

## WHY DO GREAT WHITE PELICAN CHICKS DIE SUDDENLY ON AREL ISLAND, BANC D'ARGUIN, IN MAURITANIA ?

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There are five major coastal upwelling regions in the world : the California current off the USA, the Humboldt current off Peru, the Canary current off Northwest Africa, the Benguela current off Southwest Africa and the Somali current in the Indian Ocean east of Africa, in which about a half of the world's fish catches are made. The cold, nutrient-rich waters of these regions favour high primary production, leading to optimal reproduction and survival of fish and providing an exceptionally high fish production for a marine ecosystem (Schaeffer, 1970 ; Cushing, 1971 ; Barber & Smith, 1981 ; Hartline, 1980 ; Glantz, 1980). The most spectacular consequence of this high fish production is the presence of thousands or even millions of seabirds which take advantage of this bountiful food supply (Crawford & Shelton, 1978 ; Duffy, 1983 ; Duffy *et al.*, 1984 ; Schreiber & Schreiber, 1984 ; Duffy & Siegfried, 1987 ; Adams *et al.*, 1992). Most of the coastal upwellings are seasonal. Only the upwelling on the Peruvian coast is permanent but even this varies in intensity with the season.

Along the Mauritanian coast (West Africa) there is also a seasonal coastal upwelling (Wooster *et al.*, 1976 ; Sevrin-Reyssac, 1993) which affects the waters of the Banc d'Arguin (19.45 N 16.16 W) from December to April. From the month of May, a warming of the water column occurs, then in July warm water coming from Guinea arrives and remains until November. As in other areas of upwelling, the Banc d'Arguin also supports large concentrations of fish-eating seabirds (de Naurois, 1969 ; Mahé, 1985 ; Campredon, 1987) and particularly Great White Pelicans.

The heavy and spectacular mortality of chicks in December-January of the Great White Pelican (*Pelecanus onocrotalus*) and of Cormorants (*Phalacrocorax carbo lucidus*) nesting together on Arel island had been recorded as early as the 1960s (de Naurois, 1969) and was again noted in the 1970s by Trotignon & Trotignon (1981) and Trotignon *et al.* (1980) in the 1970s and finally by Mahé (1985) and Campredon (1987) in the 1980s. Up to 1080 dead chicks were counted in January 1980 (Trotignon & Trotignon, 1981). These authors also noted heavy kleptoparasitism by pelicans on cormorants nesting on Arel island. All the authors immediately concluded that the adult Great White Pelicans were no longer capable of feeding their chicks and that these died from starvation. But no-one could find a rational explanation for this fact. We therefore propose to review the status of the

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Great White Pelican in Africa, and particularly in West Africa, to study the phenology of pelicans nesting on Arel island and attempt to explain why a large proportion of the Great White Pelican chicks hatched on Arel island die suddenly from the beginning of the month of December.

## METHODS

Two expeditions were made to the Banc d'Arguin, one in November 1980 and the second in September 1981. The priority aim on both visits was to collect regurgitates from chicks, to assess the breeding phenology of the species nesting on Arel island and to carry out continuous observations of pelican activity on the island. The secondary aim was to determine the preferred feeding sites of pelicans on the Banc d'Arguin and the periods during which they fished. Travelling over the Banc was done at high tide in a Zodiac, navigating by compass. Observations on feeding sites were also carried out at night.

## RESULTS

### THE STATUS OF *PELECANUS ONOCROTALUS* IN AFRICA

There are two distinct populations of Great White Pelicans (*Pelecanus onocrotalus*): an African population and a Palearctic one. The size of the latter has been estimated at a little over 10 000 pairs (Crivelli *et al.*, 1991a), and the African population contains about 75 000-80 000 breeding pairs (Crivelli & Schreiber, 1984). In our present state of knowledge there is no indication of any exchanges between these two populations.

