were used as reference points during future surveys.

El Niño events are known to cause widespread seabird breeding failures, lowered reproductive success and colony abandonment due to a collapse in the marine food chain (Wooster and Fluharty 1985, Wilson 1991). Along the eastern Pacific rim these phenomena manifest themselves oceanographically in above normal sea surface temperatures, a depression of the thermocline and a rise in sea level (Hamilton and Emery 1985, Norton et al. 1985). To test the hypothesis that these events also affect marine peregrines, we compared breeding success of years under ENSO (El Niño Southern Oscillation) influence, including 1981 which had a non-ENSO type warm water episode of similar magnitude, with breeding success during non-ENSO years when sea surface temperatures were normal. Wilson (1991) identified the 1981 warm event and determined that 1983, 1984 and 1988 were years when Washington outer coast seabirds were affected by warm episodes of ENSO-type origin. From monthly El Niño advisories produced by the National Marine Fisheries Service, we concluded that 1993, 1997 and 1998 also were ENSO years. Of the warm water episodes that occurred during this study, the 1981 and 1988 events were of moderate intensity (Wilson 1991), while the remaining episodes were severe.

Trends in the data were determined with Spearman rank correlation analysis using SYSTAT 7.0 for windows (Wilkinson 1997). This program also produces a smooth curve for scatter plots by running along the x values and finding predicted values from a weighted average of nearby y values (Cleveland 1979). To aid in the interpretation of our data, we added these curves to data sets that showed significant trends.

RESULTS

We found nesting peregrines throughout our study area, although 56% of the territories were located between the point on the coast west of the southern tip of Lake Ozette and 5 km south of the mouth of the Hoh River (Fig. 1). Sixty-six percent of known breeding pairs nested on islands, while the remainder occurred on mainland cliffs facing the Pacific Ocean. We documented 102 successful breeding attempts in at least 25 distinct territories (alternate nesting ledges in the same area were considered one territory).

The number of peregrines increased substantially during our study with the largest increase occurring after 1988. Occupied sites increased from three in 1980 to 21 in 1998 with a peak of 24 in 1997 (Fig. 2A). This trend was significant (r_s = 0.95, $N = 19$, $P < 0.001$). Breeding pairs increased from two in 1980 to 17 in 1998 (Fig. 2B), while the number of successful breeding pairs increased from two to 13 (Fig. 2C). The trends in both breeding pairs and successful breeding pairs were significant ($r_s = 0.98$, $N = 19$, $P < 0.001$; and $r_s = 0.93$, $N = 19$, $P < 0.001$, respectively). Because the sharp increase in sites after 1988 coincided with a change in study methods from a combination of methods to monitoring nest sites solely by helicopter, we also analyzed the 1980–88 and 1989–98 data sets separately. Breeding pairs and successful breeding pairs all showed significant positive trends during both time periods (1980–88: $r_s = 0.92$, $N = 9$, $P < 0.002$; $r_s = 0.61$, $N = 9$, $P < 0.05$, respectively; 1989–98: $r_s = 0.95$, $N = 10$, $P < 0.001$; and $r_s = 0.92$, $N = 10$, $P < 0.001$, respectively).

The failure rate of breeding pairs varied between 0–60% ($\bar{x} = 27\%$). Excluding the data from 1980–82 due to small sample sizes, the failure rate showed no trend (Fig. 3A). The number of young per breeding pair varied between 0.8–2.5 young ($\bar{x} = 1.7 \pm 0.5$) and showed no trend (Fig. 3B). Peregrine breeding success was influenced by El Niño events and a non-ENSO type warm episode that occurred during 1981 (Fig. 3C). The number of young per successful pair varied between 1.5–3.0 young ($\bar{x} = 2.3 \pm 0.4$) and showed a significant positive trend for the 1980–98 period ($r_s = 0.54$, $N = 19$, $P < 0.02$). When only normal years were considered, the number of young per successful pair also increased significantly ($r_s = 0.59$, $N = 12$, $P < 0.05$). The difference of the two trend lines (Fig. 3C) showed how El Niño events influenced long-term monitoring of marine peregrines on the Washington coast. The moderate events of 1981 and 1988 only moderately depressed peregrine breeding success (Fig. 3C). During warm water years, successful pairs had smaller broods (Fig. 4). The mean number of young per successful pair during warm water years was 2.2 ± 0.9 ($N = 41$), compared to 2.6 ± 0.8 ($N = 59$) during normal years ($t_{98} = -2.6$, $P = 0.01$).

