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RELATIVE ABUNDANCE AND SEASONAL DISTRIBUTION OF SEABIRDS IN THE CANAL DE BALLENAS, GULF OF CALIFORNIA[1]

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The Gulf of California is a 1,000 km long subtropical sea with relatively high primary productivity and extremely dynamic oceanography (Alvarez-Borrego 1983). It is the northern range limit in the eastern Pacific and adjacent waters for five species of tropical Pelecaniformes, and the southern range limit for several temperate seabird species and one family, Alcidae. Furthermore, 70–98% of the world population of six seabirds breed in the Gulf of California (Black Storm-Petrel *Oceanodroma melania,* Least Storm-Petrel *O. microsoma,* Craveri's Murrelet *Synthliboramphus craveri,* Yellow-footed Gull *Larus livens,* Heermann's Gull *L. heermanni,* and Elegant Tern *Sterna elegans*) (Anderson 1983, Velarde 1989, Tobón-G. 1992, Tordesillas-B. 1992).

Despite the interesting biogeography of the Gulf of California and its importance to seabird populations, there are few publications on the distribution and abundance of seabirds there. Grinnell (1928) and Wilbur (1986) summarize information on the range of seabirds and specific sighting records, Anderson et al. (1976) and Anderson (1983) provide information on breeding seabirds, and Helbig (1983) made counts on three ferry crossings in the lower gulf.

None of these publications provide data on the seasonal distribution of seabirds at sea in the Gulf of California. Therefore, we made counts of seabirds during a study on cetaceans (Tershy et al. 1990) in Canal de Ballenas, central Gulf of California. Our aims were to determine (1) which species of seabirds used the study area, and (2) their relative abundance during each season in 1985–1986.

STUDY AREA AND METHODS

The study area was a 20 × 40 km section of the Canal de Ballenas (29°00′N, 113°20′W) including Bahía de los Angeles and Bahía de las Animas (see Tershy et al. 1990, 1991a for a detailed description). It is characterized by (1) three main habitat types: shallow sandy bays, rocky points and islands, and nearshore pelagic waters over 1,500 m deep; (2) extreme temporal habitat variability with temperature water conditions (<15°C) and prevailing northwest winds in winter and spring, and tropical water conditions (>26°C) with southeast winds in the summer and fall; and (3) strong tidal currents (>3 m/sec) which cause extensive vertical mixing and sustained year round primary productivity comparable to major upwelling zones (Roden 1964, Alvarez-Borrego 1983).

On 167 days between April 1985 and April 1986, we conducted 1,378 hr of offshore observations in a 4.5 m skiff and counted all seabirds within a 100-m radius. We used a consistent but non-random search method (Tershy et al. 1990, 1991a) and attempted to cover all three major habitat types on a weekly basis. Counts were made only when visibility was greater than 5 km and wind speed less than 11 km/hr (Beaufort 2 or less). Therefore, we did not correct for differences in weather or interspecific differences in sightability. We attempted to count birds which followed the boat

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TABLE 1. Relative abundance of common seabirds in the Canal de Ballenas during each season in 1985/86, expressed as number sighted per hour.

