

# Bonaire Ecology Conference

on Flamingoes, Oil Pollution and Reefs



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No. 11

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**Papers**  
**Ecology Conference**  
**on Flamingoes, Oil Pollution and Reefs**  
**BONAIRE, 25-28 September 1975.**

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Slagbaai and Mt. Brandaris

Photo by Bart de Boer

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## Introduction

The Ecology Conference in Bonaire, held from September 25 to 28, 1975, was part of the Annual Meeting of the Caribbean Conservation Association. The Conference was organized by the joint efforts of the CCA, its member, the Netherlands Antilles National Parks Foundation, and its associated member the Caribbean Marine Biological Institute.

Among the subjects of concern of the CCA there were three which were of particular interest to the Caribbean area in general, and to the Bonaire area in particular:

1. Ecological ecology and the feasibility of increasing the number of breeding sites.

2. The effects of oil pollution on the submerged fauna and flora, and measures to prevent oil pollution in the Caribbean.

3. Human interferences in wet environments.

Among the participants of the Conference there were many who requested the papers presentations to be published, and also from non-participants we were encouraged to publish their papers or abstracts.

We like to thank the Government of the Netherlands Antilles for providing financial assistance for the publication of the papers and abstracts.

We are also very grateful for the substantial gifts we received from Shell Curaçao N.V., from the Curaçao Oil Terminal (COT), and from Lago Oil and Transport Co. (Aruba).

The Editors



Ladies and gentlemen,

First of all I may wish you a hearty welcome to the Netherlands Antilles and particularly to Bonaire. As I myself was born and raised on this island, I know it very well, and I think that you could hardly have chosen a better place to hold this conference, or any conference for that matter. The island is still reasonably quiet and in my eyes very attractive, and by these tokens shall give you in between sessions the relaxation required to approach your next meeting with all the more vigour.

I am convinced you will agree with me on this at the end of your stay. You have convened to confer during the next three days on various aspects of ecology, in which field you are experts and I am not. And as a Minister of Economic Affairs & Development I am not supposed to be the most appropriate person to hold a strong defense in favor of ecological measures.

Therefore I am not going to pretend to give a contribution to your conference. Nevertheless Ecology is, however, a subject which must concern all of us, and it may interest you to hear to what extent a very small country like the Netherlands Antilles — which is moreover divided over six different islands — is at all aware of environmental problems.

I recently read somewhere that the prime concern of ecology would be the balance of eco-systems, that is the maintenance, or if necessary the re-inforcement, of a situation where the natural inter-action between the components of the system would not lead to the degeneration or even to the extinction of the living components of that system — the living components being people, ani-

Address by

Mr.

Minguel A. Pourier

Minister of

Economic Development

mals, plants and bacteria. In other words: ecology would strive to prevent the non-living components like air, water, technical installations and minerals get to dominate to such an extent that living in that particular area would become impossible. If that definition would be more or less correct, then indeed ecology concerns all of us, and environmental problems would then truly be a matter of life or death.

Fortunately we have not, so far experienced ecology catastrophes in the Antilles to the extent as to directly endanger human life. From our own experience we do know, however, which far-reaching effects certain changes in the existing balance of natural components can have. Some of you already have made your first trips on Bonaire today, and those who did will probably be astonished to hear that once this island, like Curaçao and Aruba, was covered with forest.

Not the thick, lush rain-forest one finds in many tropical areas, but still distinctly forest, which consisted of large, slow-growing trees requiring some, but not much, water to survive.

Visiting ships, however, required wood for repairs, more wood was exported for shipbuilding, while other types of trees were harvested, to use that word, for other purposes. As the slow-growing trees could not keep up with this, erosion of top-soil set in, which in turn decreased the chance of new trees to develop, with more erosion as a result. I think this coincided in time with the excessive cutting-down of forests in the South of France and Yugoslavia, with similar results.

In later years oil refineries were built on Curaçao and Aruba, which for decades pumped up large quantities of groundwater as cooling-water for the installations. The groundwater consequently fell to a level where the roots of the remaining trees could not reach it anymore, and again trees disappeared, erosion increased and the downward spiral got new impetus. The process was topped-off by the large-scale introduction of free roaming goats on the islands, goats being the only type of livestock which could survive in the very dry climate.

The combined results are visible around you: while air and seawater are still pure, land has degenerated to largely bare rock on which only cactus and some types of thorny brush can still grow. Not only has all other natural vegetation disappeared but also agriculture is only possible at the expense of relatively large investments in soil improvement and irrigation, if sufficient groundwater can at all be found in places, where salt seawater has not yet penetrated landinwards.

This rather unhappy story should at this point be completed by the statement that the same oil-refineries which made such a detrimental contribution to this process created a tremendous economic boom on Aruba and Curaçao, from which also Bonaire and the Windward Islands, and in fact many other neighbouring islands profited. Although the refineries have introduced during the last twenty years intensified programs of automatisisation with consequent large lay-offs of personnel, their direct contribution to employment and income is still considerable and it is difficult to assess how many independent other eco-

logic activities would actually have come into being on the Antilles without the existence of the refineries. In other words: while the activities of the oil industry caused certain very unpleasant, serious and long-lasting effects on the environment and thereby on living conditions on the Antilles, that same industrialisation was the basis for our economic development and still contributes considerably to our actual wealth, modest as it may be.

And this brings me to an other aspect of ecology. As I understand it, the unfavourable reactions of the natural environment as nowadays studied by ecologists are mainly those that result from human interference, from human activities. These reactions are considered unfavourable if they endanger in some important way the living components of the system, among which, ultimately, human existence. On the other hand the human activities which cause those reactions are practically always economic activities, that is activities aimed at improving living conditions, at least human living conditions. Formulating the problem in this way suggests, that as the goals of ecology and economic development are equal, the solution would simply be a matter of bringing the means to reach these goals in line. This would in many cases mean to gear the short run economic goals to the long run ecology objectives.

I used the word "simply", but of course this in itself would not be a simple matter at all. Bonaire, for instance, has in the past repeatedly been refused financial development aid by donors on the basic argument that the particular economic goal aimed at with a specific project would disturb its quiet atmosphere and scenic beauty. That argument, although honourable, is however in my opinion not sufficient to warrant a continuation of a sub-existence of 8.500 people, of which until a short time ago one third was unemployed and a large percentage still is.

I do not mean to insult you ladies & gentlemen by suggesting that ecologists are mainly concerned with quietness and scenic beauty, nor that ecologists are not realistic. I just want to illustrate that the immediate need to improve the economic level of a community may well clash with the long run goal of maintaining agreeable environmental conditions.

So the establishment of an oil terminal on Bonaire is certainly of great importance to the island's economy, but has hardly improved the scenery, and development of tourism would undoubtedly disturb Bonaire's quietness; both activities may endanger its coral reefs. But ecology of course does not aim at banning economic development, but at preventing unnecessary and irreparable damage by economic development, particularly if that damage would defeat development's own purpose.

In this connection I am proud to inform you that the Antilles and particularly Bonaire are not only aware of the environmental dangers of certain economic activities, but have actually already some regulations to prevent excessive damage. Already for several years spear-fishing on Bonaire is prohibited by law passed by the island council, and recently it was forbidden to remove black coral from the reefs.

The large area of Park Washington is reserved as a natural Park and attempts are made to add considerable terrains to this reserve. When the Salt

Company renewed operation of the old salt pans the government insisted that measures be agreed upon to protect the flamingo colonies, and it must be said that the Salt Company implemented that agreement in such a way that the flamingo population has even materially increased since. Also the Bonaire Petroleum Corporation agreed to take all measures available through today's technology to prevent spilling of oil, which would indeed be disastrous for flora and fauna in the coastal seas and in the Goto lake. Similar measures to protect the natural environment have been taken in Curaçao and Aruba, while on Aruba moreover a special environmental police group is being trained to enforce the laws in this respect. And as last examples I may mention that my government passed laws to prevent marine pollution by ships in accordance with the criteria of the United Nations International Marine Consultative Organisation and that a law is now being prepared in order to make possible the establishment of marine parks, protecting our beautiful coral-reefs.

I may conclude this talk by emphasizing the international character of many ecology problems. This is of course obvious where marine pollution by oil, chemicals or radio-active materials is concerned. Also, however, the much more acute ecology problems of the highly industrialized countries give rise to a certain tendency to export these problems to elsewhere. In some instances this can on balance be beneficial to the — so to speak — importing country: the establishment of the Bonaire Petroleum Corporation on Bonaire was partly the result of United States laws, restricting the size of oiltankers in its harbours. A recent case involved, however, the proposal for the installation of a destruction plant for poisonous chemical waste materials on a tiny island near Curaçao; this plan was, after some heated public discussion, abandoned.

While export of the problem may be a solution for the exporting area at least temporarily it is clear that the real solutions can only be found through international cooperation. Such cooperation should take place, it would seem, both in setting standards as in developing protective measures. In the world of today all national economics are after all strongly interrelated and interdependent, while nature has always been international.

The government of the Netherlands Antilles welcomes the fact that this conference is being held on Bonaire and hopes that it may stimulate international cooperation in this important field. During a recent visit Mr. Escovar Salom, Minister of Foreign Affairs of Venezuela proposed a close cooperation on all ecology matters between the Caribbean countries, which in this field face many common difficulties and share common interests. I may state here, as I did to Mr. Escovar Salom, that my government is fully prepared to participate in such cooperation and shall gladly support all other attempts to safeguard the conditions, in which our children shall live.

I thank you for your attention, ladies and gentlemen, and wish you a most productive conference and a pleasant stay on Bonaire. With these words I declare this conference officially for open.



**Address by**

**Mr.**

**A. R. W. Sint Jago**

**Lieutenant**

**Governor of Bonaire**

It gives me great pleasure to be here addressing a few words to you which I hope will be of interest. The Minister has already welcomed you, and I would also like to offer a word of welcome. Further I would like to congratulate the committee for organizing this Ecology Congress on our Island of Bonaire.

I am indeed happy that so many of you have accepted the invitation and so grasped the opportunity to give more attention to the ecology-problems. It is almost needless to stress how important the ecology is for humanity.

If I look at the literature I find that the ecology is not given the attention it deserves although pollution nowadays is an international problem and that every country is forced to react.

On this island the situation has taken a turn for the better, thanks to action by the Bonairian Government.

Legal and effectual protection is given to the flamingoes. They are guarded as the chief attraction and the pride of our island. The Bonaire parrot is likewise protected. Furthermore, spearfishing has also been prohibited and since January of this year we have an ordinance prohibiting taking away and having in possession black coral.

A big problem we have on our island is the grazing of goats in a semi-wild state, which is a major danger for the natural balance of soil and vegetation. I know it is one of the most difficult problems in view of the fact that these animals are often the chief means of livelihood for a great many poor people.

Nevertheless there must be some way to save the island from deterioration by unrestricted grazing.

If we look at the Caribbean area we see that this region is affected in different ways by various types of pollution, in its broadest and most serious aspects.

We find sea-pollution by spilled oil, air-pollution by refineries and automobiles, land-pollution by glass bottles, rubber tires, aluminium cans etc.

The crisis is severe and has assumed unexpected proportions. For these reasons the task that falls upon us requires all efforts we can mobilize to protect the environment and transform this beautiful Caribbean area into a better place to live.

With great sincerity I wish you all success. Thank you.

## The Caribbean Conservation Association

On the occasion of the holding of its Ninth Annual General Meeting in Bonaire ~ desires to pay tribute to **LODEWISK DANIEL GERHARTS** for the part he has played in improving the quality of life for the people of this beautiful island of Bonaire.

He has shown concern not only for the material welfare of the people of Bonaire, by raising their standard of living through the encouragement of every area of the economy, but also for their spiritual well-being, by using every means to preserve and develop the natural beauty of their environment.

To this end he has fought to conserve the flamingoes, the parrots, the fish and the coral reefs of the island and has worked to make the National Park Washington a haven of peace and tranquillity.

The Association thus wishes to place on record its appreciation of the contribution made by **LODEWISK DANIEL GERHARTS** to the protection and enrichment of the environment of the island of Bonaire, and thus to the conservation of the Caribbean as a whole.

Bonaire  
25 September 1975

*J. A. Connell*  
President



At the end of his address Mr. J. A. CONNELL, President of the Caribbean Conservation Association (to the left) handed a scroll to Mr. L. D. GERHARTS, Secretary National Park Washington Committee



#### Introduction

The total population of the Caribbean Flamingo, *Phoenicopterus ruber ruber*, consists of 50,000 - 60,000 birds, according to Sprunt (1975), making it one of the rarest flamingo (sub) species in the world. We can distinguish four separated populations; the biggest breeds on Inagua (Bahamas) and Cuba and consists of about 10,000 breeding pairs. 3000 pairs are breeding in Yucatan, about 100 pairs live in the Galapagos and 2000 — 2500 pairs reproduce in Bonaire.

The South-Caribbean population, including sub-adult birds, represents about 15% of the total Caribbean population, or 7,000 — 10,000 birds. This population has used Bonaire as a breed-

## Ecological aspects of the Flamingos on Bonaire

by

JAN ROOTH

Research Institute for  
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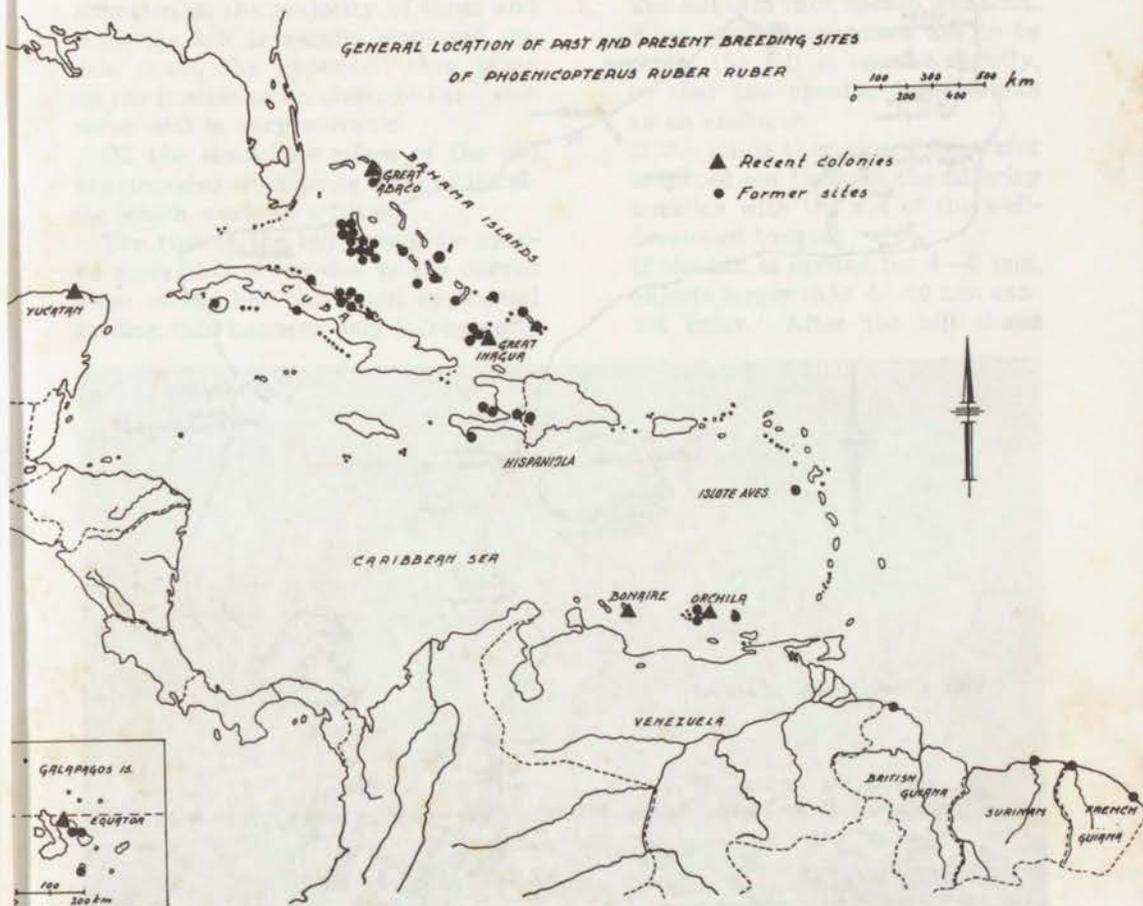
ing site since at least 1681. After breeding the birds migrate along the coast of South America to Colombia, Venezuela, the Guyanas and as far as the Amazon in Brazil. Allen (1956) assumed that this was a single population while Haverschmidt (1970) supposed there to be a separate group in Surinam and Cayenne which bred in the latter country. We are probably dealing with one population which chiefly breeds on Bonaire, but until more information is available, the matter is uncertain.

#### Habitat

Flamingo habitats throughout the world have many characteristics in common. Nearly all biotopes have

shallow water with a high salt concentration, usually accompanied by a red colouration, generally ascribed to Flagellates. In many places the water level is very variable, since the biotopes

are situated in dry areas, or in areas where at least periodically droughts can occur. Places where fresh water or sea water flow in, are important for bathing and drinking. Usually the bio-



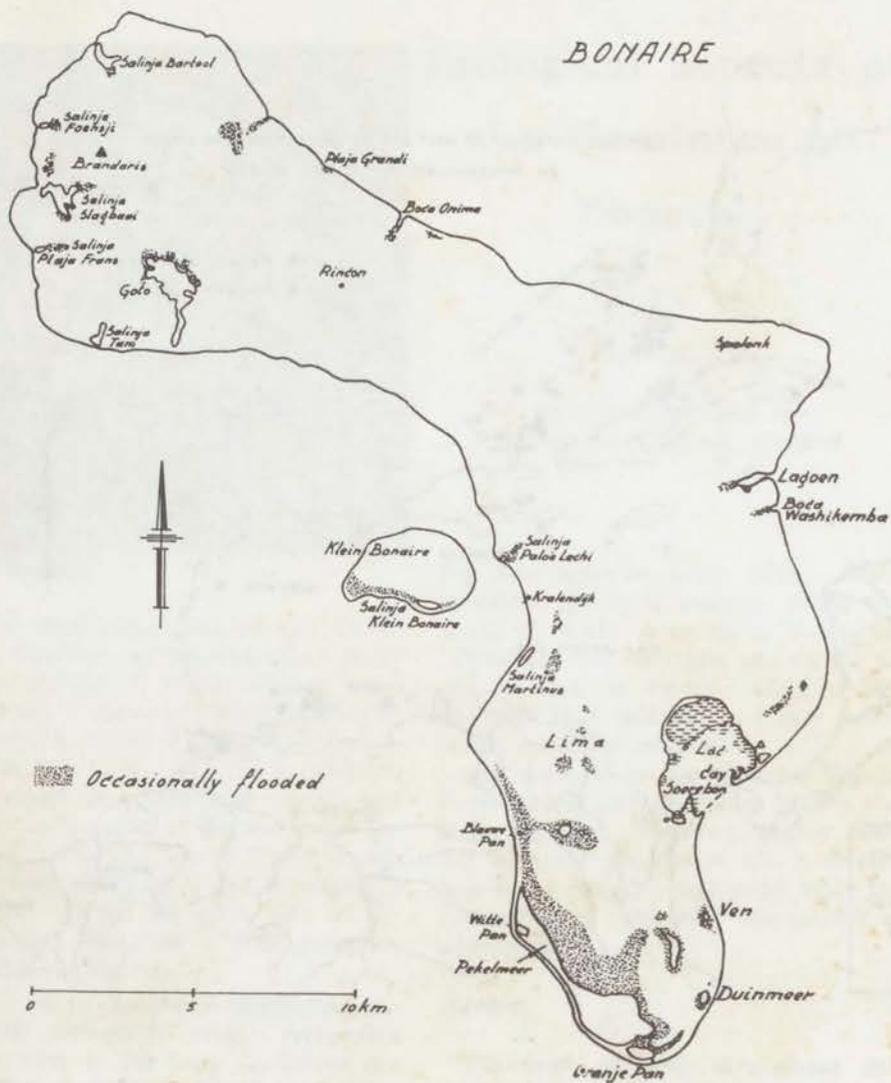
General location of past and present breeding sites (after ALLEN 1956)

tope is situated in a desert landscape, and the (summer) temperature is high.

As food in these biotopes Allen reports especially algae, Protozoa, Mollusca, Crustacea, insects and water plants. These food sources do not usually occur simultaneously; rather

only a few species predominate in one habitat.

Thus it would appear that the flamingos are locally monophagous. (Various bird species with a particular bill-structure appear to be specialized for one or more types of food).



Sketch-map of Bonaire.

### Bill and filter

Jenkin (1957) has given an extensive description of the anatomy and function of the bill and the filterapparat.

The bill is bent halfway along its length and the upper-bill is flat but provided with a ridge or keel, the under-bill is much heavier and higher in its construction. This differs from the situation in the majority of birds and since the bill is usually employed upside down, the upper-bill then takes on the function of an under-bill and vice versa and is very movable.

On the inside the edges of the bill are provided with dense rows of lamellae which work as a filter.

The tips of the bill cannot be opened more than 4 cm due to the curved form of the bill itself, and by normal feeding this happens only infrequently

during the seizing of larger prey.

The hardly extensible oesophagus is, in fact, unsuitable for dealing with larger objects so that in general the bill is only slightly open during the feeding process, with a more or less regular space between the halves of the bill.

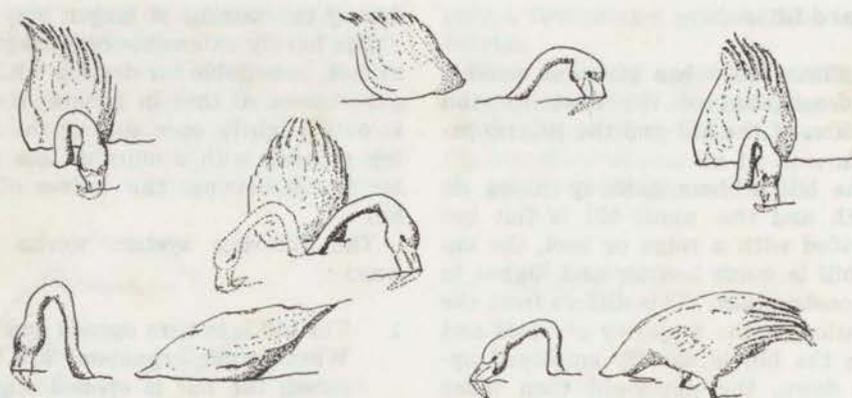
The filtering system works in 2 ways :

1. The bill is in turn opened and shut. When larger organisms are to be eaten, the bill is opened slightly, so that the opening itself works as an excluder. If the bill is then closed the water is forced out through the filtering lamellae with the aid of the well-developed tongue. If the bill is opened for 4—6 mm, objects larger than 4—10 mm cannot enter. After the bill closes



The Bonaire breeding site.