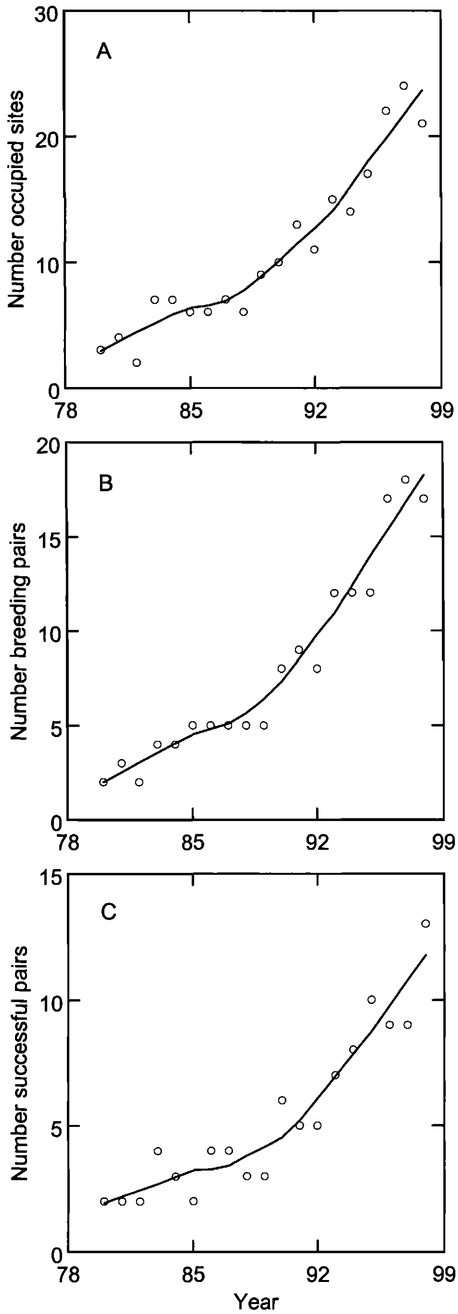

Figure 2. Number of occupied sites (A), breeding pairs (B) and successful pairs (C) of Peregrine Falcons on the outer coast of the Olympic Peninsula, Washington during 1980–98.

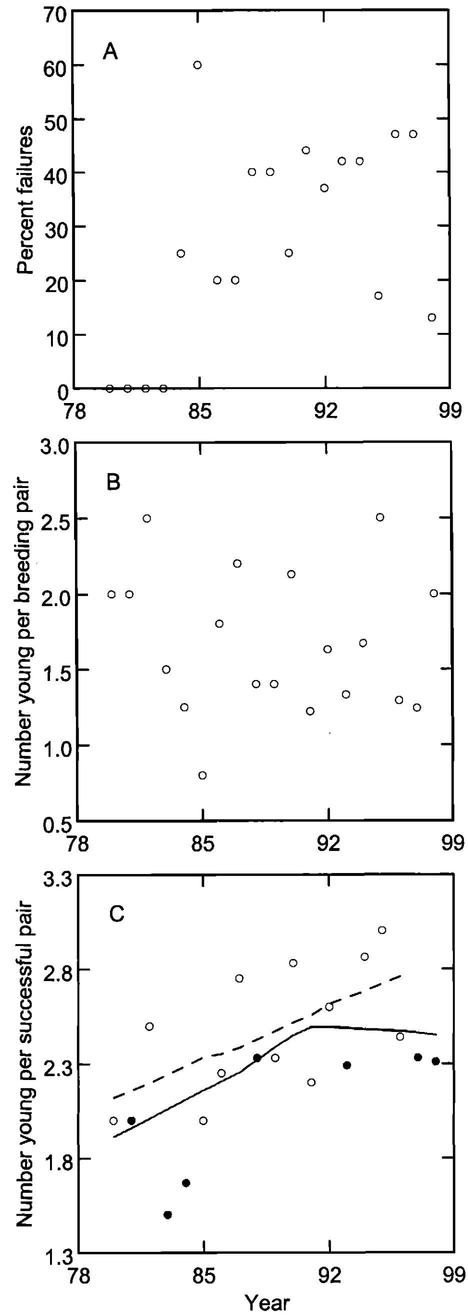

Figure 3. Percent failures (A), number young per breeding pair (B) and number young per successful pair (C) of Peregrine Falcons on the outer coast of the Olympic Peninsula, Washington during 1980–98. Solid black circles represent years under the influence of warm oceanic conditions. The solid line represents all years, while the dashed line represents normal (non-ENSO) years.

