BEHAVIORAL EXPLOITATION OF HUMAN MARITIME ACTIVITIES BY THE GREAT CORMORANT *PHALACROCORAX CARBO*

JUSTIN LOCK[1,2]

[1]*School of Biological Sciences, University of Auckland, PB 92019, New Zealand*
[2]*Current address: Center for Conservation and Evolutionary Genetics, National Zoological Park, Smithsonian Institution, Washington, DC 20008, USA (lock.justin.c@gmail.com)*

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Many species are threatened by the growth and spread of human populations around the world (Vitousek *et al.* 1997). Some populations, however, may adapt to anthropogenic changes in the environment and exploit novel niche space or resources made available as a result of human activities (Alberti *et al.* 2003, Palmer *et al.* 2004). For example, seabird populations may rely heavily on fisheries discards as a food source (Furness *et al.* 2007, Pichegru *et al.* 2007, Navarro *et al.* 2009, 2010) and even concentrate their foraging activities to coincide spatially with commercial fishing operations (Bartumeus *et al.* 2010). Similarly, cormorants, herons and other piscivorous birds have been reported to concentrate their fishing efforts at commercial aquaculture facilities and stocked lakes and rivers (Barlow & Bock 1984, Draulans 1987, Callaghan *et al.* 1998), presumably to exploit the relatively high abundance of prey (Lekuona 2002). Here, I report on a fishing strategy used by the Great Cormorant *Phalacrocorax carbo* at a ferry wharf in Devonport, New Zealand. I provide observational data that suggest Great Cormorants concentrate their foraging activities to coincide with human maritime activity spatially and also to coincide temporally with the movement of commercial ferries.

The Devonport ferry terminal is a major hub for maritime ferry services operated between Auckland City and the surrounding islands of the Hauraki Gulf. Commercial ferries dock at the wharf every hour between 06h00 and 24h00 with additional services during peak commuter traffic periods. When docked, vessels direct their propellers perpendicularly to the wharf, generating water currents and eddies that propagate toward the shore. These water currents may confuse and propel small prey items such as invertebrates and small fish sheltering near the sediment or wharf structure into the water column, temporarily increasing the abundance of potential prey at the wharf for foraging predators. I investigated whether Great Cormorants timed their foraging trips to coincide with the arrival of ferries at the wharf, presumably to prey upon small fish that are forced into the water column by the water currents generated by docking vessels or on larger fish that are also exploiting the temporary increase in water turbulence and prey abundance in the vicinity around the wharf.

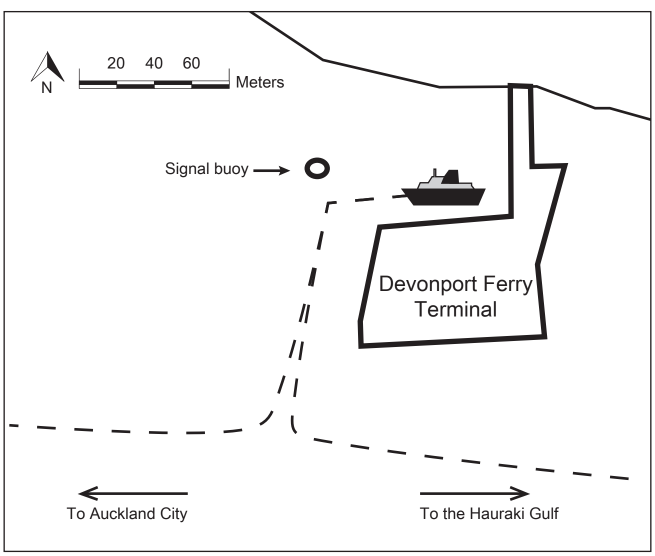

Fig. 1. Diagram showing the Devonport Ferry Terminal, Devonport, New Zealand. Great Cormorants *Phalacrocorax carbo* were often seen sunning themselves on a signal buoy located approximately 20 m from the wharf.

METHODS

For three consecutive days (11th, 12th and 13th) in May 2009, the number of Great Cormorants and the time of their arrival at the Devonport wharf (36°49′58″S; 174°47′46″E) (approximate depth = 10 m) were recorded continuously between 07h00 and 16h00. The arrival of Great Cormorants at the Devonport wharf was grouped into two categories: (1) arrivals 0–2 minutes after a ferry had arrived and (2) arrivals at all other times during observation. Differences in the number of cormorants arriving at the wharf during the two time periods were compared using a paired-samples *t*-test.

The Auckland City ferry wharf (Fig. 1) is a hub for vessels departing for ports within the Auckland Harbor and the Hauraki Gulf islands, including the Devonport wharf. To determine whether Great Cormorants timed their arrival at ferry wharfs with the arrival of docking vessels at other nearby ports (range 700 m to 6 km from the Devonport wharf), observations of cormorant foraging behavior were also conducted at three sites within the Auckland Harbor: Birkenhead (36°49′22″S, 174°44′3″E; 3.5 km from Devonport), Auckland City (36°50′34″S, 174°46′1″E; 2 km from Devonport) and Stanley Point (36°49′36″S, 174°46′54″E, 1.5 km from Devonport). These observations were carried out within seven days of the observations conducted at the Devonport wharf, lasted for four hours (conducted between 07h00 and 16h00) and included at least three ferry arrivals (range 3–7).

