Bird Populations 2:33-43

TRENDS IN WATERBIRDS AND RAPTORS AT SOUTHEAST FARALLON ISLAND, CALIFORNIA, 1974-1993[1]

PETER PYLE

AND

DAVID F. DESANTE[2]

Point Reyes Bird Observatory
4990 Shoreline Highway
Stinson Beach, CA 94970

Abstract. We examined trends in populations of migrant waterbirds and raptors arriving and wintering on Southeast Farallon Island (SEFI), California, during the 20-year period 1974-1993. Significant linear trends were detected in 19 of 56 species examined; 12 increased and seven declined. Nine species showed significant curvilinear trends, all negative. A significant proportion of decreasing waterbird species regularly winter at SEFI, and of those, greater declines were detected with wintering than with migrant individuals. To further investigate these declines we compared trends of wintering birds at SEFI with those detected with Christmas Bird Count data in coastal Marin County, California, and found many similar results. These findings suggest that changes in local environmental conditions, extending at least to the adjacent California coast, may have caused these trends. Notable declines in numbers of Red-necked Grebe *(Podiceps grisegena)*, Eared Grebe *(P. nigricollis)*, Surf Scoter *(Melanitta perspicillata)*, White-winged Scoter *(M. fusca)*, Black-bellied Plover *(Pluvialis squatarola)*, Willet *(Catoptrophorus semipalmatus)*, and Ruddy Turnstone *(Arenaria interpres)* were observed, whereas four of five raptor species showed significant increases.

Key Words: Population monitoring; trends; Red-necked Grebe; Eared Grebe; White-winged Scoter; Peregrine Falcon; Merlin; Black-bellied Plover; Willet; Southeast Farallon Island; California.

TENDENCIA DE LAS AVES ACUÁTICAS Y RAPACES DEL SURESTE DE LA ISLA FARALLON, CALIFORNIA, 1974-1993

Resumén. Estudiamos las tendencias poblacionales de las aves migratorias acuaticas y rapaces que llegaron e invernaron al Sureste de la Isla Farallon (SEFI), en Callifornia, durante un período de 20 años de 1974-1993. Una tendencia significativa lineal se detectó en 19 de 56 especies estudiadas, 12 aumentaron y 7 disminuyeron, 9 especies mostraron una tendencia significativa curvilineal, todas negativas. Una porción significativa de especies de aves acuaticas que regularmente invernan en SEFI disminuyeron y de éstas, grandes bajas se observaron en aves que invernan aquí, que en especies migratorias. Para investigar mas estas disminuciones, comparamos las tendencias de las aves que invernan en SEFI, con los datos del Censo de Aves en Navidad de la Costa del condado de Marin en California y se encontraron resultados similares. Estos resultados, indican que cambios en las condiciones ambientales locales que han alcanzado la costa de California, podrían haber sido la causa de estas tendencias. Notables disminuciones en *Podiceps grisegena, P. nigricollis, Melanitta*

[1]Received: 26 September 1994. Accepted: 14 December 1994.
[2] Present address: The Institute for Bird Populations, P. O. Box 1346, Point Reyes Station, CA 94956.

perspicillata, M. fusca, Pluvialis squatarola, Catoptrophorus semipalmatus, y *Arenaria interpres* se observaron mientras que cuatro de cinco especies de rapaces mostraron un aumento significativo.

Palabras claves: Monitoreo de poblaciones; tendencias; *Podiceps grisegena; P. nigricollis; Melanitta perspicillata; Falco peregrinus; Falco columbarius; Pluvialis squatarola; Catoptrophorus semipalmatus;* Sureste de la Isla Farallon; California.

TENDANCES DES POPULATIONS D'OISEAUX D'EAU ET DE RAPACES DANS L'ÎLE FARALLON SUD-EST (CALIFORNIE), DE 1974 À 1993

Résumé. Nous avons étudié sur vingt ans les populations d'oiseaux d'eau et de rapaces migrateurs, s'arrêtant ou hibernant sur l'île Farallon Sud-Est (SEFI), Californie, pour la période 1974-1993. Nous avons détecté une tendance linéaire significative pour 19 des 56 espèces étudiées : douze ont progressé, et sept ont décliné. Neuf espèces ont suivi une tendance curviligne significative, négative dans tous les cas. Une proportion significative d'espèces d'oiseaux d'eau en déclin hiberne régulièrement à SEFI, et parmi celles-ci les baisses les plus fortes concernent les individus hibernant plutôt que migrant. Pour comprendre mieux ces baisses, nous avons comparé les tendances des oiseaux hibernant à SEFI avec celles détectées dans les données "comptages d'oiseaux à Noël" du comté côtier de Marin (Californie). Nous avons observé de nombreuses similarités, ce qui laisse supposer que les changements de l'environnement local, qui s'étendent au moins jusqu'à la côte californienne adjacente, sont à l'origine de ces tendances. Les effectifs de grèbes jougris *(Podiceps grisegena)*, grèbes à cou noir *(P. nigricollis)*, macreuses a lunettes *(Melanitta perspicillata)*, macreuses brunes *(M. fusca)*, pluviers argentés *(Pluvialis squatarola)*, chevaliers semipalmés *(Catoptrophorus semipalmatus)*, et tournepierres à collier *(Arenaria interpres)* ont subi des baisses notables, tandis que les effectifs de quatre ou cinq espèces de rapaces ont significativement augmenté.