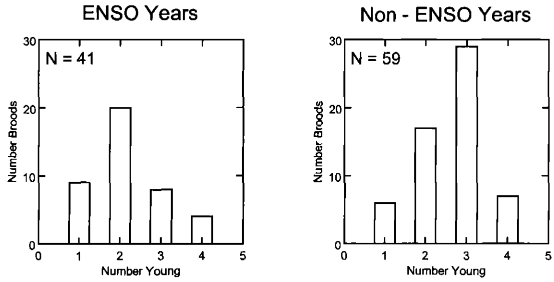

Figure 4. Number of young in Peregrine Falcon broods during El Niño Southern Oscillation (ENSO) years compared to normal (non-ENSO) years on the outer coast of the Olympic Peninsula, Washington during 1980–98.

The breeding season of Washington's coastal peregrines was protracted, and it was not uncommon to have young fledge at some nests, while other pairs were still brooding small, downy young. We estimated that fledging occurred as early as 2 June and as late as 20 July.

DISCUSSION

Our results showed that the Washington outer coast peregrine breeding population experienced a major increase during 1980–98. Breeding success improved significantly with success poorest during years of warm oceanic conditions.

Unfortunately, little published information on Washington coastal peregrines is available for comparison with our study. According to Jewett et al. (1953), the species was a common permanent resident on the Washington outer coast, with incidental nesting records for Carroll Island, Flattery Rocks and the Quillayute Needles. In 1957, Beebe (1960) searched Carroll Island, Cape Flattery and Neah Bay on the Washington coast and found no peregrines where they had been reported by Dawson and Bowels (1909). C. Anderson and S. Herman reported (Walton et al. 1988) no use of 14 historical nest sites by peregrines in 1976, but one new site was located. More recently, Paine et al. (1990) observed an increase in peregrine hunting activity on Tatoosh Island while studying the impacts of peregrines on the island's seabird community. The remoteness and ruggedness of the western Olympic Peninsula has undoubtedly prevented any detailed earlier work. This was recognized by Nelson (1969) who stated that the many nesting cliffs in Washington make a scientific check of these birds a major research problem.

The distribution of known peregrine nest sites on the Washington outer coast appeared to be related to the occurrence of islands, sea stacks and rocks, and major seabird colonies. Many of the islands and sea stacks with tall cliffs were located in the central portion of the coast, where we found most of the peregrine nest sites. Islands and sea stacks were less common in the other portions of the study area, where there were more beaches and fewer tall cliffs. Beebe (1969) found that, in coastal British Columbia, nesting peregrines preferred areas where there was an abundance of small islands and sea stacks with seabird colonies. In our study area, 90% of an estimated population of 87 600 Cassin's Auklets (*Ptychoramphus aleutica*), 98% of approximately 35 700 Leach's Storm Petrels (*Oceanodroma leucorhoa*) and 51% of about 3900 Fork-tailed Storm Petrels (*Oceanodroma furcata*) nest within this area of concentrated peregrine activity (Speich and Wahl 1989). On the coast of British Columbia, peregrines rely heavily on small alcids and storm petrels (*Oceanodroma*) for prey (Beebe 1969).

The protracted breeding season of Washington's outer coast peregrines required several productivity surveys because of the different stages of development of young at the various nest sites. We generally had to schedule at least three flights, two weeks apart, in order to determine the number of young at successful sites. The timing of fledging of Washington coastal peregrines was almost identical to that of British Columbia peregrines (Campbell et al. 1990).

The increase in the Washington outer coast nesting peregrine population observed during this study coincided with the widespread comeback of the species in western North America and elsewhere (Enderson et al. 1995, Federal Register 1999). The increase in Washington was remarkably similar to the recovery of peregrines observed in the Yukon and Colville River areas in Alaska (Ambrose et al. 1988, Enderson et al. 1995), all recovering naturally with no reintroductions. In California, the breeding population increased from 38 pairs in 1981 to 113 pairs in 1992 with the help of released birds (Kirven and Walton 1992), and Canadian *F. p. anatum* nest sites more than doubled between 1985/86 and 1990 (Holroyd and Banasch 1996). In neighboring British Columbia, the coastal *F. p. pealei* population was considered stable (Holroyd and Banasch 1996). The increase in Washington's coastal peregrine population appears to have been natural because no captive-bred young were released in the area. We cannot rule out the possibility, however, that released birds from elsewhere contributed to the increasing Washington coast breeding population. Because predecline population data for Washington are lacking, we do not know to what extent the population has recovered.

