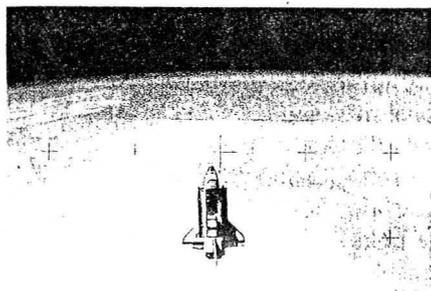


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Space Shuttle Earth Observations

Editors: Kamlesh Lulla and Michael Helfert
Space Shuttle Earth Observations Office
Code SN15
NASA/Johnson Space Center
Houston, Texas 77058, U.S.A.

A New Lagoon on the Namibian Coast of South Africa: Sand Spit Growth Documented From STS-29 Shuttle Photography

M. J. Wilkinson
Lockheed Engineering & Sciences Company
Houston, Texas 77058, U.S.A.
J. E. Blaha
Astronaut Office, NASA Johnson Space Center
Houston, Texas 77058, U.S.A.
D. Noli
P. O. Box 357, Lüderitz 9000, Namibia

(In this issue, our guest authors M.J. Wilkinson, J.E. Blaha and D. Noli are discussing an excellent application of STS-29 Shuttle photography in documenting a particular coastal environmental change along the Namibian coast. This short paper clearly illustrates the value of human-directed Earth Observation efforts aboard the Shuttle. This application also supports our comments in STS-29 mission report in this issue (Lulla *et al.* 1989) of the need to fully integrate the Shuttle database in other Earth science investigations. One of the authors, astronaut J.E. Blaha, was a pilot on this mission. – *Editors.*)

Introduction

This study of Sandwich Harbor documents one of the most dramatic landform changes to have taken place on the coast of central Namibia in historical times. It is known from sequential aerial photographs (scales 1:36,000 and 1:50,000) and old naval charts that wave action constantly reshapes the masses of sand which make up coastal strandplains, of which Sandwich is one – by erosion and sedimentation at different points.

Sandwich Harbor, lying astride the Tropic of Capricorn, is one of three such coastal strandplains on the Dune Sea coast of Namibia in southwestern Africa (Fig. 1). The strandplain shorelines are convex to the sea, and because of their shape and asymmetry they have been termed "half-hearts" in other parts of the world. Finger-like spits of sand often grow downdrift from the strandplains enclosing bays and even lagoons cut off from the sea. Such a spit is

the subject of this report.

All three classic strandplains on the Namibian coast are known to have changed in historical time. The sand spit of the Walvis Bay strandplain (Fig. 1) has been closely monitored because it protects the bay which has become the main entrepôt port for Namibia, one of only two anchorages on this inhospitable desert coastline. Mapping of the Walvis Bay sand spit over several decades has shown that it grows, shortens and changes shape (Bremner, 1985). The Conception Bay strandplain has been growing outward into the sea for most of this century: in 1910 the new German steamship *Eduard Bohlen* ran aground at Conception (Bremner, 1985). In 1973 the wreck lay 400 meters inshore of the beachline (Seely, 1974/5).

Bremner (1985) has suggested that the strandplains are located at points where rivers used to reach the coast in times past. Tanner (1982) has suggested that "half-hearts" are cellular features with sand eroded from the updrift side (south on the Namib coast) and deposited on the downdrift side. He has also suggested that larger, straighter strandplains represent more mature, higher energy coasts, whereas many, smaller cells represent immature development on coastlines with lower wave energy.

Sandwich Harbor

Changes in the remote Sandwich Harbor coastline have been even more dramatic. Sandwich comprises a strandplain 15 km long with a 9 km long lagoon – once a harbor for American whalers – attached at the north end. The

