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Life On Guam Beach Strand

by Margie Cushing Falanruw

art L Hotaling

Life On Guam

...a project to produce relevant class, lab, and field materials in ecology and social studies for Guam junior and senior high schools. Funding is through a grant under ESEA Titles III and IV, U.S. Office of Education——Department of HEW——whose policy, position, or endorsement is not necessarily reflected by the content herein.

"...to ultimately graduate citizens who are knowledgeable and conscientious about environmental concerns of Guam and the rest of the World."

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Activities

"Come unto these yellow sands

And then take hands."

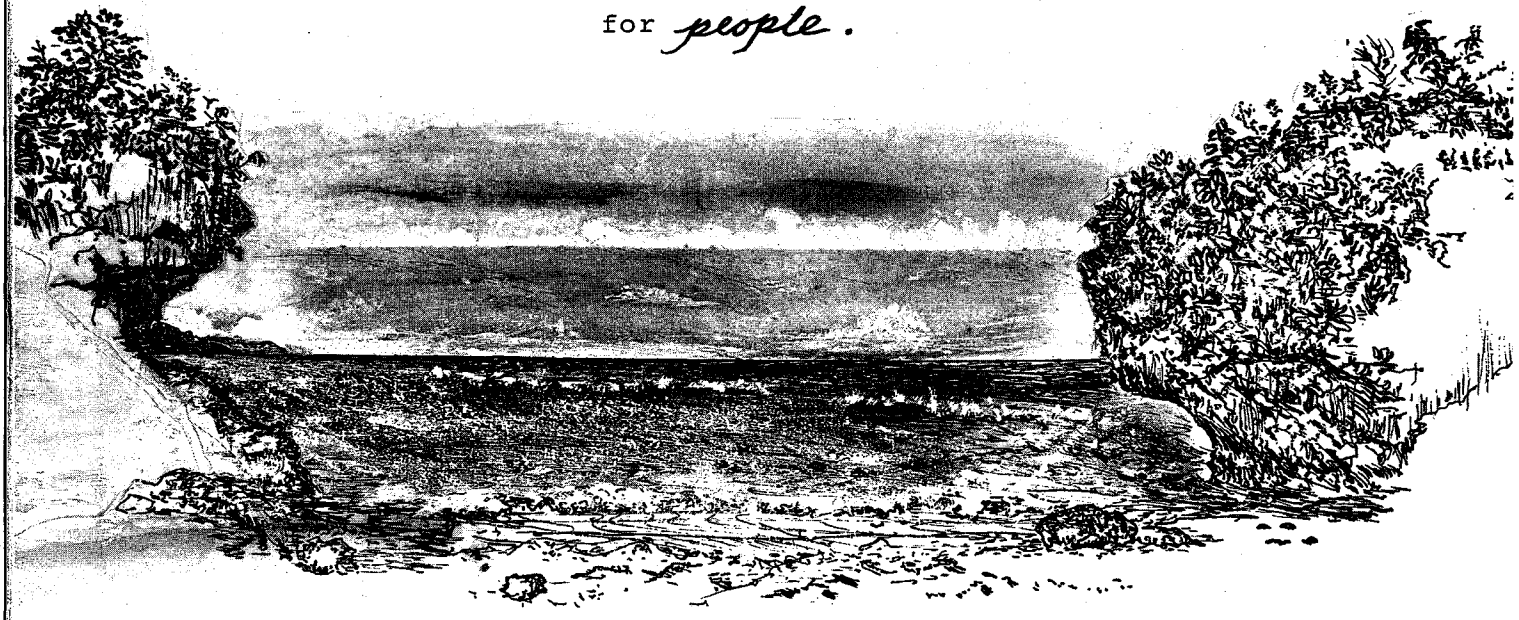
—Shakespeare

1 Introduction

WHAT'S GOING TO HAPPEN—

When you finish this unit you'll be able to recognize, describe and discuss the following:

1. PARTS of a typical SAND BEACH.
2. COMPONENTS of *sand*.
3. *Shifting* and STABILIZATION of sand.
4. COMPONENTS of *drift*.
5. TIDES, their causes, their differences, their effects.
6. *WATER* currents and wave action.
7. *Living* plants and animals of a typical GUAM BEACH.
8. VALUE of the BEACH STRAND as an *edge environment* for sea turtles, coconut crabs, birds and other animals.
9. IMPORTANCE of the beach strand in economics, subsistence, and spiritual refreshment for *people*.



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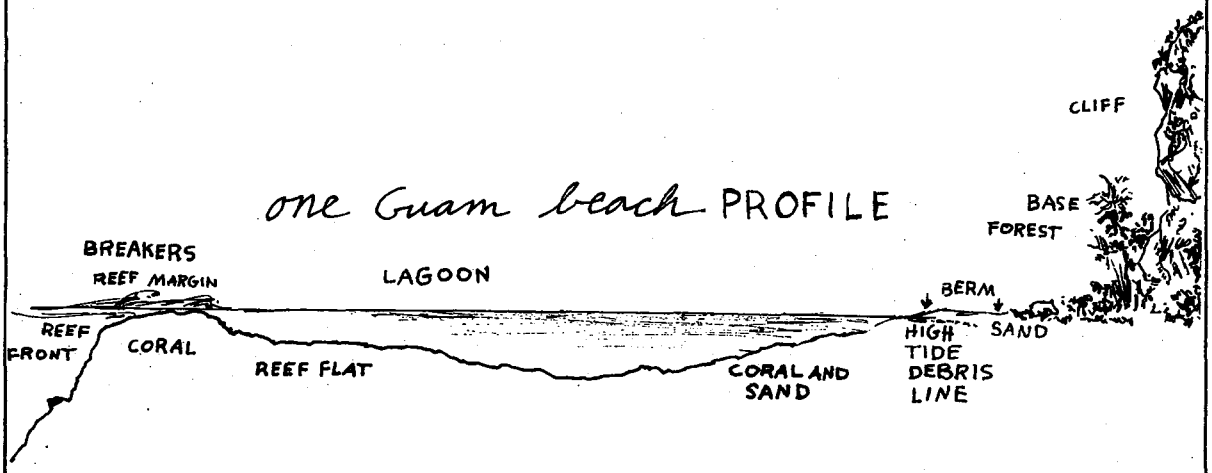
2 Beaches

A strand is the land bordering a body of water. There are many kinds of strand, including beaches.

Beaches are an accumulation of sand or rock fragments affected by ordinary wave action. They come in many sizes and shapes, from little pockets of sand gathered between cliffs and water's edge, to wide expanses of sand like Tumon and Tarague and even offshore islets like Cocos.