Mots-clés: Suivi de populations; tendances; grèbe jougris; grèbe à cou noir; macreuse brune; faucon pélerin; faucon émerillon; pluvier argenté; chevalier semipalmé; île de Farallon sud est; Californie.

BESTANDSENTWICKLUNG VON 1974-1993 BEI WASSERVÖGELN UND GREIFVÖGELN AUF DEN SÜDÖSTLICHEN FARALLON-INSELN KALIFORNIENS

Zusammenfassung. Die Bestandsentwicklung durchziehender und überwinternder Wasservögel und Greifvögel auf den südöstlichen Farallon-Inseln (SEFI) von 1974-1993 wurde untersucht. Signifikante lineare Bestandstrends ergaben sich bei 19 der 56 untersuchten Arten, von denen 12 zu- und 7 abnahmen. Weitere neun Arten wiesen Bestandsentwicklungen mit negativem Kurvenverlauf auf. Ein erheblicher Anteil der Wasservögel mit abnehmender Beständsentwicklung überwintert regelmäßig auf SEFI. Bei diesen Arten zeigte sich, daß überwinternde Vögel stärkere Abnahmen aufwiesen als durchziehende. Zur Absicherung der Befunde wurde die Entwicklung der Überwinterungsbestände mit der Entwicklung der Weihnachtzählungen an der Küste des kalifornischen Marin County verglichen. In vielen Fällen ergaben sich übereinstimmende Ergebnisse. Dies läßt darauf schließen,daß Veränderungen in den regionalen Umweltbedingungen, die sich zumindest bis in die benachbarten Festlandsbereiche erstrecken, für den Bestandsrückgang verantwortlich sein könnten. Besonders starke Abnahmen wurden bei Rothalstaucher, Schwarzhalstaucher, Brillenente, Samtente, Kiebitzregenpfeifer, Schlammtreter und Steinwälzer festgestellt, während vier von fünf Greifvogelarten signifikant zunahmen.

Schlüsselwörter: Bestandsmonitoring; Bestandstrends; Rothalstaucher; Schwarzhalstaucher; Samtente; Wanderfalke; Merlin; Kiebitzregenpfeifer; Schlammtreter; südöstliche Farallon Insel; Kalifornien.

INTRODUCTION

Trends in North American landbird populations have recently received considerable attention (e.g. Robbins et al. 1989, Hill and Hagan 1991, Hagan and Johnston 1992, DeSante and George 1994, Pyle et al. 1994); but fewer data on trends in waterbirds have been published (Ainley et al. 1994, Banks and Springer 1994, Page and Gill 1994). Relative to landbirds, waterbirds are usually colonial or are found in large flocks, often occur in habitats that are difficult to census, are not readily captured in a standardized manner, and are not well-covered by the Breeding Bird Survey (BBS; Robbins et al. 1986, Sauer and Droege 1992). Counts of wintering waterbirds or migrant raptors at concentration points have led to population monitoring of some species (see Hussell 1985, Banks and Springer 1994, White 1994), but long-term trends in most species, other than waterfowl monitored by fish and wildlife agencies, are poorly known.

Since 1968, all migrant birds have been censused daily on Southeast Farallon Island (SEFI), California (DeSante and Ainley 1980, Pyle and Henderson 1991). Assessments of landbird population trends using these data corresponded with those obtained for western North America by the BBS, suggesting that both surveys were accurately detecting landbird population changes (Pyle et al. 1994). While some of the above-mentioned problems decrease the accuracy of the migrant waterbird census on SEFI (DeSante and Ainley 1980, Pyle and Henderson 1991), the standardization of both the census and the calculations of daily arrivals should provide reliable data to detect population trends. Here we provide a supplement to Pyle et al. (1994) by examining trends in 56 waterbird and raptor species based on census data collected over a 20-year period at SEFI. To assess possible causes for observed trends in species that winter at SEFI, we have separately analyzed numbers of migrant and wintering individuals at the island, and we have compared our results with those obtained from two Christmas Bird Counts along the adjacent California coast.

STUDY SITE AND METHODS

Methods of censusing migrant birds at SEFI were described by DeSante and Ainley (1980) and Pyle and Henderson (1991). Each day since 1968, Point Reyes Bird Observatory (PRBO) biologists censused all migrant birds. Shorebird roosts and freshwater seepages were censused daily at high tide in August-March, when coastal access did not disturb breeding seabirds. Visibility permitting, five-minute counts of migrating seabirds were conducted each morning, which were used to help calculate daily totals. Roosting pelicans were also counted daily, visibility permitting. Numbers of arrivals of each species were calculated at the end of each day using all available information from observations of plumage and knowledge of the habits of species and individuals present. Wintering waterbirds were those that were observed for at least 21 days during the period 21 December to 1 March (see Pyle and Henderson 1991). Turnover of many waterbird species was more difficult to assess than it was for landbirds (DeSante and Ainley 1980); however, species-specific methods of calculating arrivals and numbers of winter residents were consistent throughout the period (see Pyle and Henderson 1991); thus, these totals should represent standardized indices to total numbers present.

