III. GENERAL DESCRIPTION OF STORM EFFECTS*

Herold J. Wiens

Direction of wind

Direction of wind from which damage was most extensive to vegetation varies from the northeast to the southwest sectors of the atoll. Roughly, in the northeastern two-thirds of the atoll the direction of tree-fall was towards the south or slightly east of south. In the southwestern third, largely towards the east. While wave and water wash did extensive damage in undermining or washing out tree roots, the overthrowing of the trees and certain structures such as towers and houses also resulted from the wind. Thus, the tree-fall direction may be taken as an indication of the direction of the most powerful or damaging winds.**

The islets of Jabor, Kinajon, Imroj, Ribon, Mejatto, Lijeron, Pinlep, and Majurirek (Elizabeth) were examined by making traverses along the beach and inland from the beach at intervals, and the directions of tree-fall were plotted on large scale maps (Figs. 6-13). On the western reef, Lijeron in the north suffered tree-fall from winds from the due north. At Pinlep, 15 miles to the south, however, the damage in tree-fall was mostly from west winds or winds from slightly north of west. On Majurirek, eight miles southeast of Pinlep, the most damaging winds were from slightly south of west. These same winds moved eastward across the lagoon to blow down two steel towers 150 feet high on the northern part of Jaluit. However, a mile northward toward Jabor on this SE reef the winds were most strong from slightly north of west, pushing lagoon water and carrying from its foundation a steel petroleum tank, 30 feet in diameter (as measured by pacing) and 25 feet high, and setting it on the land 330 feet away in a direction slightly south of east (see Pl. I-c).

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* Note: In this section, Wiens describes the effects of OPHELIA upon Jaluit Atoll. He first presents his general observations and conclusions with reference to wind directions and major changes throughout the atoll. Thereafter, he presents his observations islet by islet. Many of his observations are entered upon the islet maps that he prepared and that comprise the figures referred to in this section. It is intended that these maps be used in conjunction with the text since the maps often contain specific information not included in the text. --D.I.B.

** Blumenstock stresses the first powerful winds rather than the most powerful, and lays more stress on the effects of washing out of roots, see pp. 8-9. Fosberg considers that in addition the energy exerted by the coral-debris-filled waves played an appreciable part in uprooting of trees (personal discussion with Fosberg). --D.I.B.

Northward of here scarcely a mile away the strongest winds were blowing from a north or slightly west of north direction, or directly down the length of the wide part of Jabor Islet from the channel. Similar winds caused the extensive damage observed at Imroj, Kinajon and Mejatto.*

Degree of damage

The heaviest damage to vegetation and soils occurred in the northeast and southeast reef sectors where salt water swept across the reef and land most extensively. Of the islets observed, the most extensive damage probably occurred on Mejatto and Imroj where from 70 - 90 percent of economic trees were blown over (Pl. X-a , Pl. II-c). Jabor and Enejet suffered similar wind and wave force but neither had many coconut or breadfruit trees, and the land here is mostly government reserves. On the other hand, islets mostly affected by the westerly winds were less damaged, largely because of lack of salt water inundation very far inland from the beach. Wind damage also appears to have been less extensive.

In general, the interior of the larger islets and of the wider sections of long islets have less disturbed or undisturbed soil conditions although damage to trees may be just as severe in the middle as along parts of the periphery, depending upon local situations and at times apparently upon the whimsicalities of wind gusts. In the following discussion, islets will be taken up individually.

Jabor

The islet of Jabor is connected to the islet of Jaluit by a continuous strip of narrow land with only small breaks resulting from typhoon OPHELIA. It is difficult to tell, therefore, where Jabor ends and Jaluit begins. The whole section examined and shown in two large scale charts (Figs. 6, 7) will be considered part of Jabor Islet. The section examined by the writer on foot is about 12,300 feet in length from the north end of Jabor southward to the two steel towers where the islet widens. Here are the walls of 3 former concrete buildings, one of large size (150' by 50'). About 4000 feet south of the old hospital tower on Jabor is the remains of a Japanese petroleum storage depot where so-called Sydney Pier was situated. At the base of this pier is a large circular open-top tank surrounded by piled up coral rubble rising about 20 feet. Before the typhoon, two steel tanks 30 feet in diameter rested on circular concrete bases adjacent to the pier base and lagoonward of the large tank.

Between this locality and the wide part of Jabor and between this and the steel towers only the more or less intact remains of former Japanese blockhouses or gun emplacements serve as suitable points of reference. I have numbered these for reference on the maps (Figs. 6, 7) as Blockhouses 1 and 2 north of the tanks and 3 and 4 south of the tanks.

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* See discussions by Blumenstock, pp. 8-9, and by Fosberg, p. 53 for somewhat different views. --D.I.B.