Photo by Jan Rooth



"Skimming", walking and swimming.

particles smaller than 0,5 mm are removed.

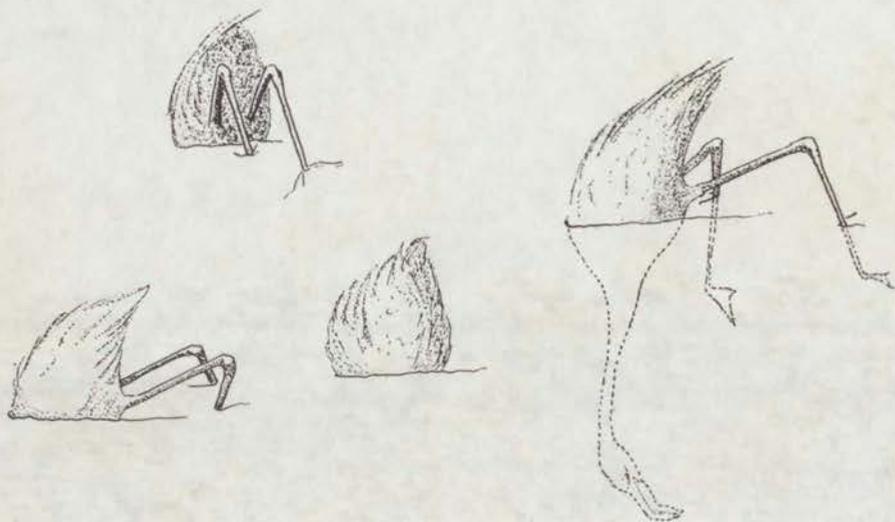
- The bill remains closed. The tongue makes a pumping movement in this case, so that water with small organisms and or particles are taken through the filter. The excess water is pumped externally via the base of the bill. In this way objects larger than 0,5

mm are not taken and smaller particles enter through the filter only.

In both methods the large tongue, provided with spines, transports the food collected on the inner side of the filter lamellae.

#### Feeding

On Bonaire there are 7 clearly different methods of searching for food.



"Grubbing".

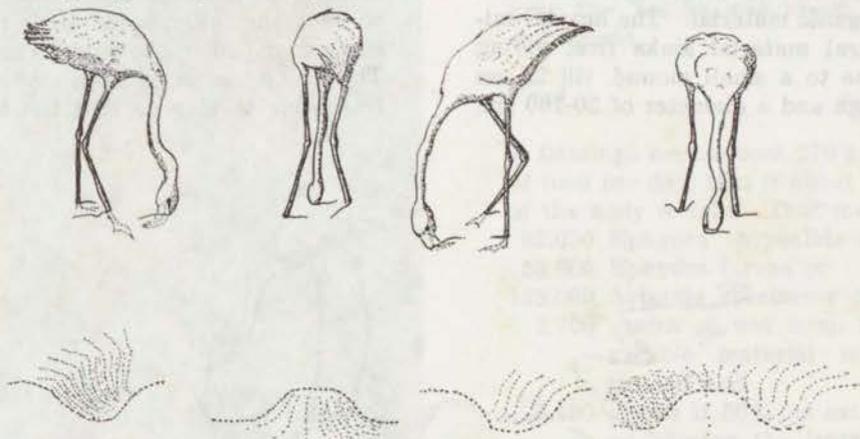


Stamping — "marking time".

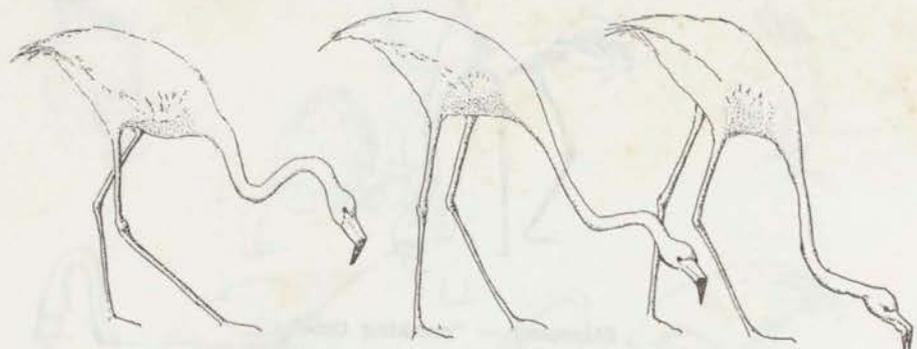
(Rooth, 1965). Not only the use of the bill (as seizing organ and filter) but also the locomotion (walking, standing, stamping and swimming) are different in each case.

- Skimming** — walking and swimming — for brine shrimps, *Artemia salina*, in the surface water. Only the extreme curved part of the bill is in the water and the head is moved by the neck to and fro, while the point of the bill skims through the upper layer of the water.
- Grubbing** — in the bottom probably especially for chrysalids of

- Walking: seizing** forceps movements — for *Ephydra* chrysalids, gastropod molluscs — and **filtering** — for *Ephydra* chrysalids, *Artemia*, etc.
- Stamping** — "marking time" — for *Ephydra* larvae. The heel-joint is continually extended and retracted during this movement, alternating both legs.



Stamping — describing a circle around the bill as centre.



"Running" — heron-like.

The head is reversed with the bill in the water, a short distance above the bottom, and moved to and fro.

If we imitate the movement of the feet with our hands we find that *Ephydra* larvae drift up at the bottom.

5. **Stamping — circling around the bill — for gastropods**

In this method the reversed bill forms the locus around which the birds stamp, describing a circle. The webbed feet strike on the bottom and cause centripetal movements which throw up mineral and organic material. The heavier mineral material sinks first giving rise to a small mound, till 25 cm high and a diameter of 50-100 cm.

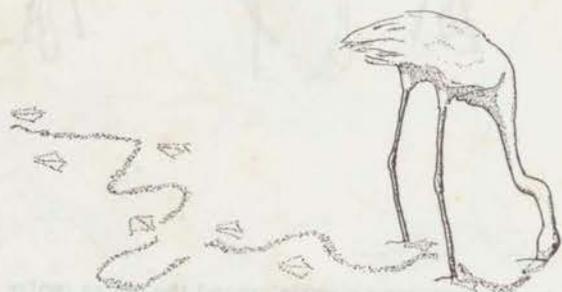
By imitation it appears that a number of molluscs — *Batillaria*, *Cerithidea* and *Cerithium* sp. — are left behind on the central mound, since they are lighter than the coral sand.

6. **Running — heron-like — for small fish**

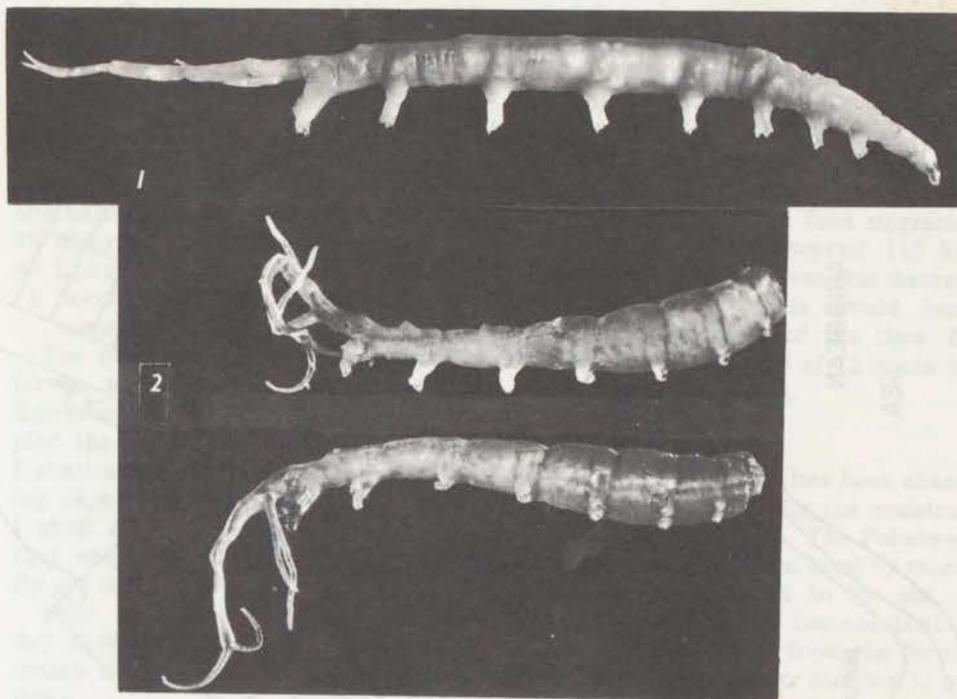
They are sticking the bill with swift movements in shallow water, without inverting it, but using it as a pair of forceps.

7. **Walking, leaving tracks of the bill — for organic ooze**

The flamingos walk, in this method, with inverted bill forwards so that the bill passes over the surface or just in the mud bottom. The head is sometimes moved from side to side so that the bill



Walking, leaving tracks of the bill.



The Brine Fly *Ephydra cinerea* 1: larva 2: chrysalid or pupa Photo by Jan Rooth



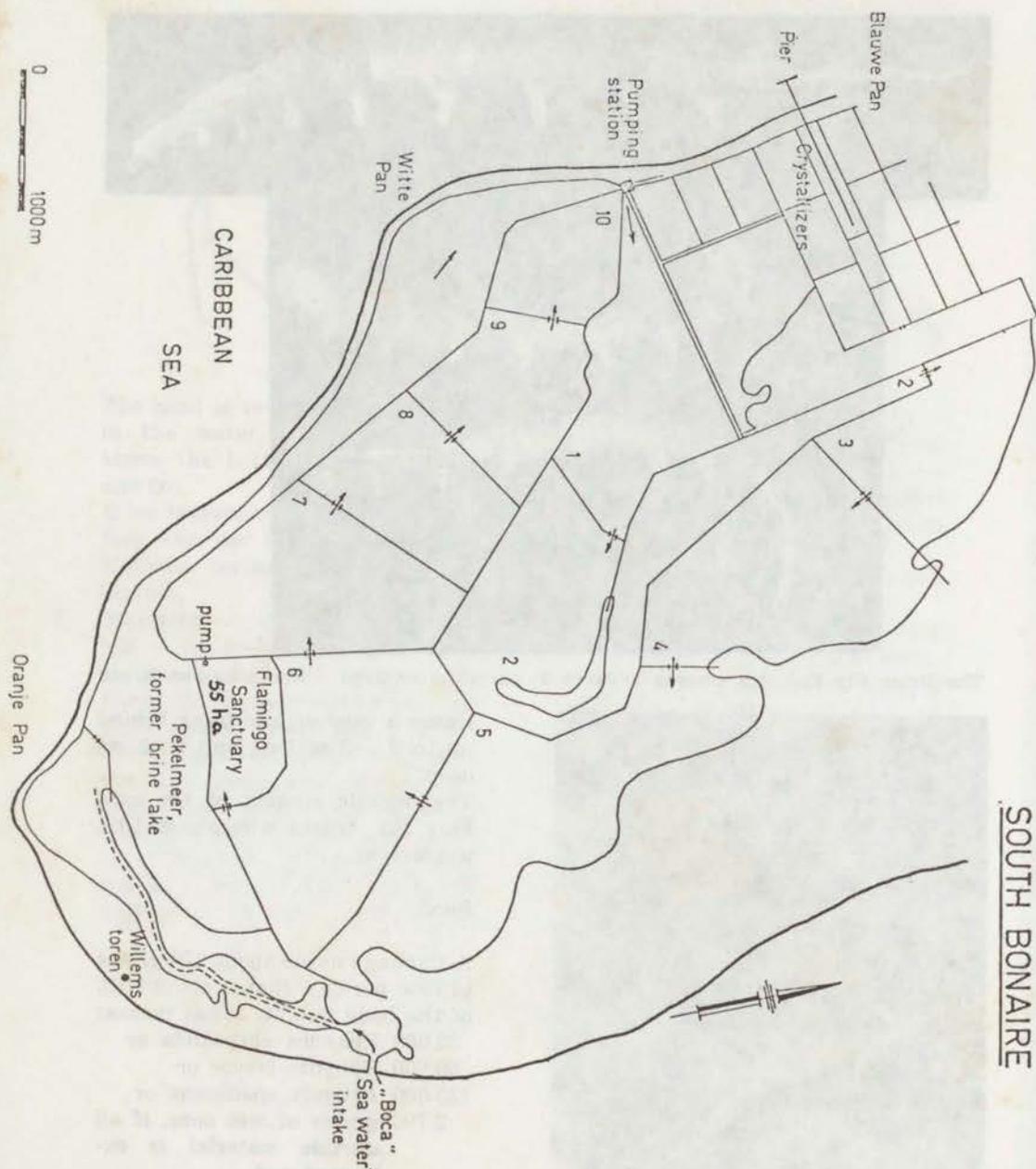
Snails (*Batillaria minima*) from Pekelmeer. Photo by Jan Rooth

leaves a very erratic track behind up to 2—3 m long and 1—2 cm deep.

The organic content of the mud near the tracks was about 10% wet weight.

**Food**

A flamingo needs about 270 grams of food per day, that is about 10% of the body weight. That means:  
 32.000 *Ephydra* chrysalids or  
 50.000 *Ephydra* larvae or  
 135.000 *Artemia* specimens or  
 2.700 grams of wet ooze, if all useable material is extracted and  
 5.400 grams if 50% is extracted. Seeing the length of the gut and the hard



droppings, which consist almost entirely of mineral material the birds can probably manage with eating 3-5 kg ooze.

Flamingos search for food for about one half day at a time. That means:  
 45 Ephydra chrysalids per minute  
 60 Ephydra larvae per minute  
 2 liters water with 200 Artemias per minute.

The main food on Bonaire were the larvae and pupae of the Brine fly, *Ephydra cinerea*. I have only sampled the chrysalids quantitatively and I shall attempt to calculate the carrying capacity of the different habitats. I shall simplify matters by assuming that only the chrysalids of the Brine fly are eaten.

1000 flamingos therefore eat per day 32.000.000 chrysalids, which is per month a total of 1.000.000.000 (a billion).

**Carrying Capacity**

On the basis of quantitative samples of stones and salt crusts, the occupation percentage of *Ephydra* chrysalids and the potential sites in the different habitats (see Rooth, 1965), I calculated that the Pekelmeer can have about 20 times the number of chrysalids as Goto, and Goto about 1½ times the number in Slagbaai, with maxima of 2.376.732.000 in Pekelmeer.

128.472.000 in Goto

89.930.000 in Slagbaai

When ¼ — ⅓ of the population of chrysalids is consumed the *Ephydra*

population remains the same. This results in a large turn-over.

The carrying capacity of Slagbaai is about 100 — 200 birds, of Goto 700 — 1000 birds.

In the Pekelmeer area with numbers over 2500 there was an over-exploitation, which resulted in food migration to Venezuela, a distance of 140 km. The flamingos could cover this distance in 2 — 3 hours. This would leave about half or more of the time for feeding out of a period of 12 hours between dawn and sunset.

**Change of habitat**

The Pekelmeer area has been changed in 1968 and 1969 by the construction of the condensers. The Pekelmeer has been brought to sea level by means of an open connection to the sea, so that the salinity has become that of the sea. By pumping from the former Brine lake to condenser number 1, water slowly flows through all the condensers to number 10.

As it flows the concentration increases to near saturation point and this brine is pumped to the crystallizers.

The new developments have changed the food situation considerably. Brine-fly and Brine-shrimp are dependent on a high salinity and, at the start of the operation in 1969, only occasionally found good conditions. In order to obtain quantitative information on the abundance of Brine-flies, I checked the condensers for the presence of chrysalids in March 1970 and again in July 1973, with the results shown in the Table.

Occupation percentages of *Ephydra cinerea* pupae from 50 samples (See Rooth 1965 for method).

|              | 1970 | 1973 | 0/00 Salt in 1973 |
|--------------|------|------|-------------------|
| Condenser 10 | 86   | 26   | 231               |
| Condenser 9  | 58   | 36   | —                 |
| Condenser 8  | 22   | 38   | 136.1             |
| Condenser 7  | 12   | 4    | 105.7             |
| Condenser 6  | 2    | 0    | 74.2              |
| Condenser 5  | 4    | 0    | 61.8              |
| Condenser 4  | 0    | 0    | 59.0              |
| Condenser 3  | 0    | 0    | 49.0              |
| Condenser 2  | 0    | 0    | 44.5              |
| Condenser 1  | 0    | 0    | —                 |
| Pekelmeer    | +    | 0    | 39.7              |
| Sanctuary    | +    | 48   | 52.0              |

In 1970, larger numbers of chrysalids were found only in the condensers with the highest salinities, that is, 9 and 10. This was perhaps because salinities were still not as high as in the former brine lake, since they had been filled with sea water only six months previously.

The expectation was that Brine-fly numbers would improve as the salinity of the condensers increased. In fact, a better food supply than in former times was anticipated, because the water surface where Brine-fly could be expected (Condenser 5—10) was now about four times that of the brine lake.

Thus, the situation in July 1973 was disappointing. The numbers of chrysalids had decreased due to the fact that the bottoms of Condenser 5—10 were largely covered by a layer some centimetres thick, of gypsum and carbonate crusts. This meant that there was not much mud available in which the larva of the Brine-fly lives. Conditioning for the Brine-shrimp was also poor. The flamingos have switched completely to another food, the molluscs *Batillaria*, *Cerithidea* and *Cerithium* species. These small gastropods

have increased and are now abundant in the Pekelmeer (former brine lake) and in Condenser 1—4 with the lowest salinities.

Possibly this new food item can supply large numbers of flamingos but I am not optimistic for the long term because reproduction and growth in molluscs occur at a slower rate than in insects.

#### Breeding habitat

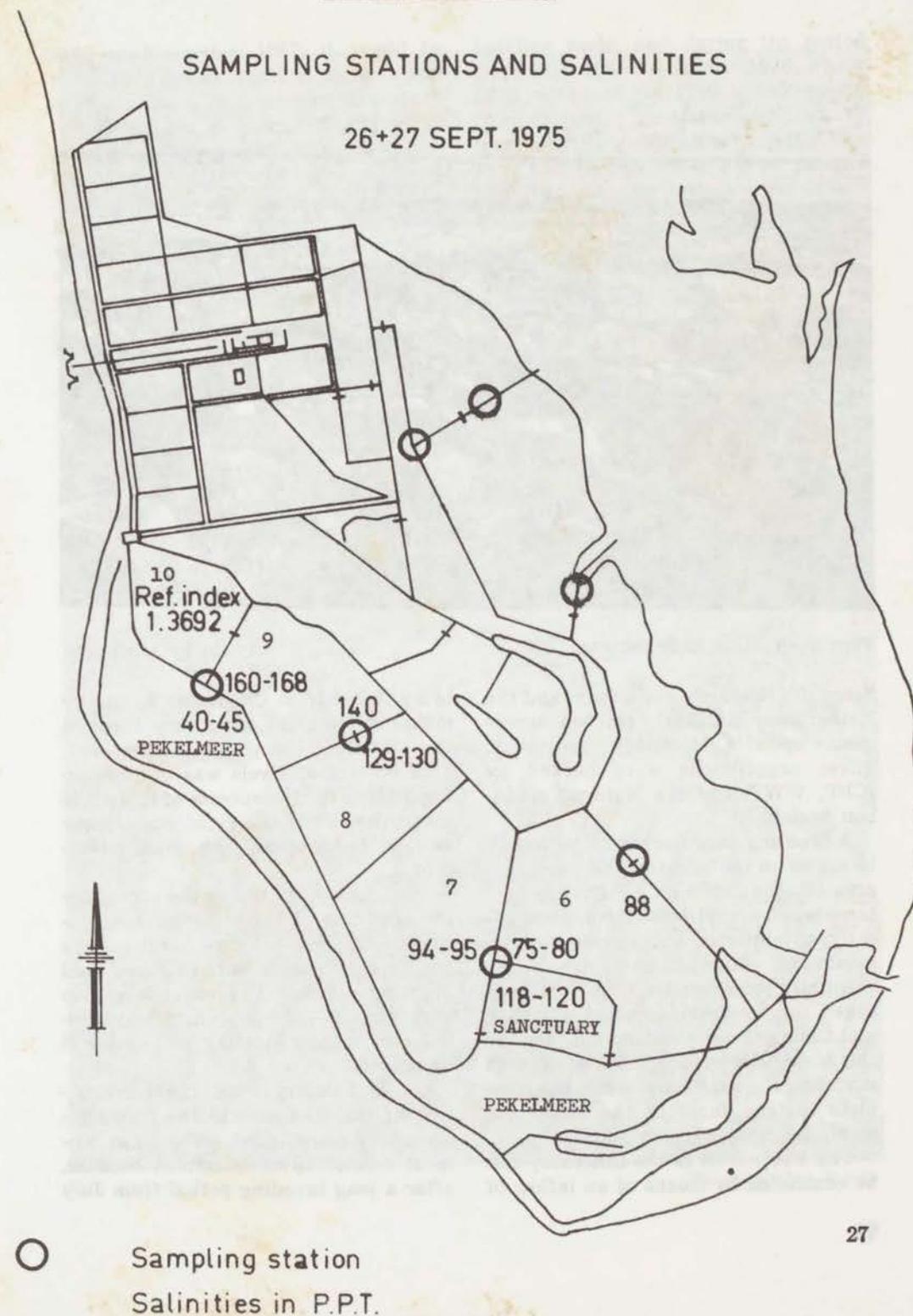
The most important breeding sites were formerly situated on the east bank of a natural brine lake. This lake was 30 — 40 cm below average sea-level supplied by underground seawater which, because of evaporation, concentrated into brine with a chlorinity three to six times that of seawater.