Beaches are always in motion. Small ones appear and disappear from time to time as waves carry sand to and away from land.



Larger, more stable beaches generally have an inland reservoir of sand. Find out what a Mainland sand beach profile looks like and diagram it in your notebook for comparison with this Guam one.

Waves carry sand inland to form berms or erode it away to be deposited in bars. Berms get widened during calm conditions, while bars result from big waves.

Horizontal movement of water currents along the shore carries sand along the beach. This photo shows how an obstruction (a rock-and-cement groin) can trap this sand on the upcurrent side and 'rob' it from the beach downcurrent.

Current shifts and man-made factors such as channels, dredging of swimming areas, construction along the shore, removal of vegetation, can affect the size and shape of a beach. Compare the buried bases of coconut trees in the preceding photo with the exposed boles (bases) further down the beach in the photo below. Here, so much of the beach has eroded away that some of the trees have now fallen.

One way to appreciate the dynamic quality of beaches is to follow the movement of individual particles. You would need to follow some particle which is distinguishable from the plain sand. One such particle is a coin. Coins are relatively heavy and tend to settle within inches of the sand surface. They can be located with the use of special metal detectors. Some coins found this way have been traced to ships which wrecked far offshore many years past. Things certainly get moved around!

Activity 1 Moving Sand

You need about two liters of dyed sand. Pour this at the water's edge. Check from time to time during your beach visit and the next day if possible, to see how the water moves this sand around. Diagram the movement in your notebook and give some causes for it.

Life on the beach strand is dynamic. The sand is the interface——the meeting place——of land and sea. Life forms from the land crowd in from one side and life forms from the sea crowd in from the other. They compete with each other or help each other to live in the changing conditions of the beach strand. There are some permanent beach residents. There are also many visitors, some who come regularly, others only rarely. The beach strand is an always-changing scene.

3 Sand

Estoril, Portugal

Ngatik, Ponape

Eleutheria

Sella Bay

Jones Beach, New York

Bermuda

Lido di Ostia, Italy

Sand consists of loose particles of hard broken rock or of broken shells and skeletons of plants and animals. The fact that sand is made up of a lot of loose particles means a number of things can happen. Sand does not form a suspension in seawater; instead, it sinks to the bottom. Unlike mud or silt shores, sand beaches allow lagoon waters to remain clear. This means there's lots of sunlight for photosynthesis. The looseness of the sand below the low tide mark lets many sand-dwellers burrow in and live there. At high tide, water reaches organisms in the intertidal zone. This water drains off as the tide ebbs. So, some sand-living organisms can be wetted and then dried without ever being exposed to the air. Water percolating through sand also carries nutrients to these organisms.

Above the high tide level, sand provides a shifting substrate not easily inhabited by vegetation. It is difficult for germinating seedlings to get a foothold in loose shifting sand where they are in danger of being covered and uncovered. As the beach is washed by waves, however, debris is thrown up to decay and become mixed with sand to fill the little spaces among the grains and make the sand more stable.

TARAGUE BEACH

New

Worn

PUNALUU BEACH, HI.

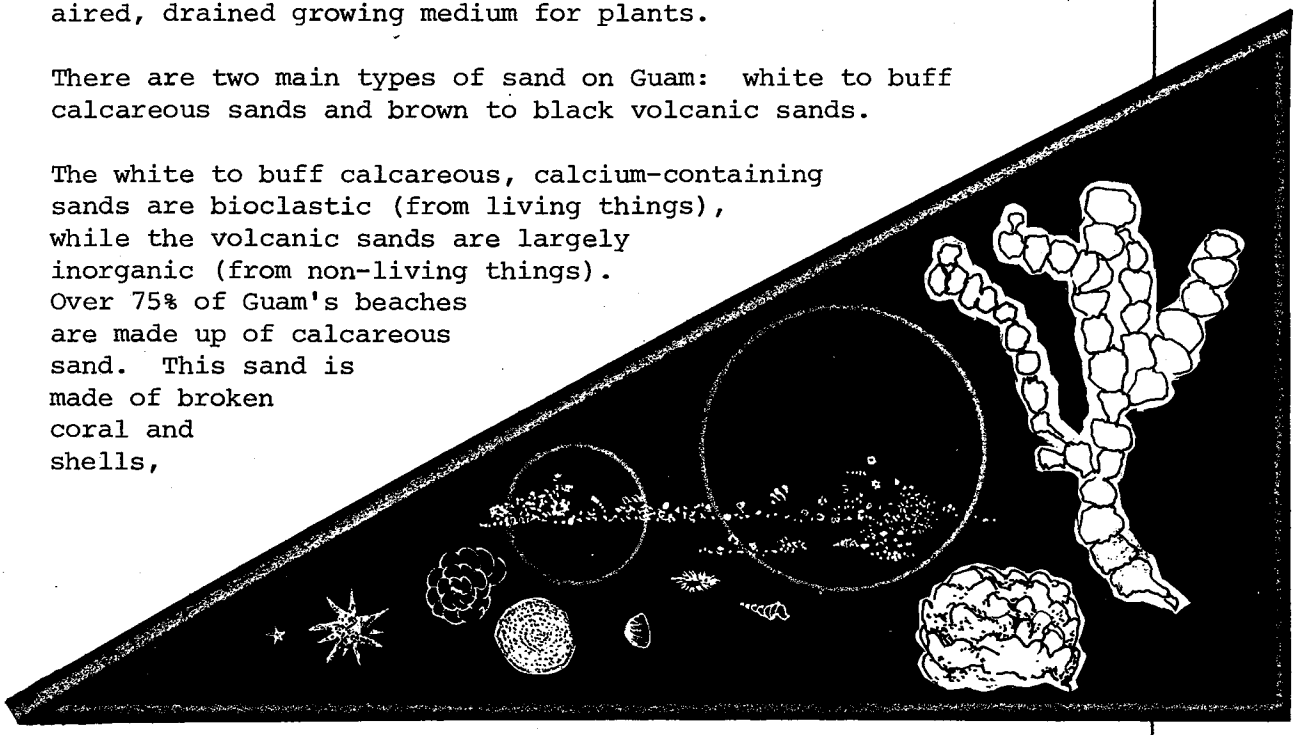
The sands on these pages are magnified about 10-20 times.

Sia

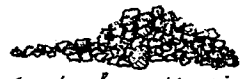
Plants can get a foothold in loamy sand and remain. They hold the sand with their root systems and eventually provide more organic material to enrich the sand. Inland from the shore, more and more loam is mixed with sand. This provides a well-aired, drained growing medium for plants.

There are two main types of sand on Guam: white to buff calcareous sands and brown to black volcanic sands.