Bar formation off Jabor

Coral rubble bars on the reef flat have developed as a result of the typhoon for almost the entire length of the seaward side of the reef from where Jabor widens opposite the old hospital southward to just past the steel towers (Pl. I-a, b). The highest rubble bars rise to about 4 feet above high tide at a number of places northward of a point about 2000 feet south of the large open tank. This height is indicated by the lack of algal staining in the upper part as contrasted with the brown stain in the tidal lower half. Southward of this point to the steel towers, the rubble accumulations generally are from half a foot to 3 or 4 feet above the reef flat. In the vicinity of the towers, they apparently rest on old beach rock. In the southern sector they form discontinuous strips 20-100 feet wide. Most of the bars are separated from the shoreside beachrock by 50 - 100 feet of the original reef flat. There are 3 stretches of these offshore bars south of the large tank rising to about 4 feet above high tide. North of the large tank there are two other such bars. In each case, the points of highest accumulation adjoin or are opposite storm-scoured breaks across the land from or to the lagoon. The land on the lagoon-side opposite these bars generally appears to have suffered severe erosion of the sediments of which it is constituted.

Since broken glass and other material deriving both from the land and from the lagoon have been found in the seaward reef bars, some of the material in these bars obviously came from the land and lagoon. However, much of the material appears to be derived from the outer reef margin and parts of the reef flat. Slabs of coral rock 2-3 inches thick form imbricated beds on the seaward slopes of the bars, and the landward fronts of the bars have the abrupt terminations of delta talus. Local inhabitants also stated that the bars smelled of rotting reef organisms after the storm, so that fresh materials from the live reef must have formed a large part of the bar. We may conclude, therefore, that the reef margin also suffered severe mechanical erosion from the waves, although much of the debris may have come from the bases and lower parts of the surge channels, as indicated by Banner (pp. 76-77).

So far as the writer observed, few large blocks of rock were torn off from the reef margin and tossed up onto the reef, unless some were buried under the higher accumulations of cobble-size and smaller boulder-size debris in the seaward reef bars. However, on the new bar on the lagoon side about half way between Blockhouses nos. 3 and 4 there is a block of coral about 6 feet in diameter which appears freshly broken off, because the top half standing out of the tides is white and lacks algal staining, while the lower half is only stained light brown where algae have grown between tide levels (Pl. I-d).

Bars are also found on the lagoon reef (see charts, figs. 6, 7), freshly formed as shown by their white coloring. Lack of time did not permit close examination of these. The most prominent bars run in an arc from the large coral block mentioned in the foregoing paragraph to the Sydney Pier base opposite the large tank. A fresh gravel bar also runs roughly parallel to the land strip northeastward from the broken remnants of Sydney Pier.

Just northward of Blockhouse no. 4 a fresh looking bar has formed on the lagoonside somewhat northward of low cobble bars on the seaward side. A new bar was added also to the lagoon reef in the northernmost parts of Jabor between the main pass and the old pier where the rusting hulk of a ship sits on the beach. This runs for about 800 feet in a narrow strip 200 - 300 feet offshore. The materials on it appear to have been derived from parts of the shore near the northern tip of the islet of Jabor and from sediments in the channel fringe.

Of the sections observed, the materials forming the bars were mostly pebbles, cobbles, and small boulders. Very few sand-size particles were apparent in most of the bars. This seems to indicate that most of the finer sediments may have been washed into deeper lagoon or ocean waters and that there was little disturbance of the lagoon bottom where most of the sand and finer material normally accumulate. This accords with the limited bottom inspections near shore by Banner (p. 78), who found the corals under 3-4 feet of water in the lagoon apparently generally unaffected by the storm. However, when the writer examined the same areas on foot in 1956, he found virtually no sand beaches along this entire stretch of land either on the lagoon or seaward side. During the present examination the writer found only one small section of the beach several hundred feet long and about 20 feet wide where fine sand was mixed with coarse pebbles and cobbles. This was on the seaward side not more than 200 - 300 feet northward of the fallen steel towers.

Land erosion and land-build-up on Jabor

In general, although in a few places debris accumulation has widened the land area and has added to the land surface above tide level, the net result appears to have been a significant reduction in the land area suitable for economic plantations. For the most part the old algae-blackened beach rock on the seaward side has remained intact, although here and there the violence of the storm has broken off slabs several feet in diameter, undermined sections of the rock on the landward side or scoured a breach between lagoon and seaward reefs. Undoubtedly the greater consolidation of this generally intertidal rock has served to protect the land in the manner of a low seawall.

Scouring of the less consolidated rock and sediments directly landward of the top of the beach rock in most cases has left a trough between the line of beach rock and the new shore ridge that now runs 10 - 20 feet from the old beach ridge that once adjoined the beach rock (Pl. II-a). At high tide this trough is partly filled with water. This general aspect is observable the entire length of the seaward side from the steel towers northward to where the island widens.