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Fig. 1 Sandwich Harbor Strandplain The Namib Desert Sand Sea and coastline are seen obliquely in this south-looking, hand-held photograph from Space Shuttle *Discovery* (51I Mission, October 1986). Convex, "half-heart" strandplains and associated downdrift sand spits on the coast are: Sandwich Harbor (1), an uninhabited lagoon, sanctuary for coastal birds; Conception Bay (2), an equally uninhabited strandplain with a very small lagoon, south of Sandwich, part of an administrative area known as "Diamond Area No. 1"; and Walvis Bay (3), the main port town of Namibia. The wreck of the steamship *Eduard Bohlen* now lies at least 400 meters inshore (arrow) on the Conception Bay strandplain. The road (4) from Walvis Bay to Windhoek, the capital of Namibia, appears in the foreground. The Kuiseb River (5) separates the sand sea from the rocky flats in an abrupt boundary. Most of the view comprises the Namib-Naukluft Park, a wildlife refuge. (Photograph 51I-35-002)

lagoon is protected from the great South Atlantic swells by a thin bay-mouth sand spit (Figs 1, 2, 3). The bay-mouth spit seems to be very unstable: early naval charts (summarized with additional mapping by Schultze, 1907) and word-of-mouth reports (D. Boyer, pers. comm.) indicate that the major mouth can shift hundreds of meters in the course of a few seasons, that the spit is periodically breached at different points and that nearshore sea floor topography is changeable.

One specific change in the strandplain-lagoon complex began in 1961: on B/W aerial photographs from that year (scale approximately 1:36,000) a short sand spit is visible breaking the continuity of the coastline (arrow, Fig. 2a). Once begun, the trend continued dramatically: by 1977 a cluster of several spits appears on 1:50,000 air photos forming a new, small strandplain. Locally the coastline has been advanced 500 meters out into the ocean. The newest spit, pointing east, ends in the sea forming a small bay on its shoreward side (Fig. 2b).

A less obvious but larger coastline change is also evident. By 1977 the major bay-mouth spit of Sandwich Harbor has retreated eastwards, significantly reducing lagoon width from 3 to 2 km in the 15-year period. The 1977 coastline is thus broadly more sinuous than the 1961 coastline, and shows evidence of an incipient new lagoon.

STS-29 Photography

Ground and aerial photography of the area around Sandwich is difficult to acquire because it is a remote wildlife refuge (ground access is possible only across large dunes of shifting sand). Prints (at a scale of about 1:610,000) of hand-held 70mm shots taken in 1989 by the STS-29 crew show marked extension of the new spit. During the twelve years which have elapsed since the previous good vertical photography of 1977, the tip of the spit has advanced so far that it has coalesced with the bay-mouth spit (Fig. 3). The result is the formation of a new lagoon attached to the seaward side of Sandwich Harbor.

Narrowing of Sandwich Harbor lagoon appears to have continued unabated as the bay-mouth spit has been pushed yet further east. Even at the scale of the 250-mm hand-held photograph, the widest part of central Sandwich Harbor lagoon can be calculated at about 1500 meters, half the width in 1961. Interpreted positions of the 1961 and 1989 shorelines (dotted and dashed lines, Fig. 3) give a sense of these coastal changes.

Significance

Shuttle hand-held photography gives graphic geological evidence of the rate of development of spit-lagoon complexes. Almost thirty years have elapsed for completion of the cycle, between growth of the incipient spit in 1961 to the rejoining of the elongated spit with the major bay-mouth sand spit. The fact that the present coast is



2a



2b

Fig. 2 The New Sandwich Harbor Spit 2a: Sandwich Harbor 1961. 2b: Sandwich Harbor 1977. Black-and-white aerial photographs of Sandwich Harbor lagoon show development of a small sand spit in 1961 (arrow) into a prominent convex feature 15 years later. Less obvious is the significant narrowing of Sandwich Harbor lagoon itself, although changes in the shape of the bay-mouth spit are clear. Long, gently curved lines on both photographs are ancient beaches: these indicate the position of past shore lines and the great changeability of the shape of these strandplains. (Photographs: 503/C9/9016, 774/C2/1642)