	Mar–May	Jun–Aug	Sep–Oct	Nov–Feb	Mean
Hours (n = 1378)	464	555	235	124	
Heermann's Gull *Larus heermanni*	9.36	6.59	2.86	8.38	6.80
Red-necked Phalarope *Phalaropus lobatus*	20.58	0.43	1.98	0.06	5.76
Brown Pelican *Pelecanus occidentalis*	2.75	9.64	1.71	3.58	4.42
Yellow-footed Gull *Larus livens*	2.92	3.19	4.93	4.92	3.99
Blue-footed Booby *Sula nebouxii*	0.87	3.68	4.59	3.29	3.11
Brown Booby *Sula leucogaster*	0.89	1.35	0.67	5.88	2.24
Pacific Loon *Gavia pacifica*	1.51	0.01	0.004	2.87	1.10
Eared Grebe *Podiceps nigricollis*	2.29	0.02	0.01	1.52	0.96
Least Storm-Petrel *Oceanodroma microsoma*	0.01	2.59	0.72	0.00	0.83
Elegant Tern *Sterna elegans*	1.41	1.13	0.19	0.47	0.80
Bonaparte's Gull *Larus philadelphia*	2.19	0.00	0.00	0.73	0.73
Black Storm-Petrel *Oceanodroma melania*	0.04	2.18	0.41	0.00	0.66
Sooty Shearwater *Puffinus griseus*	0.10	0.73	1.96	0.02	0.70
Brandt's Cormorant *Phalacrocorax penicillatus*	1.19	0.23	0.18	0.92	0.63
Magnificent Frigatebird *Fregata magnificens*	0.26	1.34	0.67	0.17	0.61
Craveri's Murrelet *Synthliboramphus craveri*	0.61	0.02	0.00	1.08	0.43
Royal Tern *Sterna maxima*	0.28	1.03	0.07	0.18	0.39
Pink-footed Shearwater *Puffinus creatopus*	0.01	0.88	0.15	0.11	0.29
Double-crested Cormorant *Phalacrocorax auritus*	0.44	0.36	0.19	0.13	0.28
Sum	47.74	35.44	21.49	35.23	34.98

only once. Uncommon seabirds were also counted in the spring and summer of 1983 and 1984.

We periodically calibrated distance estimates using landmarks of known distance on the beach from which we launched our skiff. Only days with >2 hr of effort and weeks with more than two days of observations are included in the analysis. We did not make counts during the first week of June, the third and fourth week of September, the fourth week of November, all of December, and the last three weeks of February.

We separated the study year into the four seasonal periods (Mar 1986 and Apr–May 1985 = 464 hr; Jun–Aug = 555 hr; Sep–Oct = 234 hr; Nov–Feb = 125 hr) in which we calculated relative densities (number of birds sighted divided by the number of boat hours). Seabirds were identified following Harrison (1983). Under some conditions we were unable to discriminate between Double-crested (*Phalacrocorax auritus*) and Brandt's Cormorants (*P. penicillatus*), Royal (*Sterna maxima*) and Elegant (*S. elegans*) Terns, Pomarine (*Stercorarius pomarinus*) and Parasitic (*S. parasiticus*) Jaegers, and Red (*Phalaropus fulicaria*) and Red-necked (*P. lobatus*) Phalaropes. The unidentified birds, 22% of the total for each genus, were added to the daily total for each species in proportion to the total number of birds identified to species in that genus.

RESULTS AND DISCUSSION

Relative abundance. Forty-two species of seabirds were seen in the study area. Nineteen species were each sighted over 100 times and accounted for >99% of all seabirds sighted (Table 1). These included 13 of the 14 Gulf of California breeding seabird species (excepting the Red-billed Tropicbird, *Phaethon aethereus*).

TABLE 2. Monthly occurrence of uncommon seabirds in the Canal de Ballenas, Gulf of California. For each species top row is number of birds sighted, bottom row is number of days with sightings. No counts were made in December.