The focus of the research station on SEFI, when it was established in 1968, was to census and band landbirds. Although migrant waterbirds were noted at this time, more rigorous observation of these species, including the daily counts of shorebirds, seabirds, and pelicans, did not begin until 1974. Thus, we have excluded the years 1968-1973 from this analysis.

We examined trends in 56 species for which at least 100 individuals were observed (5/yr) and that were recorded in at least 15 of the 20 years. We investigated temporal trends using linear and polynomial regression on numbers of arrivals and winterers of each species recorded each year. These totals were log-transformed to normalize the data and to allow us to model totals in a multiplicative rather than an additive fashion (see Pyle et al. 1994). Significant curvilinear effects, indicating that a short-term cycle was occurring or that a significant linear trend was accelerating or decelerating, were estimated by examining the statistical significance of quadratic polynomial regressions. All statistical analyses were

performed using the STATA statistics program (Computing Resource Center 1992). Significance was assumed at the $P < 0.05$ level. "Marginally-significant" linear trends are indicated when $0.05 \leq P < 0.10$.

To assess trends relative to seasonal status of waterbirds at SEFI, we classified species as wintering if more than 10% of total arrivals were winter visitants or residents as defined by Pyle and Henderson (1991). The remainder of the species were considered non-wintering. For this analysis, we classified species as increasing or decreasing if they showed either a significant linear trend or a significant curvilinear trend in the absence of a linear trend. We also analyzed data from the entire series of Christmas Bird Counts (CBCs) conducted at Point Reyes Peninsula (1970-1993) and Marin County (southern) (1975-1993). Totals from these counts were log-transformed and trends were calculated after statistical adjustment for the total number of party-hours recorded during each count. See Bock and Root (1981) and Drennan (1981) for more information on Christmas Bird Counts and their use in detecting population trends.

RESULTS

Significant linear trends at SEFI were detected in 19 of 56 species (Table 1; Figure 1). Seven species declined and 12 species increased. Positive, marginally-significant trends were also detected for three species. Significant curvilinear trends were recorded for eight species, all of which were negative. Accelerating declines were recorded for two species, Red-necked Grebe and Willet (see Figure 1).

Significant differences were found between wintering and non-wintering species in the proportions that increased, remained unchanged, and decreased (see Table 1; $\chi^2 = 13.87$, $P = 0.001$ when unchanging species were included; $\chi^2 = 8.93$, $P = 0.003$ when unchanging species were excluded). Significantly more decreasing species were found among wintering than non-wintering species while more increasing species were found for non-wintering than for wintering species. We re-analyzed these data excluding the six species of large *Larus* gulls and found greater significant differences ($\chi^2 = 15.23$, $P < 0.001$ including unchanging species; $\chi^2 = 11.45$, $P = 0.001$ excluding unchanging species).

Other than Thayer's Gull—whose numbers may have been affected by increased observer awareness of this species' identification—no waterbird species that wintered at SEFI showed an overall increasing trend. Nine species, however, showed decreasing trends: four inshore neritic species (Red-necked and Eared grebes, White-winged Scoter, and Red-breasted Merganser) and five shorebird species (Black-bellied Plover, Willet, Ruddy and Black turnstones, and Surfbird). Ten wintering species showed no trends. By contrast, seven non-wintering species increased and only two non-wintering species, Sooty Shearwater and Brown

TABLE 1. Linear and curvilinear trends (1974-1993) of 56 species at SEFI using regression of log-transformed values. Symbols are as follows: -ns, -ms, -, --, ---(or with "+") = insignificant ($P > 0.1$), marginally significant ($0.05 < P < 0.1$), and significant (at $0.010 < P < 0.050$, $0.001 < P < 0.010$, and $P < 0.001$) declines (or increases), respectively. See Figure 1 for illustrations of different linear and curvilinear patterns. The superscript ™ indicates a wintering waterbird species at SEFI (see text).

Species	Sample	Trends	
		Linear	Curvilinear
A. WATERBIRDS			
Pacific Loon *(Gavia pacifica)*	37157	++	--
Common Loon *(G. immer)*	1104	+ms	-ns
Red-necked Grebe *(Podiceps grisgena)*™	112	-	-
Eared Grebe *(P. nigricollis)*™	9956	---	+ns
Western Grebes *(Aechmophorus occidentalis/clarkii)*	521	-ns	-ns
Black-footed Albatross *(Diomedea nigripes)*	242	+	-ns

TABLE 1. Continued.