Scouring of this narrow part of the islet, which occupies all but about 3000 feet of the entire 12,000-foot section examined, is more severe on the lagoon side. In some instances this has resulted in channels cut almost or entirely through from lagoon to seaward reef, probably by headward erosion by water pouring over the land from the seaward side.*

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* Blumenstock believes there was primary water movement from seaward but secondary movement from lagoon to sea, see pp.17-18.--D.I.B. /But see also p. 12.--Ed./

The addition of debris to the land has largely been in a layer from the newly formed shore ridge toward the lagoon (Pl. III-b). This type of debris addition is usually found only where the land widens to 200 - 300 feet or more. In the narrower parts no additional layer occurs on top of the old land surface. On the contrary, a layer of partly consolidated or loose material may most often be observed to have been stripped from narrow and sometimes from wider land surfaces, occasionally with small remnants of the original layers left in the form of platforms.

Especially noted erosional features in this section include a beach stretch 200 feet north of the steel towers where the new seaward shore ridge is now 30 feet inland from the seaward beach rock. Stumps of now dead Pemphis trees stand out of the sand and gravel all the way out to the edge of the beach rock, showing that the vegetated land reached this far prior to typhoon OPHELIA (Pl. III-a).

Lagoonward of the concrete buildings next to the steel towers wave action had washed out a channel from the reef that bifurcates to form two channels cutting inland around the northern sides of the two buildings nearest the seaward reef. The channels each end in a kind of swirl on the seaward sides of the buildings and do not cut all the way across this wide part of the land. The position of the buildings may have tended to funnel the ocean water into a stronger stream causing headward erosion of the land at these places.

Other especially noteworthy washouts of land occurred about 800 feet south of Blockhouse no. 4; at other areas half-way between Blockhouses 3 and 4; 500 feet south of Blockhouse 3, to the north and south of the high mound surrounding the large storage tank, and in most of the areas northward of Blockhouses 2 and 1 in the narrow part of the islet.

The widest channel cut across the land occurs at the north base of the high mound around the large tank (Pl. I-c). Here, at high tide, water runs across into the lagoon in a large stream. A smaller channel cuts through a 4 foot depth of conglomerate about 550 feet north of Blockhouse 2 (Pl. II-b), while still another channel has been cut through as far as the seaward beach rock about 900 feet north of Blockhouse no. 1.

On Jabor proper (the northern 3000 feet or wide part of the islet) the most damaging winds blew southeasterly roughly parallel to the islet as indicated by the direction of tree-fall*. Shore damage was severe all around the island. Inundation apparently occurred over most of the islet, although the soil surface was not much disturbed in the higher middle parts 400 - 500 feet inland from the north end and 300 - 400 feet from the remaining 6-foot high concrete seawall on the northeast side. The seawall was broken in its southern 200 - 300 feet as far as the triangular concrete structure which dates back to German times. The deposition of gravel and rocks was much reduced by the protection of the seawall along

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* For different estimates see Blumenstock, p. 8.
-- D.I.B.

the northeast side. Beginning with the triangular structure, however, gravel sheet deposition with a front depth of up to three feet advanced inland 200 - 300 feet from the seaward shore ridge as far south as the building occupied by the expedition and by the agriculturist. From this building southward the entire land surface has been strongly disturbed either by scouring or by deposition. The surface is covered with pebbles, cobbles and small boulders up to 6 inches thick and 1 - 2 feet in other dimensions. Except for the toppled trees and still standing trunks of Pandanus the scene looks like the bed of a rocky river. Only a few strips and patches of the original soil surface are identified by occasional growths of grasses such as Lepturus.

On the lagoon shore, the two stone and concrete piers on which the government generator equipment and a warehouse stood now are merely piles of coral rubble that protrude into the lagoon. The former 4-foot high seawall of cemented coral blocks along the lagoon shore has been stripped down to remnants 1-2 feet high, and at the north end some 200 feet of it has been torn off and upturned altogether. Rubble from the lagoon reef flat and shore has been scattered inland 30-50 feet in the northern half of the islet. The greatest piling up of coral rubble has occurred on the shore facing the channel, for the most damaging winds blew directly inshore across the channel from the north and hit this coast area squarely*.

Near the bend in the seawall on the eastern part of the channel shore a 50 foot break in the wall allowed the storm waves to scour out a semi-circular hollow backed by a curved shore ridge of pebbles, with additional debris spreading inland from it. At the northern point of the islet the seawall is buried by a gravel and rubble shore ridge that rises to the highest peak of any seen on the various islets, about 10 feet above low tide. This ridge slopes channel-ward in a gravel beach out about a hundred feet and drops off into deep channel water. Since, prior to the typhoon, the bottom at the base of the seawall dropped off quickly into the depths of the channel, the amount of debris filling in the channel fringe here is considerable. The shoaling of water in this area and westward across one of the branch channels has made it hazardous for ships to enter by the most direct channel to the Jabor anchorage, and forces ships such as the Roque to use the more northerly channel running northward past Enejet.

Inland, rubble has been deposited in a two-foot depth around the concrete walls of the agriculturist's former home completed just two years before the typhoon and situated 100 feet from the seawall. Farther inland, however, the ground surface is little disturbed, and ornamental croton hedges continue to flourish, although most of the trees are blown over.