	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Feb	Mar	Total
Common Loon[4]	2	5					1		19	5	19	51
Gavia immer	1	3					1		7	2	5	19
California Gull[3]									32			32
Larus californicus									2			2
Pomarine Jaeger[4]	6	9					1	1	5		4	26
Stercorarius pomarinus	3	3					1	1	3		4	15
Red-billed Tropicbird[4]		4		2	1		3	8	3	1	1	23
Phaethon aethereus		3		2	1		3	3	3	1	1	17
Ring-billed Gull[4]									19	1		20
Larus delawarensis									2	1		3
Black-vented Shearwater[4]			2	1	1	6	4	2	2			18
Puffinus opisthomelas			2	1	1	3	3	2	2			14
South Polar Skua[4]				2	5		2	7				16
Catharacta maccormicki				1	3		2	3				9
Sabine's Gull[4]		10					1					11
Larus sabini		2					1					3
Red Phalarope[4]	1					7	2					10
Phalaropus fulicarius	1					1	1					3
Parasitic Jaeger[4]				2	4				2		1	9
Stercorarius parsiticus				2	1				2		1	6
Black Tern[4]		3	1									4
Chlidonias niger		2	1									3
Buller's Shearwater[4]				1	1	1						3
Puffinus bulleri				1	1	1						3
Common or Arctic Tern[3]							3					3
Sterna hirundo or *S. paradisaea*							1					1
Clarke's Grebe[3]									1			1
Aechmophorus occidentalis									1			1
Western Grebe[4]								1				1
Aechmohporus occidentalis								1				1
Red-throated Loon[1]		1										1
Gavia stellata		1										1
Northern Fulmar[3]			1									1
Fulmarus glacialis			1									1
Wilson's Storm-Petrel[3]							1					1
Oceanites oceanicus							1					1
Wedge-rumped Storm-Petrel[2]			1									1
Oceanodroma tethys			1									1
Black-legged Kittiwake[2]	1											1
Rissa tridactyla	1											1
Gull-billed Tern[1]					1							1
Sterna nilotica					1							1
Least Tern[2]				1								1
Sterna antillarum				1								1
Caspian Tern[2]	1											1
Sterna caspia	1											1

[1] Seen in 1983 only.
[2] Seen in 1984 only.
[3] Seen in 1985 only.
[4] Seen in all years, data for 1985 only.

None of the 23 remaining species accounted for more than 0.1% of the seabird sightings, and 10 species were only sighted once (Table 2). Two of these, the Northern Fulmar (*Fulmarus glacialis*), and Wilson's Storm-Petrel (*Oceanites oceanicus*), were not reported for the Gulf of California by Wilbur (1986).

Wilbur lists only three records of South Polar Skuas (*Catharacta maccormicki*), in the Gulf of California. However, we regularly saw them in the summer and fall of 1985 (Table 2), 1984 (n = 12), and 1983 (n = 11).

The relative abundances of Gulf of California breeders generally agree with the estimated abundances for the entire Gulf of California in Table 9.2 of Anderson (1983). However, our data, collected within 20 km of the largest storm-petrel colony in the Gulf, suggest that Least (*O. microsoma*) and Black (*O. melania*) Storm-Petrels are more or less equally abundant, while Anderson (1983) records Least Storm-Petrels as being an order of magnitude more abundant than Black Storm-Petrels.

Seasonal distribution. The seasonal distribution of the 13 species that breed in the Gulf of California (Fig. 1) generally agrees with what is known about their migratory movements and breeding season. Least Storm-Petrels winter off the Pacific coast of Baja California south to Ecuador and Black Storm-Petrels winter from central California south to Ecuador (Palmer 1962). Both species move into the Gulf of California to breed in the summer (Crossin 1974). Isla Partida, 20 km southeast of the study area, is the largest known breeding colony for these two species (Anderson et al. 1976), with egg dates from late spring to early summer (Bent 1922). Black and Least Storm-Petrels were frequently seen together in large mixed species rafts and were the only two species for which daily sightings were positively correlated (r = 0.83, degrees of freedom = 165, t_2 = 18.93, $P < 0.001$).

Large numbers of Brown Boobies (*Sula leucogaster*) and Blue-footed Boobies (*S. nebouxii*) breed on Isla San Pedro Mártir, 100 km southeast of the study area, from February to July (Nelson 1978, Tershy et al. 1992). Boobies were essentially absent from the study area from April to mid-June when most breeding adults would be attending chicks or eggs on San Pedro Mártir. Their numbers increased during the late summer when most nests on San Pedro Mártir would have either fledged young or failed. For Brown Boobies the overall sex and age ratio (males : females : immatures) was 1.0: 1.5:0.3 (Tershy and Breese 1990). The late summer increase in booby numbers coincided with the migration of large concentrations of Pacific sardines (*Sardinops sagax*) and threadfin herring (*Opisthonema* sp.) into the study area (Hammann et al. 1988). Mixed-species flocks of Brown and Blue-footed Boobies frequently fed on these two fish species (Tershey and Breese 1990, Tershy et al. 1992).