Because of changing water-levels (partly caused by seasonal fluctuations in sea-level) there was a wide, salty, muddy border, 5 km in length, where flamingos could build their nests. In 1966, after lengthy negotiations, the Antilles International Salt Company and the conservationists, (The Flamingo Committee of the Foundation for

## SOUTH BONAIRE

### SAMPLING STATIONS AND SALINITIES

26+27 SEPT. 1975





Former situation in Pekelmeer.

Photo by Jan Rooth

Scientific Research in Surinam and the Netherlands Antilles) reached agreement upon a flamingo sanctuary. These negotiations were backed by ICBP, WWF, and the National Audubon Society.

A breeding sanctuary of 55 ha was to be set up in the midst of the condenser area of about 2000 ha. Fifty-five hectares was a compromise figure, biologically a minimum but economically a maximum. So while the size of the sanctuary was smaller than had been asked for, its form, location, the dike and timing of the construction, were as the biologists wished. Dikes were to surround the sanctuary, while the complete eastern shore of the brine lake would be replaced by a dike.

The water-level in the sanctuary can be controlled by means of an inflow of

briny water from Condenser 6, and by pumping from the sanctuary through the "flamingo-pump" to Condenser 7. This control of levels was of primary importance for the success of the whole enterprise, since the right consistency of mud for nest-building must be obtained.

In choosing the site of the sanctuary the condition of the soil was taken into consideration — as well as the bird's traditional attachment to their old breeding places. The water-level can vary from 0—10 cm and, in transitional areas, good building material will be present.

On 13 January 1968, the construction of the dike around the flamingo-sanctuary commenced. The right moment seemed to have arrived because, after a long breeding period from July

1966 to November 1967, it would be some time before nesting could be expected again. In order not to disturb the flamingos, it had been agreed to build the dikes as low as practical — less than 1 m high and with a slope of 1 in 4. Thus it would be easy for the birds to cross them on their way to the nearby condensers in search of food, and to the former brine lake which, because of lower salinity (the same as seawater), had become attractive for bathing and drinking.

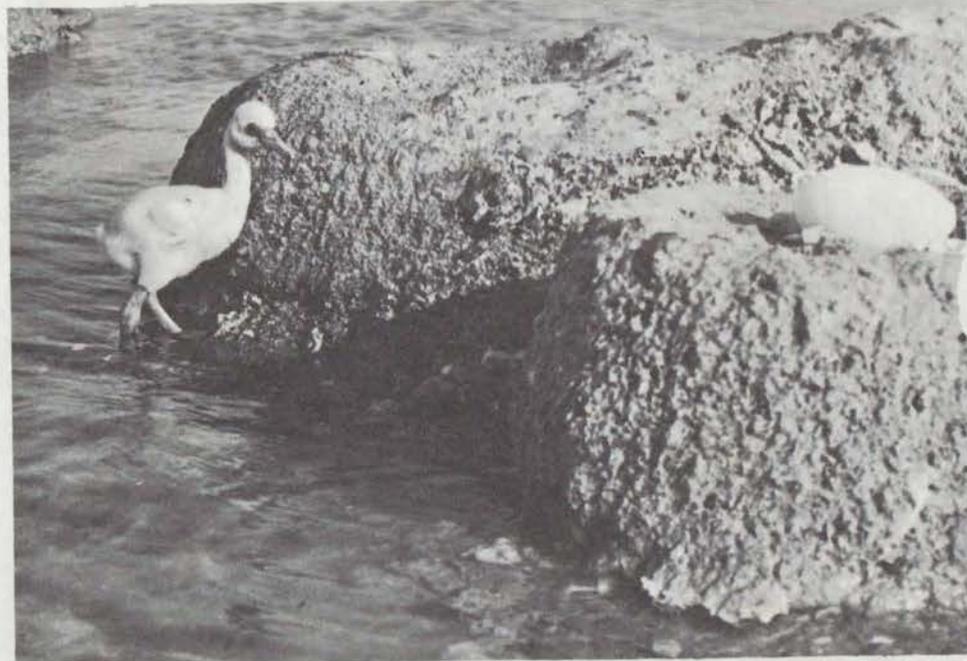
By April 1969, the pumping station was finished, so that the filling of the ten new condensers and the creation of the flamingo sanctuary could begin.

#### Reproduction

On December 13, 1969, flamingos were observed in the sanctuary for the first time. They immediately began

building nests, and during the period December 1969 — March 1970, about 2300 pairs bred and 1700 — 1800 young were fledged. The birds accepted the new situation despite the fact that the food supply was still far from favourable. The change in the system of water management, the time taken to fill all condensers and evaporate water to concentrate the brine, temporarily caused a food shortage, during which the flamingos had to find supplementary food elsewhere on the island and in Venezuela.

In May and June 1970, hundreds of pairs bred again on the island. At the end of December 1970, further nests were built in the same sanctuary: in January 1971, eggs were laid and in March and April 1971, 800 young varying between one and three months of age were seen. In 1972 flamingos bred from April to June. Again in



Egg and chick.

Photo by Jan Rooth



Nest building, the bird on the right is threatening.

March 1973, there were between 500 and 1000 young, but at the beginning of April the colony was cruelly disturbed by two lowflying planes. This resulted in 400 nests with deserted eggs, 200 young dead birds, dozens of scattered and abandoned young, and only 300 — 400 larger young that probably survived. Breeding occurred again in

1974 and 1975, but in 1975 also low flying planes caused disturbance.

Since the start of the man-made breeding sanctuary in 1969 the flamingos have bred there 5 times successfully.

I have calculated earlier (Rooth, 1965) that the population will be stable if there are 3 successful reproduc-



Flamingo of about 6 weeks old.

Photo by Jan Rooth

tive seasons in every 6 — 7 years. The last 6 years we have had 5 such suc-

cessful seasons, so the population might increase.

#### REPRODUCTION OF THE FLAMINGOS ON BONAIRE

| Year        | Reproduction | Pairs | Juveniles | Breeding time       |
|-------------|--------------|-------|-----------|---------------------|
| 1944        | — disturbed  | —     | —         | —                   |
| 1944 - 1950 | —            | —     | —         | —                   |
| 1950        | +            | 1000  | 600       | August              |
| 1951        | +            | 1000  | ?         | Summer              |
| 1952        | — flooded    | ?     | ?         | July                |
| 1953        | —            | —     | —         | —                   |
| 1954        | —            | —     | —         | —                   |
| 1955        | +            | 1400? | 800       | March - May         |
| 1956        | +            | ?     | 3000?     | February - March    |
| 1957        | +            | ?     | 3000?     | February - March    |
| 1958        | —            | ?     | ?         | February            |
| 1958 - 1959 | +            | 700   | 300       | December - January  |
| 1959 - 1960 | +            | 2150  | 1600      | December - August   |
| 1960 - 1961 | +            | 1200? | ?         | November - April    |
| 1961        | —            | 1000? | 150       | May - July          |
| 1962        | +            | ?     | many      | January - February  |
| 1963        | +            | ?     | ?         | January - May       |
| 1964        | ± disturbed  | ?     | 1000?     | January - March     |
| 1964 - 1965 | +            | ?     | 1000?     | December - February |
| 1965 - 1966 | — disturbed  | ?     | ?         | December - February |
| 1966        | +            | ?     | ?         | August - November   |
| 1966 - 1967 | — flooded    | ?     | ?         | December - January  |
| 1967        | +            | ?     | ?         | February - November |
| 1968        | —            | —     | —         | —                   |

#### 1969 SANCTUARY FILLED WITH WATER

|             |               |       |             |                  |
|-------------|---------------|-------|-------------|------------------|
| 1969 - 1970 | +             | >2300 | >1500       | December - March |
| 1970 - 1971 | +             | ?     | > 800       | December - April |
| 1972        | +             | ?     | (1000*)     | March - July     |
| 1973        | ± disturbance | ?     | 500 -100    | January - April  |
| 1973 - 1974 | +             | ?     | 1500 - 1800 | December - March |
| 1974 - 1975 | +             | ?     | 1500        | December - March |

(\* according to other sources)

## Conclusions

The man-made breeding-sanctuary constructed amidst the condensers has been accepted by the flamingos. They have bred there in 6 successive years.

By controlling of the water level in the sanctuary it is possible to prevent the flooding of nests and the loss of eggs and young. This might increase the population.

The menace of disturbance by planes remains, and poachers and bird-photographers must also be discouraged from entering the sanctuary.

An observatory with telescopes for the interested public near Oranje Pan could be an alternative solution. This and efficient wardening is of the utmost importance.

The food situation has changed totally, the flamingos have switched from the larvae and pupae of the Brine fly, *Ephydra cinerea*, to small molluscs *Cerithidia* sp. and *Cerithium* sp.

The big difference in turnover between those insects and the gastropods will cause a decrease in the food situation on Bonaire.

The birds can react in 3 ways :

- a) They can feed more in the natural brine lakes elsewhere on the island, where the Brine-fly still occurs. The most important brine lakes, however, Goto and Slagbaai, are threatened by an nearby oil-terminal and a plan for an oil refinery.
- b) More food migration to the coastal marshes of Venezuela near Chichiriviche.
- c) The birds stop using Bonaire as a breeding site.

Bonaire is up till now the main breeding site of the South-Caribbean flamingo population and therefore it is

of vital importance for the conservation and management of this population to investigate the food situation on Bonaire and near Chichiriviche in Venezuela.

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## Resumen

# Aspectos ecológicos de los flamencos en Bonaire

por

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El refugio creado por el hombre para permitir la procreación de los flamencos en medio de las instalaciones industriales para la producción de sal ha sido plenamente aceptado por los flamencos. Durante 6 años consecutivos han hecho allí sus nidos.

Regulando el nivel de agua en el refugio se logra evitar la inundación de los nidos y la pérdida consiguiente de huevos y cría. Así podría esperarse un aumento de la población.

Persiste sin embargo el peligro de los ruidos molestos producidos por aviones. También hay que evitar intrusos tales como cazadores y fotógrafos de aves.

Un observatorio con telescopios cerca de Oranje Pan para el público interesado podría ofrecer una alternativa conveniente. Esto en combinación con guardianes competentes es considerado de suma importancia.

La base de alimentación ha cambiado por completo: Los flamencos han dejado de comer las larvas y ninfas de la mosca de salmuera (*Ephydra cinerea*) para alimentarse de pequeños moluscos (*Cerithidea*, *Cerithium* y *Batillaria*).

La gran diferencia en el consumo entre tales insectos y los gastropodos hace previsible el deterioro de la situación alimenticia en Bonaire.

Las aves pueden reaccionar de tres maneras :

- a) se alimentan mas en las naturales lagunas de salmuera en otras partes de la isla donde aun se encuentra la mosca de salmuera. Sin embargo las mas importantes lagunas de salmuera, Goto y Slagbaai, enfrentan las consecuencias negativas de un terminal petrolero además de un proyecto de refinería en la misma área.
- b) migración aumentada en busca de alimentos en las ciénagas del litoral Venezolano en las cercanías de Chichiriviche.
- c) las aves abandonan sus nidos en Bonaire y mudan la colonia en parte o totalmente a otro sitio.

Hasta el momento Bonaire representa el mayor nucleo de procreación de la población de flamencos en la parte meridional del mar Caribe.

Para la conservación y el cuidado de esa población se considera pues de sumo interés investigar la situación alimenticia en Bonaire y en la región de Chichiriviche en Venezuela. Estas investigaciones de la situación alimenticia acaban de arrancar y serán continuadas durante un año por lo menos.

## A New Colombian Site for the American Flamingo (*Phoenicopterus ruber*)

by  
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National Audubon Society, Florida

In June of 1974 I was invited to visit Colombia to investigate the occurrence of American flamingos at a new salt production site. Officials of the salt company, Concesiones de Salinas, S.A., were interested in the flamingos which were seen regularly in the vicinity of their works, and they wished to have checked the possibility of their nesting.

They also wished to have suggestions on furthering their well-being.

As a result I made a short visit to Manaure on the Guajira Peninsula on 26, 27 and 28 June 1974. Flamingos were found.

It is well known that flamingos occur in suitable habitats along the Caribbean coast of South America. Rooth (1965) has done an excellent job of summarizing the sites mentioned in the literature. In Colombia all of the reports have been along the more humid portions of the coast, west of the town of Santa Marta, in the vicinity of the delta of the Rio Magdalena. Nesting has been reported in the Ciénaga Grande. Allen (1956) stated that there had been no recent report from Colombia. The present instance then, was of particular interest as it came from a portion of the coast which had never been involved in previously known flamingo occurrence.

### The Area

The Guajira Peninsula forms the northeastern extremity of Colombia,

partially enclosing, and forming the western shore of, the Gulf of Venezuela. It is arid to almost desert-like in aspect. The vegetation takes on a drier look east of the foothills of the Santa Marta Mountains, becomes thorn scrub in the vicinity of Riohacha and increasingly desertlike on the peninsula itself. The latter area is covered with sparse scrub and cactus. The region is thinly populated, largely by the Guajira Indians, a people who have retained much of their original culture and are still primarily nomadic herds-men of cattle and goats.

The salt works are located immediately on the coast at Manaure, some 50 km east of Riohacha and about 470 km directly west of Bonaire.

Originally the area now used to produce salt consisted of large, very low lying salinas which were periodically flooded by high tides and wind-driven water from the sea. There are extensive areas of this type along the coast east of Riohacha. The soil is a fine, sandy clay that blows easily and dust can be a problem.

The salt operation is a large one covering some 3992 ha. It spreads out over some 20 km parallel with the coast and varying in width from 1 to 4 km. It was constructed, I believe, in the early 1970s and is just now coming into full production.

For centuries the Guajiras have harvested salt from natural salines and have used this commodity as their

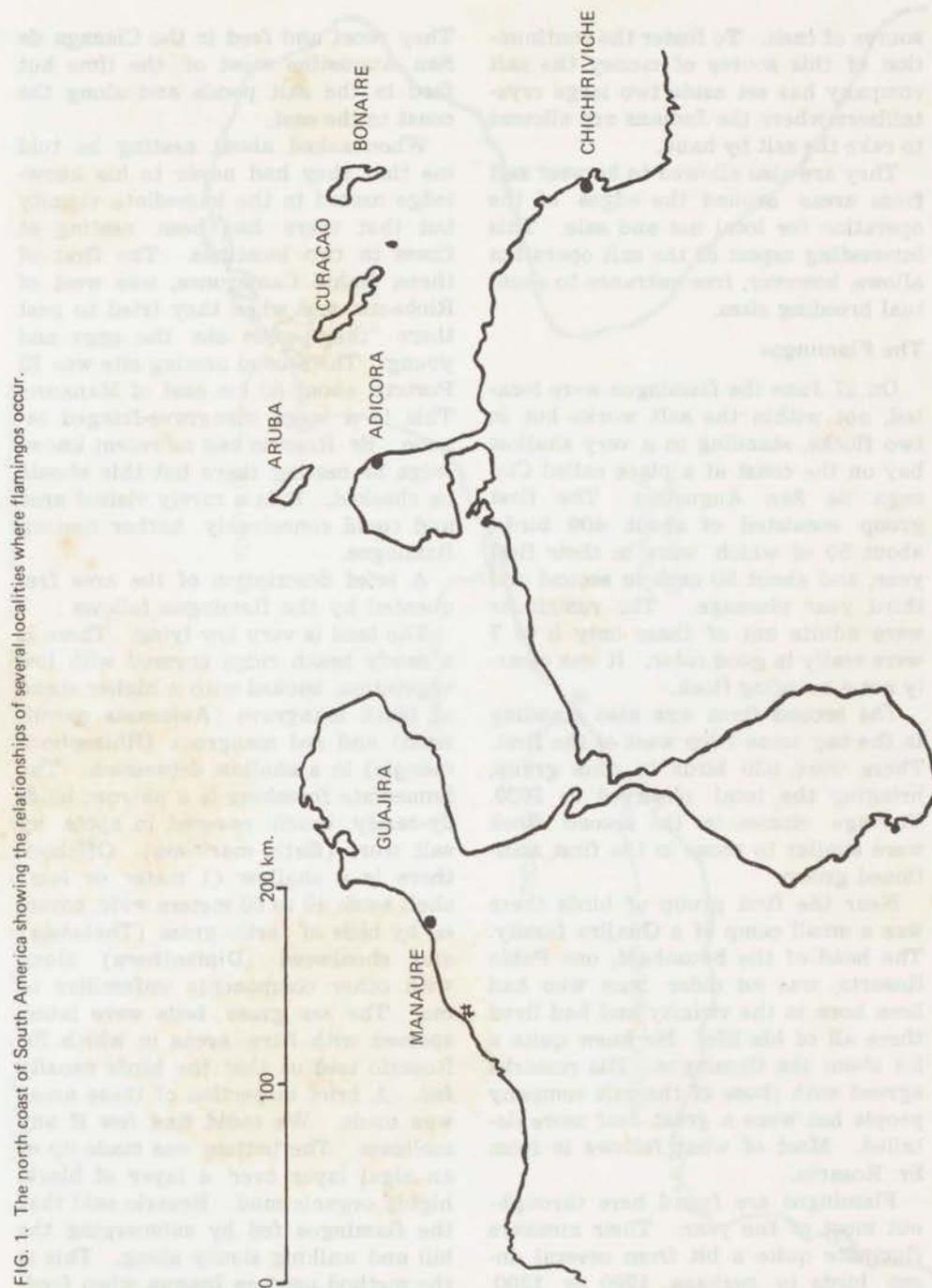


FIG. 1. The north coast of South America showing the relationships of several localities where flamingos occur.

source of cash. To foster the continuation of this source of money the salt company has set aside two large crystallizers where the Indians are allowed to rake the salt by hand.

They are also allowed to harvest salt from areas around the edges of the operation for local use and sale. This interesting aspect of the salt operation allows, however, free entrance to eventual breeding sites.

#### The Flamingos

On 27 June the flamingos were located, not within the salt works but in two flocks, standing in a very shallow bay on the coast at a place called Cienega de San Augustine. The first group consisted of about 400 birds, about 30 of which were in their first year, and about 50 each in second and third year plumage. The remainder were adults but of these only 5 to 7 were really in good color. It was clearly not a breeding flock.

The second flock was also standing in the bay some 1 km west of the first. There were 630 birds in this group, bringing the total observed to 1030. The age classes in the second flock were similar to those in the first mentioned group.

Near the first group of birds there was a small camp of a Guajira family. The head of the household, one Pablo Rosario, was an older man who had been born in the vicinity and had lived there all of his life. He knew quite a lot about the flamingos. His remarks agreed with those of the salt company people but were a great deal more detailed. Most of what follows is from Sr. Rosario.

Flamingos are found here throughout most of the year. Their numbers fluctuate quite a bit from several dozen birds to perhaps 1200 or 1300.

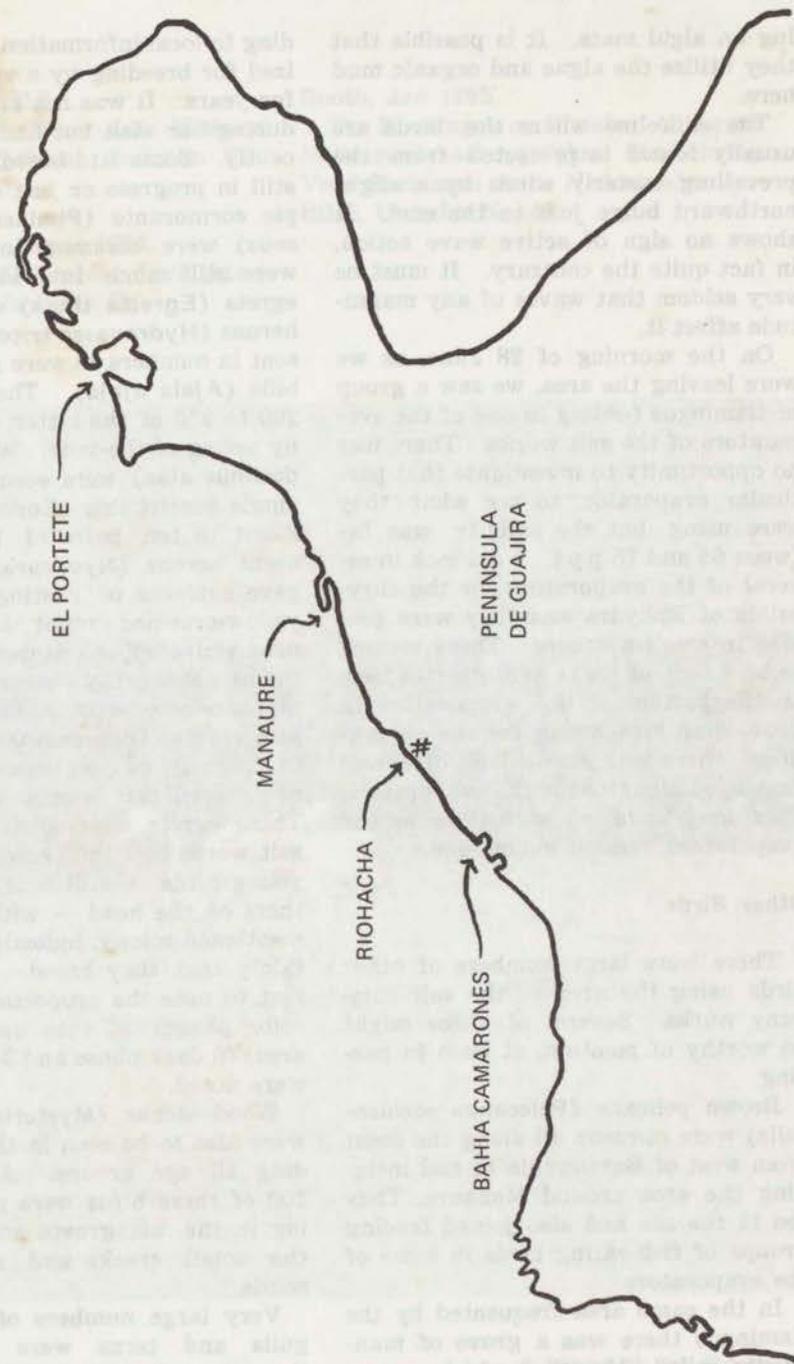
They roost and feed in the Cienega de San Augustine most of the time but feed in the salt ponds and along the coast to the east.