Three geographical « sub-populations » can be considered to exist in Africa: a western population (Mauritania, Senegal and Mali), a central population (Chad and Cameroon) and a southern-eastern population (Djibouti, Ethiopia, Kenya, Tanzania, Zambia, Botswana, Namibia and South Africa). The southern-eastern sub-population is thriving. The central sub-population has greatly declined, notably with the disappearance of breeding Great White Pelicans in Nigeria and only a few hundred breeding pairs remaining in Cameroon (Mahé, 1988) and in Chad.

The western sub-population has changed greatly over the last twenty-five years. With the exception of the regular nesting on the Banc d'Arguin and at Aftout es Saheli in Mauritania, no breeding by Great White Pelicans had been recorded in West Africa until 1972 when Jarry and Larigauderie (1974) described the first attempt at nesting by Great White Pelicans at Djoudj in Senegal. Unfortunately this was unsuccessful and it was not until 1976 that the first successful breeding by Great White Pelicans was observed at Djoudj (Dupuy, 1976). Since this date Great White Pelicans have bred irregularly at this site. In March 1991, a colony of about 2 000 pairs was observed (C. Perennou, pers. comm.). A second colony settled on a sand bank at Kallisaye for a few years, but this colony no longer exists. In some years up to 10 000 breeding pairs have been counted in Senegal. Finally, the Great White Pelican bred only once in Mali at Toguéré Koumbé, following exceptionally heavy rains (Urban, 1984).

The first mention of the Great White Pelican on the Banc d'Arguin dates from Portuguese sailors in the 15th century. They do not however state whether the species was nesting at this period. It was in 1957 (de Naurois, 1969) that the breeding of Great White Pelicans was recorded for the first time in West Africa on Arel island on the Banc d'Arguin. Since this date breeding by Great White Pelicans has occurred regularly on Arel island. Between 1957 and 1969, 100 to 400 pairs were recorded (de Naurois, 1969); there was then an increase between 1977-1982 with 800 to 1 500 pairs (Trotignon & Trotignon, 1981; Mahé, 1985; this study). Campredon (1987) confirmed that this increase continued in 1984-85 with ca. 3 000 pairs. The Great White Pelican has only bred on Arel island at the Banc d'Arguin. Of all the islands of the Banc d'Arguin this is the furthest from the coast. It is never submerged even at equinoctial spring tides, and is therefore available for breeding birds throughout the year. In addition, birds are completely protected from terrestrial predators such as jackals and hyenas.

#### PHENOLOGY

The Great White Pelican is totally absent from the Banc d'Arguin from February to the end of June. The first individuals arrive at the Banc in July and the earliest laying has been observed on the 17 August 1965 (de Naurois, 1969). The majority of birds lay in September-November, but small groups of nests with eggs can still be observed between December and January. These late clutches are probably renesting attempts. Because of the wide spread in breeding date and successive waves of laying, the breeding birds form very distinct cohorts. Within each cohort all nests are synchronised, i.e. at the same stage of development ( $\pm 5$  to 10 days).

Between 17 and 22 November 1980 7 breeding cohorts were counted, including 360 nests with a mean clutch size of 1.25 eggs/nest (Table I), a crèche of 150 chicks aged 4-5 weeks and another crèche of 300 chicks aged 8 to 10 weeks, some of which were able to fly. There was a significant linear relationship

TABLE I

*Clutch size in breeding units counted between 17 and 22 November 1980 on Arel island*

	N° of nests	Stage	Clutch size
	41	eggs	1.24
	11	eggs	1.00
	106	eggs	1.35
	60	hatching	1.30
	88	eggs	1.49
	7	eggs	1.14
	47	hatching	1.21
Total	360	Mean $\pm$ S.D. Range	1.25 $\pm$ 0.16 (1-3 eggs/nest)

between mean clutch size per cohort and the number of nests in the cohort ( $N = 7$ ;  $r = 0.87$ ,  $F = 13.96$ ,  $P < 0.01$ ). The larger the size of the cohort the greater the clutch size (Fig. 1). The total number of breeding birds was estimated at between 800 and 1000 pairs. At the same date 700 nests of *Phalacrocorax carbo lucidus* were counted, all at the egg stage.