Species	Sample	Trends	
		Linear	Curvilinear
Northern Fulmar (*Fulmarus glacialis*)*	7645	+ns	-ns
Pink-footed Shearwater (*Puffinus creatopus*)	10387	+ns	-ns
Buller's Shearwater (*P. bulleri*)	25061	+ns	-ns
Sooty Shearwater (*P. griseus*)	4406159	-	+ns
Brown Pelican (*Pelecanus occidentalis*)	269198	-	-ns
Great Blue Heron (*Ardea herodias*)	123	+ns	+ns
Brant (*Branta bernicla*)	12650	+ns	-ns
Canada Goose (*B. canadensis*)	739	+ns	+ns
Green-winged Teal (*Anas crecca*)	259	+	-ns
Northern Pintail (*A. acuta*)	2183	-ns	+ns
Surf Scoter (*Melanitta perspicillata*)*	4094	-ns	+ns
White-winged Scoter (*M. fusca*)*	293	-ns	--
Red-breasted Merganser (*Mergus serrator*)*	282	-	-ns
Black-bellied Plover (*Pluvialis squatarola*)*	959	+ns	---
Lesser Golden-Plovers (*P. dominica/fulva*)	117	+ns	-ns
Semipalmated Plover (*Charadrius alexandrinus*)	212	+ms	+ns
Killdeer (*C. vociferus*)*	419	-ns	-ns
Willet (*Catoptrophorus semipalmatus*)*	717	--	-
Wandering Tattler (*Heteroscelus incanus*)*	1058	-ns	+ns
Spotted Sandpiper (*Actitis macularia*)	107	+ns	+ns
Whimbrel (*Numenius phaeopus*)*	1130	+ms	-ns
Marbled Godwit (*Limosa fedoa*)	449	+ns	+ns
Ruddy Turnstone (*Arenaria interpres*)*	367	-ns	--
Black Turnstone (*A. melanocephala*)*	2227	-	-ns
Surfbird (*Aphriza virgata*)*	166	+ns	-
Sanderling (*Calidris alba*)	131	-ns	+ns
Western Sandpiper (*C. mauri*)	808	+	+ms
Least Sandpiper (*C. minutilla*)	398	++	+ns
Baird's Sandpiper (*C. bairdii*)	213	+ns	+ns
Pectoral Sandpiper (*C. melanotos*)	281	-ns	-ns
Dunlin (*C. alpina*)	142	+ns	-ns
Short-billed Dowitcher (*Limnodromus griseus*)	879	+	-
Long-billed Dowitcher (*L. scolopaceus*)	282	+ms	-ns
Red-necked Phalarope (*Phalaropus lobatus*)	100147	-ns	+ns
Red Phalarope (*P. fulicaria*)	131589	+ns	-ns
Pomarine Jaeger (*Stercorarius pomarinus*)	283	+	-ns
Bonaparte's Gull (*Larus philadelphia*)	7757	+ns	-ns
Heermann's Gull (*L. heermanni*)	8771	+ns	-ns
Mew Gull (*L. canus*)*	540	+ns	-ns
California Gull (*L. californicus*)	29438	+ns	+ns
Herring Gull (*L. argentatus*)*	6956	+ns	+ns
Thayer's Gull (*L. thayeri*)*	361	+	-ns
Glaucous-winged Gull (*L. glaucescens*)*	9922	-ns	+ns
Black-legged Kittiwake (*Rissa tridactyla*)*	23897	-ns	+ns
Ancient Murrelet (*Synthliboramphus antiquus*)*	341	-ns	+ns
B. RAPTORS			
Northern Harrier (*Circus cyaneus*)	132	++	-
Sharp-shinned Hawk (*Accipiter striatus*)	240	++	-ns
American Kestrel (*Falco sparverius*)	288	+ns	+ns
Merlin (*F. columbarius*)	139	+++	-ns
Peregrine Falcon (*F. peregrinus*)	356	+++	-ns

