SHORT COMMUNICATION

El Niño Caused Collapse of the Sábalo Fishery (*Prochilodus lineatus*, Pisces: Prochilodontidae) in a South American River

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Abstract *El Niño* is well known to affect marine fishery. The Southern Oscillation, however, may also have a strong effect on riverine fish production in floodplains via its effect on river discharge. In years with high river discharges larger parts of the floodplain are inundated, increasing the surface area of suitable nursery grounds for young fish stock. In this way high river discharges are thought to have a positive effect on fish production, while low discharges are thought to have a negative effect. The collapse of the sábalo fishery in the Pilcomayo River in Bolivia, for instance, can be attributed to the 1990–1995 *El Niño* event and subsequent overexploitation of the fish stocks.

The *El Niño*-Southern Oscillation (ENSO) phenomenon has important biological impacts. During the 1982/1983 warm ENSO extreme, increased sea surface water temperatures caused a major decrease in nutrient levels and primary production in the eastern Pacific, resulting in a decline in fish production. This affected not only the anchovy fishery in Peru but also sea birds and sea mammals on the Galapagos Islands (Barber and Chavez 1983, 1986).

On the continents, ENSO has its effects mainly through changes in rainfall probability (Stone et al. 1996). For instance, there is a close correlation between the Southern Oscillation and cereal production (Cane et al. 1994). Until now there have been no records of a relationship between ENSO and the production of riverine fish. The severe decline in the supply of sábalo (*Prochilodus lineatus*, Prochilodontidae) in the South American Pilcomayo River between 1990 and 1995, however, coincided with the longest *El Niño* event on record (Trenberth and Hoar 1996). As ENSO is known to exert a strong effect on rainfall patterns and consequently on river discharge (Poveda and Mesa 1997; Richey et al. 1989; Stone et al. 1996), we examined the possible relationship between discharge levels of the Pilcomayo River, the Southern Oscillation Index, and sábalo catches in the Pilcomayo River.

The sábalo is a migratory i lophagous fish of the South American La Plata basin. The fish was formerly abundant in the Pilcomayo River, where sábalo fishing was of major importance for the indigenous Guarani people and fishermen in the Bolivian Chaco (Bayley 1973). The sábalo feeds in the floodplain of the River in the lower Chaco (Paraguay and Argentina) where large areas are normally flooded in summer. At the end of summer the mature (2- to 3-year-old) fish leave the floodplain and migrate upstream to the north to spawn in the foothill streams of the Bolivian Andes. North of the Bolivian town of Villa Montes, where the river enters the Andean region, the migrating fish pass through a narrow canyon in which their progress is hampered by strong water currents. They can continue their migration only along the banks of the river, where stream velocities are lower. The fishermen of Villa Montes take advantage of this by setting fish traps along the canyon shores. The fish traps function day and night throughout the fishing season and require only little effort. Since 1980 the Bolivian fishery authorities (CDP) have been able to make fairly accurate estimations of the amount of fish caught in the Pilcomayo River by monitoring the amount of fish sold from these fish traps.

Floodplain dynamics is very important for juveniles of the sábalo, for which the floodplains represent nursery grounds (Bayley 1991). In the Pilcomayo, discharges are high in summer and low in winter, creating a strong so-called flood-pulse (Bayley 1973, 1991). In dry periods the floodplains are covered with terrestrial or semiterrestrial vegetation, which dies off when the areas are flooded. The resulting detritus is an important food source for the young detritivorous sábalo (Bowen et al. 1994). In years with high river discharges larger parts of the floodplain are inundated, increasing the surface area of suitable nursery grounds for the young fish stock. In this way high river discharges are thought to have a positive effect on fish production, while low discharges are thought to have a negative effect (Welcomme 1979, 1995). As the migrating sábalos are 2–3 years old (Bayley 1973), the catches in a given year can be compared with the mean discharge during the preceding 3 years. River discharges of the Pilcomayo are measured daily at the Argentine village of La Paz, just upstream from the point at which the river enters the floodplain area.