When asked about nesting he told me that they had never to his knowledge nested in the immediate vicinity but that there had been nesting at times in two locations. The first of these, Bahia Camarones, was west of Riohacha and when they tried to nest there "the people ate the eggs and young." The second nesting site was El Portete, about 80 km east of Manaure. This is a large mangrove-fringed lagoon. Sr. Rosario had no recent knowledge of nesting there but this should be checked. It is a rarely visited area and could conceivably harbor nesting flamingos.

A brief description of the area frequented by the flamingos follows:

The land is very low lying. There is a sandy beach ridge covered with low vegetation, backed with a higher stand of black mangrove (*Avicennia germinans*) and red mangrove (*Rhizophora mangle*) in a shallow depression. The immediate foreshore is a narrow, muddy-sandy beach covered in spots by salt wort (*Batis maritima*). Offshore there is a shallow (1 meter or less) shelf some 40 to 60 meters wide, covered by beds of turtle grass (*Thalassia*) and shoalweed (*Diplanthera*) along with other components unfamiliar to me. The sea grass beds were interspersed with bare areas in which Sr. Rosario told us that the birds usually fed. A brief inspection of these areas was made. We could find few if any molluscs. The bottom was made up of an algal layer over a layer of black, highly organic mud. Rosario said that the flamingos fed by submerging the bill and walking slowly along. This is the method used on Inagua when feed-

FIG. 2 The Guajira Peninsula, Colombia, showing localities of importance to flamingos.



ing on algal mats. It is possible that they utilize the algae and organic mud here.

The shoreline where the birds are usually found is protected from the prevailing easterly winds by a slight northward bulge just to the east. It shows no sign of active wave action, in fact quite the contrary. It must be very seldom that waves of any magnitude affect it.

On the morning of 28 June, as we were leaving the area, we saw a group of flamingos feeding in one of the evaporators of the salt works. There was no opportunity to investigate that particular evaporator to see what they were using but the salinity was between 65 and 75 p.p.t. I did look in several of the evaporators for the chrysalids of *Ephydra* and they were present in small numbers. There seemed to be a lack of rocks and other objects on the bottom of the evaporators to provide an attachment for the chrysalids. There was also a lack of a well developed algal mat in the evaporators. This may build up with time as the evaporators remain submerged.

#### Other Birds

There were large numbers of other birds using the area of the salt company works. Several of these might be worthy of mention, at least in passing.

Brown pelicans (*Pelecanus occidentalis*) were common all along the coast from west of Baranquilla to and including the area around Manaure. They fed in the sea and also joined feeding groups of fish-eating birds in some of the evaporators.

In the same area frequented by the flamingos there was a grove of mangroves called "Musiche" which, accor-

ding to local information, has been utilized for breeding by a variety of birds for years. It was not an active colony during our visit but had been very recently. Some late breeding was either still in progress or just over. Neotropic cormorants (*Phalacrocorax olivaceus*) were common and their nests were still much in evidence. Snowy egrets (*Egretta thula*) and Louisiana herons (*Hydranassa tricolor*) were present in numbers as were roseate spoonbills (*Ajaia ajaja*). There were some 200 to 250 of the latter, including many young-of-the-year. White ibis (*Eudocimus alba*) were seen along with a single scarlet ibis (*Eudocimus ruber*). Eight to ten pairs of black-crowned night herons (*Nycticorax nycticorax*) gave evidence of nesting and a single yellow-crowned night heron (*Nyctanasa violacea*) was present.

One noteworthy observation was the presence of substantial numbers of reddish egrets (*Dichromanassa rufescens*) in the area; de Schauensee (1964) does not record this species for Colombia. These egrets were distributed in the salt works and the presence of several young birds — still bearing down feathers on the head — within the above mentioned colony, indicates almost certainly that they breed. It is of interest to note the proportion of the two color phases of this species in this area, 70 dark phase and 34 white phase were noted.

Wood storks (*Mycteria americana*) were also to be seen in the area including all age groups. Approximately 100 of these birds were present roosting in the mangroves and feeding in the small creeks and natural tidal ponds.

Very large numbers of waders and gulls and terns were to be seen throughout the salt works.

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Feeding Flamingos

Photo by Jan Rooth

## Notes on a visit to Chichiriviche (Venezuela)

by

B. DE BOER AND J. Rooth

Netherlands Antilles National Parks Foundation  
and

Research Institute for Nature Management, Holland

From 1 — 6 October 1975 a field trip was made to Chichiriviche.

The area in which the flamingos were found to reside takes up the biggest part (5.330 ha) of the Refugio de fauna silvestre de Cuare, en Chichiriviche (Estado Falcon). This area consists of a vast, shallow inner bay interspersed with small islands and mangrove stands. The seawater enters through a natural canal at the S.E. end of the bay. As it mingles with fresh water from the surrounding swamps it becomes more brackish. However, at the time the visit was made the rainy season had started already with abundant rainfall, so it is conceivable that in dry periods the water stays saltier. The bay is divided in a S.E. and a N.W. part by the road leading to Chichiriviche.

On arrival large flocks of flamingos were present at either side of the road. Counts made on the following days gave estimates from 3300 (counted on 3 October) to 4000 (5 October) individuals.

Observations made during the following days gave a rough picture of the activity pattern during day time. In the morning the flamingos were feeding, mostly in the S.E. part of the bay. This feeding continued until about 10 o'clock when most of the flamingos were resting. We gathered that for this resting they might go over to the far N.W. side of the bay, on the other

side of the road. However, in this part of the bay some feeding was also observed. Late in the afternoon the flamingos started feeding again, which at least in one observed case again involved migration to the S.E. part of the bay. Display activities occurred at times, sometimes involving a considerable part of the group (some hundreds). This is a promising sign for the coming breeding season.

On investigating which food the flamingos would take in this area it was found that the bottom on the bay consisted for the largest part of clay covered with a layer of organic mud. There was a small seagrass, (*Ruppia spec.*) growing on this substrate. Some small species of Crustacea lived in the S. E. part of the bay but was not found yet in the N.W. part. Nearer to the inlet a small snail (*Batillaria minima*) proved to be abundant in very shallow water.

All the organisms mentioned here and the organic mud could be a possible food source for the flamingos. It remains to be investigated which of these are really being used.

In the future monthly trips will be made to this area.

It will be investigated how many flamingos use this area for feeding and how big the migration of flamingos from Bonaire will be, especially in the breeding season. In order to establish which food the flamingos use and how

abundant this food is, samples will be taken on different points in the bay and observations will be made in which places the flamingos tend to feed most. Observations on behaviour will be made.

The same program will be carried out in Bonaire and the results of the two areas will be compared. In this way we hope to gain a better understanding of the feeding biology of this colony of flamingos.



photo by Bart de Boer

## Discussion on Flamingo problems

chaired by

INGVAR KRISTENSEN

Member of the Bonaire Flamingo  
Sanctuary Committee

The question was put: "Why, in the last century, have so many flamingo colonies disappeared?" The reason seems to be that part of the habitat has been changed by human interference, and that the breeding colonies have been disturbed not only by men but also by introduced animals: cats, dogs, pigs etc.

What has to be done to protect the still existing colonies? Mr. R. A. Clement pleads for re-assessment of the total number of flamingoes in the Caribbean.

The Yucatan colony seems to be threatened by touristic development. Although the Mexican Government is making great efforts to integrate the planning of industry, agriculture, social development (family planning included), recreation, tourism, parks and conservation — the natural isolation of the flamingo breeding sites will disappear and unless effective measures are taken, this will affect the necessary tranquillity in the colony.

According to Mr. Sprunt and Mr. Rooth, the breeding colony of Great Inagua seems to be protected best of all.

Protection of the breeding colony of Bonaire is excellent, but the feeding areas are endangered, especially by industrial development (salt, oil, radio installations, etc.) Part of the feeding grounds are near Chichiriviche (Venezuela). That area has got official pro-

tection but the protection has to be made more effective. Prof. E. Mondolfi proposes an evaluation. The matter should be promoted by the CCA, the Audubon Society, FUDEMA and IUCN together.

What is the economic importance of the Bonaire flamingo colony?

In general, Mr. Rooth states, it is difficult to evaluate the importance of flamingoes, just like evaluating the importance of a gothic cathedral. However, the flamingoes are the trade mark of Bonaire, as Mr. Booi remarked. The flamingoes form a touristic attraction; but, as we have calculated, the income from "flamingo-tourism" does not equal the income from industry. However, the flamingoes increase the attractiveness of Bonaire as a tourist island.

What is the effect of air traffic near the flamingo sites?

Planes crossing the feeding area cause temporary disturbance but the flamingoes will return soon or even immediately after the plane has disappeared.

In the breeding season, however, any disturbance on the breeding sites can be disastrous: the birds disappear and do not return in weeks, months or even years which results in the death of chick and of eggs that will not hatch. Planes crossing the breeding sites are worst of all. Mr. Rooth thinks that

the profile of a plane may frighten the flamingoes as it resembles that of a bird of prey. If that is the case, Lorenzo Giuliani Jr. asked, do the flamingoes behave in the same way if a (noiseless) glider crosses the colony?

Would it be possible to establish new colonies?

Every time flamingoes start breeding outside the few wellknown breeding areas one hopes that this could be the start of new breeding centre.

Bonaire flamingoes started breeding in the northern part of the island, in Lake Goto and in Slagbaai, and with some success too, but this breeding is not continued every year. Besides the breeding efforts of the Bonaire colony in the Colombian part of the Guajira Peninsula, as mentioned by Mr. Sprunt, breeding efforts have been observed in the eastern part of Venezuela, in Laguna Unare, a well-known feeding area, but although nests have been built, nesting has never been successful. (Probably disturbed by poachers).

Since breeding on Great Inagua and on Bonaire has been so successful in recent years, why shouldn't we catch a flock of juveniles and ship them to a really suitable place in the Caribbean to form a new colony? Most of the requests that came in, however, are from zoos or parks that like to purchase flamingoes. The Bonaire Sanctuary Board would never sell. Moreover, no flamingoes should be caught to be kept in captivity — only birds with broken wings after flying against wire etc. can be sent to zoos and parks.

In fenced-in areas even small groups of flamingoes (30 specimens e.g.) may

start breeding. Under natural conditions, however, a breeding group should consist of at least 400 birds. A possible new breeding site should meet the following conditions:

Mud available of the right consistency, for building nests.

Rather stable water level (no flooding of the nests).

Briny areas seem to be most suited, but less briny water (seawater, brackish or freshwater) should be nearby as the juveniles must have drinking water within walking distance.

A sufficient amount of food should be nearby, and if the area is limited, complementary feeding areas should be protected effectively against intruders like cats, dogs and humans (biologists included), and against planes crossing nearby.

In Guadeloupe, e.g. there is an area that meets almost all the conditions mentioned here, however, with one exception: the area is rather limited, and there are no complementary feeding areas in the neighbourhood.

In the Caribbean, there seem to be only two areas that could house a new breeding colony: one is Haiti — but it may be very difficult to protect the colony against poaching. The other possibility is the Dominican Republic. Mr. Sprunt and Mr. Rooth will consider this matter together with Rev. D. Dod, naturalist from Sto. Domingo, about the possibilities there, including the necessary support in all respects from the Government. If a prosperous new colony could be established it would be of extreme importance to the survival of the still vulnerable Caribbean flamingo population.

Abstract

## Toxic effects of crude oils and dispersant to the Stony Coral, *MADRACIS MIRABILIS*.

by  
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 and  
**H. A. M. DE KRUIJF**  
 Caribbean Marine Biological Institute  
 Curaçao.

Curaçao is surrounded by fine fringing reefs, and lies within a zone of very heavy oil tanker traffic. Little is known about the toxic effect of oils and detergents on stony corals. The toxic effect of Nigerian crude oil, For-

cados crude oil, Tia Juana Pesado crude oil, Forcados long residue, Shell Dispersant LTX, and mixtures of oils and dispersant to the abundant stony coral *Madracis mirabilis* were studied (Table 1, and Fig. 1)

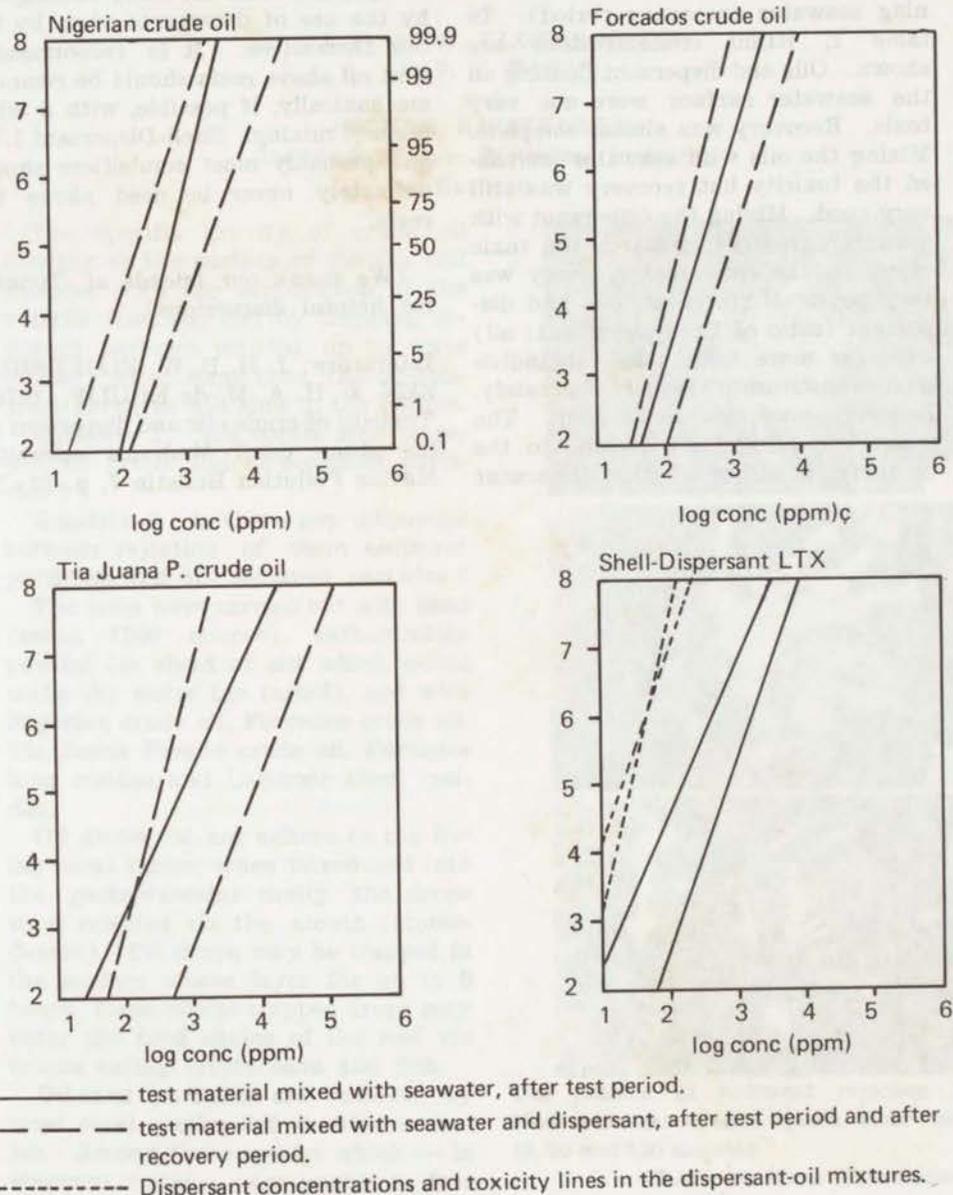
TABLE I

The RD<sub>50</sub> and LD<sub>50</sub> concentrations (in ppm) of various crude oils and Shell-dispersant LTX for the stony coral *Madracis mirabilis*. The RD<sub>50</sub> concentrations are the 50 response doses after the test period, the LD<sub>50</sub> concentrations are the 50 mortality doses after an additional 24 hours of recovery in running seawater. The figures between brackets in the last column are the RD<sub>50</sub> and LD<sub>50</sub> concentrations of Dispersant in the oil-dispersant-seawater mixtures.

|                            | without Dispersant |                  | with Dispersant  |                  |                  |                  |
|----------------------------|--------------------|------------------|------------------|------------------|------------------|------------------|
|                            | on surface         |                  | mixed            |                  | mixed            |                  |
|                            | RD <sub>50</sub>   | LD <sub>50</sub> | RD <sub>50</sub> | LD <sub>50</sub> | RD <sub>50</sub> | LD <sub>50</sub> |
| Nigerian crude oil         | 2309               | <10 <sup>5</sup> | 602              | <10 <sup>5</sup> | 232<br>(23)      | 1824<br>(182)    |
| Forcados crude oil         | 1939               | <10 <sup>5</sup> | 696              | <10 <sup>5</sup> | 304<br>(30)      | 2025<br>(202)    |
| Forcados long residue      | 6406               | <10 <sup>5</sup> | 2162             | 54070            | -                | -                |
| Tia Juana Pesado crude oil | 3342               | <10 <sup>5</sup> | 540              | 63720            | 342<br>(34)      | 7264<br>(726)    |
| Shell-Dispersant LTX       | <10 <sup>5</sup>   | 38550            | 162              | 700              | -                | -                |

LITERATURE: J. H. B. W. ELGERSHUIZEN & H. A. M. DE KRUIJF, 1976: Toxicity of crude oils and dispersant on the stony coral *Madracis mirabilis*. *Marine Pollution Bulletin* 7, p.

FIG. 1. Toxicity of some crude oils mixed with seawater after the test period, to *Madracis mirabilis*, and of dispersant mixed with seawater, and of oil-dispersant mixtures (10 : 1) with seawater. The probits mean the probability that a certain percentage of the test series is dead. The steeper a line and the more it is to the left the more toxic a combination of substances is.



Twenty coral branches were exposed for 24 hours (test period) to each of the test-solutions. An additional 10 branches were exposed to seawater (control). During another 24 hours, corals were allowed to recover in running seawater (recovery period). In table 1, RD50 concentrations are shown. Oils and dispersant floating on the seawater surface were not very toxic. Recovery was almost complete. Mixing the oils with seawater increased the toxicity but recovery was still very good. Mixing the dispersant with seawater greatly increased the toxic effect on the coral and recovery was very poor. Mixtures of oils and dispersant (ratio of 1:10, dispersant: oil) were far more toxic than the individual constituents tested separately. Recovery was also quite poor. The synergetic effect may be due to the emulsifying effect of the dispersant

causing more toxic water soluble fraction (WSF) of oil to dissolve in water and to the combined effect of the cell-wall attacking dispersant and the WSF. We conclude that in case of a major oil spill the reefs are more endangered by the use of detergents than by the oils themselves. It is recommended that oil above reefs should be removed mechanically, if possible, with a minimum of mixing. Shell-Dispersant LTX and probably most emulsifiers should definitely never be used above the reefs.

(We thank our friends at Carmabi for helpful discussions).

Literature: J. H. B. W. ELGERSHUIZEN & H. A. M. de KRUIJF, 1976: Toxicity of crude oils and dispersant on the stony coral *Madracis mirabilis*. Marine Pollution Bulletin 7, p. 22 - 25.

Abstract

## Oil sediment removal in Corals

by  
 J. H. B. W. ELGERSHUIZEN,  
 R. P. M. BAK  
 and  
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The specific gravity of crude oil floating at the surface of the sea will increase with the evaporation of the volatile fraction, and by trapping sediment particles whirled up by wave action. After some time, the oil-sediment particles will sink to the bottom.

Question 1: are corals able to reject oil drops and oil-sediment particles?

Question 2: is there any difference between rejection of clean sediment particles, and oil-sediment particles?

The tests were carried out with sand (mean 1200 micron), carborundum powder (in stead of silt which would make the water too turbid), and with Nigerian crude oil, Forcados crude oil, Tia Juana Pesado crude oil, Forcados long residue and Lagomar short residue.

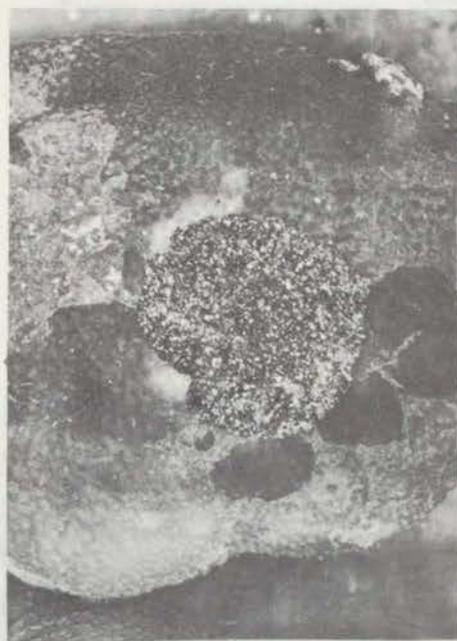
Oil drops did not adhere to the living coral tissue; when introduced into the gastrovascular cavity the drops were rejected via the mouth (stomodaeum). Oil drops may be trapped in the surface mucus layer for up to 5 hours; these mucus-trapped drops may enter the food chains of the reef via mucus eating crustaceans and fish.

Oil-sand particles are removed by most coral species but at different rates. Among those species which — in stagnant water — are unable to free



The pattern of sediment rejection in *Meandrina meandrites* shown after resp. 10, 50 and 120 minutes.

Photos by Hans Elgershuizen



A. *Porites astreoides* fails to reject a mixture of 0.75 g. sand and 1 cc Forcados long residue. B. The underlying dead parts of the colony after removal of the patch 48 hours later.

Photos by Hans Elgershuizen

themselves from any particles, are *Acropora palmata*, *Acropora cervicornis* and *Porites astreoides* (in their natural habitat, wave action may take over). Also *Agaricia agaricites* sometimes has problems, although to a lesser extent: small particles trapped in mucus are not always removed. Some species — *Montastrea annularis*, *Dichocoenia stokesii* and *Mycetophyllia aliciae* show lethal effects if they do not succeed to get rid of the oil-sand particles within 24 hours, especially if low viscosity oils are involved.

In general, corals are able to free themselves from oil-sand particles in exactly the same way as they remove or reject sand or silt. Important in

this respect are:

1. the shape of the colony (branched, flat, hemispherical, etc);
2. the surface of the colony: flat (cerioid), bumpy (plocoid) or with grooves (meandroid);
3. the polyps: their morphology, their size, activity, etc.

Moreover, wave action and currents may be of great importance, and also the action undertaken by the corals themselves: movements of the expanded polyps, ciliar movement, mucus secretion and removal of the mucus layer.