Brown Pelicans (*Pelecanus occidentalis*) breed in the study area in late winter and early spring. In late summer, Brown Pelicans from other parts of the Gulf stage in the study area before migrating over Baja California to the Pacific (Anderson 1983). Like boobies, they feed on the late summer concentrations of Pacific sardines and threadfin herring.

Double-crested and Brandt's Cormorants breed in the study area during the early winter, on the Islas Gemelitos and Isla Coronadito, and can be found in the area year-round (Anderson 1983). The peaks of individuals sighted in early February and late April are in part due to several large feeding aggregations and newly fledged chicks.

Magnificent Frigatebirds (*Fregata magnificens*) do not breed in the central Gulf, but there is a large colony on the Pacific side of Baja California Sur and several colonies in western Mexico near the mouth of the Gulf (Bent 1922). Peak numbers in the study area occured in July and August perhaps in response to relatively predictable summer winds, or the post-breeding dispersal of males from southern breeding colonies in June (Osorno et al. 1992). The overall adult sex ratio was extremely male biased (11:1).

Approximately 350,000 Heermann's Gulls, 50,000 Elegant Terns, and 15,000 Royal Terns (*S. maxima*) breed on Isla Rasa, 23 km southeast of the study area. These three species breed between late February and early July, after which much of the population migrates to the Pacific coast (Verlarde 1989, Tobón-G. 1992, Tordesillas-B. 1992). The lowest numbers of Heermann's Gulls and Royal Terns correspond with the peaks of Heermann's Gull and Royal Tern abundance off the Pacific coast of Southern California (Briggs et al. 1978). Although Heermann's Gulls are frequently observed stealing food from feeding Brown Pelicans (Anderson 1983, Tershy et al. 1991b), their numbers began to decline at the same time the numbers of Brown Pelicans in the study area started to increase.

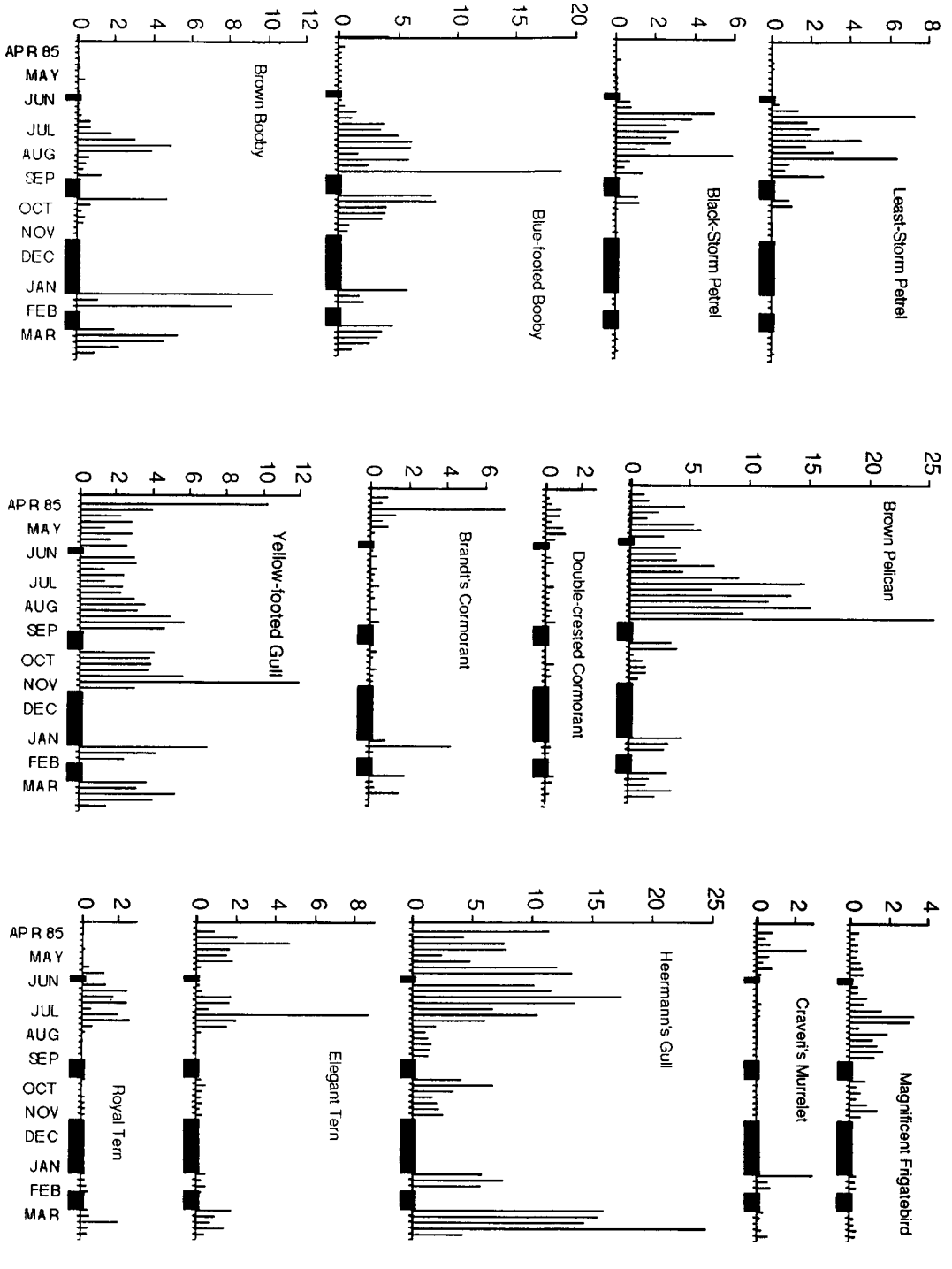
The number of Yellow-footed Gulls sighted per hour were less variable than for all other seabirds. This may be because individuals, compared to other species, are quite resident, and Yellow-footed Gulls do not normally aggregate in large numbers at mixed species feeding flocks.