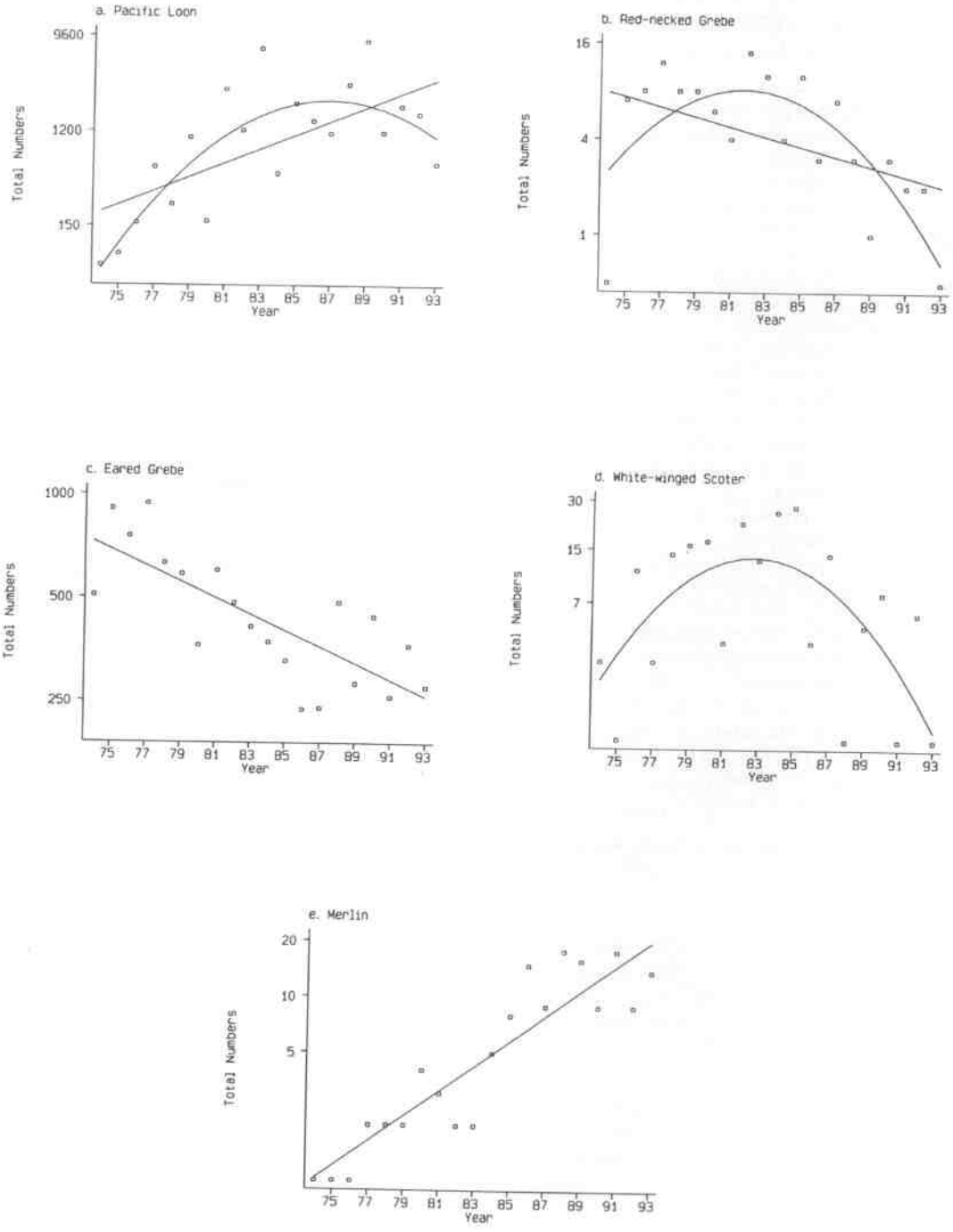
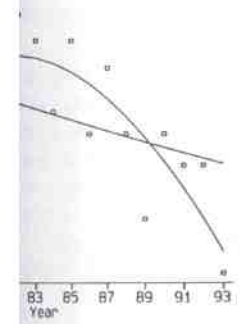
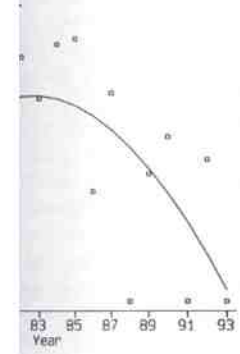
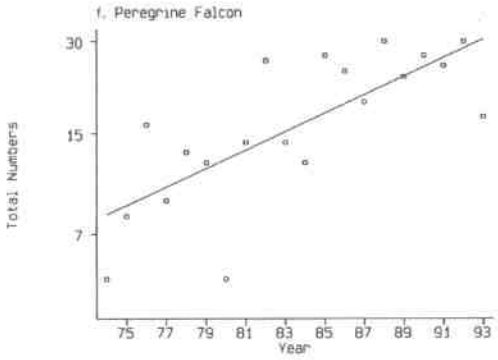


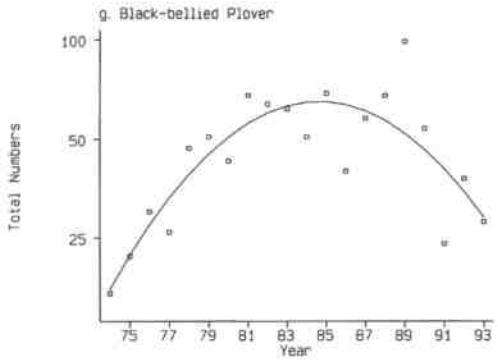
FIGURE 1. Ten examples of trends of species, including the most notable population changes detected on SEFI. Significant linear and/or curvilinear lines based on regressions of log-transformed values are presented. See Table 1 for linear and curvilinear significance levels.

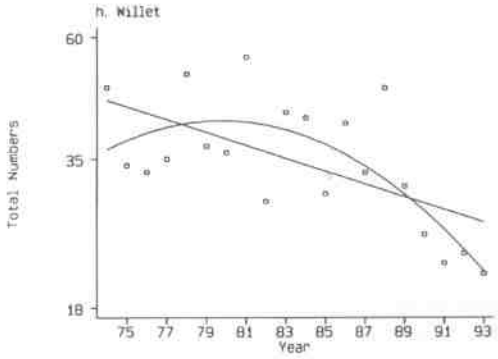
FIGURE 1. Continued.

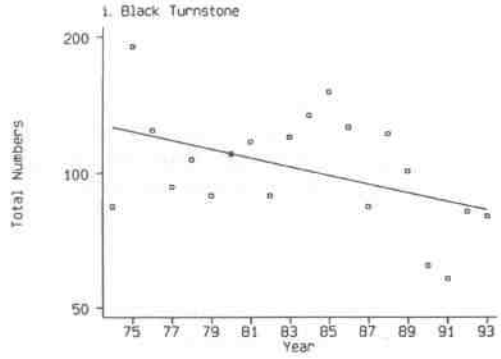


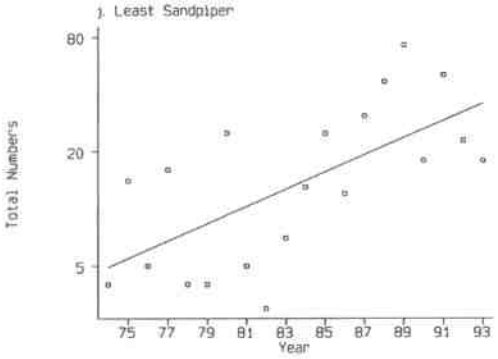












hanges detected on SEFI.
alues are presented. See

FIGURE 1. Continued.