At all of the study sites, observations were made from the terminal buildings immediately adjacent to the wharfs using binoculars (Bushnell, 8×). It is unlikely that the observer disturbed the normal behavior of the birds due to the regular commuter traffic common around the terminal buildings. All statistical analyses were performed using IBM SPSS (v. 19.0).

RESULTS

Three to four Great Cormorants were routinely observed perching on a signal buoy about 20 m from the Devonport wharf (Fig. 1); these birds often spread their wings and faced toward the sun. To dock at the wharf, ferries passed within 10–20 m of the signal buoy (Fig. 1). Often, Great Cormorants remained on the buoy until the ferry had passed them and had begun mooring at the wharf, when one, sometimes two or rarely three, would fly from the buoy, land in the water immediately adjacent to the ferry and begin diving. After resurfacing, cormorants were often observed manipulating and then swallowing small fish. Once a ferry had departed, the Great Cormorants hunting at the wharf frequently returned to rest on the signal buoy. However, on 32 occasions (48%, n = 66), no cormorants were seen in the water when a ferry docked at the port.

Great Cormorants arrived at the wharf significantly more often during the two minutes after the arrival of a ferry than at any other time (paired *t*-test; $P < 0.0005$) (Table 1, Fig. 2). Also, during the two-minute interval after the arrival of a ferry (102 arrivals over the three days of observations), an average 0.22 cormorants/min arrived compared with only 0.013 cormorants/min during the rest of the observation period (Table 1). These data suggest that the arrival of Great Cormorants at the Devonport wharf was likely correlated with vessels docking there.

At the other three sites within Auckland Harbor, no cormorants were seen resting or foraging.

DISCUSSION

The strong currents generated by the propellers of vessels docking at the Devonport wharf may force small fish from the shelter of the wharf structure or sediment and into the water column. The results of the statistical analyses presented here suggest that Great Cormorants foraging near the Devonport ferry terminal concentrated hunting dives in the area adjacent to ferries docking at the wharf. Great Cormorants arrived at the wharf significantly more often when a ferry was docking than at any other time during the observational period (Fig. 2). Moreover, cormorants were only rarely observed hunting at the wharf when ferries were not mooring at the dock (16 independent observations during 20.6 observation hours). Interestingly, no cormorants were observed either hunting or perching at three other ferry terminals within the Auckland harbor (<6 km from the Devonport wharf). Nonetheless, the association between the arrival of ferries and cormorants at the Devonport wharf suggests that a small and potentially local population of birds have learned to exploit the water currents generated by docking vessels to aid in hunting prey.

The results of this study are not surprising given the rich literature documenting cormorant and human interactions. For example, previous research has demonstrated that cormorants are frequent and unwanted predators of fish at aquaculture facilities and commercially stocked lakes and rivers (Draulans 1987). Lekuona (2002) showed that cormorants accounted for 53% of annual stock losses at an aquaculture farm in southwest France. Moreover, cormorants are commonly observed in greater density in lakes and rivers stocked by sport fishermen than in rivers and lakes that are not stocked (Callaghan et al. 1998). A notable difference between reports of cormorants hunting at aquaculture farms and the results of the present study is that, in the former, cormorants simply forage in areas that have high prey abundance, whereas, in this study, cormorants appear to have learned a behavior associated with a specific location. Hence, the correlation between cormorant and ferry arrivals at the Devonport wharf demonstrate that cormorants may be able to learn specific behaviors to exploit human activities, in addition to simply locating and hunting at aquaculture farms and stocked waters.

There is an extensive literature on the relationships between seabirds and human fishing activities. Bartumeus *et al.* (2010), for example, found that the foraging patterns of Audouin's gull *Larus audouinii* could be predicted based on the movements of fishing vessels; on days when fishing boats operate, the foraging range of Audouin's gulls was significantly smaller and correlated with the movements of fishing vessels compared with the foraging range of the gulls on Sundays and public holidays when fishing vessels did not operate. The results of Bartumeus *et al.* (2010) and similar studies (e.g., Arcos & Oro 2002, Pichegru, Ryan *et al.* 2007, Navarro, Louzao *et al.* 2009) are directly comparable to the results presented here: a local group of cormorants has learned to modify their natural foraging behavior to coincide with human activities, presumably to improve catch-per-unit effort of hunting dives.