Craveri's Murrelets breed throughout the northern Gulf of California in the winter and spring, then migrate south and west to the Pacific coast (DeWeese and Anderson 1976). We observed small numbers of Craveri's Murrelets in June and July, suggesting some are year-round residents. Anderson (1983) suggested that Craveri's Murrelets and Eared Grebes (*Podiceps nigres*) might be potential competitors which avoid competition because their seasonal distributions were different. In the small geographic range of the study area, we found that the 1985–1986 seasonal distribution of Craveri's Murrelets and Eared Grebes (Figs. 1, 2) overlapped almost completely.

Six species occur, but do not breed in the Gulf of California (Fig. 2). Eared Grebes winter in the study area (Anderson 1983) and apparently fly there directly from Mono Lake and the Salton Sea (Jehl 1988). We frequently observed large concentrations of Eared Grebes associated with fin whales that were feeding on the euaphausiid *Nyctiphanes simplex*.

Pacific Loons (*Gavia pacifica*) winter in the study area (Anderson 1983). Their seasonal distribution is similar to that off the Pacific coast of California (Briggs et al. 1978, Harrison 1983).

We did not identify any Short-tailed Shearwater (*Puffinus tenuirostris*) in the Canal de Ballenas and are assuming that the majority of dark shearwaters we sighted were Sooty Shearwaters (*P. griseus*). The seasonal