Literature : R. P. M. BAK & J. H. W. ELGERSHUIZEN, 1976 : Patterns of oil sediment rejection in corals. *Marine Biology* 1976, 9 pp (in press).

Kinematic viscosity (cSt)  $\Delta$  specific gravity (15.6°C)  
(30°C)

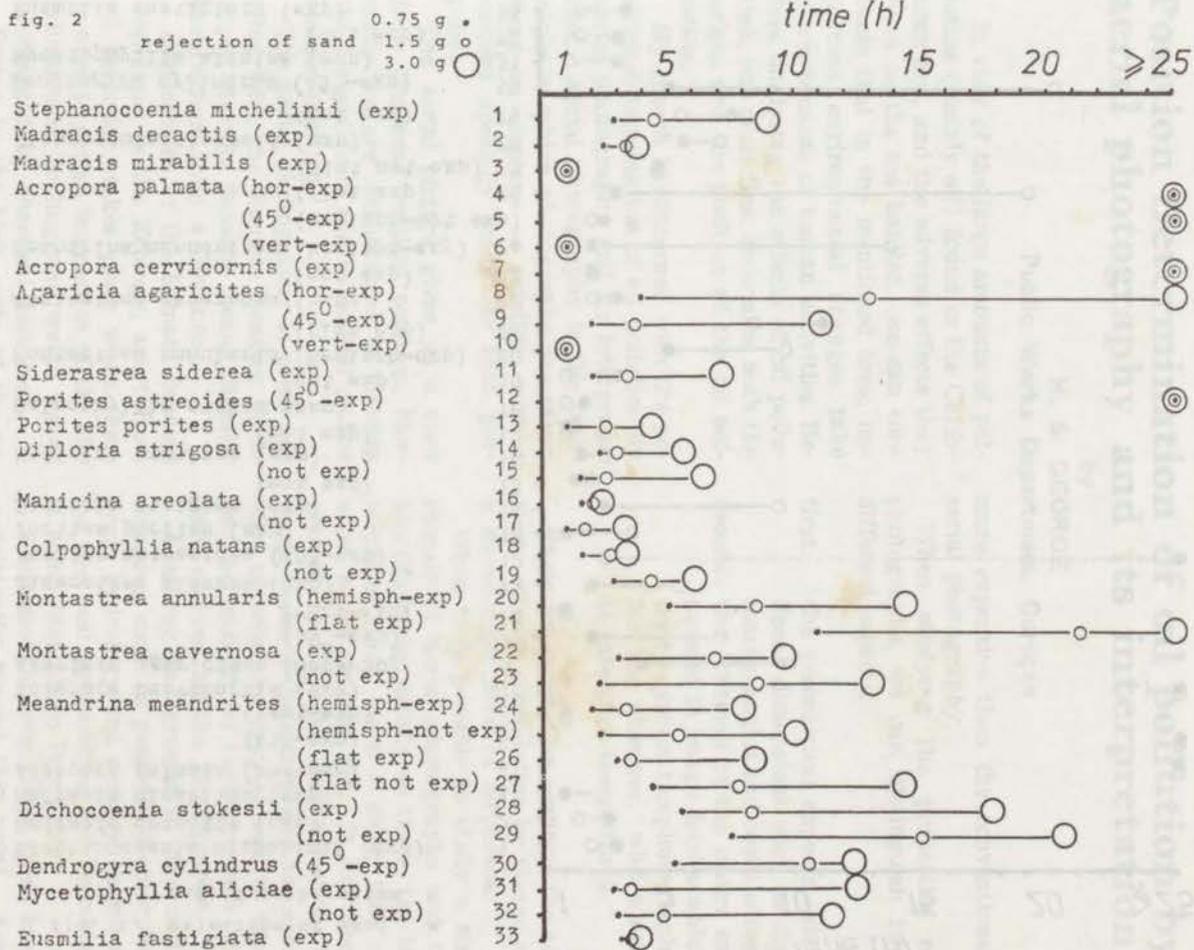
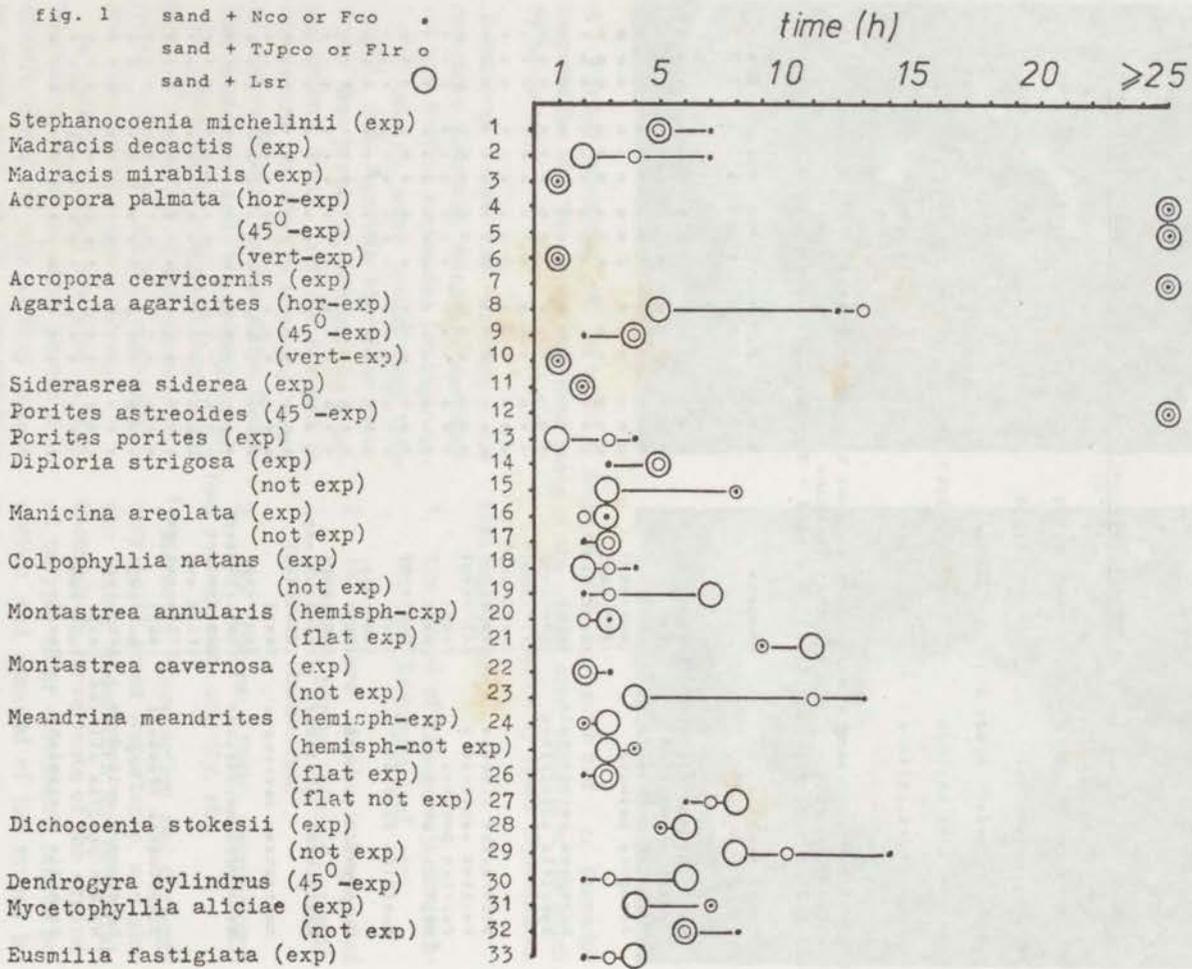
|                            |             |       |
|----------------------------|-------------|-------|
| Nigerian crude oil         | 5,734       | 0,871 |
| Forcados crude oil         | 7,230       | 0,871 |
| Tia Juana pesado crude oil | 4066,--     | 0,985 |
| Forcados long residue      | 4000 - 5000 | 0,940 |
| Lagomar short residue      | 15.000,--   | 1,014 |

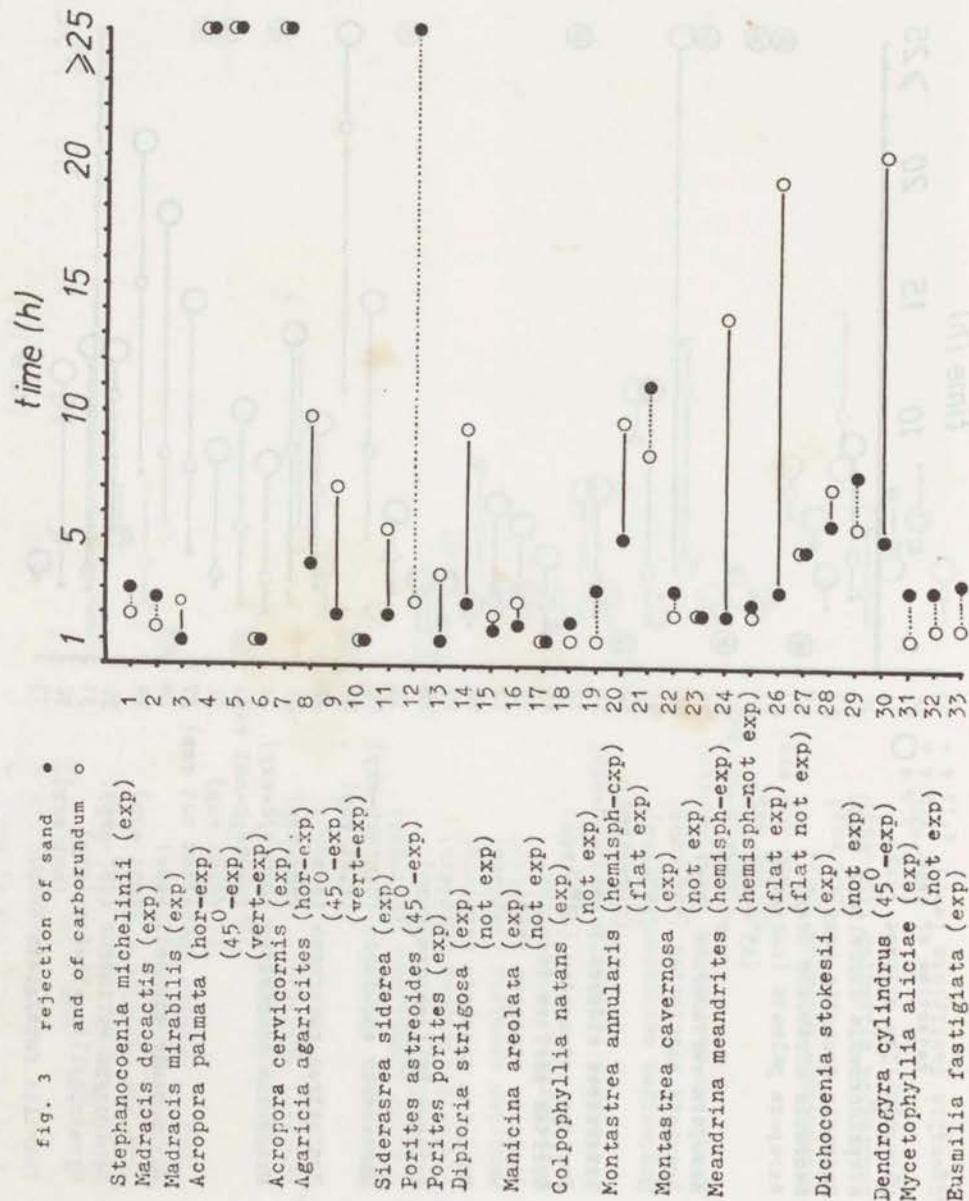
Rejection of oil-sand combinations in some hermatypic corals

+ within 24 hours o not within 24 hours

(1) 0.75 g sand + 1 cc oil, (2) 2 g sand + 2 cc oil, (3) 4 gr sand + 3 cc oil

| Coral species                             | Remarks | N.c.o. |   |   | F.c.o. |   |   | TJPCo |   |   | F.l.r. |   |   | L.s.r. |   |   |
|---|---------|--------|---|---|--------|---|---|-------|---|---|--------|---|---|--------|---|---|
|   |         | 1      | 2 | 3 | 1      | 2 | 3 | 1     | 2 | 3 | 1      | 2 | 3 | 1      | 2 | 3 |
| <i>Stephanocoenia michelini</i> (exp)     |         | +      | + | + | +      | + | + | +     | + | + | +      | + | + | +      | + | + |
| <i>Madracis dedactis</i> (exp)            |         | +      | + | + | +      | + | + | +     | + | + | +      | + | + | +      | + | + |
| <i>Madracis mirabilis</i> (exp)           |         | +      | + | + | +      | + | + | +     | + | + | +      | + | + | +      | + | + |
| <i>Acropora palmata</i> (hor-exp)         |         | o      | o | o | o      | o | o | o     | o | o | o      | o | o | o      | o | o |
| (45°-exp)                                 |         | o      | o | o | o      | o | o | o     | o | o | o      | o | o | o      | o | o |
| (vert-exp)                                |         | +      | + | + | +      | + | + | +     | + | + | +      | + | + | +      | + | + |
| <i>Acropora cervicornis</i> (exp)         |         | o      | o | o | o      | o | o | o     | o | o | o      | o | o | o      | o | o |
| <i>Agaricia agaricites</i> (hor-exp)      |         | +      | o | o | +      | o | o | +     | o | o | +      | o | o | +      | o | o |
| (45°-exp)                                 |         | +      | o | o | +      | o | o | +     | o | o | +      | o | o | +      | o | o |
| (vert-exp)                                |         | +      | + | + | +      | + | + | +     | + | + | +      | + | + | +      | + | + |
| <i>Siderastre siderea</i> (exp)           |         | +      | + | + | +      | + | + | +     | + | + | +      | + | + | +      | + | + |
| <i>Porites astreoides</i> (45°-exp)       |         | o      | o | o | o      | o | o | o     | o | o | o      | o | o | o      | o | o |
| <i>Porites porites</i> (exp)              |         | +      | + | + | +      | + | + | +     | + | + | +      | + | + | +      | + | + |
| <i>Diploria strigosa</i> (exp)            |         | +      | + | + | +      | + | + | +     | + | + | +      | + | + | +      | + | + |
| (not exp)                                 |         | +      | + | + | +      | + | + | +     | + | + | +      | + | + | +      | + | + |
| <i>Manicina areolata</i> (exp)            |         | +      | + | + | +      | + | + | +     | + | + | +      | + | + | +      | + | + |
| (not-exp)                                 |         | +      | + | + | +      | + | + | +     | + | + | +      | + | + | +      | + | + |
| <i>Colpophyllia natans</i> (exp)          |         | +      | + | + | +      | + | + | +     | + | + | +      | + | + | +      | + | + |
| (not-exp)                                 |         | +      | + | + | +      | + | + | +     | + | + | +      | + | + | +      | + | + |
| <i>Montastrea annularis</i> (hemisph-exp) |         | +      | + | + | +      | + | + | +     | + | + | +      | + | + | +      | + | + |
| (flat-exp)                                |         | +      | o | o | +      | o | o | +     | o | o | +      | o | o | +      | o | o |
| <i>Montastrea cavernosa</i> (exp)         |         | +      | + | + | +      | + | + | +     | + | + | +      | + | + | +      | + | + |
| (not-exp)                                 |         | +      | + | + | +      | + | + | +     | + | + | +      | + | + | +      | + | + |
| <i>Meandrina meandrites</i> (hemisph-exp) |         | +      | + | + | +      | + | + | +     | + | + | +      | + | + | +      | + | + |
| hemisph-not exp)                          |         | +      | + | + | +      | + | + | +     | + | + | +      | + | + | +      | + | + |
| (flat exp)                                |         | +      | + | + | +      | + | + | +     | + | + | +      | + | + | +      | + | + |
| (flat-not exp)                            |         | +      | + | + | +      | + | + | +     | + | + | +      | + | + | +      | + | + |
| <i>Dichocoenia stokesii</i> (exp)         |         | +      | o | o | +      | o | o | +     | o | o | +      | o | o | +      | o | o |
| (not exp)                                 |         | +      | o | o | +      | o | o | +     | o | o | +      | o | o | +      | o | o |
| <i>Dendrogyra cylindrus</i> (45°-exp)     |         | +      | + | + | +      | + | + | +     | + | + | +      | + | + | +      | + | + |
| <i>Mycetophyllia aliciae</i> (exp)        |         | +      | o | o | +      | o | o | +     | o | o | +      | o | o | +      | o | o |
| (not exp)                                 |         | +      | o | o | +      | o | o | +     | o | o | +      | o | o | +      | o | o |
| <i>Eusmilia fastigiata</i> (exp)          |         | +      | + | + | +      | + | + | +     | + | + | +      | + | + | +      | + | + |





## Position Determination of oil pollution by aerial photography and its interpretation.

by  
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 Public Works Department, Curaçao

In view of the large amounts of pollution (mainly oil) found in the Caribbean Sea, and the adverse effects they have on the sea habitat, one can conclude that in the mentioned area, important environmental changes take place, because of human activities. Before analysing the effects of oil pollution, one must first determine both the origin and the position of the oil pollution.

My speech is concerned with the position-determination of oil pollution by aerial photography and its interpretation. Aerial photography is the technique in which photographs are taken from an airplane or satellite, with a camera specially made for that purpose.

The aerial picture gives us a view from the near vertical position. Normally we are accustomed to viewing the terrain from the horizontal or low oblique position.

The aerial photography is often applied with the Remote Sensing Technique. Remote Sensing means literally observation from a distance.

Applications of the Remote Sensing Technique in the Ecology, apart from oil detection, takes place when there is need to get an impression of the distribution of cooling and waste water, discharged by chemical factories.

Owing to the high costs of the registration and navigation reference system, needed to record the airplane data, the Remote Sensing technique is

more expensive than the conventional aerial photography.

When studying the properties of photographs, we can distinguish two different aspects.

- first: the geometrical aspects using linear dimensions such as distances, angles and coordinates;  
 second: the contents of the image expressed in image details which try to express the photographs for the observer, who wants to interpret the pictures.

Photo-interpretation assumes the activity of data compilation by means of a stereoscopic view of airphotos.

While it is possible to study a stereopair of aerial photographs and to identify many details on these, the interpreter must have a clear idea of what he is looking for. It has been proved that photo interpretation is much easier if the interpreter has some idea of what he may expect to find, and he should be familiar with the area covered by the photographs.

A strong background in the earth sciences, such as geology, geomorphology, hydrology and ecology, seems to be the best preparation for becoming a competent photo interpreter.

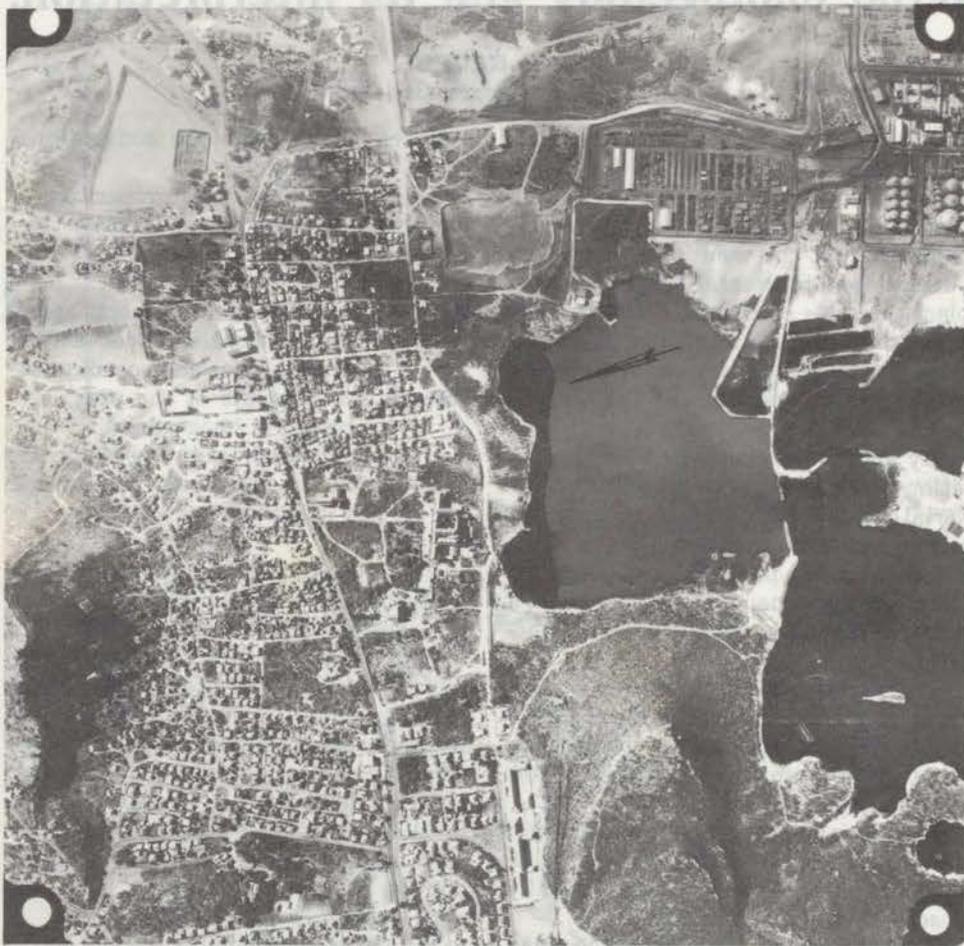
Professionals from these areas have consistently proved this point. Another well-equipped group consists of landplanners and other professionals who have wide experience in mapping

land resources, identifying them in the field, and interpreting their capabilities for land use.

Many interpretation techniques are possible with panchromatic black and

white photographs. Black and white film has proven to be the most versatile film for interpretative purposes and is the most widely used.

On black and white film all features



This black and white photograph, taken in 1957, illustrates an oil slick in the northwest area of Schottegat. In that time no measures were taken to prevent oil pollution. For the identification of oil pollution, the photographs should be examined and analysed with respect to the photographic tone. In general the tone of an object will depend on how much light is reflected. The more light is reflected, the lighter the tone on the photograph. Therefore oil spills are darker than surrounding waters (on black and white photographs).

On infrared black and white photographs, oil spills are lighter than surrounding waters.

will be recognized on the photograph by tones ranging from dark to light.