Because our study area was a very rugged stretch of coastline with many islands, sea stacks and mainland cliffs, some of our nest sites were difficult to find. A few of the nesting ledges were hidden in vegetation, under overhanging tree roots or in the backs of small cliff caves. Therefore, the possibility existed that we may have missed some nesting pairs altogether or found nesting pairs one or more years after their first breeding attempt. This may have resulted in underestimating the total number of nest sites, and underestimating or overestimating the rate of breeding population increase. While we could not quantify how this affected our study, we feel that we were able to locate >90% of occupied sites or breeding pairs using our search methods. Because the 1980–88 and the 1989–98 data subsets both showed significant positive trends, and because we surveyed the entire study area each year during peregrine and seabird surveys (which were done by helicopter since 1984), we feel that the switch from a combination of methods to exclusively aerial surveys did not result in the observed increase in the peregrine population.

Our mean of 1.7 young per breeding pair was well below Nelson's (1990) comparable estimate of 2.3 young per pair. The 73% mean success rate of Washington coastal breeding peregrines was considerably lower than the 84% reported for Langara Island, British Columbia (Nelson 1990), perhaps reflecting in our study area a higher number of young recruits with a greater likelihood of nesting failure. These differences were not only due to higher breeding success of Langara Island birds, but may also have been related to the different methods of collecting data. The Langara Island nest sites were only visited during a 8–10 d period when nestlings were of banding age (Nelson 1990). We conducted breeding surveys at sites prior to hatching, thus documenting early failures. In several instances during subsequent surveys in the same year, adult falcons were absent at failed sites. Errors in our estimation of the number of breeding pairs on the Washington coast may have also occurred because we could not confirm if eggs were actually laid at all sites. We may also have missed some pairs that laid eggs late. We suggest caution when comparing our data on breeding pairs with other studies.

There are few published studies of sufficient duration to detect trends in the number of peregrine young per successful pair on the west coast of North America. For Langara Island, Nelson (1990) reported a mean of 2.8 young per successful pair (range = 2.0–3.3) during 1980–89. During the same time period, we found a mean of 2.1 young per successful pair (range = 1.5–2.8). The peregrine population on the Queen Charlotte Islands did not experience the same declines documented elsewhere (Beebe 1969), with the Langara Island population being stable and reproductively healthy during 1968–89 (Nelson 1990). Breeding success for the peregrines in our study area continued to improve to an average of 2.5 young per successful pair during 1993–98, perhaps reflecting a population with more mature members than during the early years. It was encouraging that this measure of reproductive success of Washington's coastal peregrines had approached that of the healthy Langara Island birds. The population increase in Washington apparently is different from that in other west coast states. In California where DDT application was heavy through 1972, the reproductive success of peregrines during 1981–92 was below normal but increased due to the release of large numbers of captive-bred young (Kirven and Walton 1992).

Adverse effects of El Niño on peregrine breeding success have not been previously reported because there are few studies of sufficient duration to include an adequate sample of El Niño years. On the Washington outer coast, numbers of Double-crested Cormorants (*Phalacrocorax auritus*), Brandt's Cormorants (*P. penicillatus*) and Common Murres (*Uria aalge*) were sharply reduced during warm water episodes (Wilson 1991). It was very likely that the smaller seabirds, which are part of the peregrine's prey, were similarly affected during such years, thereby reducing prey available to successful pairs and limiting the number of young they produced. Given that the most spectacular instances of interannual variability in marine ecosystems are El Niño events (Cane 1983), these findings were not surprising. Future research on marine peregrines in the eastern subarctic Pacific Ocean must consider potential ENSO depressed breeding success since El Niños occur regularly at intervals of 2–10 yr (Cane 1983). Data collected during severe El Niño and post-El Niño years represent highly abnormal environmental conditions and should be used with caution.