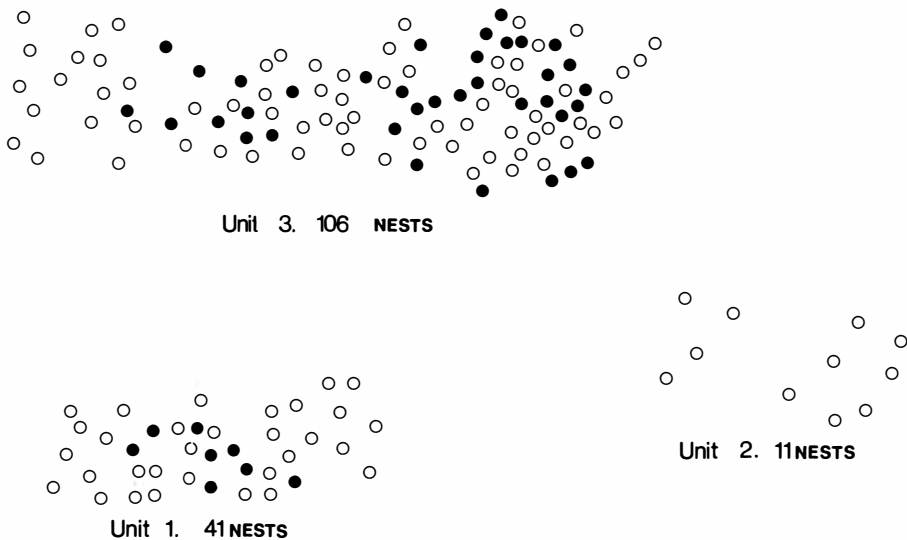


Figure 1. — Clutch size in nests of 3 breeding units in 1980. Filled circles : nests with two eggs, open circles : nests with one egg.

From 11-26 September 1981 three breeding cohorts of Great White Pelicans were counted, totalling 350 nests, all at the egg stage. For technical reasons it was not possible to determine the clutch size. At this time no cormorants were nesting on Arel island. A literature search was made for all counts of dead Great White Pelican chicks on Arel island, to which were added our own counts and these have been plotted against date (Fig. 2). It can be seen that mortality is negligible in October and November, although many chicks are present at this time, but mortality becomes important from mid-December. Adults start to leave the Banc d'Arguin in mid-November and by December-January the majority of adults have left the Banc and headed south. The main « summering » sites (December-June) for Great White Pelicans breeding in Mauritania is presumed to be in Senegal and Mali.

#### FEEDING ECOLOGY

The diet of *Pelecanus onocrotalus* breeding on Arel island is made up of fish and crustaceans (Tab. II), but prawns and crab claws only made up a small proportion of the food ingested. Most of the prey are of small size (less than 150 mm).