When an area is subject to air pollution, Infrared-Black and white photography can be used. The film has the ability to penetrate haze.

Normally seven main characteristics can be recognized on the photo and utilised for interpretation. These are tone, shadow, texture, pattern, shape,

size and situation. For the identification of oil pollution the photographs should be examined and analysed with respect to the photographic tone.

In general the tone of a particular object will depend on how much light is reflected from it into the camera.

The more light is reflected, the lighter the tone of the photograph.



Infrared black and white photograph, showing oil spills in the western part of Schottegat (1975). When an area is subject to air pollution, infrared black and white photography can be used. The film has the ability to penetrate haze.

Therefore oil slicks are darker than the surrounding water.

Water surfaces usually have a fairly dark tone.

In spite of this, similar water surfaces can vary considerably dependent on sun position, waves, depth and clarity of the water.

It is quite possible to have similar features appearing on one photograph in completely different tones. Nevertheless, the photographic tone is im-

portant for identification of oil pollution.

Photographic tone and pattern are of great importance for the interpretation of coral reefs. Dark areas outlined by white margins are vegetation covered coral islands.

The outer margin of the reef is commonly marked by a white line of breaking surf, and the reef itself stands in strong contrast to the surrounding water. The shallow water of the lagoon



Oil spills from vessels, at the Brionwharf, in the eastern part of Schottegat (1975).

appears only slightly less dark than the reef. When the aerial photographic interpretation, with respect to detection of oil pollution is reliable, the position of oil slicks can be fixed on the photographs. After this, it is possible to make a planning where oil catchers must be located. By interpretation of aerial photographs, taken at different periods under varying wind conditions, it is possible to determine in what direction the oil slicks go, and where the oil will accumulate.

By means of a stereoscopic view of air photographs, the movement and size of an oil slick can be charted.

With two or more runs of photographs, it may be proved that an area, formerly polluted with oil, has become pollution free, assuming that no efforts are made to make the oil sink to the bottom of the sea.

There are other methods to detect oil pollution, nevertheless the use of aerial photographs has the advantage, that apart from oil pollution, also other

information, essential for further environmental analysis and measures, can be obtained.

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## La Contaminación del Ambiente Marino por los Hidrocarburos

por

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Los mares son objeto de muchos tipos de contaminación originada por factores muy diversos. El petróleo es uno de ellos. En este artículo se menciona brevemente las varias fuentes de contaminación, por petróleo.

### Cloacas :

Los mares, ríos y lagos de todo el mundo están recibiendo permanentemente una gran variedad de residuos domésticos e industriales mezclados en las aguas negras no purificadas o solo parcialmente tratadas.

### Descargas Industriales :

Grandes cantidades de escombros y otros desechos se vierten en las aguas cercanas a las costas de muchos países.

### Insecticidas/Fertilizantes :

Muchos ríos y lagos han sufrido grandes cambios ambientales como resultado del manejo equivocado (sobre todo en la aplicación excesiva) de fertilizantes e insecticidas.

### Contaminación Termal :

Muchas industrias requieren agua para el procedimiento de enfriamiento causando daño ecológico por el cambio de la temperatura del agua.

### Petróleo :

Para un mejor entendimiento del problema, se han clasificado las diferentes

fuentes de la contaminación. (Véase cuadro No. 1 anexo).

### Tanqueros :

Obviamente gran parte de los derrames está directamente relacionado a las operaciones de la industria petrolera. La industria está muy consciente de éste problema y comparte la general preocupación por el posible deterioro ecológico que el petróleo derramado podría causar a la larga, y los daños inmediatos causados por los derrames masivos producidos por accidentes. El petróleo derramado como consecuencia de las operaciones normales de los tanqueros se ha podido reducir mediante la utilización del sistema "Load on Top" ("Carga Encima") aplicado mundialmente en forma voluntaria por la gran mayoría de los operadores de tanqueros.

El procedimiento del sistema "Load on Top" (LOT) es el siguiente: Al haber descargado una parte (menos del 1%) de la carga del tanquero queda adherida a las paredes y en el fondo de las cisternas. Este petróleo se mezcla con el agua de lastre que el tanquero vacío necesita para poder regresar al próximo puerto de carga.

Esta mezcla de agua y petróleo en las cisternas de lastre siempre fué vertida al mar antes de tomar el próximo cargamento. Ahora bien, con el sistema de LOT se separa el petróleo del agua y se bombea a un tanque especial.

El cargamento próximo está cargado encima; es decir los residuos de la carga anterior forman parte de la nueva carga en vez de ser echados al mar. Obviamente el volúmen total así no vertido al mar es enorme. (Teóricamente digamos 0,5% del crudo transportado por tanqueros, o sea 8 millones de toneladas al año).

Los derrames de las sentinas pueden ser reducidas con mejores procedimientos operacionales. Esto es el caso de accidente en alta mar así como el de los puertos ó terminales los cuales en casi todos los casos se deben a errores humanos; es igual para los tanqueros que para los demás barcos.

### Producción/Refinación :

La tecnología mejorada contribuye en mucho a la reducción de los derrames. Programas de entrenamiento en todas las ramas de la industria están diseñados para crear conciencia al personal operador.

### Aceites Usados :

Realmente poco se sabe del destino final de las muchas toneladas de aceites lubricantes desechados, sobre todo de los lubricantes automotores. Se sabe que muchísimo terminará en el mar, directamente o por las alcantarillas y los ríos. Solamente se acabará con ésto por la implantación de leyes y reglamentos, es decir por acción de parte de las autoridades.

### Legislación Internacional :

El problema de la contaminación de los mares por petróleo solamente puede ser solucionado por cooperación internacional de los Gobiernos. La entidad internacional de las Naciones Unidas, llamada "Organización Consultativa Marítima Inter-Gubernamental" (IMCO) ha recomendado y aceptado varios

convenios para prevenir la contaminación de las aguas del mar. Los puntos más importantes de los Convenios principales están sumarizados en el cuadro No. 2.

Los países marítimos más importantes pertenecen al grupo que formó el Convenio de 1954 y que limita la descarga de petróleo en las aguas dentro de 50 millas de las costas. (En las aguas territoriales obviamente lo prohíbe la legislación nacional de cada país). Sin embargo las enmiendas del año 1969 que limitan y prácticamente eliminarían las descargas en alta mar más allá de las 50 millas, todavía no han sido aceptadas por un número suficiente de Gobiernos para poder ser implantados mundialmente. Faltan todavía países marítimos como Grecia, Panamá, Italia y Holanda y todos los países del Caribe (cuadro 3).

México, la República Dominicana, Panamá y Venezuela son los países del Caribe que firmaron el Convenio de 1.954; sin embargo no ratificaron las enmiendas de 1.969.

El Convenio de 1973 teóricamente acabaría con las descargas operacionales, sin embargo, aparte de los problemas políticos y legales que se vieron tan claramente en la tercera Conferencia de las Naciones Unidas sobre Derechos del Mar, que se llevó a cabo en Caracas el año pasado, hay también varios problemas que actualmente cualquiera tienen solución técnica. Por lo tanto la meta inmediata de todos los gobiernos debería ser la ratificación de las Enmiendas de 1969. Sería un buen paso adelante en la lucha contra la contaminación marina con grandes posibilidades de lograrlo en un tiempo relativamente corto, lo que seguramente no es el caso con el Convenio de 1.973.

### Flota Mundial de Tanqueros :

Para un mejor entendimiento del problema internacional y su solución, damos un cuadro de los principales países marítimos especificando el porcentaje del tonelaje de los tanqueros de cada uno (cuadro 4).

### Movimiento de Tanquero :

Las rutas principales de los tanqueros emanan en el Medio Oriente (77% del total transportado). Sin embargo, el Caribe ya está en el segundo lugar con un 10%, y éste volúmen aumentará con los grandes terminales de transferencia requeridos para satisfacer la creciente demanda de petróleo importado en los Estados Unidos.

### Protección contra derrames accidentales :

El número creciente de tanqueros en el Caribe aumenta el riesgo de accidentes que podrían causar derrames masivos. Para una mejor protección y preparación de modo de combatirlos, las Compañías Petroleras que operan en el área del Caribe se han organizado con el fin de ayudarse mutuamente. Equipos para contener, recoger y dispersar petróleo derramado han sido colocados en puntos estratégicos y personal está siendo adiestrado para manejarlo. Las compañías invierten grandes sumas de dinero para desarrollar equipos adecuados y dispersantes ecológicamente aceptables.

TABLE 1

### OIL DISCHARGED INTO THE OCEANS (TONS / YEAR)

| Tankers              |                 | Other vessels        |                 |
|----------------------|-----------------|----------------------|-----------------|
| Operations           | 800.000         | Operations           | 250.000         |
| Accidents            | 200.000         | Accidents            | 150.000         |
|                      | <hr/> 1.000.000 |                      | <hr/> 400.000   |
| Other Oil Industry   |                 | Land Based           |                 |
| Off-shore production | 100.000         | Used automotive oils | 750.000         |
| Refinery effluents   | 250.000         | Used industrial oils | 250.000         |
|                      | <hr/> 350.000   |                      | <hr/> 1.000.000 |

TABLE 2

### IMCO CONVENTIONS: LIMITATION OF DISCHARGES BY TANKERS

|  | 1954 Convention                 | 1954 Convention +<br>1969 Amendments  | 1973 Convention  |
|--|---------------------------------|---|--|
| Definition of oil:                             | Black oils                      | Idem  | Black and white oils Everywhere  |
| Discharges prohibited:                         | Within 50 miles of land         | Idem  | No visible traces, unless established by instruments that discharge < 15 ppm.  |
| Discharge criteria within prohibited zone:     | Prohibited in excess of 100 ppm | Idem  | 1. Idem  |
| Discharge criteria outside of prohibited zone: | No restrictions                 | 1. tanker proceeding on route   | 2. Idem  |
|  |                                 | 2. discharge > 60 lts/mile prohibited   | 3. Idem, but > 1/30.000 for new tankers prohibited.  |
|  |                                 | 3. total quantity discharged > 1/15.000 of total cargo carrying capacity prohibited |  |
| Construction requirements:                     | —                               | —   | 1. Segregated ballast for tankers > 70.000 tons<br>2. L.O.T. mandatory<br>3. Mandatory monitoring and control systems. |

TABLE 3

INTERNATIONAL CONVENTION FOR THE PREVENTION OF POLLUTION OF THE SEA BY OIL — 1954

Situation in 1975

|             |             |              |                       |              |
|-------------|-------------|--------------|-----------------------|--------------|
| Algeria     | France ✓    | Japan ✓      | Netherlands (N. Ant.) | Spain        |
| Australia ✓ | Germany (W) | Jordan       | New Zealand           | Sweden ✓     |
| Belgium ✓   | Ghana       | Kuwait       | Nigeria               | Switzerland  |
| Canada ✓    | Greece ←    | Lebanon ✓    | Norway                | Syria        |
| Yemen       | Iceland ✓   | Liberia ✓    | Panama ←              | Tunisia ✓    |
| Denmark ✓   | India ✓     | Libya        | Philippines ✓         | USSR ✓       |
| Dom. Rep.   | Ireland     | Madagascar ✓ | Poland                | UK ✓         |
| Egypt ✓     | Israel      | Mexico       | Portugal              | USA ✓        |
| Fiji ✓      | Italy ←     | Monaco       | Saudi Ar. ✓           | Venezuela    |
| Finland ✓   | Ivory C.    | Morocco      | Senegal               | Yugoslavia ✓ |

✓ : 1969 amendments accepted = 23 (needed for entry into force: 34)  
 (Japan, Sweden, UK: implemented through national legislation).

TABLE 4  
 FLOTA MUNDIAL POR PABELLON ( TONELAJE )

|                         | TANQUEROS | TOTAL |
|-------------------------|-----------|-------|
| Liberia                 | 29%       | 17%   |
| Japón                   | 11%       | 13%   |
| Gran Bretaña            | 13%       | 10%   |
| Noruega                 | 9%        | 8%    |
| Grecia                  | 6%        | 7%    |
| USSR                    | 3%        | 6%    |
| USA                     | 4%        | 5%    |
| Panamá                  | 3%        | 3%    |
| Francia                 | 5%        | 3%    |
| Italia                  |           | 3%    |
| Otros Europa Occidental | 12%       |       |
| Otros                   | 5%        | 25%   |
|                         | 100%      | 100%  |

Abstract

## Marine Pollution by Oil

by

LORENZO T. GIULINI

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Of the estimated round 3 million tons of oil which each year end up in the oceans, about one third is due to tanker operations (see table 1).

Of these 1 million tons about 80% are operational discharge (oil mixed in the ballast water) and about 20% are accidental spills.

The operational discharges have been limited to a great extent since the introduction, about 15 years ago, of the Load on Top System which is a common procedure voluntarily applied by the great majority of the world tanker operators. By this method oil washed from tanks is not discharged into the sea but is retained in a special slop tank on board the ship. The next oil cargo is located on top of the oil and water mixture, and both are discharged at the receiving terminal and worked up.

Present international legislation prohibits international discharges within 50 miles from the nearest land. However no worldwide agreement has been reached yet which would lead to a total ban of intentional discharges on the high seas (see table 2).

Acceptance of the 1969 amendments of the 1954 IMCO (Inter-governmental Maritime Consultation Organization) Convention which is presently in effect, would be an important step as it puts

limits to the total quantities that each tanker can discharge outside of the prohibited zones. Admittedly only the 1973 Convention provides a near satisfactory solution to the many problems (for instance it makes segregated ballast tanks for tankers greater than 70.000 tons mandatory, i.e. ballast water would stay oil free as it would be kept in a separate system). However, unfortunately there are still too many technological problems and legal or political snags to make acceptance and implementation possible (see table 3).

Accidental oil spills, small ones in harbours as well as the massive ones that result from maritime disasters are generally the results of human errors. Unfortunately these cannot be eradicated, however, everything is being done to reduce its occurrence. (Regulations, controls, training, technological aids etc.).

If a spill takes place, alert procedures and contingency plans are being developed in order to get fast action (preferably to contain and remove the oil from the water or to disperse it if removal proves to be impossible and shore pollution has to be avoided). Large amounts of money are spent for the development of adequate equipment and ecologically acceptable dispersants.

## Some remarks regarding the Utility and Mechanism of Chemical Dispersants

by

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Company, N.J.

The use of chemical dispersants in the handling of oil spills is still somewhat misunderstood. However, there have been numerous field applications and extensive laboratory research that have helped to clarify their role.

To consider the subject of oil spill handling in general, oil spill prevention techniques are obviously the best approach. However, if a spill has occurred and oil spill containment and recovery are not feasible, then chemical dispersion must be considered in order to minimize contamination. As long as the oil remains on the surface as an intact film of oil, it represents not only a source of shore contamination (both property and biological) should the oil become "beached", but is also a hazard to marine fowl. Further, removal of this oil layer from the surface and dispersion into fine droplets definitely enhances microbial degradation of the oil.

The mechanism of dispersing oil by the use of dispersants (which are based on surface active agents) consists mainly of a reduction of the oil/water interfacial tension. Since the surface active agent consists of both an oil compatible and water soluble fraction, it arranges itself at the oil/water interface and thus lowers interfacial ten-

sion as schematically shown in Figure 1A. Thus, when a fixed amount of mixing energy, WK, is applied, as in Figure 1B, appreciably more interfacial area ( $A_o/w$ ) is formed simply due to the lowered interfacial tension ( $G_o/w$ ) since :

$$WK = A_o/w G_o/w$$

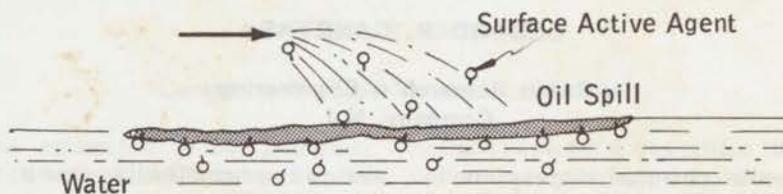
However, in addition to the above aspect, it is important that the selected surface active agent possesses a molecular structure to prevent droplet coalescence. This is schematically shown in Figure 1C wherein the hydrophilic portion of the surface active agent prevents coalescence since it acts as a "fender" and physically parries droplet collision.

The beneficial aspects of this mode of chemical treatment can be readily seen in Figure 2. In this experiment, sea water, Kuwait crude oil and beach sand were mixed in a graduate. This was meant to simulate an oil spill that might come in contact with sediment churned up into the water column. It can be seen that after contacting, the sand has become oil wetted. Hence, the oil would persist in the marine sediment for some time.

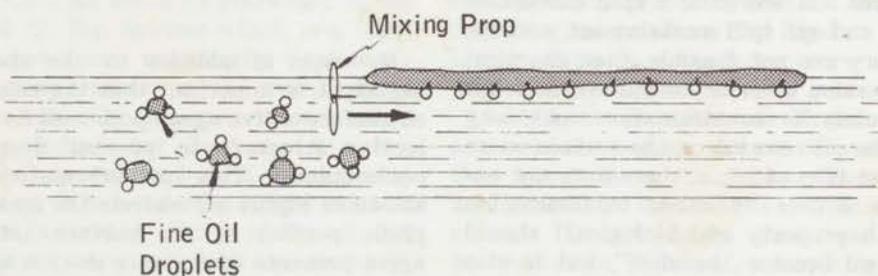
Figure 1

MECHANISM OF CHEMICAL DISPERSION

A) Chemical Dispersant Applied



B) Mixing Readily Forms Droplets

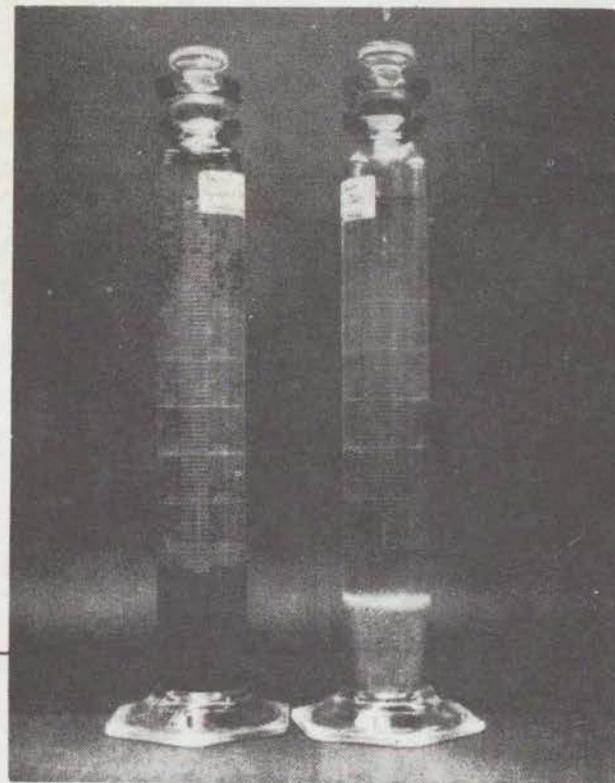


C) Droplet Coalescence Prevented By Dispersant



Figure 2

RELATIVE EFFECTS OF OIL AND OIL + COREXIT 7664 MIXTURE ON MARINE SEDIMENT SAMPLES SHOWN AFTER AGITATION & PURGING



OIL & SEA WATER

OIL + COREXIT 7664 + SEA WATER

However, when the experiment is repeated with a representative treatment of COREXIT 7664 dispersant applied to the oil, the oil does not wet the sand but remains as discrete droplets. Hence, shore surfaces, bird feathers, etc., are not oil contaminated when contacted by the chemically treated oil.

Finally, it is important in any assessment of the biological effects of chemical dispersion to consider the above mechanism and the actual concentrations that exist. Chemical dispersion does not sink the oil but simply physically transforms it into dispersed droplets in the upper three feet or so of the water column. The rate of dispersant addition of a typical work boat repre-

sents a chemical concentration of approximately 2 ppm in this zone and even this low level only persists for a short interval. During an extensively surveyed oil spill in the Gulf of Mexico where 65,000 bbl of oil were discharged and sprayed with 2000 drums of chemical dispersant, the oil-in-water concentration at one mile from the spill was 1 ppm and the dispersant concentration was unmeasurable ( $< 0.2$  ppm) (1).

**Note :**

- (1) "Chevron Main Pass Block 41 Oil Spill, McAuliffe et al. Proc. on Control of Oil Spills, March 1975, pg 555—565.

C. C. A. Ecology Conference BONAIRE, September 1975  
Netherlands Antilles National Parks Foundation  
"STINAPA" No. 11, Curaçao 1976

Abstract

## Coral Distribution in the Bahia de Patanemo, Venezuela

by

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Estación de Investigaciones Marinas de Margarita de la Fundación La Salle de Ciencias Naturales.

and

JEAN ARAUD

Fundación La Salle de Ciencias Naturales — Curaçao.

Contribución No. 60 Estación de Investigaciones Marinas de Margarita.

The Bahia de Patanemo is located at  $10^{\circ} 28' N$ . Latitude and  $67^{\circ} 50' W$ . Longitude, approximately 5 miles east of Puerto Cabello on the central Venezuelan coast. The semi-V shaped bay, recessed some 2000 meters into the coastal mountains, has a maximum depth at its entrance of some 30 meters. A small sandy beach is located at the apex of the bay with a saline mangrove lagoon on its west side and a small creek, the Rio Patanemo, adjacent to the beach on the other (Fig. 1).

From the mouth of the lagoon out to the tip of Punta Peñón on the western side and from approximately 500 meters from the beach out to the tip of Punta Yapascua on the eastern side, the coastline is a rocky shore. In these zones the most prolific growth of corals is found. The most conspicuous and most abundant species is *Acropora palmata*. The seaward limit of the *A. palmata* growth seems to be, with few exceptions, the 5-meter isobath. The other most common species found in the zone are *Diploria labyrinthi-*

*thiformis*, *Millepora alcicornis*, *Agaricia agaricites*, and *Porites porites*. *Acropora cervicornis* is present in the bay and seems to be found mostly in very local concentrations. Also found, but not as common as the previously named species, are species of *Montastrea*, *Colpophyllia* and *Diploria*, along with a wide variety of gorgonians and sponges.

The Bahia de Patanemo has been selected as the site for the future development of a major tourist center aimed primarily at an international market. Plans for the development include several hotel complexes, a large marina and yacht club, restaurants, tennis courts, and 18-hole golf course, a zoological park, and a center for marine investigations with a large public aquarium. Some 980,000 square meters are planned for the construction at a cost of over \$ 460 million, and creating some estimated 30,000 new jobs in the area.