We believe the increase in number of pairs of peregrines in our study area, as well as the improved breeding success, was primarily due to the discontinued use of DDT and the resulting reduction in DDE levels (a metabolite of DDT) in the peregrine's prey (Cade et al. 1988, Peakall 1990, Enderson et al. 1995, Henny et al. 1996). Evidence exists that these pesticide levels in western Washington have declined. Schick et al. (1987) documented declines in DDE and PCB residues in shorebirds collected during winter and spring in four western Washington estuaries. Shorebirds are important prey species for falcons wintering on the Washington coast (Buchanan et al. 1986, Buchanan 1996). Further evidence comes from nine addled peregrine eggs collected from four nests in our study area between 1987–91. These eggs had DDE residue levels of ≤10.8 ppm ($\bar{x}$ = 4.3 ± 2.8 wet weight, adjusted for moisture loss; Washington Department of Fish and Wildlife, unpubl. data). These levels were considered below concentrations known to affect peregrine productivity (Peakall 1976).

Although the American Peregrine Falcon was recently removed from the federal Endangered Species List (Federal Register 1999) and its populations are increasing in many areas, we do not know the current or historical carrying capacity for the species in our study area. We recommend that intensive survey efforts be continued until populations have stabilized. Federal regulations under the Endangered Species Act require a minimum 5-yr monitoring period for the Peregrine Falcon after delisting (Federal Register 1999).

ACKNOWLEDGMENTS

We thank J. Atkinson, E. Cummins, R. Harkins and R. Spencer for assistance in the field. K. McAllister helped with tabulating data. C. Henny, R. Knight, K. Kilbride, W. Koenig, T. Loughin, R.W. Nelson and D. Varland provided many helpful comments on earlier versions of this manuscript. Special thanks also to E. Cummins, B. Hesselbart, J. Kincheloe, K. Ryan, J. Takekawa and J. Welch for help in funding the flights. The U.S. Fish and Wildlife Service and the Washington Department of Fish and Wildlife paid for the aerial surveys.

LITERATURE CITED

AMBROSE, R.E., R.J. RITCHIE, C.M. WHITE, P.F. SCHEMPF, T. SWEM AND R. DITTRICK. 1988. Changes in status of Peregrine Falcon populations in Alaska. Pages 73–82 *in* T.J. Cade, J.H. Enderson, C.G. Thelander and C.M White [EDS.], Peregrine Falcon populations: their management and recovery. The Peregrine Fund, Boise, ID U.S.A.

BEEBE, F.L. 1960. The marine peregrines of the northwest Pacific coast. *Condor* 62:145–189.

———. 1969. The known status of the Peregrine Falcon in British Columbia. Pages 53–60 *in* J.J. Hickey [ED.], Peregrine Falcon populations: their biology and decline. Univ. Wisconsin Press, Madison, WI U.S.A.

BUCHANAN, J.B. 1996. A comparison of behavior and success rates of Merlins and Peregrine Falcons when hunting Dunlins in two coastal habitats. *J. Raptor Res* 30:93–98.

———, S.G. HERMAN AND T.M. JOHNSON. 1986. Success rates of the Peregrine Falcon (*Falco peregrinus*) hunting Dunlin (*Calidris alpina*) during winter. *Raptor Res.* 20:130–131.

CADE, T.J., J.H. ENDERSON, C.G. THELANDER AND C.M. WHITE [EDS.]. 1988. Peregrine Falcon populations: their management and recovery. The Peregrine Fund, Boise, ID U.S.A.

———, M. MARTELL, P. REDIG, G. SEPTON AND H. TORDOFF. 1996. Peregrine Falcons in urban North America. Pages 3–13 *in* D.M. Bird, D.E. Varland and J.J. Negro [EDS.], Raptors in human landscapes. Academic Press, London, U.K.

CAMPBELL, R.W., N.K. DAWE, I. MCTAGGART-COWAN, J.M. COOPER, G.W. KAISER AND M.C.E. MCNALL. 1990. The birds of British Columbia. Royal British Columbia Museum, Victoria, British Columbia, Canada.

CANE, M.A. 1983. Oceanographic events during El Niño *Science* 222:1189–1195.

CLEVELAND, W.S. 1979. Robust locally weight regression and smoothing scatterplots. *J. Am. Stat. Assoc.* 74:829–836.

DAWSON, W.L. AND J.H. BOWELS. 1909. The birds of Washington. Occidental Publ. Co., Seattle, WA U.S.A.

ENDERSON, J.H., W. HEINRICH, L. KIFF AND C. WHITE. 1995. Population changes in North American peregrines. *Trans. N. Am. Wildl. and Natur. Resour. Conf.* 60: 142–161.

FEDERAL REGISTER. 1999. Endangered and threatened wildlife and plants: final rule to remove the American Peregrine Falcon from the federal list of endangered and threatened wildlife, and to remove the similarity of appearance provision for free-flying peregrines in the conterminous United States. *Federal Register* 64: 46541–46558.