The white to buff calcareous, calcium-containing sands are bioclastic (from living things), while the volcanic sands are largely inorganic (from non-living things). Over 75% of Guam's beaches are made up of calcareous sand. This sand is made of broken coral and shells,



the remains of calcareous red algae, and a green alga, Halimeda. Many of the shells are from foraminifera, (= forams) which give us some of our paper shells.


Acapulco, Mexico

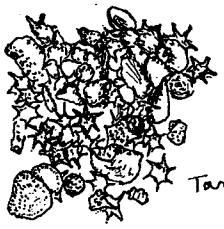
Volcanic beach sands are found mostly in coastal bays of southern Guam. They are deposited by the many streams which flow over the weathering and eroding volcanic rock.


Sahara Desert

Activity 2 Sand Analysis


White Sands, New Mexico

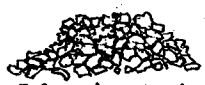
Materials: Notebook and pencil
Vials of different sand samples
Magnifying glass
Watchglasses
Dilute hydrochloric acid (HCl)
Stirring rod.


Tarague


Mayaguez, Puerto Rico

Work individually or in pairs or small groups. Make a data chart like the one on the next page but bigger. Examine at least 5 samples of sand and fill in the first 3 lines of your chart.


Totaranui Beach, So. Isl., New Zealand


Siar Island, Madang, New Guinea


Desert, Washington


Pis, Truk


Avila, California


Great Sand Dunes National Monument

6

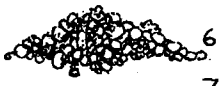
Composition of Beach Sands

line	SAMPLE No:	1	2	3	4	5	6
1							
2	BEACH						
3	COLOR						
4	OTHER CHARACTERISTICS						
5	MAGNIFIED PARTICLES						
6	REACTION WITH HCl						
7	AMOUNT OF RESIDUE						
8	CONCLUSION (approximate % of $CaCO_3$ sand)						

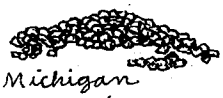
Examine several grains of each sample with a magnifying glass and on your data sheet draw what you see.

Label the particles if you can (foraminifera, shells, fine sand and silt, Halimeda debris, coral bits, calcareous red algae, other).


Lee side Bahamas


McGregor, Iowa


Pingelap, Ponape


Lake Michigan dune

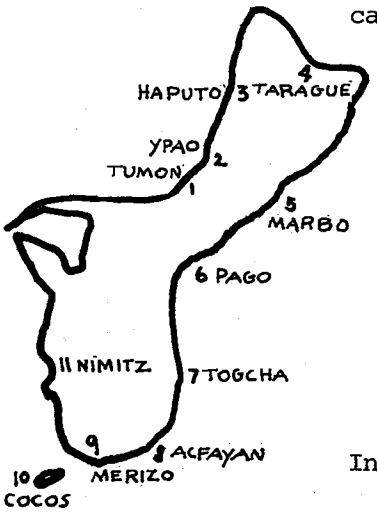

Mediterranean coast, Turkey

Now pour the samples into separate watchglasses. Add dilute hydrochloric acid and stir. Note down the reaction on line 6, and the amount of residue on line 7. The less residue, the greater the percentage of calcareous sand.

Compare your sands with the samples from Guam beaches analyzed below.

Composition of Beach Sands, in Percent
(After Emery)

Beach Locality	1	2	3	4	5	6	7	8	9	10	11
	%	%	%	%	%	%	%	%	%	%	%
Organic carbonate	100	100	100	100	100	44	100	61	98	100	98
Foraminifera	5	1	2	1	1	1	12	1	0	58	2
Shells	25	38	10	20	44	7	30	23	38	5	49
Fine sand & silt	20	0	0	0	0	0	0	0	0	0	1
Halimeda debris	5	1	1	15	20	0	15	0	1	2	3
Coral	35	55	77	50	20	29	13	15	20	20	15
Calcareous red algae	10	5	10	14	15	7	30	21	39	15	26
Miscellaneous	0	0	0	0	0	0	0	1	0	0	2
Inorganic	0	0	0	0	0	56	0	39	2	0	2



Activity 3 Composition and Distribution of Beach Sand

Objective: To discover something about the composition and distribution of beach sand.

Materials: One calcareous sand beach, transect line, sampler squares or circles, pill vial or core tube or shovels.

Grouping: Students may work alone or in teams of two or more.

Lay out a transect perpendicular to the water's edge up the berm and inland as far as you care to go. Station yourselves individually or in groups at equal distances along the transect. Have each student put down a sample square or circle (may be a circular wire, can or box imprint, etc.) and describe the sand within the area. At each station, samples may be taken by pushing a pill vial straight into the sand and reaching under and capping or otherwise closing it. In this way a shallow vertical sample may be obtained. If a transparent core sampler or long glass tube is available, it can be used to obtain a deeper vertical sample. If none is available, sift through the top sand to see if it is different from the underlying sand, and then dig with shovels to expose a sand profile. Depth of the sand profile may be measured from the surface down. This might be done as part of a slope measurement activity. The samples may then be made into an exercise chart and analyzed. Results may be taped on the wall in sequence. A student chosen to be 'Principal Investigator of Sand Composition and Distribution', goes along the charts and describes any differences in sand or any trends in composition with distribution from the water's edge inland.

4 Tides

People's life on Guam once involved being aware of the tides in order to plan boat trips, or to know when certain types of fishing would be best. Even today, Pacific Islanders generally have a fair idea of the tidal condition even if they don't have tide tables.

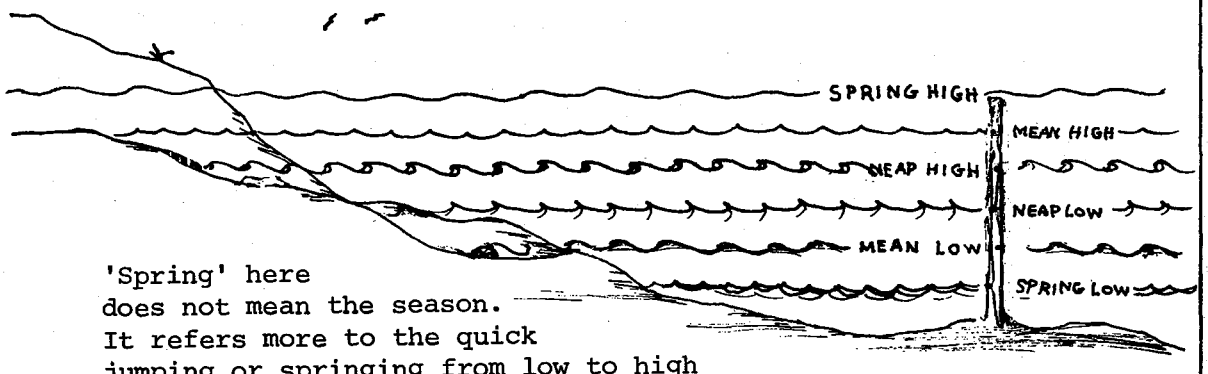
For marine organisms living within the reach of tidal waters, the state of the tide is a matter of life or death. The restless tide determines when intertidal (between high and low tide lines) organisms will be wet, dry and fed. It determines where they will live, both in distance from the water's edge and depth in the water or beach sand. It also extends and limits the activity range of swimming organisms.