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* For differing views, see Blumenstock, p. 8.
-- D.I.B.

Soil and vegetational damage on Jabor Islet

In general, 95% of the trees on this islet were toppled or snapped off at varying heights above the ground. From the concrete house in which the expedition stayed southward, virtually none of the original ground surface and ground vegetational cover remain except at small high spots such as the slope up to the large storage tank. In this area coconut trees still may be found growing at widely separated intervals. Almost all Pandanus appear to be killed, although the prop roots and part of the lower trunk may remain. No trees of large size grew in this area except near the Expedition Headquarters. These are mostly Calophyllum, and they have been toppled, with their great shallow root systems standing high in the air. Some of them have re-sprouted leaves on a few limbs, since the trees often retain a few roots still buried in their growing positions. On a number of the wider rocky platforms of the islet, however, the hardy Pemphis, stripped of smaller branches and twigs and left with vertical trunks 1 - 2 inches in diameter, has begun sprouting leaves on these remnants (Pl. VIII-c) and will no doubt soon be essentially recovered.

On the wide northern part of Jabor a few large Calophyllum trees near the base of the northern pier have not been uprooted and are sprouting leaves from trunks and large limb remnants. All the Casuarina trees which were up to 6 - 8 inches in trunk diameter were uprooted by wave wash and wind* and most of the other large trees and the coconut and Pandanus trees were uprooted or killed by trunk snapping. However, shrubs, weeds and grasses over most of the interior in an area 500 feet wide by some 1000 - 1500 feet long appear relatively undisturbed and similar in aspect to what they were in 1956.

Damage to structures

In general, all wooden buildings were demolished and thatched houses smashed flat by the wind. Some roofs were pulled back into position and are temporarily used. All houses require rebuilding, however. Concrete structures stood up well although the lower stories were inundated and doors and windows washed out. Cisterns mostly remained intact, but were contaminated.

Kinajon Islet

This islet stands between two of the channels of the Northeast Pass and across the channel southeast of Imroj Islet (Fig. 1). It is an oblong islet about 2500 feet in length by about 1500 feet in width at the widest part (Fig. 8). Much of the northern third of the islet appears to be occupied by a depression partly overgrown by mangroves. A smaller mangrove depression also is found in the eastern bulge of the islet. The southwestern third formerly (during World War II) contained some Japanese vegetable gardens covering about an acre in the middle. This area has fewer trees and a more open aspect.

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* But see Fosberg, p. 54.-- F.R.F.

The north end of the islet with the large mangrove swamp faces the seaward reef. Coral debris up to small-boulder size was carried inland by storm waves as much as 50 - 100 feet along the northern third of the shore-line, filling the seaward parts of the large mangrove swamp with gravel. The front of this deposit is 2-3 feet high. This deposition did not occur at the channel sides of the islet in the wide western indentation or along the eastern and southern shores. The latter two sectors were in the lee of the waves. The western channel escaped such inshore deposition possibly because of lack of reef shoaling from the deep channel and perhaps because the waves may have run more parallel with the coast than across it.

The beach sediments deposited by the storm in the western indentation are mostly sand and silt with small amounts of pebbles. The only other beach with similar sandy character is a small section 150 - 200 feet long directly southwest of the eastern bulge of the islet. The beach in the northern third of the islet is composed of coarse pebbles, cobbles and small boulders. In the rest of the shoreline small to medium size pebbles form the beach and shore ridges.

Erosion of the original shore appears most severe in the northeast sector where a 20-foot wide strip inland from the old beach rock has been scoured away and the new shore ridge moved this distance inward. At the southwest end erosion has eaten away about 10 feet of the original land along the shore, and about the same amount of erosion occurred as a result of the storm in the northeast sector just north of the eastern bulge of the islet. In the southern leeward and lagoonward sectors, however, an initial scouring of the shore washed out the roots of strand trees. Subsequent to this, pebble and cobble deposition has added a 10 - 20-foot wide strip of loose sediments to the shore. In the southeast lagoonside bend of the islet there are two shore ridges or storm ramparts 20 feet apart, and the strand trees blown over by the storm are partly buried by sediments.

The tree-fall direction in most parts of the islet was slightly east of south.* The largest percentage of tree destruction appears to be in the northern peripheral areas where an estimated 90% of the trees were uprooted. The largest percentage of trees left standing and growing appear to be around the small mangrove depression in the eastern bulge of the islet. Here about one-half of the coconut trees remain standing with growing fronds.

In most of the rest of the islet between 60 - 75% of the trees were felled. The taller mangrove trees had their foliage stripped off the top half, and some are dead, but most of them are forming new leaves. The smaller lower mangroves appear little damaged and relatively flourishing.

Except for the parts of the periphery of the islet damaged by gravel deposition, by storm wave scouring, or by uprooting of trees, the ground cover of low plants such as grass, weeds and shrubs appear to have been affected by the storm.