HAMILTON, K. AND W.J. EMERY. 1985. Regional atmospheric forcing of interannual surface temperatures and sea level variability in the Northwest Pacific. Pages 22–30 *in* W.S. Wooster and D.L. Fluharty [Eds.], El Niño North: Niño effects in the Eastern Subarctic Pacific Ocean. Washington Sea Grant Program, Univ. Washington, Seattle, WA U.S.A.

HENNY, C.J., W.S. SEEGAR AND T.L. MAECHTLE. 1996. DDE decreases in plasma of spring migrant Peregrine Falcons. *J. Wildl. Manage.* 60:342–349.

HICKEY, J.J. [ED.]. 1969. Peregrine Falcon populations: their biology and decline. Univ. Wisconsin Press, Madison, WI U.S.A.

HOLROYD, G.L. AND U. BANASCH. 1996. The 1990 Canadian Peregrine Falcon (*Falco peregrinus*) survey. *J. Raptor Res.* 30:145–156.

JEWETT, S.G., W.P. TAYLOR, W.T. SHAW AND J.W. ALDRICH. 1953. Birds of Washington state. Univ. Wash. Press, Seattle WA U.S.A.

KIRVEN, M.N. AND B.J. WALTON. 1992. The Peregrine Falcon population recovery in California from 1981 to 1992. U.S. Bur. Land Manage. Rep., Sacramento, CA U.S.A.

NELSON, M.W. 1969. The status of the Peregrine Falcon in the Northwest. Pages 61–72 *in* J.J. Hickey [ED.], Peregrine Falcon populations: their biology and decline. Univ. Wisconsin Press, Madison, WI U.S.A.

NELSON, R.W. 1990. Status of the Peregrine Falcon, *Falco peregrinus pealei*, on Langara Island, Queen Charlotte Islands, British Columbia, 1968–1989. *Can. Field-Nat.* 104:193–199.

NORTON, J., D. MCLAIN, R. BRAINARD AND D. HUSBY. 1985. The 1982–83 El Niño event off Baja and Alta California and its ocean climate context. Pages 44–72 *in* W.S. Wooster and D.L. Fluharty [Eds.], El Niño North: Niño effects in the Eastern Subarctic Pacific Ocean. Washington Sea Grant Program, Univ. Washington, Seattle, WA U.S.A.

PAINE, R.T., J.T. WOOTTON AND P.D. BOERSMA. 1990. Direct and indirect effects of Peregrine Falcon predation on seabird abundance. *Auk* 107:1–9.

PEAKALL, D.B. 1976. The Peregrine Falcon (*Falco peregrinus*) and pesticides. *Can. Field-Nat.* 90:301–307.

———. 1990. Prospects for the Peregrine Falcon, *Falco peregrinus,* in the nineties. *Can. Field-Nat.* 104:168–173.

SCHICK, C.T., L.A. BRENNAN, J.B. BUCHANAN, M.A. FINGER, T.M. JOHNSON AND S.G. HERMAN. 1987. Organochlorine contamination in shorebirds from Washington state and the significance for their falcon predators. *Environ. Monitoring Assess.* 9:115–131.

SPEICH, S.M. AND T.R. WAHL. 1989. Catalog of Washington seabird colonies. U.S. Fish Wildl. Serv. Biol. Rep. 88, Washington, DC U.S.A.

WALTON, B.J., C.G. THELANDER AND D.L. HARLOW. 1988. The status of peregrines nesting in California, Oregon, Washington, and Nevada. Pages 95–104 *in* T.J. Cade, J.H. Enderson, C.G. Thelander and C.M. White [EDS.], Peregrine Falcon populations: their management and recovery. The Peregrine Fund, Boise, ID U.S.A.

WILKINSON, L. 1997. SYSTAT for windows: statistics, version 7.0. SYSTAT Inc., Evanston, IL U.S.A.

WILSON, U.W. 1991. Responses of three seabird species to El Niño events and other warm episodes on the Washington coast, 1979–1990. *Condor* 93:853–858.

WOOSTER, W.S. AND D.L. FLUHARTY [EDS.]. 1985. El Niño North: Niño effects in the Eastern Subarctic Pacific Ocean. Washington Sea Grant Program, Univ. Washington. Seattle, WA U.S.A.

Received 30 July 1999; accepted 9 February 2000