The rising or coming in of the tide is flood tide, and the highest point after flood tide is high tide. When the tide is falling or going out, it is ebb tide. The lowest point after ebb tide is low water. Tidal changes may create currents, especially when water must pass through obstructed places. Within about an hour of high and low water there is little water flow and it is slack tide.

The average height of high tides is mean high tide (or water). The average height of low tides is mean low water. The lowest point to which the water falls is spring low tide and the highest point to which tidal waters rise is spring high tide. The smaller tide ranges are neap tides. The difference between neap high and neap low tide is less than that of either mean or spring tides.

Here's a diagram showing the relative water levels for different tides: Copy it in your notebook.

Relative Height of Tides



'Spring' here does not mean the season. It refers more to the quick jumping or springing from low to high tide...at spring tide the water rises faster than at other tides. (Why?)

There are two high and two low tides about every 24 hours and 50 minutes. One high is higher than the other, and one low is lower than the other. The lower low tides are averaged and give a reading called 'mean lower low water'. This is the 'base line' and appears on Guam tide tables as 0.0 feet.

Activity 4 Tide Tables

Since it would take us too long to study tides directly we will use tide tables to learn something about them. Tide tables give the predicted high and low water levels for each day of the year.

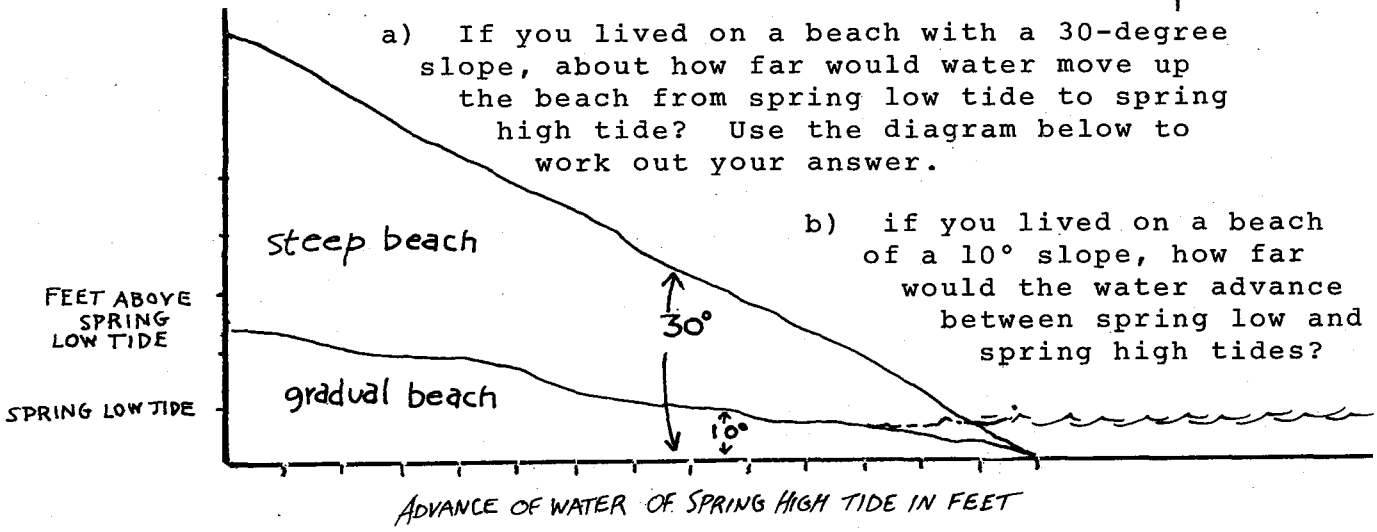
Materials: Guam tide tables, any year will do,
or page 11, if complete tables aren't available.

Work in pairs.

1. Go through your tide table and find the highest and lowest tides for each month. List them in your notebook. What are the highest and lowest tides for the year? Place these values on your tide diagram for spring high and low tides. When do these tides occur? Based on this information:

a) If you lived on a beach with a 30-degree slope, about how far would water move up the beach from spring low tide to spring high tide? Use the diagram below to work out your answer.

b) if you lived on a beach of a 10° slope, how far would the water advance between spring low and spring high tides?



2. If you were planning a fishing trip on June 6th, and wanted to set a net at the highest tide and check it at the lowest tide, would you be checking it in the daylight, or by flashlight or torch?

3. Start with the first of the nearest month. How long is it from one high tide to the next? Figure out the number of hours and minutes between

successive high tides for the first 5 days of this month. Is this time constant or variable? Based on your results, answer the following:

a) If it is high tide at 10:30 PM, when will the next high tide occur?

b) If it is low tide at 1:15 AM, when will the next low tide occur?

4. Use the first five days of the month. How much later each day is the first high tide? Based on that, if you went swimming at high tide today at 10:25, about what time would you go to the beach 3 days from now in order to swim at the same tide?

Activity 5 Graphing Tides

Materials: Notebooks, Guam tide tables, graph paper, felt tip pens.

Work in pairs.

Graph the high and low tides for one week of the year. Your teacher will assign the week. Other students will graph tides during the weeks before or after yours. Then all the graphs will be combined.

Place the new and full Moons on your tide graph by drawing them in above the graph on the appropriate date lines.

Reading Tide Tables

On the next page are the Guam tide tables for four months of 1977. The first column shows the date of the month and day of the week. Column two gives h.m. - hour and minute on a 24-hour scale - 0000 is midnight, 1200 is noon, 2359 is 11:59 PM. The last two columns show tide height in feet and in meters.