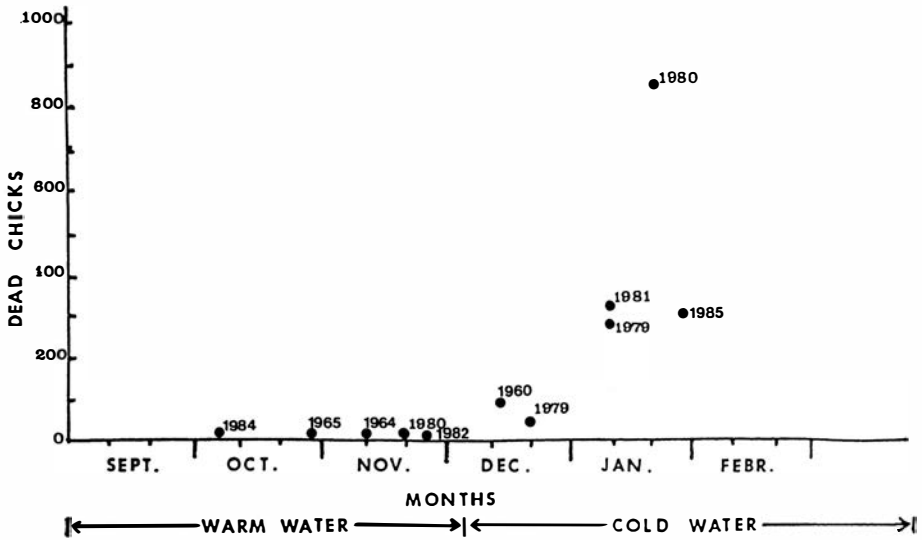


Figure 2. — Chick mortality throughout the breeding season on Arel island.

TABLE II  
The diet of the Great White Pelican

Fish & Crustacea species	Number of prey (% occurrence)*	Range of prey fork length (mm)
Syngnathidae <i>Syngnathus sp.</i>	6 (16.6)	158-172
Serranidae <i>Mycteroperca rubra</i>	5 (16.6)	94-137
<i>Dicentrarchus punctata</i>	8 (33.3)	89-290
Pomadasydae <i>Pomadasyr rogeri</i>	5 (16.6)	90-95
Sparidae <i>Dentex sp.</i>	2 (11.1)	172-255
Pomacentridae <i>Abudefduf analogus</i>	132 (94.4)	40-139
Gobiidae <i>Gobius paganellus</i>	26 (83.3)	20-112
Blenniidae <i>Malacoctenus sp.</i>	4 (16.6)	66-80
Mugilidae <i>Mugil cephalus</i>	1 (5.5)	420
Atherinidae <i>Atherina sp.</i>	8 (5.5)	38-71
Soleidae <i>Solea sp.</i>	1 (5.5)	125
Penaeidae <i>Penaeus duorarum</i>	52 (88.8)	60-65

\* Number of regurgitates 18, collected in November 1980.

On several occasions Great White Pelicans have been observed actively feeding at night in the shallowest water in channels at low tide or on the rising tide. On the 22 November at sunrise, Arel island was completely deserted by adult pelicans, with the exception of a few individuals that still had young chicks (less than 15 days). All arrivals and departures of adults were recorded until the end of observations at 1400 h. The first birds started arriving on the island from the feeding grounds from 0930 h, with a peak of arrivals at 1100 h ; after 1145 h no more arrivals were recorded (Fig. 3). No birds left the island before 1400 h ; the majority preened themselves, slept or loafed after feeding their young. The Great White Pelicans breeding on Arel island can go in search of food as far away as Cap Timiris (65 km from Arel). The preferred feeding sites are around Arel island, in the Ajoueir-Tidra region, the Saint-Jean bay and the area between Aouatif bay and Cap Tessit (Mahé, 1985 ; this study).

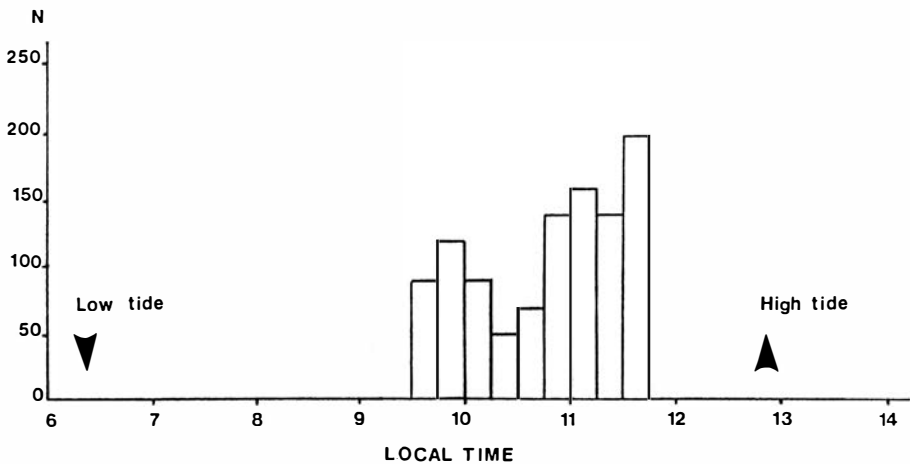


Figure 3. — Number of Great White Pelicans returning to Arel island from their feeding grounds in each 15 min period, in relation to the state of the tide.