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* No one dominant direction according to Fosberg, notes. --D.I.B.

Imroj Islet

Imroj lies across the pass northwest from Kinajon and is about 4,200 feet long by 1000 feet wide 1000 feet from the northwest end, and about half this width in the southeast half (Fig. 9). It was and is the principal inhabited islet presently having about half of the atoll's population. Prior to the storm it had a very luxuriant aspect, with dense plantings of coconut, pandanus and many breadfruit trees.

Marked shore-line changes have occurred all around the islet. The old pier was not very well built and consisted mainly of uncemented coral blocks piled up in a regular line covered by coral sand and silt. This is now merely a mass of coral blocks protruding lagoonward into water of 4 - 6 foot depths.

The greatest shore and land damage has been on the seaward or northeast side. The islet extends roughly northwest to southeast, and the most damaging winds came from the northwest at a diagonal across the islet, as indicated by the direction of tree-fall.* Violent beach and shore scouring occurred on the seaward side, and pebbles, cobbles and small boulders were carried inland and deposited 50 - 150 feet from the old shore ridge. The mangrove depression at the northwest end is partly filled with gravel.

Water from the ocean scoured several shallow depressions across the lagoonward half, in the southeastern two-thirds of the islet. The closeness of the coconut and Pandanus plantings and the depth of root penetration made the soil disturbance unusually great. Each overturned tree resulted in the pulling out of a great mass of soil and gravel by the densely massed roots and the excavation of large holes 2 - 3 feet deep and 6 - 8 feet in diameter. The result is an extraordinarily rough surface which presents a very difficult problem in the replanting of the islet.

Vegetation damage

An estimated 90 to 95% of the economic trees were uprooted by the storm and a large part of the ground cover was killed on the seaward half of the islet.

House damage

All houses on the islet were demolished. Some reconstruction has been done through the use of scrap material from the old structures, but many of the people still must live in the most make-shift shelters. The materials for thatch-making are available only in very small quantities since most of the Pandanus and coconut leaves were destroyed by the storm, and few are growing.

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* North to northeast according to Fosberg (notes) and Blumenstock --D.I.B.

Ribon Islet

Ribon is a tiny islet about 450 feet long by about 250 feet wide oriented northeast to southwest (Fig. 10). A strip of beach rock runs roughly at right angles to this direction from the middle of the northeast beach northwestward for about 500 feet. Small boulders and gravel form a sheet up to a foot in depth near the northwest end of the beach rock strip and about 100 feet in diameter. A few yards farther northwestward a pebble and cobble bar about 60 feet wide rises to about 6 feet above the reef flat and runs at lower heights and narrower widths in three discontinuous strips in a southwesterly direction. This bar appears to have been freshly built by the typhoon waves.

The northeast end of the islet faces the pass opening to the ocean, and a 20-foot wide strip of the former land appears to have been scoured away between the old beach rock and former shoreline and the present shore ridge. Pebbles and cobbles have been washed inland and partly fill a rocky depression about 100 feet wide and 300 feet long running parallel to the northeast shore. A thriving stand of shrubby Pemphis grows on the rock of the depression.

At the southwest end of the islet a cobble and gravel spit has been built lagoonward for a distance of about 220 feet in a strip 5 - 6 feet wide and up to about high tide level or slightly above. At the landward end the current eddy of the storm waves apparently swirled to form an oblong to circular rampart or beach ridge around a depression 1 - 2 feet below the ridge level and filled with flotsam.

The islet has a high shore ridge all around it formed of pebbles and cobbles. In the southern half of the islet there is a double shore ridge which rises to the highest level on this side of the islet. While the strongest storm waves appear to have come from the north and piled up the 6-foot bar on the reef flat in this direction, the direction of tree-fall was to the southwest, indicating a wind of maximum violence from the direction of the open pass or northeast. The position of Mejatto Islet and of the pass may have influenced somewhat the apparently differing direction of the tree fall both on Imroj and Mejatto from that on Ribon. The protection afforded by Mejatto situated to the windward (with reference to the storm) of Ribon, also may have resulted in the decreased tree damage. Some 6 - 10 coconut trees were downed, 14 were left standing and growing. Most of the Pisonia trees still have their trunks and chief limbs intact and are regrowing leaves. Guettarda and Scaevola growing among the rotting old coconut stumps and Asplenium nidus continue to flourish in the interior of the islet. So little disturbance on such a small islet can only be attributed to its geographic position relative to Mejatto Islet and the open pass.

Mejatto Islet

Mejatto Islet is about 12,500 feet long and from 450 - 600 feet wide, although near the northern end it widens to over 2,200 feet (Fig. 1). Its long axis is roughly north northwest to south southeast. It lies north of the pass NW of Imroj (Fig. 1).