Pelican, decreased. Twenty-two non-wintering species showed no trends (see Table 1).

Among the five wintering species that showed significant linear declines, two (Red-breasted Merganser and Willet) showed significant declines in the number of wintering individuals but no trend in the number of migrant individuals, while a third species, Eared Grebe, showed greater significant decreases in winterers than in migrants (Table 2). The remaining two species showed no trends in either seasonal group. A sixth species, Surf Scoter, that did not show a significant linear decline overall, decreased significantly as a winterer. Of the four wintering species with no linear trend but a significant negative curvilinear effect (Table 1), two, White-winged Scoter and Black-bellied Plover, also showed the same curvilinear patterns for wintering individuals but non-significant trends for migrants. The remaining two species showed no trends for either seasonal group. Numbers of wintering Whimbrels increased. Only Eared Grebe showed a significant linear trend (negative) in numbers of migrant individuals (Table 2).

Our results on many wintering species compared favorably with those derived from CBC data. Of six wintering waterbird species showing linear declines at SEFI, overall and/or among winterers, three (Eared Grebe, Surf Scoter, and Willet) also declined significantly on at least one of the two CBCs (Table 3). The other three species showed no trend or, in the case of Black Turnstone, showed a significant linear increase on one count and a marginally significant decrease on the other. The only increasing wintering species on SEFI, Thayer's Gull, also showed significant linear increases on both CBCs. Two of four wintering waterbirds showing no linear decline but a significant curvilinear decline at SEFI, White-winged Scoter and Ruddy Turnstone, showed significant linear or curvilinear declines on at least one CBC, while the other two showed no CBC trends. Of eleven wintering waterbirds showing significant linear trends on at least one CBC, eight declined while only three, including two large *Larus* species, increased (Table 3); moreover, all three significant curvilinear trends shown by wintering waterbirds on these CBCs were negative.

TABLE 2. Linear and curvilinear trends (1974-1993) for migrant and wintering individuals of the twenty wintering waterbird species at SEFI. See Table 1 for significance level codes.

	Migrants		Winterers	
Species	Linear	Curvilinear	Linear	Curviliner
Red-necked Grebe	+ns	-ns	+ns	-ns
Eared Grebe	--	-ns	---	++
Northern Fulmar	+ns	+ns	-ns	-
Surf Scoter	+ns	+ns	-	-ns
White-winged Scoter	-ns	-ns	+ns	-
Red-breasted Merganser	-ns	-ns	-	++
Black-bellied Plover	+ns	-ns	+ns	-
Killdeer	-ms	-ns	+ns	-ns
Willet	-ns	-ns	--	-ns
Wandering Tattler	-ns	+ns	-ns	-ns
Whimbrel	+ns	+ns	+	-
Ruddy Turnstone	-ns	-	+ns	-ns
Black Turnstone	-ns	+ns	-ns	-ms
Surfbird	+ns	-ns	+ns	+ns
Mew Gull	+ns	+ns	+ns	-ns
Herring Gull	+ns	+ns	-ns	+ns
Thayer's Gull	+ms	+ns	-ns	+ns
Glaucous-winged Gull	+ns	+ns	-ns	+ns
Black-legged Kittiwake	+ns	+ns	-ns	-ns
Ancient Murrelet	+ns	+ns	-ns	+ns

TABLE 3. Linear and curvilinear trends based on log-transformed totals from the Point Reyes Peninsula (1970-1993) and Marin County (southern)(1975-1993) Christmas Bird Counts, adjusting for total party-hours of coverage. Results for 13 of 20 waterbirds and four of five raptors are shown; the remaining six waterbird and one raptor species showed no significant linear or curvilinear trends for either count. See Table 1 for significance level codes.

	Point Reyes		Southern Marin	
Species	Linear	Curvilinear	Linear	Curviliner
A. WATERBIRDS				
Eared Grebe	-ns	-ns	---	-ns
Surf Scoter	+ns	+ns	--	+ns
White-winged Scoter	-ns	-ns	--	-ms
Killdeer	--	+ns	-ns	-ns
Willet	---	+ns	+ns	+ms
Wandering Tattler	-	+ns	--	-ns
Whimbrel	-ms	--	+ns	-ns
Ruddy Turnstone	-ns	---	+ns	-ns
Black Turnstone	-ms	-ns	+	+ns
Mew Gull	-	+ns	-ns	-ns
Herring Gull	-ns	-ns	-	+ns
Thayer's Gull	+++	---	+	+ns
Glaucous-winged Gull	++	-ms	-ms	+ns
B. RAPTORS				
Northern Harrier	+ns	+ns	++	-ns
American Kestrel	--	-ns	-ms	-ns
Merlin	++	+ns	+++	+ns
Peregrine Falcon	+++	+ns	++	+ms

Four of the five raptor species showed increasing trends on SEFI (Northern Harrier, Sharp-shinned Hawk, Merlin, and Peregrine Falcon); the remaining species, American Kestrel, showed no significant trend (Table 1). These trends also compared favorably with CBC data, with three of the four increasing species at SEFI (Northern Harrier, Merlin and Peregrine Falcon) also increasing on one or both CBCs, while American Kestrel showed a significant linear decline on one of the two CBCs (Table 3).