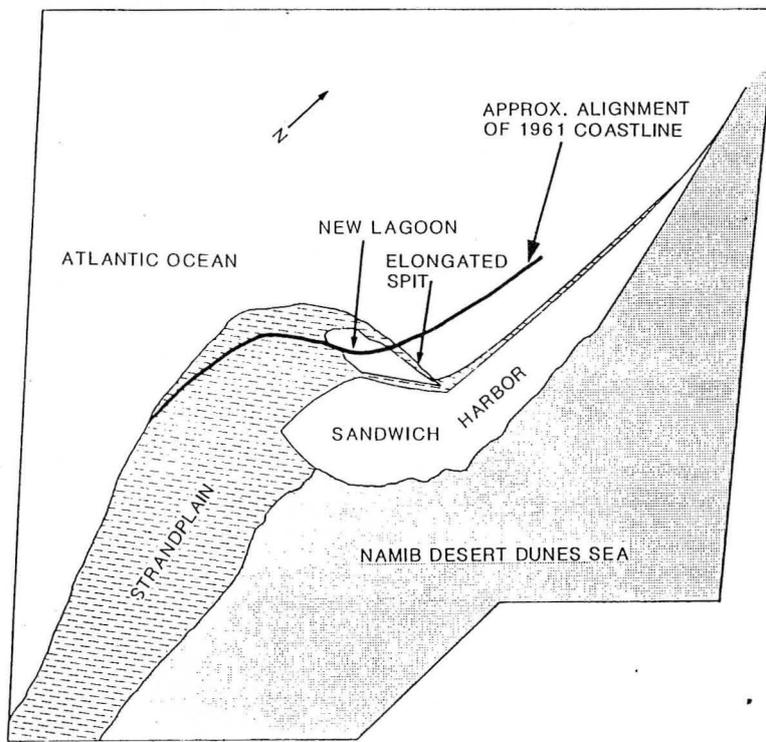


Fig. 3 Shuttle Evidence of Spit Change This near-vertical, hand-held photograph, also from Space Shuttle *Discovery* (Mission STS-29, March 1989), shows the new spit extended so far that it has coalesced with the main bay-mouth spit of Sandwich Harbor lagoon – completing a cycle begun almost thirty years earlier (diagram shows an expanded interpretation of the detail of the photograph). The new, small lagoon is completely closed off from the open ocean. This event must have occurred after the Shuttle photo in Fig. 1 was taken in 1986, in which the lagoon is still open to the sea. (Photograph S29-153-018)

more sinuous than that of 1961 suggests that the erosional-depositional strandplain "cell" has changed somewhat, perhaps towards a less energetic system at least at the north end. The lagoon behind the new spit constitutes a smaller unit and supports this interpretation of decreased energy and more local deposition. Why this should have happened is at present unknown.

In ecological terms, the growth of the sand spit has given rise to a new lagoon, providing a body of quiet, saline water. As the lagoon of Sandwich Harbor has shrunk, the new protected body of water has increased the size of habitat available to sea birds which congregate in shallow, coastal lagoons such as these. Sandwich is one of the most important such sanctuaries on thousands of miles of the west coast of the continent. Thousands of Greater and Lesser Flamingoes use the lagoon. Access by tourists is restricted, and low-flying airplanes must give Sandwich a wide berth.

In navigational terms, spit growth is a crucially important topic. Spits create lagoons which are large enough to act as anchorages on an otherwise very inhospitable coastline. Sandwich Harbor was one such anchorage for American whalers for many decades last century, and Walvis Bay continues to act as the primary port for Namibia. On the other hand, sand spits can be extremely hazardous as they can suddenly alter contours of the near-shore seabed. The wreck of the steamship *Eduard Bohlen*, now 400 m inland on the Conception Bay strandplain, may well have resulted from the sudden growth of an unmapped, possibly submarine sand body.

Acknowledgements

The Namibian Department of Survey and Mapping is thanked for permission to reproduce the aerial photographs. The Department of Nature Conservation and Tourism is thanked for permission and logistical help (to MJW) in gaining access to the area.

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Fig. 4 Ship Wrecks and Shifting Sands This painting of the German steamship *Eduard Bohlen* shows how it might have looked shortly after running aground in 1909 on the Conception Bay strandplain, south of Sandwich Harbor. Rapid, unexpected changes in sea-bottom topography as a result of sand movement may have contributed to the disaster. Today the hulk lies mastless, stripped of paint by corrosive sand blast and surrounded by a great sand dune which trails downwind of the wreck for almost two kilometers. ("*The Eduard Bohlen Low Tide 1916*," by permission of the artist, Keith Alexander.)