This islet suffered even more from wind and wave destruction than Imroj. With the exception of about the northern 2000 feet and 500 - 600 feet on the southern end, the entire islet appears to have been swept by ocean water and severely eroded and cut up. Gravel sheets were laid over large parts of it from the seaward side half to three-quarters of the way across the islet. Many channels were cut across the islet.

Coconut, Pandanus and other trees not only were blown over and washed out but a large number were washed into the lagoon where many stumps are visible on the lagoon reef and many trunks stand in the deeper water of the lagoon slope. From 1 to 4 feet of the original soil were washed from much of the islet although in other areas 1 - 3 feet of gravel cover the original surface (Pl. II-d, Pl. X-b).

A map for plotting data directly was not made before going to this islet. Instead a traverse line by plane table was made by Blumenstock and the writer down the length of the islet southward from a point 3000 feet from the north end, and notes were taken along the route of the traverse which was measured by pacing (Fig. 11). Most of the traverse route was near the seaward shore-ridge. The return trip to the point of origin w s made separately by Blumenstock and by the writer, who paced the last leg of the traverse (2475 feet) alone and returned along the lagoon side of the islet pacing only the first 500 feet from the south end. The features noted on the map of Mejatto (Fig. 11) thus are less exactly located and less correctly oriented than on the other maps made by the writer.*

At the starting point a very large Calophyllum tree standing at the lagoon shore has survived the storm. Its branches were broken back to the few remaining main limbs, but leaves are sprouting again from them.

Immediately to the south of this tree ocean water had poured across and scoured out a large channel across the islet. Coral debris from this area forms a convex bar on the lagoon side reef enclosing a shallow pool. Many similar bars and pools occur along the length of the islet opposite other channels cut across the islet so that the bars give a scalloped appearance to the lagoon side.

At station 3 (700 feet south of station 1) the land is badly eroded and many coconut tree trunks still standing have lost their crowns. A channel is almost cut through to the seaward reef by headward erosion and is about 150 feet wide.

At station 4 (560 feet south of 3) the erosion channel makes a 90-foot break in the ledge rock at the seaward side and a hole filled with water at low tide is scoured out landward of the beach. Two to three feet of the original surface are stripped from the seaward half of the islet, leaving high mounds of gravel where Pandanus or coconut roots remain in place.

A characteristic feature on this islet is the scour-pit formed on the down-stream side of the tree stumps opposite the accumulation of gravel and flotsam on the upstream side (see McKee, p. 40).

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* Traverse distances given are, I believe, correct within 10% --D.I.B.

While the lagoon sides of islets most often have sand beaches, Mejatto's sand beaches (if there were any) appear to have been washed away into the lagoon leaving only pebble and cobble beaches. Washed out tree stumps are numerous on the shallow lagoon reef and slope between stations 4 and 5.

The distance between stations 4 and 5 is 365 feet and between 5 and 6 it is 825 feet. About 200 feet south of station 5 is a barren wash or channel cut through, with no vegetation left. In this area a blown over Barringtonia tree 2 feet in diameter is sprouting a few leaves from the trunk. Some 550 feet south of station 5 a channel working headward from the lagoon side has left a V-shaped indentation. On the seaward side is a low spread-out cobble and boulder bar. The land between sea and lagoon, here about 275 feet wide from shore ridge to the channel head, is badly eroded and pitted and extremely hummocky. Some 3-7 feet of the soil and gravel have been removed.

In the vicinity of station 6 three trees with wide buttresses, which are probably breadfruit, are still standing upright but have had branches, bark and leaves stripped and appear dead. Many coconut tree stumps lie on the lagoon reef.

At station 6 there is another lagoon outwash channel-indentation, and at the mouth of it lies a dead breadfruit tree trunk with roots and some limbs. Near the lagoon close to a standing breadfruit tree trunk and two lagoon shore Calophyllum trees a patch of the original soil, black humus mixed with sand, remains. Lepturus grass growing in a thick mat on this soil apparently survived the typhoon inundation.

Stations 6 and 7 are separated by 550 feet. Two discontinuous patches of bouldery rubble lie off the seaward beach here but are not heaped up sufficiently to constitute bars. Stations 7 and 8 are 550 feet, and 8 and 9 are 825 feet apart. In the vicinity of station 9 there appears to have been a large breadfruit grove prior to the typhoon; 10 - 12 large trees with buttressed trunks and limb sections still standing indicate the remains of this grove. Much flotsam has been accumulated around their bases.

Station 10 lies 1310 feet south of station 9 and from station 10 to the southeast end of the islet is 2475 feet. North and south of station 9 on the seaward reef from 5 - 150 feet offshore are patches of scattered coral cobbles and small boulders.

Between stations 9 and 10 there is an extensive scoured-out backridge trough inshore from the new pebble shore ridge. The central part of the islet rises to about the ridge height or more and is covered by a sheet of gravel. Most of the coconut and Pandanus trunks and stumps have been uprooted and washed lagoonward. Few remain standing.