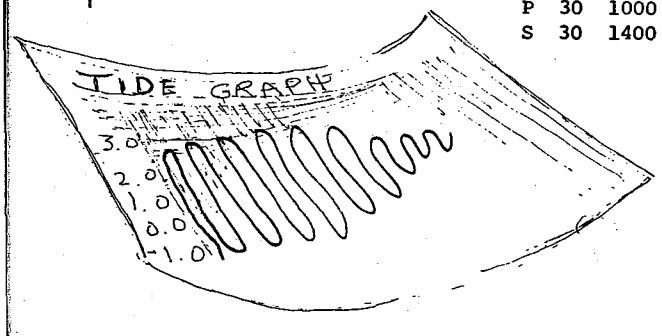
Beneath the tide tables are short columns showing astronomical events for the four months. Here is the key: ● new Moon; ◐ first quarter; ○ full Moon; ◑ last quarter; E, Moon on the Equator; N, S, Moon farthest north or south of the Equator; A, P, Moon in apogee or perigee; $\odot_1$ Sun at vernal equinox; $\odot_2$ Sun at summer solstice; $\odot_3$ Sun at autumnal equinox; $\odot_4$ Sun at winter solstice.

11

March

DAY	TIME h.m.	HEIGHT ft.	HEIGHT m.	DAY	TIME h.m.	HEIGHT ft.	HEIGHT m.
1 TU	0538	2.0	0.6	16 W	0612	2.3	0.7
	1034	1.5	0.5		1150	1.3	0.4
	1537	2.1	0.6		1659	2.1	0.6
	2300	0.1	0.0		2353	0.0	0.0
2 W	0615	2.2	0.7	17 TH	0650	2.4	0.7
	1130	1.4	0.4		1236	1.1	0.3
	1637	2.1	0.6		1802	2.2	0.7
	2345	0.0	0.0				
3 TH	0649	2.3	0.7	18 F	0038	0.1	0.0
	1215	1.3	0.4		0722	2.4	0.7
	1733	2.2	0.7		1318	0.9	0.3
					1857	2.2	0.7
4 F	0026	-0.1	0.0	19 SA	0120	0.2	0.1
	0721	2.4	0.7		0751	2.4	0.7
	1257	1.1	0.3		1353	0.7	0.2
	1823	2.3	0.7		1944	2.2	0.7
5 SA	0106	-0.1	0.0	20 SU	0155	0.4	0.1
	0748	2.4	0.7		0816	2.4	0.7
	1335	0.9	0.3		1427	0.5	0.2
	1912	2.4	0.7		2028	2.2	0.7
6 SU	0145	0.0	0.0	21 M	0230	0.5	0.2
	0818	2.5	0.8		0842	2.4	0.7
	1415	0.7	0.2		1502	0.4	0.1
	2004	2.4	0.7		2109	2.2	0.7
7 M	0223	0.1	0.0	22 TU	0302	0.7	0.2
	0847	2.5	0.8		0905	2.3	0.7
	1454	0.4	0.1		1534	0.4	0.1
	2056	2.4	0.7		2151	2.1	0.6
8 TU	0305	0.3	0.1	23 W	0331	0.9	0.3
	0918	2.5	0.8		0930	2.3	0.7
	1539	0.3	0.1		1608	0.3	0.1
	2150	2.3	0.7		2236	2.1	0.6
9 W	0346	0.6	0.2	24 TH	0406	1.0	0.3
	0953	2.5	0.8		0954	2.2	0.7
	1628	0.1	0.0		1643	0.3	0.1
	2252	2.2	0.7		2326	2.0	0.6
10 TH	0430	0.9	0.3	25 F	0439	1.2	0.4
	1028	2.5	0.8		1023	2.2	0.7
	1720	0.0	0.0		1724	0.3	0.1
11 F	0003	2.1	0.6	26 SA	0017	1.9	0.6
	0518	1.1	0.3		0521	1.3	0.4
	1112	2.4	0.7		1058	2.1	0.6
	1822	0.0	0.0		1814	0.3	0.1
12 SA	0125	2.0	0.6	27 SU	0123	1.9	0.6
	0622	1.4	0.4		0612	1.5	0.5
	1203	2.3	0.7		1137	2.0	0.6
	1931	0.0	0.0		1908	0.3	0.1
13 SU	0255	2.1	0.6	28 M	0239	1.9	0.6
	0747	1.5	0.5		0731	1.5	0.5
	1305	2.2	0.7		1230	2.0	0.6
	2043	0.0	0.0		2008	0.3	0.1
14 M	0421	2.1	0.6	29 TU	0342	2.0	0.6
	0925	1.6	0.5		0854	1.5	0.5
	1424	2.1	0.6		1339	1.9	0.6
	2154	0.0	0.0		2112	0.3	0.1
15 TU	0525	2.3	0.7	30 W	0437	2.1	0.6
	1048	1.4	0.4		1005	1.4	0.4
	1547	2.1	0.6		1504	2.0	0.6
	2257	0.0	0.0		2211	0.2	0.1
				31 TH	0519	2.2	0.7
					1058	1.2	0.4
					1613	2.0	0.6
					2300	0.2	0.1

	d.	h.m.
○	6	0313
E	6	1800
P	9	0900
◑	12	2135
S	13	0100
E	19	1900
●	20	0433
⊙1	21	0343
A	25	0800
N	27	0500
◐	28	0827