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TABLE 1
Great Cormorants *Phalacrocorax carbo* arriving at the Devonport ferry wharf during two time intervals

Number of cormorants at wharf	Number of arrival episodes	
	0–2 minutes after ferry	All other times
1	23 (53.5%)	16 (100%)
2	10 (23.3%)	0
3	10 (23.3%)	0
Total arrival episodes	43	16
Arrivals per minute[a]	0.22	0.013

[a] Significantly different between the two time periods, $P < 0.0005$.

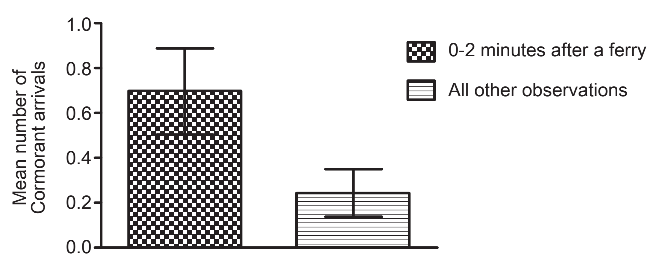

Fig. 2. Number of Great Cormorants *Phalacrocorax carbo* arriving at the Devonport wharf, New Zealand, during two time intervals. Great Cormorants arrived significantly more often (paired *t*-test; $P < 0.0005$) during the two-minute interval after a ferry arrived (mean 0.70 arrivals per observational period SEM 0.096, n = 66) than at any other time (mean 0.24 arrivals per observational period SEM 0.053, n = 66).

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REFERENCES

ALBERTI, M., MARZLUFF, J.M., SHULENBERGER, E., BRADLEY, G., RYAN, C. & ZUMBRUNNEN, C. 2003. Integrating humans into ecology: Opportunities and challenges for studying urban ecosystems. *Bioscience* 53: 1169–1179.

ARCOS, J.M. & ORO, D. 2002. Significance of fisheries discards for a threatened mediterranean seabird, the Balearic Shearwater *Puffinus mauretanicus*. *Marine Ecology Progress Series* 239: 209–220.

BARLOW, C.G. & BOCK, K. 1984. Predation of fish in farm dams by Cormorants, *Phalacrocorax spp. Australian Wildlife Research* 11: 559–566.

BARTUMEUS, F., GIUGGIOLI, L., LOUZAO, M., BRETAGNOLLE, V., ORO, D. & LEVIN, S.A. 2010. Fishery discards impact on seabird movement patterns at regional scales. *Current Biology* 20: 215–222.

CALLAGHAN, D.A., KIRBY, J.S., BELL, M.C. & SPRAY, C.J. 1998. Cormorant *Phalacrocorax carbo* occupancy and impact at stillwater game fisheries in England and Wales. *Bird Study* 45: 1–17.

DRAULANS, D. 1987. The effectiveness of attempts to reduce predation by fish-eating birds — a review. *Biological Conservation* 41: 219–232.

FURNESS, R.W., EDWARDS, A.E. & ORO, D. 2007. Influence of management practices and of scavenging seabirds on availability of fisheries discards to benthic scavengers. *Marine Ecology Progress Series* 350: 235–244.

LEKUONA, J.M. 2002. Food intake, feeding behaviour and stock losses of Cormorants, *Phalacrocorax carbo*, and Grey Herons, *Ardea cinerea*, at a fish farm in Arcachon Bay (southwest France) during breeding and non-breeding season. *Folia Zoologica* 51: 23–34.

NAVARRO, J., LOUZAO, M., IGUAL, J.M., ORO, D., DELGADO, A., ARCOS, J.M., GENOVART, M., HOBSON, K.A. & FORERO, M.G. 2009. Seasonal changes in the diet of a critically endangered seabird and the importance of trawling discards. *Marine Biology* 156: 2571–2578.

NAVARRO, J., ORO, D., BERTOLERO, A., GENOVART, M., DELGADO, A. & FORERO, M.G. 2010. Age and sexual differences in the exploitation of two anthropogenic food resources for an opportunistic seabird. *Marine Biology* 157: 2453–2459.

PALMER, M., BERNHARDT, E., CHORNESKY, E., COLLINS, S., DOBSON, A., DUKE, C., GOLD, B., JACOBSON, R., KINGSLAND, S., KRANZ, R., MAPPIN, M., MARTINEZ, M.L., MICHELI, F., MORSE, J., PACE, M., PASCUAL, M., PALUMBI, S., REICHMAN, O.J., SIMONS, A., TOWNSEND, A. & TURNER, M. 2004. Ecology for a crowded planet. *Science* 304: 1251–1252.

PICHEGRU, L., RYAN, P.G., VAN DER LINGEN, C.D., COETZEE, J., ROPERT-COUDERT, Y. & GREMILLET, D. 2007. Foraging behaviour and energetics of Cape Gannets *Morus capensis* feeding on live prey and fishery discards in the Benguela upwelling system. *Marine Ecology Progress Series* 350: 127–136.

VITOUSEK, P.M., MOONEY, H.A., LUBCHENCO, J. & MELILLO, J.M. 1997. Human domination of earth's ecosystems. *Science* 277: 494–499.