This general aspect is found southward over most of the area between station 10 and the end of the islet, except for the last 500 feet. Around the curve of the shore lagoonward of the pass between Mejatto and Imroj two pebble and cobble ridges flank the shore, the inner one about 20 feet inland. The lagoon half of this part of the islet has retained

much of its original vegetation. Part of the area is occupied by a mangrove depression separated from the lagoon only by a pebble shore ridge.

There are two or three separate depressions in which mangroves are growing in this part of the islet. The one nearest the end of the islet is partly filled with pebbles and cobbles washed in from the seaward side (Pl. III-c). Many of the small mangrove trees appear to have been broken off but some stalks are still alive and have re-sprouted. Many low young coconut trees also have survived in this area. Northward of the southern mangrove depression and its surrounding trees there has been considerable erosion of the land back of the lagoon shore. A pool 3 feet deep and 20 by 50 feet in horizontal dimensions has been scoured out and many coconut palms overturned but not washed from the site of growth.

In this vicinity and adjacent to an outwash channel-indentation stands a concrete cistern with brackish water. It was sunk 2 feet into the ground with the walls rising 2.5 feet above the old ground level. Here the surface of the ground is not greatly disturbed. Northward of this the soils are badly eroded and cut up. Approximately opposite station 7 but on the lagoon side of the islet is another mangrove depression elongated parallel to the axis of the islet. Pebbles and cobbles have filled in about three-fourths of the depression from the seaward wash to a depth of about three feet (Pl. III-d).

The extreme northwest end of Mejatto was not visited by the writer, but a view from the schooner in the lagoon showed many more coconut and other trees to be standing here. Obviously, less wind and water damage had occurred in this widest part of the islet.

Lijeron Islet

This small islet on the northwest reef measures an estimated 300 by 600 feet but was not paced off.

On the east end a sand beach 50 feet wide borders the islet. The north and south sides are concave indentations protected from the normal waves from the east and have developed beach rock. At the west end there is a narrow neck of rock extending to a rock platform less than half the size of the eastern part of the islet and supporting a pure dense stand of Pemphis. This contrasts with the almost pure stand of Pisonia on the eastern and larger and higher part of the islet. A few Cordia and Tournefortia trees and perhaps half a dozen coconut trees also are on the eastern section. There appears to be little significant topographic change resulting from the storm save possibly the development of a long sand hook southward from the eastern sand beach. Some sand was spread in a sheet half-way across the islet from the north.

The vegetation on this small islet also survived well. A few Pisonia and Cordia and 2 - 3 coconut trees were toppled, the direction of fall being due south.

This isolated uninhabited islet is the nesting place for hundreds of white-capped noddy terns which are relatively tame. Most of the nests contained a young chick or an egg at the time of our visit. Overhead circled many terns and frigate birds.

About a dozen terns and one young frigate bird were caught by the Jaluit islanders from our schooner to take home for eating. Some eggs also were collected apparently for the same purpose.

Pinlep Islet

Pinlep Islet is situated on the west reef of Jaluit (Fig. 1). Between the islet and the lagoon proper is a faroe or secondary lagoon of relatively shallow depths resulting from the upbuilding of a reef enclosing a triangular body of water. The northwest shore faces a wide reef flat, but the oceanward reef to the south is narrow. The islet is about 8,500 feet long. The eastern half runs between 500 and 800 feet in width. The central portion of the western half is widest, about 2,200 feet. The main inhabited parts appear to have been along the lagoon-facing sectors of this wide portion (Fig. 12).

Our small boat made a landing near the middle of the islet after crossing the secondary lagoon. The schooner had to stand some distance off the reef of the secondary lagoon so as not to drift onto the reef, since the wind blew toward this reef from the east.

In an interview with the oldest inhabitant, named Brown-Smith, we were informed that the first severe storm wind of the typhoon blew from the north starting at about 6 p.m. By about 10 p.m. the wind had shifted to blow from the south with great violence. Our informant stated that it was this wind that blew down most of the trees. However, almost all the trees downed had fallen in an easterly direction, so that the most violent blow must have come from the west. If the first violent winds were from the north followed by violent west winds, as the tree-fall appears to indicate, the cyclonic whirl must have moved westward and then northwestward.

The most severe damage inflicted on the trees appears to have been near the western end of the islet where an estimated two-thirds to three-quarters of the coconut, Pandanus, breadfruit and other trees were killed. The central part of the south and seaward sides of the islet appear to have had the smallest proportion of the trees toppled, between one-third and one-half. The writer did not traverse the eastern half of the islet and cannot describe the extent of damage in this portion.

Along the beach north of the Brown-Smith hut, coconut trees were bent over northeastward, but were not completely overturned. Many breadfruit trees were toppled over along the village road parallel to the lagoon beach. Others remain standing but have most of the limbs broken off. These and others with some large roots still in the ground are sending out new leaves. Near the northwest beach a mangrove stand in a mucky depression has most of its trees stripped of leaves and twigs, and the

trees appear dead. The northwest facing shore here is badly eroded and has retreated 10-15 feet. The character of the beach sediments along the shores observed are shown in Fig. 12.