June

DAY	TIME h.m.	HEIGHT ft.	HEIGHT m.	DAY	TIME h.m.	HEIGHT ft.	HEIGHT m.
1 W	0028	1.2	0.4	16 TH	0118	1.4	0.4
	0600	2.6	0.8		0629	2.3	0.7
	1308	-0.5	-0.2		1342	-0.2	-0.1
	2011	2.5	0.8		2052	2.3	0.7
2 TH	0124	1.3	0.4	17 F	0158	1.5	0.5
	0645	2.6	0.8		0703	2.3	0.7
	1356	-0.7	-0.2		1414	-0.2	-0.1
	2103	2.6	0.8		2129	2.3	0.7
3 F	0216	1.4	0.4	18 SA	0236	1.5	0.5
	0731	2.6	0.8		0733	2.2	0.7
	1444	-0.7	-0.2		1445	-0.2	-0.1
	2156	2.6	0.8		2204	2.3	0.7
4 SA	0313	1.4	0.4	19 SU	0314	1.5	0.5
	0820	2.5	0.8		0807	2.2	0.7
	1532	-0.7	-0.2		1517	-0.2	-0.1
	2248	2.6	0.8		2236	2.3	0.7
5 SU	0409	1.4	0.4	20 M	0353	1.5	0.5
	0912	2.4	0.7		0839	2.2	0.7
	1622	-0.5	-0.2		1552	-0.1	0.0
	2340	2.6	0.8		2310	2.4	0.7
6 M	0512	1.4	0.4	21 TU	0435	1.4	0.4
	1007	2.2	0.7		0921	2.1	0.6
	1713	-0.3	-0.1		1628	0.0	0.0
					2345	2.3	0.7
7 TU	0029	2.5	0.8	22 W	0521	1.4	0.4
	0617	1.3	0.4		1010	2.0	0.6
	1113	2.0	0.6		1707	0.1	0.0
	1804	0.0	0.0				
8 W	0118	2.5	0.8	23 TH	0021	2.3	0.7
	0727	1.1	0.3		0617	1.2	0.4
	1227	1.8	0.5		1112	1.9	0.6
	1858	0.3	0.1		1749	0.3	0.1
9 TH	0205	2.4	0.7	24 F	0057	2.4	0.7
	0836	0.9	0.3		0716	1.0	0.3
	1358	1.7	0.5		1232	1.8	0.5
	1957	0.6	0.2		1840	0.6	0.2
10 F	0251	2.4	0.7	25 SA	0135	2.4	0.7
	0938	0.7	0.2		0821	0.8	0.2
	1528	1.7	0.5		1405	1.7	0.5
	2100	0.9	0.3		1939	0.8	0.2
11 SA	0332	2.4	0.7	26 SU	0217	2.4	0.7
	1030	0.5	0.2		0921	0.4	0.1
	1650	1.8	0.5		1540	1.8	0.5
	2158	1.1	0.3		2045	1.1	0.3
12 SU	0410	2.4	0.7	27 M	0304	2.5	0.8
	1119	0.3	0.1		1016	0.1	0.0
	1757	1.9	0.6		1706	1.9	0.6
	2257	1.2	0.4		2158	1.3	0.4
13 M	0449	2.3	0.7	28 TU	0353	2.5	0.8
	1158	0.1	0.0		1112	-0.2	-0.1
	1851	2.0	0.6		1818	2.1	0.6
	2349	1.3	0.4		2307	1.4	0.4
14 TU	0525	2.3	0.7	29 W	0442	2.5	0.8
	1235	0.0	0.0		1204	-0.4	-0.1
	1936	2.1	0.6		1917	2.3	0.7
15 W	0035	1.4	0.4	30 TH	0013	1.4	0.4
	0557	2.3	0.7		0535	2.6	0.8
	1310	-0.1	0.0		1255	-0.6	-0.2
	2015	2.2	0.7		2009	2.5	0.8

	d.	h.m.
P	2	0100
○	2	0631
S	3	0300
◑	9	0107
E	9	1400
A	15	0700
N	17	0200
●	17	0423
⊙2	21	2214
E	24	0800
◐	24	2244
P	30	1000
S	30	1400

September

DAY	TIME h.m.	HEIGHT ft.	HEIGHT m.	DAY	TIME h.m.	HEIGHT ft.	HEIGHT m.
1 TH	0345	0.6	0.2	16 F	0309	0.2	0.1
	0948	2.2	0.7		0928	2.4	0.7
	1550	0.6	0.2		1524	0.7	0.2
	2203	2.3	0.7		2123	2.4	0.7
2 F	0423	0.5	0.2	17 SA	0355	0.1	0.0
	1036	2.1	0.6		1025	2.3	0.7
	1625	0.8	0.2		1607	0.9	0.3
	2231	2.2	0.7		2158	2.4	0.7
3 SA	0506	0.5	0.2	18 SU	0443	0.0	0.0
	1131	2.0	0.6		1129	2.2	0.7
	1707	1.0	0.3		1657	1.1	0.3
	2303	2.2	0.7		2237	2.3	0.7
4 SU	0554	0.5	0.2	19 M	0539	0.0	0.0
	1230	1.9	0.6		1242	2.1	0.6
	1749	1.2	0.4		1755	1.3	0.4
	2342	2.1	0.6		2329	2.2	0.7
5 M	0649	0.5	0.2	20 TU	0645	0.0	0.0
	1343	1.8	0.5		1408	2.1	0.6
	1846	1.3	0.4		1915	1.5	0.5
6 TU	0027	2.0	0.6	21 W	0030	2.1	0.6
	0749	0.5	0.2		0800	0.1	0.0
	1502	1.8	0.5		1531	2.2	0.7
	1957	1.4	0.4		2048	1.5	0.5
7 W	0127	2.0	0.6	22 TH	0151	2.1	0.6
	0852	0.4	0.1		0914	0.1	0.0
	1615	1.9	0.6		1639	2.2	0.7
	2118	1.4	0.4		2211	1.4	0.4
8 TH	0231	2.0	0.6	23 F	0317	2.1	0.6
	0952	0.3	0.1		1023	0.1	0.0
	1707	2.0	0.6		1730	2.3	0.7
	2224	1.4	0.4		2314	1.2	0.4
9 F	0337	2.0	0.6	24 SA	0436	2.1	0.6
	1043	0.2	0.1		1122	0.1	0.0
	1749	2.1	0.6		1811	2.4	0.7
	2314	1.3	0.4				
10 SA	0434	2.1	0.6	25 SU	0006	0.9	0.3
	1129	0.2	0.1		0542	2.2	0.7
	1826	2.2	0.7		1212	0.2	0.1
	2357	1.1	0.3		1849	2.4	0.7
11 SU	0525	2.2	0.7	26 M	0045	0.7	0.2
	1211	0.1	0.0		0637	2.3	0.7
	1857	2.3	0.7		1258	0.3	0.1
					1920	2.4	0.7
12 M	0036	1.0	0.3	27 TU	0127	0.5	0.2
	0615	2.3	0.7		0729	2.3	0.7
	1251	0.1	0.0		1339	0.4	0.1
	1924	2.3	0.7		1950	2.4	0.7
13 TU	0110	0.8	0.2	28 W	0202	0.4	0.1
	0701	2.4	0.7		0815	2.3	0.7
	1329	0.2	0.1		1417	0.6	0.2
	1951	2.4	0.7		2015	2.3	0.7
14 W	0151	0.6	0.2	29 TH	0237	0.3	0.1
	0747	2.4	0.7		0900	2.3	0.7
	1405	0.3	0.1		1452	0.8	0.2
	2021	2.4	0.7		2042	2.3	0.7
15 TH	0227	0.4	0.1	30 F	0309	0.2	0.1
	0837	2.4	0.7		0942	2.2	0.7
	1444	0.4	0.1		1524	1.0	0.3
	2051	2.4	0.7		2109	2.2	0.7

	d.	h.m.
◑	6	0033
A	6	0400
N	7	0300
●	13	1923
E	14	0500
P	18	1900
S	20	1400
◐	20	1618
⊙3	23	1330
E	27	0300
○	27	1817