As a first step in the development, the Fundación La Salle de Ciencias Naturales and the Sociedad de Ciencias

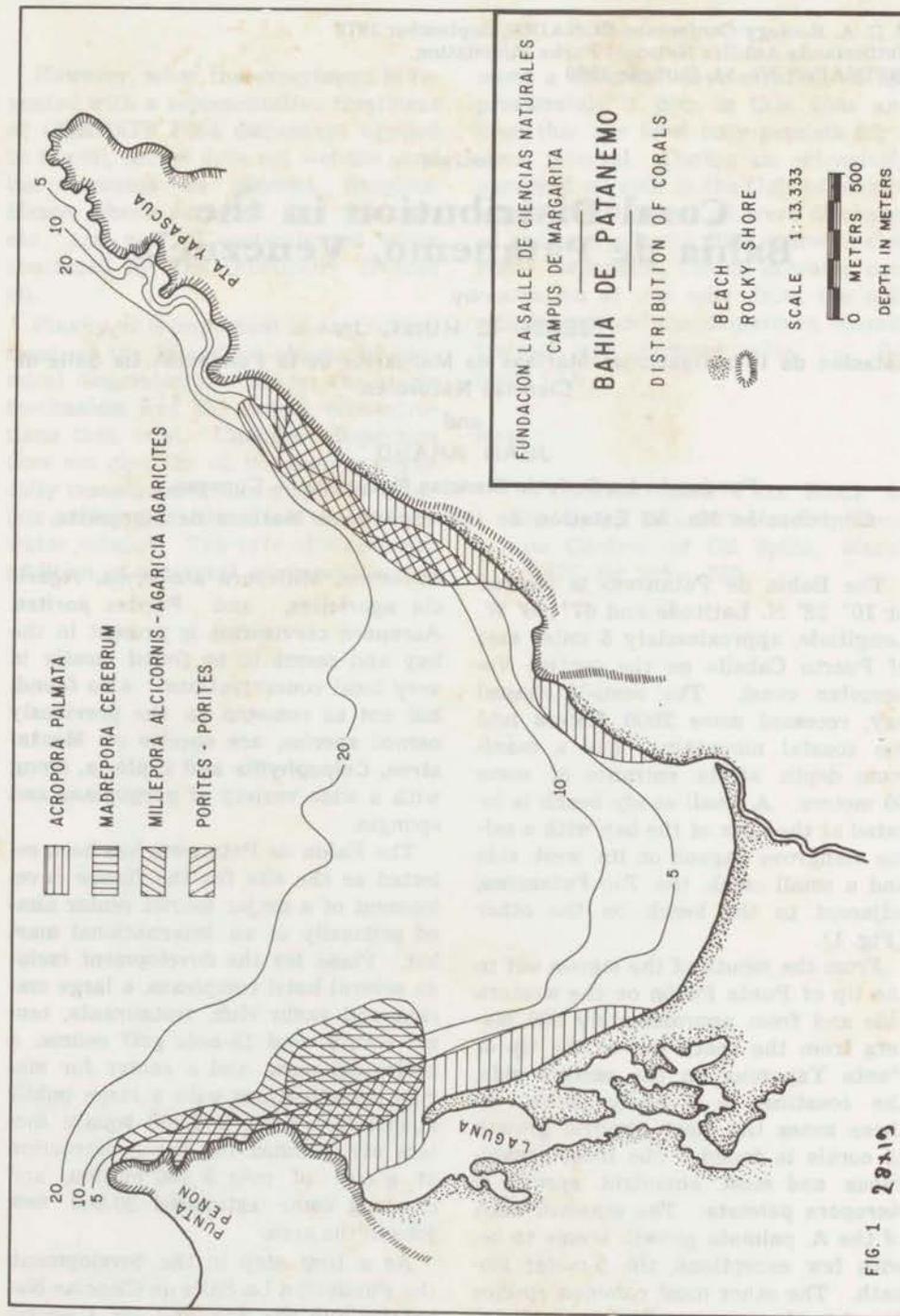
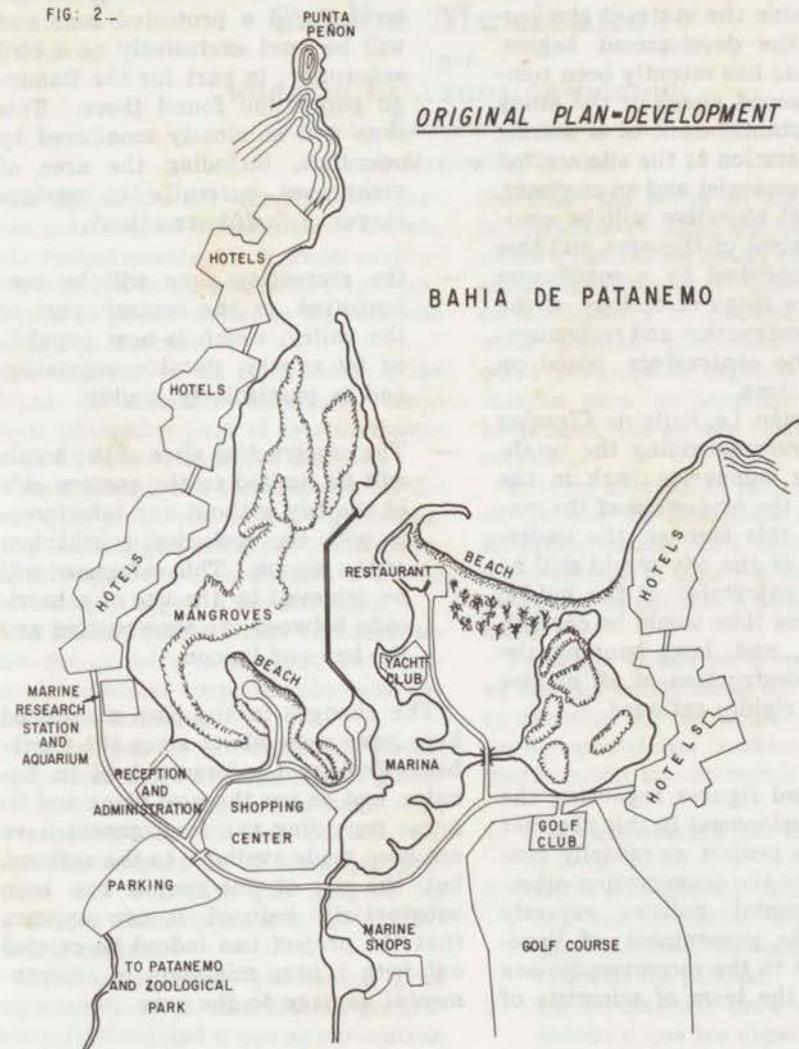


FIG. 2.



Naturales La Salle were contracted to carry out preliminary investigations of terrestrial and marine ecology, bathymetry, oceanography and marine geology of the Bahía de Patanemo in order to determine the state of the ecology before the development begins. This first phase has recently been completed. The second phase of the study will be the establishment of a marine investigation station at the site staffed by a resident ecologist and an engineer. Their principal objective will be environmental control of the area and this will be accomplished by a continuous monitor of the stage of ecology of the bay during construction and recommendations to the contractors based on these observations.

The Fundación La Salle de Ciencias Naturales is recommending the establishment of a submarine park in the area aimed at the protection of the marine life. In this manner, the underwater beauty of the bay would still be open for the enjoyment of the public, but at the same time would be carefully supervised, and laws banning the collection or destruction of all marine life would be rigidly enforced.

#### Note :

The plan and figures regarding the size of the development in this abstract pertain to the project as initially conceived. Due to the conservation-oriented environmental policies recently adopted by the government of Venezuela, and due to the recommendations submitted by the team of scientists of

the Fundación La Salle, the following changes have been made in the projected development :

- the entire area of the lagoon will be declared a protected zone and will be used exclusively as a bird sanctuary; in part for the flamingo population found there. This zone will be closely monitored by scientists, including the area of mangroves currently in various stages of "selfdestruction".
- the recreation zone will be concentrated in the central part of the valley, which is now populated by a very durable vegetation and is particularly muddy.
- The construction sites of the hotels will be limited to the eastern side of the bay without any interference with the ecological equilibrium of the lagoon. This safeguard will be achieved by the use of a barricade between the construction and the bay and lagoon.

The changes in the plan mentioned here have come about since the Caribbean Ecology Conference held in Bonaire, and as yet the new plans and figures regarding the development have not been made available to the authors, but the size of the project has been substantially reduced. It now appears that the project can indeed be carried out with a bare minimum of environmental damage to the zone.

C. C. A. Ecology Conference BONAIRE, September 1975  
Netherlands Antilles National Parks Foundation  
"STINAPA" No. 11, Curaçao 1976

## Parques Submarinos en el Caribe Mexicano

por

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Comisión Nacional de Obras en  
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La aplicación del concepto de parques marinos, es relativamente nuevo, solo recientemente ha logrado aceptación mundial como prioridad importante para la preservación de los recursos biológicos marinos.

En especial, se ha considerado a las playas y arrecifes coralinos, como áreas adecuadas para el establecimiento de Parques Naturales Marinos.

Los arrecifes son formaciones coralinas, que junto con otros organismos, tales como algas calcáreas y moluscos, cuyos esqueletos se acumulan a través del tiempo, llegan a formar islas.

La unidad fundamental de construcción del arrecife es el coral, un celenterado colonial emparentado con las anémonas marinas.

Los pólipos se alimentan de noche, capturando diversos organismos planctónicos con la ayuda de sus tentáculos, y unas células ciliadas que se encuentran después de la boca que producen una corriente que acarrea las partículas alimenticias a la cavidad digestiva central.

Otros organismos que tienen gran importancia en la distribución geográfica y profundidad a que se encuentran los corales, son las algas unicelulares microscópicas, denominadas zooxantelas, éstas crecen en los tejidos del pólipo, — pudiendo encontrarse varios miles en un solo pólipo y son responsables de la coloración de la colonia.

Durante las horas de luz y cuando la claridad del agua permite una adecuada penetración de los rayos solares, estas algas toman el dióxido de carbono del agua y lo fotosintetizan como otras plantas, produciendo oxígeno y otros compuestos orgánicos manufacturados para su beneficio y el de su hospedero, que en este caso es el pólipo coralino.

Este es un tipo de relación simbiótica, ya que los beneficios son mutuos. El pólipo proporciona seguridad y un nicho estable el alga y a cambio recibe un aporte de oxígeno y nutrientes orgánicos.

Para que exista un arrecife coralino en buenas condiciones de crecimiento, se necesita la conjunción de una serie de condiciones ambientales que a continuación se enumeran :

1. La temperatura no debe ser menor de 20°C.
2. La sedimentación debe ser mínima; las partículas de sedimento al caer bloquean los canales alimenticios de los pólipos.
3. La iluminación debe ser máxima, debido a que las algas zooxantelas que viven en los pólipos la requieren para la fotosíntesis.
4. Debe haber corrientes o acción de las olas que mueven el agua por encima de la superficie ya que de esta manera los pólipos capturan

el plancton necesario para su alimentación.

5. La salinidad debe ser igual a la del agua oceánica ya que los corales son estenohalinos y una disminución por debajo del 25% altera los procesos de regulación iónica.

En México, estas condiciones se presentan en algunas islas aisladas del Golfo, situadas la mayoría enfrente del puerto de Veracruz, y en las costas del Caribe.

La creciente contaminación, así como el aumento de la presión demográfica están provocando que el hombre vuelva los ojos hacia los paisajes submarinos, en busca de un lugar donde encontrar recreación y descanso espiritual, lo cual ha producido un enorme incremento del deporte del buceo, que desafortunadamente en algunos casos ha sido la causa de la destrucción masiva de la fauna y flora marina, debido principalmente a la ignorancia por parte de algunos buzos de la fragilidad e importancia de estos ecosistemas. El hombre es un intruso en este medio y su presencia si no es controlada puede causar serias alteraciones, ya que estos ecosistemas son muy sensibles a cualquier cambio, y con el simple hecho de que una especie desaparezca, o con la contaminación de las aguas se rompe el equilibrio ecológico, lo cual trae como consecuencia la muerte del arrecife, sucediendo esto si se carece de reglamentos efectivos para protegerlos de la destrucción y no se educa al público para preservarlos.

La destrucción de estos arrecifes, así como los accidentes que en éstos puedan ocurrir, son en la mayor parte debidos a la ignorancia por parte del turismo que acude a estas zonas, de lo que es un arrecife, así como la clase de

precauciones que es necesario tomar para evitar accidentes con algunos organismos peligrosos y los cuidados necesarios para evitar su destrucción.

Para proporcionar, al visitante esta clase de información tan necesaria se ha planeado el establecimiento de un centro de interpretación.

La interpretación podrá definirse como el arte de explicar el lugar del hombre en su medio, de aumentar el interés del público por la importancia de esta relación, y de despertar el deseo de contribuir a la conservación ambiental.

Dentro del Reglamento General del Sistema de Parques Naturales, existe un capítulo específico sobre parques submarinos, para aplicarse al área del parque.

1. Se encuentra prohibido cortar, mutilar, desplazar o extraer cualquiera de las formaciones coralinas existentes en el arrecife.
2. La pesca con arpón se encuentra prohibida en la zona del parque, así como la captura de peces ornamentales para acuarios.
3. Ninguna persona podrá destruir, desfigurar, desplazar o quitar cualquier señal o aviso, ya sea flotante o submarino.
4. Ninguna embarcación deberá anclar de manera que destruya el te o submarino.
5. Ninguna operación de dragado, excavado o llenado está permitida en el área del parque.
6. Todos los botes de alquiler que conduzcan pasajeros deben cumplir con las condiciones de seguridad y permisos adecuados.
7. Se encuentra prohibido en las tiendas cercanas al parque, la venta de corales y conchas extraídos de los arrecifes.

México está estudiando y acondicionando las áreas necesarias para preservar sistemas o muestras de la ecología del país, para el uso y disfrute de las presentes generaciones, pero importante es para nosotros que estas áreas se utilicen como centros de investigación y la motivación de nuestros

jóvenes a valorar los recursos del mar — futuro granero de la humanidad —, pues es señores, El Mar un recurso vital que todos y cada uno de nuestros países, debe de proteger para preservar algo de lo bello de este planeta para la supervivencia de los hijos de nuestros hijos.

Abstract

## Necessity of conservation of slow growing organisms like BLACK CORAL.

by

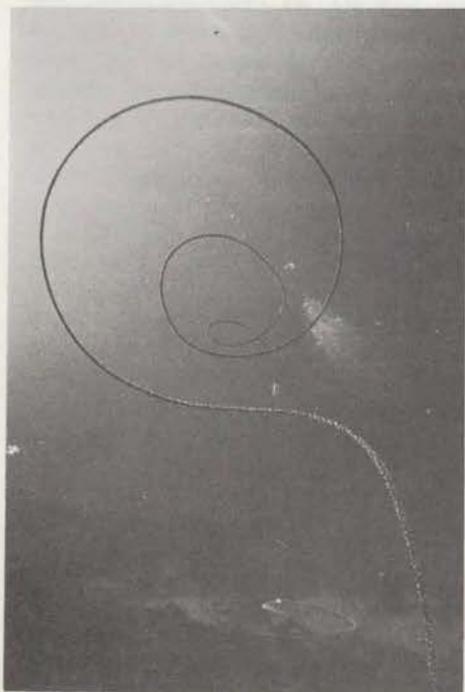
CEES NOOME  
and  
INGVAR KRISTENSEN

Caribbean Marine Biological Institute,  
Curaçao.

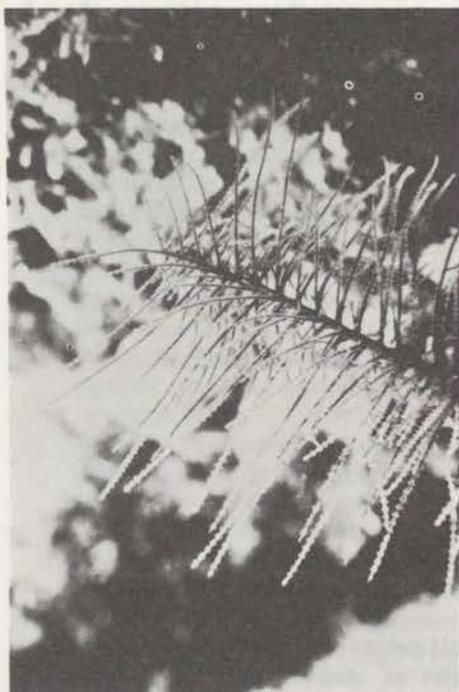
Prohibiting measures should be taken only if adequate. It is the task of the biologist to prove the necessity of prohibition.

Indications are clear: The narrow fringe of the reefs around the Nether-

lands Antilles Leeward Islands (only 50 to 150 metres) makes them vulnerable to destruction. Deterioration of large parts of the Curaçao reefs is obvious. Large reef fishes have been shot, small reef fishes are caught alive for the



Wire Coral (*Stichopathes gracilis*), depth 40 m. Photo by Cees Noome



Black Coral (*Euantipathes hirta*), depth 40 m. Photo by Cees Noome

aquarium trade, shells are collected in quantity, corals are collected — especially black coral. CARMABI did already some research on the devastating effect of spearfishing on groupers (by Jan Kees Post) and these investigations will be continued. The effect of collecting small coral fish will be dealt with by Hans de Kruijf in next paper.

As long as nets are used and corals are spared, OK, but in practice this does not happen. Drugs are also used which kill fish and invertebrates in numbers. Shell collectors are worst of all: using crow-bars they even turn coral colonies upside down to see whether there are shells underneath.

Coral collecting is a rather new menace to the reefs, especially of the highly priced Black Corals. If they were growing as fast as filamentous algae, no prohibition would have been necessary. The fact that most black coral around Curaçao has vanished, makes it improbable that they are quick growers. Mr. NOOME worked at CARMABI for half a year on this subject, and some of his findings are presented here. (The investigations are now being continued by Mr. F. LANG da SILVEIRA).

Wire Corals and Black Corals (*Antipatharia*) are found at depths below 10 m; in the shade of rocks they may grow above 10 m, but that is exceptional. Their greatest density is between 15 and 50 m. Below 20 m they form polyps all around the stem. If transplanted to shallower water, polyps were formed only on the underside.

Mr. Noome measured the increase of length of antipatharians, in situ as well as using cuttings. Some cuttings were planted in the sea bottom but without success. If tied to a rope in the sea, they showed some growth, and



Daily growth rings in Wire Coral (*Stichopathes gracilis*). Distance of the rings one micron. Photo by Cees Noome

also in the aquarium growth could be observed.

Quickest growth was found in wire coral, averaging 9 mm per week during 3 months. Maximum growth per week was 16.3 mm, but only during a limited period. Growth is not confined to the top although, there, growth is at least 20× quicker than in the lower parts of the coral. Growth at the top could be observed as taking place in daily layers. In cross sections, numerous rings of about 1 micron are present.

Antipatharians from car wrecks that were dumped 6 years ago showed about 2000 rings, indicating that these rings are day-rings. As all rings are about 1 micron thick, a coral piece of 1 cm diameter suggests an age of 15 years. A wire coral (*Stichopathes gracilis*) of 50 cm in length showed on cross section at the base (2 mm diameter) about 1000 rings which means that the coral could be 3 years old. This means that unbridled picking of such corals will exhaust the stock in a short time. Therefore, stringent protecting measures are absolutely necessary.

Resumen

## Necesidad de medidas conservacionistas con respecto a organismos de lento crecimiento tales como el Coral Negro.

por

CEES NOOME

e

INGVAR KRISTENSEN

Instituto Biológico Marino del Caribe,  
(CARMABI), Curazao

Si hay que tomar medidas de protección es esencial que resulten adecuadas. Es la tarea del biólogo comprobar que tales medidas son imprescindibles.

Hay consideraciones bien claras: La estrechez misma de la franja de arrecifes alrededor de las islas a sotavento (no mas de 50 — 150 metros) puede contribuir a su ulterior destrucción. Es obvio que grandes sectores de los arrecifes de Curazao ya han sufrido deterioro. Se han perseguido los peces grandes de arrecife, los peces pequeños se cogen para venderlos luego al comercio de acuarios, se recogen cantidades de conchas, también se recolectan corales y muy especialmente el coral negro. Carmabi ha hecho investigaciones con respecto a los efectos desastrosos de la pesca de arpón de los meros (por Jan Kees Post). Tales investigaciones continuarán. Estudios se han dedicado igualmente a las consecuencias de la pesca de pececitos de coral. Tal pesca se puede tolerar mientras se utilizan redes y no dañan los corales. Pero la práctica es otra. A mas de esto se utilizan drogas que matan un sinnúmero de peces e invertebrados.

Los coleccionistas de conchas son los que causan mas daño. Utilizando pies de cabra tumban colonias enteras de corales para ver si por debajo se encuentra alguna que otra concha.

La recolección de coral constituye una nueva amenaza para los arrecifes y muy en especial para el tan codiciado coral negro. Si su crecimiento fuera tan rápido como el de las algas filamentosas no hubiera sido necesario prohibir su recolección. El simple hecho de que el coral negro ya haya desaparecido en su mayor parte en los arrecifes de Curazao excluye la conclusión de que puedan ser de crecimiento rápido. El Señor NOOME ha dedicado medio año de trabajo en el Carmabi al estudio de este materia y algunos de sus conclusiones se recogen en esta presentación. (Sr. F. LANG da SILVEIRA de São Leopoldo, Brazil, está ahora continuando estos estudios).

Corales Alambre y Corales Negros (*Antipatharia*) se encuentran a una profundidad de mas de 10 metros. A la sombra de rocas pueden prosperar a menos de 10 metros pero eso es mas bien la excepción. Se encuentran con



Black Coral (*Aphanipathes pennacea*)

Photo by Don Stewart, Bonaire

mas frecuencia entre 15 y 50 metros. A mas de 20 metros de profundidad forman pólipos alrededor del tallo. Al transplantarlos a aguas menos profundas los pólipos se forman unicamente en la parte inferior.