## DISCUSSION

The recent increase in the number of breeding pairs at Arel is certainly related to the recent start of breeding by Great White Pelicans in Senegal. If this regular breeding in Senegal continues, a further increase in the number of breeding pairs on Arel island can be expected.

The mean clutch size recorded on Arel island is particularly low (this study ; Campredon, 1987) compared to the value of 1.93 for Great White Pelicans breeding in Greece (Crivelli *et al.*, 1991b) and 1.62 to 1.91 recorded in East Africa (Brown *et al.*, 1982). This low clutch size is attributed to heavy predation by Grey-headed Gulls (*Larus cirrhocephalus*) and Lesser Black-backed Gulls (*Larus fuscus*). It is not surprising, therefore, that the mean clutch size in the larger

breeding cohort is greater than that in the smaller cohorts, as it is likely that there is less opportunity for gulls to take an egg in a large breeding cohort than in a small cohort.

Great White Pelican chick mortality only really occurs as from the month of December and only becomes massive in January-February. It is indisputably related to the arrival of cold water (upwelling) on the Banc d'Arguin at the start of or mid-December. Although this mortality occurs every year it varies quantitatively from year to year. When the majority of breeding pairs start breeding and lay at the beginning of September, the number of chicks dying in December-January is lower than when a large number of birds start breeding in October, since it takes about 100 days from laying to fledging of the chicks. Preliminary and limited results of our study of the diet of Great White Pelicans in November, before the arrival of upwelling, show clearly : a) that the most abundant species in the regurgitates in both numbers and percentage occurrence is *Abudedduf analogus*, a fish typical of warm water and known to be abundant in Senegal (J. Maigret, pers. comm.) ; b) that the majority of the other species found in the regurgitates are species such as gobies, sand smelts, blennies and pipefish, typical of shallow water.

This last point is supported by observations of adult Great White Pelicans feeding exclusively at low tide or on the rising tide in the shallowest parts of the channels, even if this means feeding at night. The main advantage for pelicans in feeding at low tide is that the fish are concentrated in the channels and the density is therefore much higher than at high tide, making the communal fishing of these birds more efficient. To our knowledge, this is the first time that night-time feeding by Great White Pelicans has been recorded on a regular basis (McNeil *et al.*, 1993). In other areas of Africa and in the Palearctic night-time feeding activity has only been observed accidentally, either on freshwaters or coastal habitats. It should also be added that it is unusual to observe Great White Pelicans feeding in marine environments.

Unfortunately, data on the fish populations of the Banc d'Arguin area are still fragmentary, and especially so for the shallow waters (Campredon & Schrieken, 1989 ; Jager, 1993). Maigret (1977) considered that the rich resources of the Banc d'Arguin are essentially made of pelagic fish which come to this area to spawn.

## CONCLUSION

The arrival of the first Great White Pelicans on the Banc d'Arguin coincides with the arrival of warm water coming from the Gulf of Guinea. Massive mortality of chicks still unable to fly and the departure of young capable of flight and of adults coincides with the arrival of cold water (upwelling) which forces the warm water further south. This rather fast change of water also corresponds with a drastic change in fish populations, especially in shallow waters, the preferred feeding site of Great White Pelicans (Guillet & Crowe, 1981 ; Crivelli *et al.*, 1991b ; Crivelli, unpublished data). In the cold water period the fish population is composed mainly of fish that inhabit the deeper waters (Maigret, 1977). The shallow waters are almost devoid of fish and only the cormorant is capable of feeding here because of its ability to dive deeply. As the Great White Pelican only feeds at the surface and in shallow water it is unable to capture food, which causes famine among the