Previous investigators have blamed overexploitation and contamination of the river by mining activities in the upper course of the river for the major decrease in sábalo catches recorded during the 1990s. The sábalo catch, however, proves to be very closely correlated with the mean river discharge in preceding years (Pearson's correlation coefficient = 0.94; Fig. 1). Thus it seems likely that the decreased fish catches in the 1990s were caused by decreased river discharges, reducing the nursery areas for the juvenile fish (Welcomme 1979). Since it is one of the few means of subsistence for the local population, fishing effort did not decrease during the 1990s, despite the fact that catches decreased each year. This led to a severe overexploitation of the already weakened sábalo population. Since 1995 mean river discharges have increased again. Fish catches, however, have not recovered, and with only 40 tons the official 1998 sábalo catch in Villa Montes was the lowest ever recorded. Based on a study of the population dynamics of the sábalo in the 1980s, Payne and Harvey (1989) predicted as early as 1989 that sábalo fishing in the Pilcomayo River could effectively be destroyed within a few years by a combination of poor recruitment and heavy fishing.

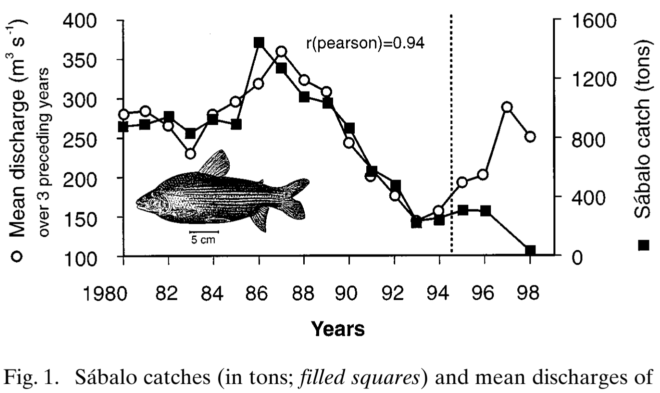

Fig. 1. Sábalo catches (in tons; *filled squares*) and mean discharges of the Pilcomayo River over the preceding 3 years (in cubic meters per second ; *open circles*). Mean discharge over the preceding years is defined as the mean annual discharge for the year in question and the preceding 3 years. The data on the discharges of the Pilcomayo river in the village of La Paz, Argentina, were obtained from EVARSA (Buenos Aires, Argentina) and those on sábalo catches in Villa Montes from ADEPESCA (Villa Montes, Bolivia)

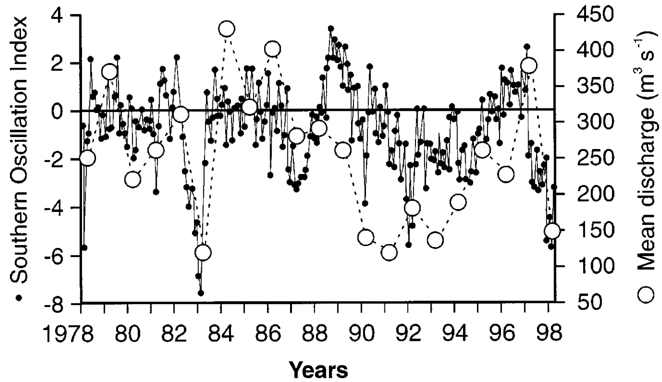

Fig. 2. Mean monthly values of the Southern Oscillation Index (*dots*) and mean annual discharges (in cubic meters per second) of the Pilcomayo River (*open circles*) since 1978. Mean annual discharge values were obtained from EVARSA (Buenos Aires, Argentina). Values are calculated for the hydrological year, which runs from October of the previous year until September of the current year. The Southern Oscillation Index is the difference between the standardized sea level pressures at Tahiti and Darwin (Australia). Negative values indicate the phenomenon known as *El Niño*

The period in which the mean annual river discharges were consistently low and sábalo fishing collapsed appears to coincide well with the 1990–1995 *El Niño* event (Fig. 2). Furthermore, the 1982–1983 and the 1997–1998 *El Niño* events, which were two of the most severe on record, coincide with markedly low mean annual river discharges in the Pilcomayo. These patterns indicate a relationship between ENSO and discharge of the Pilcomayo River.

We conclude that ENSO can have a strong effect on riverine fish production in floodplains via its effect on river discharge. The example of the Pilcomayo River strongly suggests that such a relationship exists for migrating fish that have their nursery grounds in the floodplains of undisturbed river systems. In the case of the Pilcomayo River, the prolonged low Southern Oscillation Index (Fig. 2) in the first half of the 1990s (the longest *El Niño* event ever recorded) in combination with overexploitation of the fish stocks very probably led to the observed collapse of the sábalo fishery.

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