El Sr. NOOME hizo mediciones de crecimiento longitudinal de antipatharias, tanto in situ como por medio de recortes. Algunos recortes se sembraron en el fondo del mar, empero sin éxito. Amarrados a una cuerda en el mar se les notó cierto crecimiento. Lo mismo ocurrió en el acuario. El coral alambre resultó ser el de crecimiento mas rápido. Se estableció un promedio de 9 mm por semana durante un período de 3 meses. El mayor crecimiento registrado era de 16,3 mm por semana, pero unicamente durante un período muy limitado.

El crecimiento no se limita a la parte superior pero si se observa que en esa parte la rapidez de crecimiento excede en 20% al de la parte inferior del coral. En la parte superior el creci-

miento se observa en la forma de capas diarias. En cortes transversales se observan numerosos anillos de aproximadamente 1 micrón de espesor.

En Antipatharias recolectadas de carros arruinados botados al mar hace 6 años se contaron como 2000 anillos, lo cual comprueba que efectivamente se trata de anillos diarios.

Ya que todos los anillos miden aproximadamente un micrón se puede suponer que un pedazo de coral de 1 cm de diámetro debe tener 15 años. En un coral alambre (*Stichopathes gracilis*) de 50 cm de largo se observaron 1000 anillos en un corte transversal hecho en la base (2 mm de diámetro), justificando la conclusión de que el specimen en cuestión pudo tener aproximadamente 3 años.

Permitir la recolección de estos corales sin limitación agotaría su existencia en un lapso sumamente corto.

Estrictas medidas de protección así evidentemente resultan imprescindibles.

Abstract

## Recolonization experiments of the coral reef fish GRAMMA LORETO, the Royal Gramma.

by

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and  
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The Royal Gramma is among the most wanted aquarium fishes from the Caribbean and is certainly exported in greater numbers from Curaçao than any other fish (in 1974 over 10.000 live individuals were exported).

Is there overfishing of this fish or not? To answer this question, some longterm recolonization experiments were carried out on Curaçao reefs. Three large quadrats subdivided into smaller ones were counted weekly. The population density in the untouched control quadrat increased from 56 individuals in March to 89 in October and then declined to 70. We observed monthly influxes of very small juveniles, though this did not alter strongly the resident population. We captured and removed nearly half of the population in the second quadrat after an initial series of control counts.

There was nearly no migration of the adults from the immediate vicinity into this quadrat. Recolonization was accomplished by rather large juveniles. The increase in population density after capture and removal was

larger than in the control but similar to the immediate vicinity. In the third experiment at intervals of about three months we repeatedly removed half of the population in the quadrat. Recolonization was fast after the first three times but no influx of individuals was found after the fourth time. The near vicinity showed an increase which was very much like the fished area. First very young juveniles and many older ones recolonized the area; after the last two catches no small juveniles were observed. Since this species belongs to a group with protogynous hermaphroditism, the males are the largest individuals. Only the largest individuals are caught, consequently the resultant population will not have males and has no reproductive potential. Thus after repeated captures there will be no recruitment, and thus no repopulation except through immigration of larger juveniles, being the only age group which, in our opinion, tends to migrate, though slowly.

We concluded from these experiments that fishing itself is not harm-

A each square = 3,3 x 3,3 m

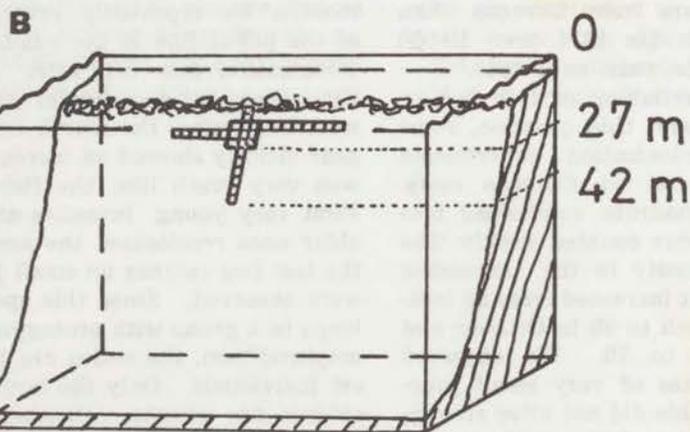
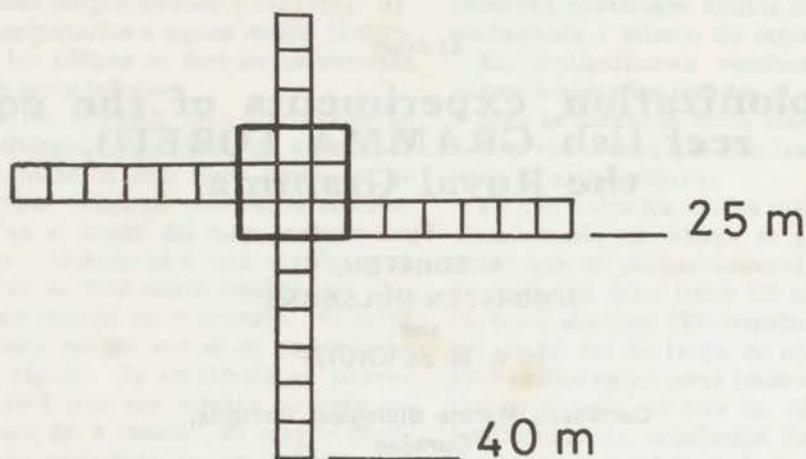


FIG. 1 A. Schematic representation of the experimental areas. Royal grammas were captured and removed from the nine squares in the center. The 'legs' were used for monitoring the gramma population in the immediate vicinity of the catching area.

1 B. The location of the experimental area on the reef.

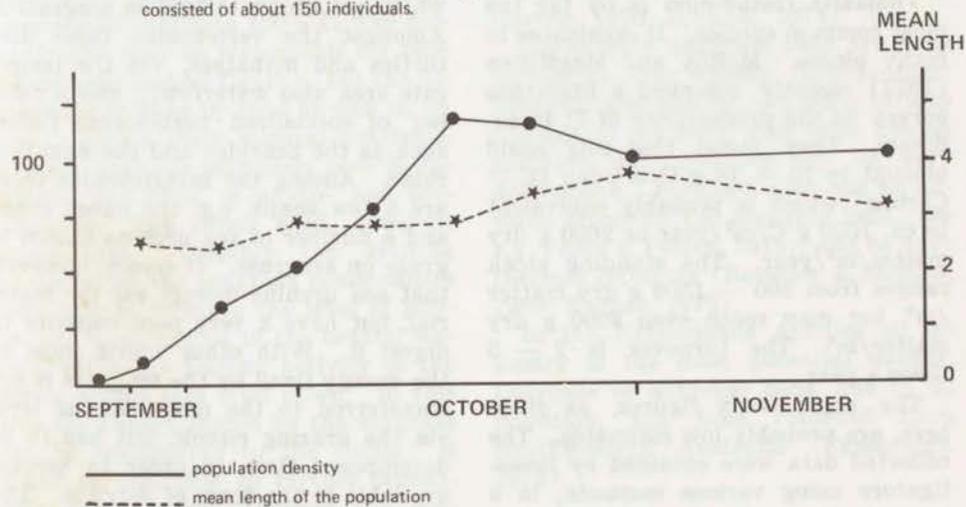
ful to the population but that certain rules have to be followed :

- a. Fishing in one area should not be done repeatedly; intervals of four or more months should be observed ;
- b. Less than half the population density should be fished;

c. Some large males should be left.

From all observations we finally can state that at this moment a real danger for the *Gramma loreto* in Curaçao reef does not exist except when drugs are used in large quantities.

FIG. 2. Recolonization by the Royal gramma, *Gramma loreto*, after removal of the complete population. The vertical axis at the left represents the number. The original population consisted of about 150 individuals.



## The role of seagrasses in shallow coastal waters in the Caribbean

by

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Seagrass communities are widely distributed in the shallow coastal waters of tropical seas, and they belong to the most productive communities which are known on earth. Nevertheless they have not received much attention of biologists, and the present interest in these communities dates from the last ten years, (McRoy, 1973).

In the Caribbean 7 species of seagrasses have been found, of which 6 are recorded from the Netherlands' Antilles (Den Hartog, 1970).

*Thalassia testudinum* is by far the most common species. It dominates in many places. McRoy and MacMillan (1973) recently compiled a literature survey on the productivity of *T. testudinum*. They found that this could amount to 10 — 16 g C/m<sup>2</sup>/day (C = Carbon) which is probably equivalent to ca. 1000 g C/m<sup>2</sup>/year or 2600 g dry matter/m<sup>2</sup>/year. The standing stock ranges from 500 — 1500 g dry matter/m<sup>2</sup>, but may reach even 8000 g dry matter/m<sup>2</sup>. The turnover is 2 — 5 times a year.

The productivity figures, as given here, are probably low estimates. The collected data were obtained by investigators using various methods; in a number of cases the compiled data concern only leaf productivity. As in *T. testudinum* 55 — 90% of the biomass occurs in the bottom sediments, omitting rhizome growth may lead to capi-

tal errors. One can, therefore, conclude from the compilation of McRoy and MacMillan (1973), that an annual production of ca. 1000 g C/m<sup>2</sup> is a minimum estimate, and that ca 2000 g C/m<sup>2</sup> probably will be closer to reality for well-developed tropical seagrass beds. This high productivity is reached without auxiliary energy gifts by man.

In spite of the high productivity of the seagrass beds there is only a remarkably small number of organisms which are known to feed on seagrasses. Amongst the vertebrates these are: turtles and manatees, (in the temperate area also waterfowl), and a number of specialized herbivorous fishes, such as the Scaridae and the Acanthuridae. Among the invertebrates there are a few snails, e.g. the queen conch and a number of sea urchins known to graze on seagrass. It seems, however, that sea urchins merely eat the material, but have a very poor capacity to digest it. With other words, most of the energy fixed by the seagrass is not transferred to the next trophic level via the grazing circuit, but has to be decomposed first, in order to become available in the form of detritus. The occurrence of pentosans in the detritus may further make it unpalatable for a number of organisms.

It is an established fact, that most of the seagrass material does leave the

ecosystem. Broken leaves float away, uprooted plants do the same. They may be deposited on the beach, trapped by algal mats, used by sea urchins as a cover, sink to deep trenches in the sea, etc. In seagrass beds one rarely sees loose pieces.

Decomposition of the material under anaerobic circumstances seems to be a very slow process. Under aerobic conditions the decomposition takes place rapidly (Fenchel, 1973).

The crucial question is, what happens with this material and which other communities depend on it. Here may be a link with the coral reef system.

According to Van den Hoek, Wanders and Cortel-Breeman (1975) the coral reefs have also an extremely high productivity, up to 2700 g C/m<sup>2</sup>/year. The corals contribute 1800 g C, due to the symbiosis with zooxanthellae (*Gymnodinium microadriaticum*), the algal felts produce 500 g C and the crustose Rhodophyta 400 g C. The zooxanthellae may be responsible for photosynthetic carbon fixation, but the corals need to take up food as well in order to obtain their mineral nutrients. Tropical seas are extremely poor in nutrients and thus in phyto- and zooplankton. The corals need, however, zooplankton. Possibly the detritus produced by the seagrass communities may help to increase the level of phyto- and zooplankton in the coastal waters, while the feeding activity of the corals brings this level down. In this way the energy stored by the seagrass can be transferred to the corals. It would be desirable to further investigate this relation between the seagrass- and the coral-reef system.

Apart from this very important trophic aspect the seagrass beds fulfil many other functions. They serve as

nursery grounds and provide shelter for shrimps and many fishes, the adults of which live in quite other habitats. Seagrass beds are probably rather essential to the juvenile stages of various reef fishes.

Another important function is the substrate extension, which enables the establishment on the leaves of many epilithic organisms, which otherwise cannot occur in that locality.

The substrate extension may be 400 to 600 (—1800) % (McRoy & MacMillan, 1973). The algae and invertebrates living on and between the leaves form an important food resource for herbivores and predators. As a consequence of the very special habitat conditions a number of species have been developed, which only can be found on or between the seagrass.

Finally it has to be mentioned that seagrass beds play an important part in the stabilization of the seabed, and protect the bottom from erosion (Den Hartog, 1970, Schubel, 1974).

Regrettably seagrass beds are very vulnerable to human interference: dredging and boating can cause serious damage to the beds; also some fishing methods, e.g. trawling can be very destructive. Pollution also has an adverse effect on the seagrass beds (see e.g. Peres & Picard, 1975), and so have thermal effluents (Roessler & Zieman, 1969; Zieman, 1970).

In the Netherlands Antilles oil industry is the most potential danger. Decrease of seagrass beds, due to oil pollution, has been recorded from Southwestern Australia (Cambridge, 1975).

Therefore, it is recommended, that the seagrass beds have to be protected just as the reef communities, for the following reasons:

1. the high productivity of the seagrass communities which makes them a potential energy resource.
2. the extensive areas which are covered by these communities.
3. the possible links with the food web of the coral reef system.

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C. C. A. Ecology Conference BONAIRE, September 1975  
Netherlands Antilles National Parks Foundation  
"STINAPA" No. 11, Curaçao 1976

Abstract

## Reef Communities and Human Interference: A positive view

by

E. TOWLE

Island Resources Foundation  
U. S. Virgin Islands

Not all aspects of contemporary human interference in tropical coastal areas necessarily have a negative or destructive effect. At least four elements of present-day "human interference" offer, despite their "intruding" character, to ameliorate if not eliminate some of the negative impacts or disbenefits in this specialized man-environment interaction at the edge of the sea.

The four elements are :

1. Research activities
2. Educational activities
3. Marine Park + Preserve Development activities

4. Coastal Zone Management Planning activities

Each of these four elements has marine resource management implications, and management is simply another form of human interference although presumably more benign + less sectoral.

This paper reviews the positive management possibilities implicit in each of the four modes of human interference in reef communities mentioned above and outlines some cautionary considerations + recommended constraints while giving special emphasis to the marine parks element within a Caribbean concept.

Abstract

## Human participation in reef communities

by

DON STEWART

Aquaventure Dive Complex  
at Hotel Bonaire

North America is producing new divers at an almost alarming rate.

By the close of 1974 there were over 800,000 certified divers, according to internationally recognized organizations. If one interpolates the latest available statistics, it will be noted that almost a quarter million divers will vacation in the Caribbean this year, bringing with them more than \$ 125,000,000 in disposable income.

It thus becomes obvious that sensible reef management is an immediate necessity. To not be cognizant of the dangers of mismanagement is to threaten the economic health of our islands. We must constantly remind ourselves that a reef is a once in a lifetime occurrence.

A favorite reef of mine is the Karpata reef and our diving guests concur in our conception of its beauty. Opened in June of 1964 a land entry is possible via a small pebble beach. The reef major is approached by a sixty foot channel carved through living Elk and Antler corals. I knew Karpata as a virgin; a half mile stand of fans and Gorgonians. One fan measures over 9 feet wide and 7½ feet high. This reef is mazed with canyons and overhangs, even a small cave; growing and healthy in every respect.

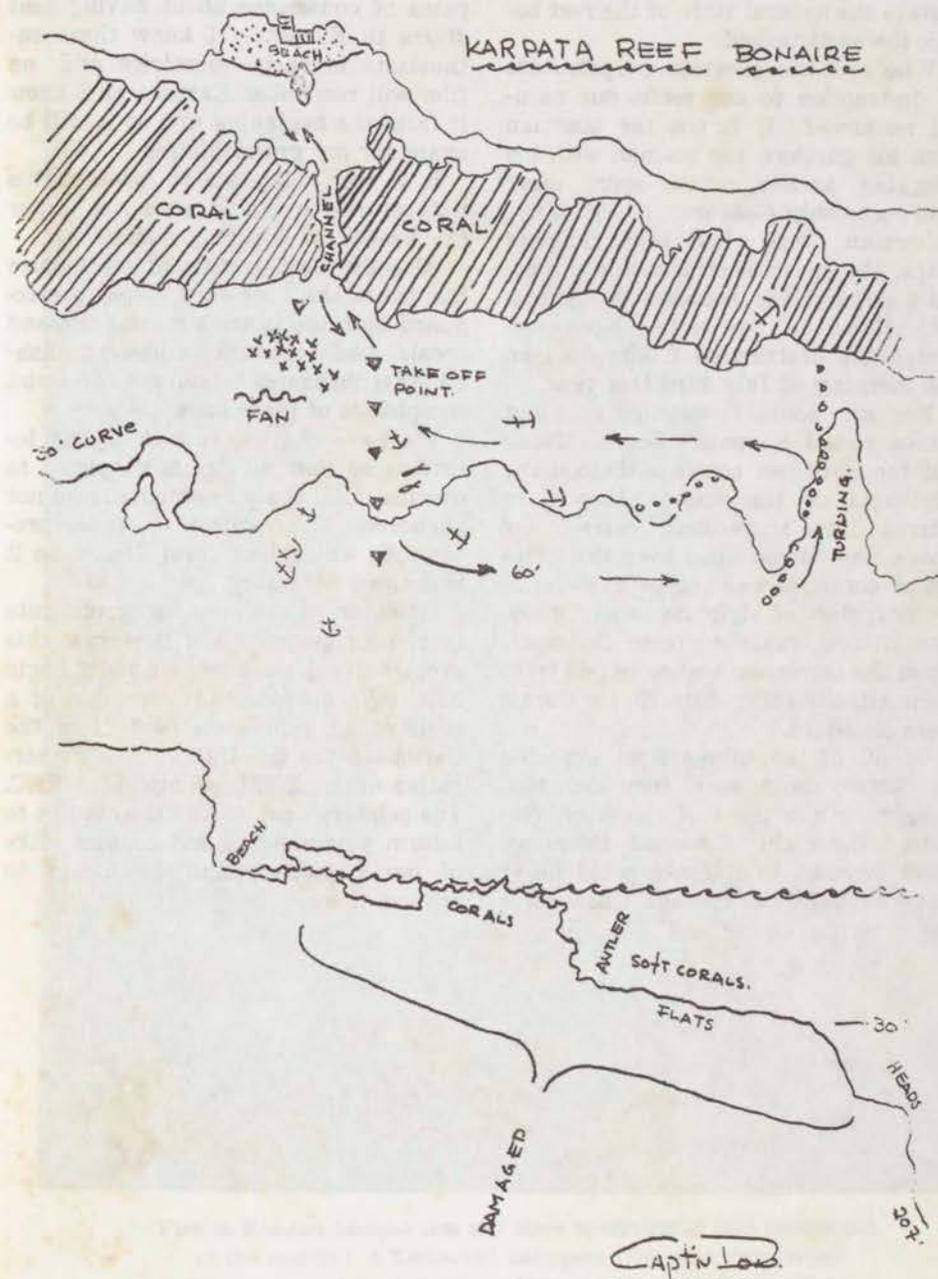
Since that first day in June '64 there have been 8,894 entries through that narrow channel to the breath-taking

view below. Karpata alone accounts for a gross income of \$ 65,719.00 in diving fees, plus the dispersement of thousands of dollars funnelled into the island proper.

What price has Karpata reef paid for the economic benefits reaped by the island's population? There has been damage, particularly at the takeoff point and the turning area of the dive. However, it may surprise you the adverse effects upon Karpata have been negligible.

Karpata is where we first began to hand feed the fish on Bonaire. By 1968 the feeding of Hansel and Grettle, the twin Coneys, had become an exciting pastime for the divers. The Yellow Tail Snapper was the easiest to tame; however, the Coneys were the most aggressive feeders. In time we witnessed the entire population of the reef to become friendly with underwater man. As we would swim across the canyon, we would be greeted by a sizable school of mixed fishes to escort us to the exit.

Daily encounters such as this makes one realize that humans and fish are capable of coexistence. Divers of their own volition often attempt to repair the damage others have imposed on a reef. Hundreds of times I have seen a diver prop up a fallen Gorgonian or re-establish Black Coral twigs a poacher left behind. All of these efforts are ad-



mirable in their intent, but do little to restore the natural state of the reef before it was disturbed.

Who are the greatest perpetrators of destruction to our reefs, our natural resource? It is not the landman with his garbage, the seaman with his dragging anchor, or the sport diver who seeks only pleasure. Not even the fisherman with his indiscriminate traps, the spearfisherman, nor the coral merchant who represent the greatest affront to our reefs. None can match the destruction I witnessed on the morning of July 23rd this year.

For six hours I watched six foot waves pound Karpata's beach. None but the strongest corals withstood the onslaught of the seas. Sands were stirred into suspension, carried off shore, and rained upon even the deepest of corals, whose polyps were totally incapable of stripping such mass. The lettuce corals suffered the most. Even the Gorgonians were ripped from their attachments; entire Brain Corals were dislodged.

Of all of the things least expected to destroy with such fury and thoroughness was the reef's creator, Nature. The eight thousand divers we have directed to Karpata could never have wrought the damage I saw after

that storm. I no longer have any pains of conscience about having sent divers to Karpata. I know these enthusiasts in their memories and on film will remember Karpata as I knew it from the beginning and as it will be again for my grandchildren.

It is our obligation to protect this natural resource and preserve it for the benefit of future generations.

Already the Government of Bonaire has taken the necessary steps to safeguard both the island's marine life and corals. And Aquaventure has established other measures to enforce the strict compliance of these laws.

We have charted enough diving locations so that no site is subjected to overuse. All boats are moored and not anchored. In addition to these precautions we replant coral life, when it is deemed necessary.

However, if we are to proliferate reef management and preserve this great natural resource, we must begin now. We propose the formation of a coalition of representatives from the Caribbean for the Underwater Preservation of the Eighth Continent, UPEC. The primary goal of UPEC would be to inform governments and citizens alike of our objectives and the means to achieve them.



Fish in Bonaire became less shy since spearfishing was prohibited.  
in the middle : 5 Yellowtail Snappers (*Ocyurus chrysurus*)  
below : two striped Sergeant Majors (*Abudefduf saxatilis*)  
on top of the head : Spanish Hogfish (*Bodianus rufus*) photo Aquaventure Bonaire.

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Breeding Ruby Topaz Hummingbird (photo by R. Josephia)

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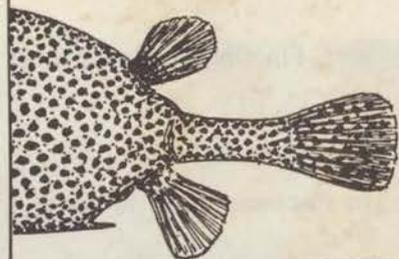
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