December

DAY	TIME h.m.	HEIGHT ft.	HEIGHT m.	DAY	TIME h.m.	HEIGHT ft.	HEIGHT m.
1 TH	0430	0.0	0.0	16 F	0529	0.0	0.0
	1159	2.3	0.7		1240	2.5	0.8
	1741	1.5	0.5		1853	1.1	0.3
	2206	1.9	0.6		2359	1.8	0.5
2 F	0512	0.2	0.1	17 SA	0624	0.3	0.1
	1238	2.3	0.7		1329	2.5	0.8
	1835	1.4	0.4		2006	0.9	0.3
	2305	1.8	0.5				
3 SA	0557	0.3	0.1	18 SU	0131	1.7	0.5
	1319	2.3	0.7		0723	0.7	0.2
	1939	1.2	0.4		1415	2.4	0.7
					2111	0.6	0.2
4 SU	0020	1.7	0.5	19 M	0310	1.7	0.5
	0646	0.5	0.2		0829	1.0	0.3
	1358	2.3	0.7		1459	2.4	0.7
	2038	1.0	0.3		2207	0.4	0.1
5 M	0153	1.6	0.5	20 TU	0440	1.8	0.5
	0749	0.7	0.2		0936	1.2	0.4
	1440	2.3	0.7		1544	2.3	0.7
	2130	0.7	0.2		2259	0.2	0.1
6 TU	0327	1.7	0.5	21 W	0552	1.9	0.6
	0854	0.9	0.3		1041	1.3	0.4
	1521	2.4	0.7		1622	2.3	0.7
	2221	0.4	0.1		2343	0.0	0.0
7 W	0448	1.9	0.6	22 TH	0647	2.1	0.6
	1000	1.1	0.3		1143	1.4	0.4
	1603	2.4	0.7		1703	2.3	0.7
	2307	0.0	0.0				
8 TH	0557	2.1	0.6	23 F	0020	-0.1	0.0
	1103	1.2	0.4		0733	2.2	0.7
	1645	2.5	0.8		1233	1.5	0.5
	2356	-0.3	-0.1		1743	2.3	0.7
9 F	0656	2.3	0.7	24 SA	0057	-0.2	-0.1
	1203	1.3	0.4		0812	2.3	0.7
	1730	2.6	0.8		1318	1.5	0.5
					1815	2.3	0.7
10 SA	0041	-0.6	-0.2	25 SU	0130	-0.2	-0.1
	0748	2.5	0.8		0845	2.4	0.7
	1300	1.4	0.4		1357	1.5	0.5
	1818	2.6	0.8		1850	2.2	0.7
11 SU	0127	-0.7	-0.2	26 M	0201	-0.2	-0.1
	0840	2.6	0.8		0917	2.4	0.7
	1353	1.4	0.4		1434	1.5	0.5
	1900	2.6	0.8		1922	2.2	0.7
12 M	0214	-0.8	-0.2	27 TU	0232	-0.2	-0.1
	0929	2.7	0.8		0950	2.4	0.7
	1447	1.4	0.4		1509	1.5	0.5
	1953	2.5	0.8		1955	2.1	0.6
13 TU	0302	-0.7	-0.2	28 W	0301	-0.2	-0.1
	1015	2.7	0.8		1019	2.4	0.7
	1543	1.4	0.4		1548	1.4	0.4
	2045	2.4	0.7		2029	2.1	0.6
14 W	0351	-0.6	-0.2	29 TH	0332	-0.1	0.0
	1105	2.7	0.8		1048	2.4	0.7
	1641	1.3	0.4		1625	1.4	0.4
	2141	2.3	0.7		2108	2.0	0.6
15 TH	0439	-0.3	-0.1	30 F	0404	0.0	0.0
	1154	2.6	0.8		1120	2.4	0.7
	1744	1.2	0.4		1708	1.3	0.4
	2243	2.0	0.6		2155	1.9	0.6
				31 SA	0438	0.2	0.1
					1151	2.4	0.7
					1754	1.2	0.4
					2249	1.8	0.5

	d.	h.m.
◑	4	0716
E	5	1100
●	11	0333
P	11	0900
S	11	1600
◐	17	2037
E	17	2300
⊙4	22	0924
A	25	0700
N	25	0900
○	25	2249

a) Do you notice any pattern in your graph? If so, describe it.

b) Is there any correlation between the tidal extremes and the phases of the Moon? If so, describe it.

c) At what depth below mean high tide would an organism have to live in order to remain under water for the entire period graphed by your class?

d) How far above mean high tide level would an organism have to live in order not ever to be submerged (underwater) during the time graphed?

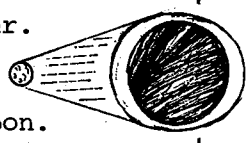
e) A certain snail on a piling at a pier needs to keep just submerged to live. What vertical distance would the snail have to move in order to remain just below the surface during the first week of the period graphed?

f) When would this snail have to move more— during the period following a new Moon, or during the period following the first quarter?

g) If you were going swimming on December 4th at a place with strong tidal currents, what time would you go in order to avoid the currents?

Tides result from the gravitational attraction of the Moon and Sun on the waters of the Earth. Of the two, the Moon has the greater influence.

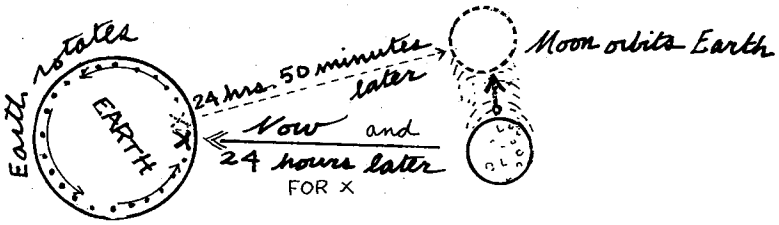
Here is a diagram of the Earth, Moon and a blanket of water. To simplify things we'll leave out land masses.



Water bulges out on the sides of Earth in line with the Moon.

The Moon revolves around the Earth in the same direction as the Earth rotates on its axis. Because of this, the Earth has to rotate once and then a little more in order for a certain place on it to be directly under the Moon again. This little more takes 50 minutes, and the tides come 24 hours and 50 minutes apart. See top of next page.

Motion AFFECTING TIDE TIMES



As the Moon revolves about the Earth in about 28 days, spring tides caused by opposition and conjunction occur about every 2 weeks, with neap tides in between.