chicks still unable to fly and forces adults and fledglings to depart towards the south. At the height of the upwelling (February-March) there are practically no breeding fish-eating birds left on the Banc d'Arguin ; only a few Caspian Terns seem to breed at this season (Mahé, 1985). Spawning by the fish of Banc d'Arguin is observed at the onset of spring (Maigret, 1977). From May onwards, fish fry appears in millions in the sea-grass beds in shallow water. It is exactly at this time of year that the 10 or 11 species of fish-eating birds (terns, gulls, African cormorants and herons) start breeding at the Banc. The peak of the breeding season for most species is in June (Mahé, 1985). All the fish-eating species feed only on fish of small size and can only capture fish in very shallow water or at the sea surface ; they take advantage of the presence of these millions of fish fry to breed successfully. When the warm Guinea water arrives the fry leaves the sea-grass beds and withdraws to the north of the Banc with the cold water, and retires to deeper water. Again, this phenomenon coincides with the end of the breeding season for the ten fish-eating species. Throughout the year at the Banc d'Arguin, there is therefore a remarkable relationship between the breeding phenology of the various species of fish-eating birds and the presence of different fish populations with varying densities and spatio-temporal behaviour patterns on which the feeding behaviour and fishing abilities of the fish-eating birds depend.

## SUMMARY

The status of the Great White Pelican in Africa in the 1980s is reviewed. During this period the size of the colony of *Pelecanus onocrotalus* located on the Mauritanian coast at the banc d'Arguin increased ten-fold owing to an influx of birds coming from newly installed colonies in Senegal. Great White pelicans are absent from the Banc d'Arguin from February to June. The first birds install on the Banc in July, coinciding with the arrival of warm waters from the Gulf of Guinea. The pelicans lay their eggs in successive waves from mid-August to the end of November. The clutch size is unusually low for the species (mean 1.25 eggs/nest). There is a positive relation between clutch size and the size of the breeding cohort ( $r = 0.87$ ,  $P < 0.01$ ). Heavy mortality of chicks of all ages is recorded from mid-December onwards, together with a massive departure of adults towards the south. This mortality appears to be due to the upwelling of cold water which displaces the warm water towards the south : this hypothesis was tested from supporting evidence. Observations on the composition of chick regurgitates, the behaviour of adults on the foraging grounds (both during the day and at night, but exclusively at low tide) and the timing of breeding of other fish-eating bird species confirmed this hypothesis.

## RÉSUMÉ

Le statut du Pélican blanc en Afrique dans les années quatre-vingts est passé en revue. Pendant cette période la taille de la colonie de *Pelecanus onocrotalus* située sur la côte mauritanienne au Banc d'Arguin a été multipliée par dix grâce à un afflux d'individus provenant des nouvelles colonies sénégalaises. Les



Pélicans blancs sont absents de février à juin sur le banc d'Arguin. Les premiers s'installent sur le banc en juillet au moment où arrivent à ce niveau les eaux chaudes provenant du golfe de Guinée. Les pélicans pondent leurs oeufs par vagues, de la mi-août à la fin novembre. La taille de leur ponte est inhabituellement basse pour l'espèce (1,25 oeufs/nid). Une relation positive existe entre la taille de la ponte et la taille de l'unité de nidification ( $r = 0,87$ ,  $P < 0,01$ ). A partir de la mi-décembre on observe une forte mortalité des poussins de tous âges et un départ massif des adultes vers le sud. Cette mortalité serait due à la remontée des eaux froides (upwelling) repoussant les eaux chaudes plus au sud : cette hypothèse est testée et étayée. Des observations sur le contenu des régurgitats des poussins, le comportement des adultes sur les lieux de gagnage (de jour comme de nuit et exclusivement à marée basse) et la phénologie de reproduction des autres espèces d'oiseaux piscivores confirment cette hypothèse.

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