DISCUSSION

The fact that most decreasing waterbirds were of species and individuals that winter commonly at SEFI (or, in the cases of Sooty Shearwater and Brown Pelican, that summer commonly at or near SEFI) suggests that changes in local environmental conditions may have been responsible for the decreases. Similar results based on Christmas Bird Count data from the adjacent Marin County coast further support this hypothesis and suggest that both Farallon and CBC censuses may be accurately detecting population changes in wintering birds. Ainley et al. (1994) documented decreasing population trends for most species of breeding seabirds in the Gulf of the Farallones during these same two decades and suggested that a decrease in prey was primarily responsible. Changes in the marine prey base or local ocean productivity could also explain the declines in several inshore neritic and rocky intertidal waterbird species documented in this study, Red-necked and Eared grebes, Surf and White-winged scoters, Red-breasted Merganser, Black-bellied Plover, Willet, Wandering Tattler, Ruddy and Black turnstones, and Surfbird. The decline in Sooty Shearwaters is consistent with an overall decline of this species in the California Current, also likely due to decreased availability of prey (Ainley et al. in press, Veit et al. in review). Of the wintering shorebirds, only the Whimbrel shows a preference for the grassy terraces rather than the rocky intertidal at SEFI (Pyle, pers. observ.); this may explain why it was the only species showing an increase in wintering

individuals. If a general depletion of the marine ecosystem is occurring at SEFI and along the adjacent California coast, it would be interesting to investigate how localized it is; that is, whether it is restricted to the Gulf of the Farallones, the California Current, or a larger area.

Alternatively, populations in the area may just be shifting their primary foraging ranges in response to long-term changes or shorter-term cycles in the marine system, such as the gradual warming of California Current waters during the past 40 years (Roemmich 1992). In this regard, the decline in Brown Pelicans at SEFI is interesting in view of their well-documented increase along the California coast in the past two decades (summarized by Ainley and Hunt 1991); thus, the change at SEFI may represent a shift towards the coast in response to shifting distributions of prey resources such as Northern Anchovy *(Engraulis mordax)*. Shifts in migration routes may possibly help explain increases in several migrant shorebird species. It is unlikely that predation by increased numbers of Peregrine Falcons at SEFI (Figure 1f) has caused observed declines, because most prey taken by Peregrines at SEFI consists of locally breeding species, and of hundreds of observations of successful predation at SEFI by Peregrines in fall and winter, no individual of any of the declining species discussed here has been observed being killed or eaten (Pyle, pers. observ.).

The causes of the declines in wintering waterbirds at SEFI and along the adjacent coast may also be linked to factors on their breeding grounds or migration routes. Page and Gill (1994) suggested that the western subspecies of Willet *(C. s. inornatus)* may be declining due to the conversion of its wetland and short-grass upland breeding habitat to small grain and row crops. Changes at the major hypersaline lakes in western North America (Jehl 1994) may have affected populations or migratory distributions of some waterbirds, particularly Eared Grebe. Most species of declining wintering waterbirds at SEFI, however, breed in Alaska or northern Canada, where potential changes to their breeding habitats are generally unknown or undocumented.

It is also of interest that populations of large *Larus* gulls generally either showed increases (Thayer's Gull) or non-significant increasing trends at SEFI and along the coast, although two species, Mew and Herring gulls, showed declines according to data from one of two Christmas Bird Counts. Ainley et al. (1994) also noted stable or increasing populations of large *Larus* gulls along the west coast of North America. Changes in the local environment may be benefitting gulls, which tend to be scavengers as opposed to specialized feeders (Spear 1988).

The increases in certain raptors at SEFI and in Marin County likely reflect general increases in populations of these species. Populations of Peregrine Falcon, Merlin and perhaps Sharp-shinned Hawk in California (and elsewhere) have increased due to the banning of certain persistent pesticides, re-introduction efforts, and positive responses to habitat alteration (White 1994).

Although we suggest possible explanations for changes observed in waterbird and raptor populations at SEFI, many questions still remain. Observed changes on SEFI could, for example, just reflect natural cycles that would require a much longer time series of observations than 20 years to detect. We urge the continued monitoring of waterbirds and raptors at SEFI and elsewhere in western North America.

ACKNOWLEDGMENTS

We thank the U.S. Fish and Wildlife Service and the Farallon Patrol for support and all of the many biologists and volunteers that helped collect data on migrant birds at SEFI (see Pyle and Henderson 1991) and on the Christmas Bird Counts. We thank Diane Sierra for summaries of the Christmas Bird Count data. The manuscript benefitted greatly from comments by David G. Ainley, Joseph R. Jehl, Jr., Dennis R. Paulson, and Richard R. Veit. This is PRBO Contribution Number 665.

LITERATURE CITED

AINLEY, D. G., AND G. L. HUNT. 1991. The status and conservation of seabirds in California. Pp. 103-114 *in* J.P. Croxall (ed.), Seabird status and conservation: a supplement. Technical Bulletin No. 11, International Council for Bird Preservation, Cambridge.