Least-Storm Petrel
Black-Storm Petrel
Blue-footed Booby
Brown Booby
Brown Pelican
Double-crested Cormorant
Brandt's Cormorant
Yellow-footed Gull
Magnificent Frigatebird
Craveri's Murrelet
Heermann's Gull
Elegant Tern
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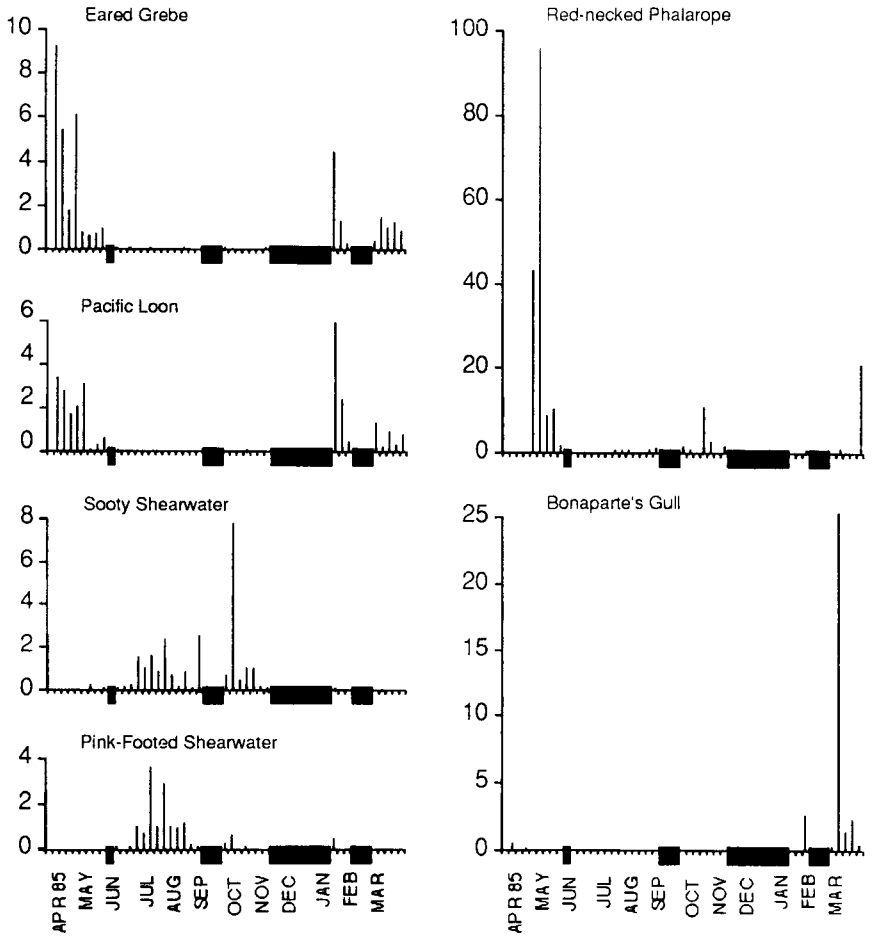

FIGURE 2. Mean weekly number of seabirds that do not breed in the Gulf of California, sighted per hour during small boat transects in the Canal de Ballenas from April 1985 to April 1986. Dark bars on X-axis indicate periods when counts were not made. Red-necked Phalaropes and Bonaparte's Gulls are not to same scale as other graphs.

distribution of the Sooty and Pink-footed (*P. creatopus*) Shearwaters largely mimic those off the Pacific coast of California (Briggs et al. 1978, Harrison 1983).

Bonaparte's Gulls (*L. philadelphis*), Red Phalaropes, and Red-necked Phalaropes (*P. fulicaria*) were most abundant in the study area during spring and fall migration. Aggregations of thousands of Bonaparte's Gulls or tens of thousands of phalaropes were seen on several occasions and account for the peaks on the graphs. Birds in these large aggregations appeared to be feeding on zooplankton which are found in rich concentrations in the study area in winter and spring (Brinton and Townsend 1980, Brinton et al. 1986). Bonaparte's Gulls in particular were often associated with fin whales which were feeding on the euphausiid *Nyctiphanes simplex*.

The majority of our data were collected in only one year, and inter-annual variation in the numbers of some species in the study area can be more than 200% (Tershy et al. 1991a). Nonetheless, our results add to the data base on the avifauna of this important but little studied region, and may be useful for further comparative studies.

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FIGURE 1. Mean weekly number of Gulf of California breeding seabirds sighted per hour during small boat transects in the Canal de Ballenas from April 1985 to April 1986. Dark bars on X-axis indicate periods when counts were not made. Graphs are at two different scales with intervals of 2 and 5 on the Y-axis.

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