Inundation was most severe and penetrated farthest inland at the west end of the islet, where the shoreline appears to have been scoured back 10-15 feet, while water-borne sediments and flotsam were carried in forty feet or more from the shore ridge. On the southerly section of this western end many Guettarda, Scaevola and Tournefortia, toppled over but only partly washed out, are sending out profuse leaf sprouts. About 1500 feet from the west end a breadfruit tree trunk still standing 80-90 feet high is sprouting leaves from parts of the large limbs remaining, although all smaller branches are gone. Along this south shore there appears to have been little salt water penetration inshore.

Majurirek Islet

Majurirek Islet is roughly 3000 feet in length (Fig. 13). Its long axis is aligned almost due north and south. Its greatest width, about 1100 feet, is near the south end, and it narrows gradually northward until at about 500 feet from its northern tip it has a width of some 600 feet. A mangrove depression about 1000 feet long by 250 feet wide occupies the south central interior of the islet. However, only sparse patches of mangrove are found, largely near the southeast fringes. Most of the depression is an open pool of salty or brackish water. A much smaller mangrove depression occurs near the southeast shore of the islet just west of the village path.

The character of the shore and beach areas at the time of the visit by the writer is shown in Fig. 13. In general, the severest storm winds of Typhoon OPHELIA came from the west, as indicated by the plotted direction of tree-fall in the chart. This accords with the observations made on Pinlep, also on the west reef, as well as with the observations made in the southern extension of Jabor Islet where the steel towers were also blown down in an eastward direction. Locally, the directions of tree-fall were not always toward the east. In a few instances where strand trees were undermined by wave wash the directions of fall were toward the beach. On the ocean side in the extreme north shore area the dominant direction of tree-fall appears to have been toward the southeast. In the southwest shore area the direction of tree-fall seems mainly somewhat north of east. At the southeast end the tree-fall was toward the southeast. Along the lagoon shore the direction was dominantly lagoonward or eastward.

Of the islets examined, this one appears the least changed morphologically along the shores. Inundation by ocean or lagoon water appears to have been restricted to a narrow zone of a few yards from the shore and only occurred locally. No significant amount of sediment was washed inshore, and the shores were only slightly scoured. Beach character probably was changed, but, without information on the nature of the beaches before the storm, the writer cannot evaluate this change. Shore retreat owing to wave-scouring occurred on the lagoonward side of the southeast bend of the islet about 100 feet north of the beach rock formation. Here an old family grave-plot was partly eroded away. The maximum retreat appears to have occurred just at and just south of the northwest

bend of the seaward shore, where from 3 to 5 feet may have been scoured away from the shore. In the southern half of the seaward area, shore retreat appears to have been less than two feet. This is the only islet aside from the small Lijeron islet ("Bird Islet") where a considerable sand beach development was observed or retained. Characteristically, this sand is on the lagoon beaches, some of it overlying beach rock.

In the interior the only morphological change resulted from the excavation of holes or pits when falling trees brought out with their root clumps large amounts of gravel and soil held by the roots. Since many trees were toppled, the topography is very uneven where this occurred. Pandanus trees were mostly snapped off below their crowns, with roots and main trunks still standing although dead. Where they were killed, coconut trees tended to be uprooted rather than snapped off below the crowns. Many of the breadfruit trees likewise had all major limbs broken off, but the trunk with remnants of limbs remains standing, with roots still in situ. Where this occurred, the tree trunks and remnant limbs are re-sprouting leaves. Even those breadfruit trees that were overturned but which retained some large roots underground are re-growing leaves.

In terms of the most important tree types, the Pandanus suffered most destruction, up to an estimated 90% of these trees being killed on most of the islet except along the lagoon shore where low young trees suffered less damage. The coconut trees at the south end of the islet between the large mangrove depression and the shore suffered up to two-thirds loss. North of the large mangrove depression about half of the coconut trees were toppled. A large grove of large Pandanus occupied the area west of the northern third of the large mangrove depression. Almost all had their crowns and limbs snapped off. Further damage had been inflicted in this area by uncontrolled burning of the fallen fronds and trees. This burning also affected coconut trees still living and some young coconut sprouts.

The mangrove and Pemphis trees fringing the southern end of the mangrove depression appear little damaged by the violent wind. Bananas blown over and killed in the northeast quarter of the islet have re-sprouted young plants from their roots.

Salt water from the oceanside during high tide probably infiltrated the mangrove depression, because the land area west of the depression is made up of boulders up to 8-10 inches in diameter and probably allows relatively free water movement through it.

Where the small-boat from our schooner landed, about 350 feet from the southeast bend of the islet, two large Calophyllum trees and one large Hernandia sonora tree remain growing on the strand, having re-sprouted leaves from the branches and trunks.

In conclusion, it appears that of all those islets examined by the writer, Majurirek escaped with the least damage to its soil and economic plants.