AINLEY, D. G., W. J. SYDEMAN, S. A. HATCH, AND U. W. WILSON. 1994. Seabird population trends along the west coast of North America: causes and the

extent of regional concordance. Pp. 119-133 *in* J. R. Jehl, Jr., and N. K. Johnson (eds.), A century of avifaunal change in western North America. Studies in Avian Biology No. 15.

AINLEY, D. G., R. R. VEIT, S. G. ALLEN, P. PYLE, AND L. B. SPEAR. In press. Variations in communities of upper tropic level predators in the California Current, 1987-1994. Calif. Coop. Oceanic Fisheries Inv. Reports.

BANKS, R. C., AND P. F. SPRINGER. 1994. A century of population trends of waterfowl in western North America. Pp. 134-146 *in* J. R. Jehl, Jr., and N. K. Johnson (eds.), A century of avifaunal change in western North America. Studies in Avian Biology No. 15.

BOCK, C. E., AND T. L. ROOT. 1981. The Chistmas Bird Count and avian ecology. Pp. 17-23 *in* C. J. Ralph and J. M. Scott (eds.), Estimating numbers of terrestrial birds. Studies in Avian Biology No. 6.

COMPUTING RESOURCE CENTER. 1992. Stata reference manual: release 3. 5th ed. Santa Monica, California.

DESANTE, D. F., AND D. G. AINLEY. 1980. The avifauna of the South Farallon Islands, California. Studies in Avian Biology No. 4.

DESANTE, D. F., AND T. L. GEORGE. 1994. Population trends in the landbirds of western North America. Pp. 173-190 *in* J. R. Jehl, Jr., and N. K. Johnson (eds.), A century of avifaunal change in western North America. Studies in Avian Biology No. 15.

DRENNAN, S. R. 1981. The Christmas Bird Count: an overlooked and underused sample. Pp. 24-29 *in* C. J. Ralph and J. M. Scott (eds.), Estimating numbers of terrestrial birds. Studies in Avian Biology No. 6.

HAGAN, J. M., III, AND D. W. JOHNSTON, EDS. 1992. Ecology and conservation of Neotropical migrant landbirds. Smithsonian Institution Press, Washington D. C.

Hill, N. P., AND J. M. HAGAN III. 1991. Population trends of some northeastern North American landbirds: a half-century of data. Wilson Bulletin 103:165-182.

HUSSELL, D. T. 1985. Analysis of hawk migration counts for monitoring population levels. Pp. 243-254 *in* M. Harwood (ed.), Hawk migration conference IV. Proceedings of the Hawk Migration Association of North America, Bothell, WA.

JEHL, J. R., JR. 1994. Changes in saline and alkaline lake avifaunas in western North America in the past 150 years. Pp. 258-272 in J. R. Jehl, Jr., and N. K. Johnson (eds.), A century of avifaunal change in western North America. Studies in Avian Biology No. 15.

PAGE, G. W., AND R. E. GILL, JR. 1994. Shorebirds in western North America: late 1800s to late 1900s. Pp. 147-160 *in* J. R. Jehl, Jr., and N. K. Johnson (eds.), A century of avifaunal change in western North America. Studies in Avian Biology No. 15.

PYLE, P., AND R. P. HENDERSON. 1991. The birds of Southeast Farallon Island: occurrence and seasonal distribution of migratory species. Western Birds 22:41-84.

PYLE, P., N. NUR, AND D. F. DESANTE. 1994. Trends in nocturnal migrant landbird populations at Southeast Farallon Island, California, 1968-1992. Pp. 58-74 *in* J. R. Jehl, Jr., and N. K. Johnson (eds.), A century of avifaunal change in western North America. Studies in Avian Biology No. 15.

ROBBINS, C. S., D. BYSTRAK, AND P. H. GEISSLER. 1986. The breeding bird survey: its first fifteen years, 1965-1979. U.S. Fish and Wildlife Serv. Resource Publication 157.

ROBBINS, C. S., J. R. SAUER, R. S. GREENBERG, AND S. DROEGE. 1989. Population declines in North American birds that migrate to the Neotropics. Proceedings of the National Academy of Science (U.S.A.) 86:7658-7662.

ROEMMICH, D. 1992. Ocean warming and sea level rise along the southwest U.S. coast. Science 257:373-375.

SAUER, J. R., AND S. DROEGE. 1992. Geographic patterns in population trends of Neotropical migrants in North America. Pp. 26-42 *in* J. M. Hagan III and D. W. Johnston (eds.), Ecology and conservation of Neotropical migrant landbirds. Smithsonian Institution Press, Washington D.C.

SPEAR, L. B. 1988. Dispersal patterns of Western Gulls from Southeast Farallon Island. Auk 105:128-141.

VEIT, R. R., P. PYLE, AND J. A. MCGOWAN. In review. Ocean warming and long-term changes in pelagic bird abundance within the California current system. Marine Ecol. Prog. Ser.

WHITE, C. M. 1994. Population trends and current status of selected western raptors. Pp. 161-172 *in* J. R. Jehl, Jr., and N. K. Johnson (eds.), A century of avifaunal change in western North America. Studies in Avian Biology No. 15.