any given day during the spawning season, successful foragers returned from both stream systems. Non-foraging ospreys at the colony showed a strong tendency to fly up the stream system from which a forager had just returned. This indicates that departing foragers were sensitive to the stream system in which the previous smelt or alewife had been caught.

Thus it appears that ospreys at this colony made use of information from ospreys fishing nearby (local enhancement) and, to a lesser extent, information from birds returning from foraging locations out of sight of the colony (information centre). But information transfer about distant food supplies is not a general feature of aggregations of breeding ospreys (refs 3,6; S. Flemming, personal communication). As I pointed out in my paper[1], as ospreys do not follow successful birds back to foraging areas, information transfer at colonies will be useful only in situations where the foraging areas are not too far from the colony. At other colonies, ospreys have to fly further simply to reach the foraging areas (ref. 3; S. Flemming, personal communication) than ospreys at the Cow Bay colony. Taken together, these results suggest that information transfer at osprey colonies is probably a fortuitous consequence of the local geography of fishing locations and the spatial and temporal distributions of available fish species, rather than a general factor promoting aggregated breeding.

ERICK GREENE
Division of Biological Sciences,
University of Montana,
Missoula,
Montana 59812, USA

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Sea-level flips

SIR—In the Mediterranean Sea, evaporation exceeds precipitation and river discharge. This drives a relatively fresh surface inflow through the Strait of Gibraltar (Fig. 1) and a slightly weaker outflow of saltier water near the bottom[1–3]. Geodetic levelling along the Spanish coast[4] shows an associated drop in mean sea level from Atlantic to Mediterranean of about 0.15 m.

Recent monthly mean sea-level data (Fig. 2), however, show that this sea-level drop is not steady but changes seasonally by about 0.1 m. We believe that understanding this variation is relevant to the broader question of whether the Strait of Gibraltar is a good climatic 'choke point' at which long-term changes in air–sea interaction over the whole Mediterranean might be detectable.

Mathematical models[5,6] show that there are two possible exchange states. One occurs if the interface between inflowing and outflowing waters at the western end of the Mediterranean is shallower than about 90 m. The surface inflow then leaves the strait as a fast, shallow, jet with a sea-level drop of about 0.20 m along the north shore due to a combination of the Bernoulli effect and friction. The exchange is said to be 'maximal' as it is the maximum consistent with the density difference and hydraulic constraints in the strait. 'Submaximal' exchange occurs if the interface just inside the Mediterranean is deeper than about 90 m; the inflow is then slower and deeper, with a mean sea-level drop of only about 0.09 m. For maximum exchange the interface depth in the strait is fixed, whereas for submaximal exchange it can rise and fall in response to changes in the volume of dense water.

FIG. 1 The Strait of Gibraltar and its environs.

It is remarkable that the difference of 0.11 m between the sea-level drop predicted for the two states is close to the changes seen in Fig. 2, suggesting that the state flips seasonally. Moreover, if each state occurs for about half the year (Fig. 2), the expected average sea-level drop of 0.15 m agrees with the result from levelling[4]. The implied flips could be related to the formation of dense Mediterranean water in the winter. This would raise the level of the interface and push the system into maximal exchange, where it might stay for the first half of the year until the reservoir of dense water has been drained down below about 90 m again[7,8].

In our recent survey[8], we found other evidence for state flips. In particular, during the 1985–86 Gibraltar experiment[9], it appeared from direct measurements in the strait[10,11] that the inflow was slow and deep in October 1985, but fast and shallow in April and early May 1986 with some supporting evidence[8], from the inferred interface height at the eastern end of the strait, for a flip towards the end of December 1985 (Julio Candela, personal communication). Figure 2 is partly consistent with this, though it suggests that the exchange was already maximal by December 1985.

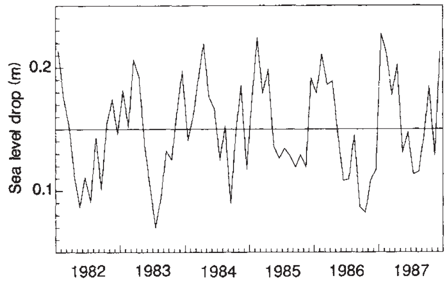

FIG. 2 Monthly mean sea level drop from Cadiz to Malaga from January 1982 to December 1987, using data obtained from the Permanent Service for Mean Sea Level. Data are plotted with a mean of 0.15 m (ref. 4). Adding suitably scaled atmospheric pressure to give the total pressure difference causes an r.m.s. change of less than 0.01 m.

The sea-level differences shown in Fig. 2 are monthly means. Meteorologically driven fluctuations, with periods of several days, could lead to flips within a month, accounting for the monthly average values in Fig. 2 that are intermediate between the two end-states. On the other hand, our analysis of sea-level fluctuations within the strait from September 1981 to September 1982 led us to the unsettling conclusion that the exchange was maximal during that period[12]. This is inconsistent with Fig. 2, which shows a period of submaximal exchange in the middle of 1982.

Present models thus fail to account for all the features in the observations and we cannot be completely sure that the hydraulic state changes seasonally. If, however, the exchange is indeed submaximal for part of the year, interannual and long-term variability in air–sea fluxes affecting the formation of dense water should be seen at the Strait of Gibraltar as a changing interface level[8]. More geodetically referenced sea-level and other oceanographic data from the Strait of Gibraltar are needed.

CHRIS GARRETT
KEITH THOMPSON
WADE BLANCHARD
Department of Oceanography,
Dalhousie University,
Halifax, Nova Scotia B3H 4J1, Canada

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