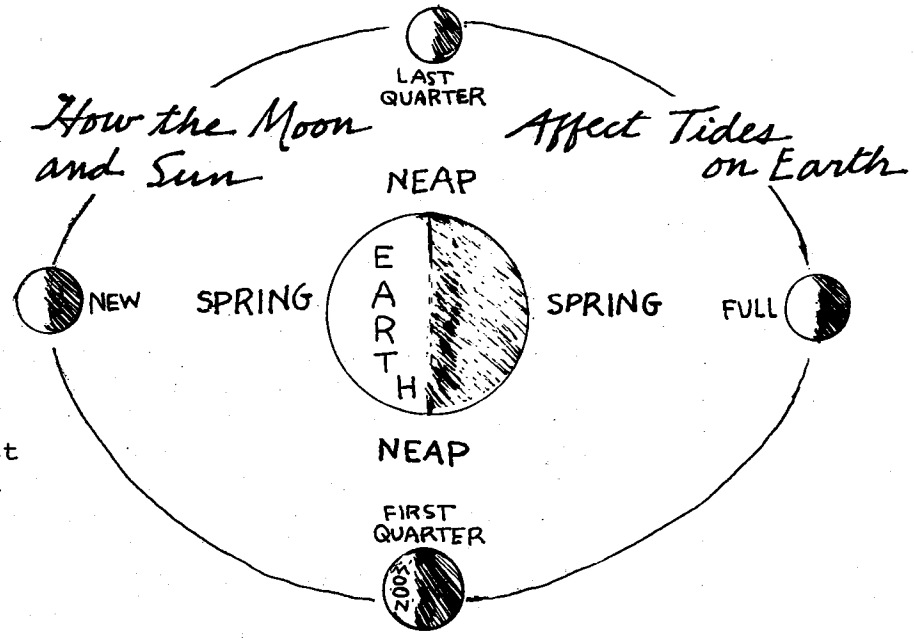
The Moon travels in an elliptical orbit around the Earth. This brings it closer to the Earth at times. If the Sun and Moon are in conjunction or opposition at one of these times, tides will be especially high and low. This occurs about twice a year and produces the highest tides of the year.

When Moon is full, Sun and Moon are in opposition and Spring tides follow.

SUN

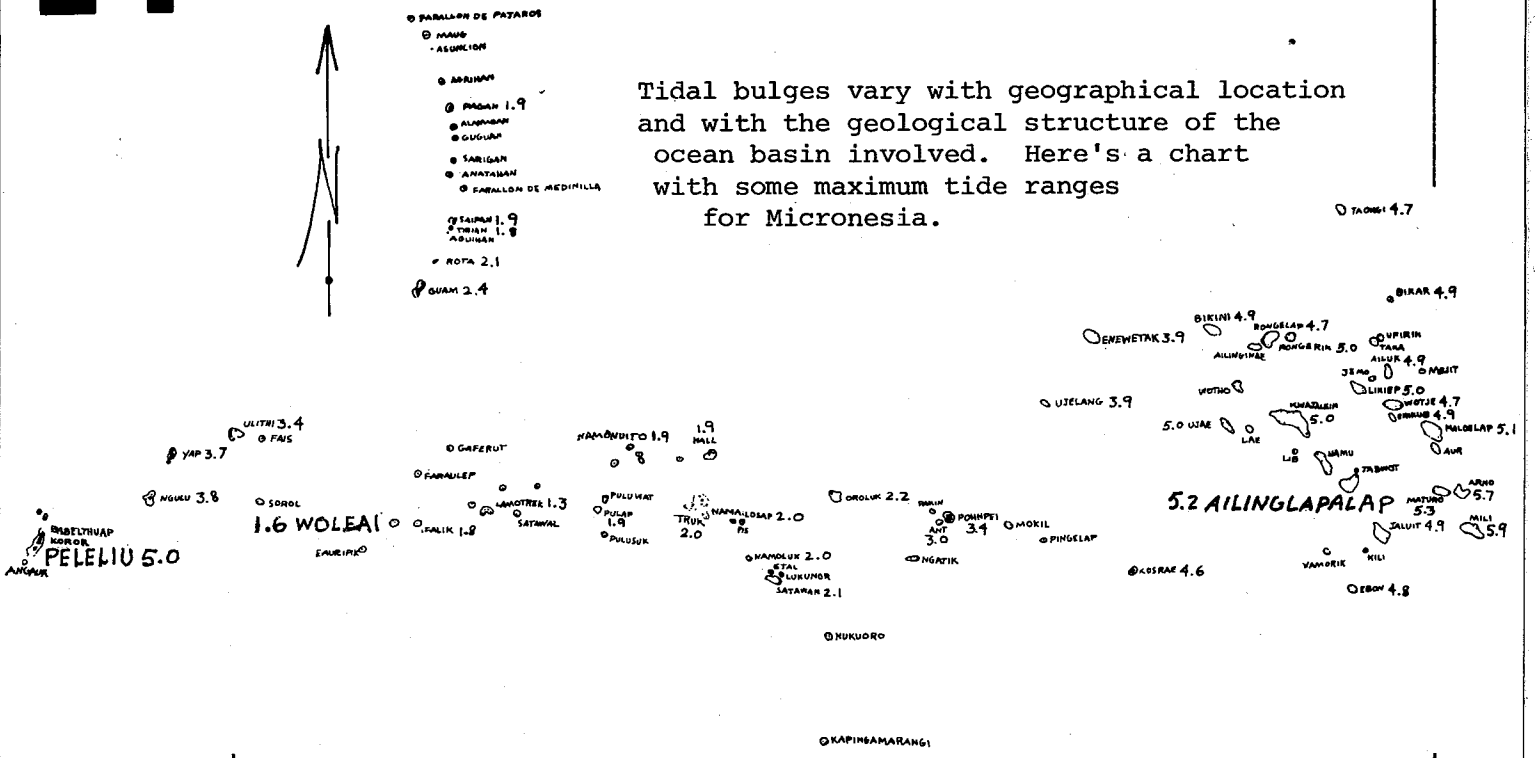
When Moon is new, Sun and Moon are in conjunction and Spring tides follow.

When Moon is in first or last quarter, Sun and Moon are in quadrature and neap tides follow.



Now let's bring the Sun's gravitational attraction into the picture. When the Sun and Moon are on the same or opposite sides of the Earth, their gravitational attraction is strongest and produces spring tides. When they 'pull' at right angles to one another it causes neap tides.

14



Tidal bulges vary with geographical location and with the geological structure of the ocean basin involved. Here's a chart with some maximum tide ranges for Micronesia.

At Guam is the mean spring tide rise greater or less than at:

Peleliu, Palau - Woleai, Yap - Ailinglapalap, Marshalls?

Can you find any trends in increasing mean spring tide rise on the map?

In order to predict tides, information from tidal measurements in a certain location is correlated (put together) with effects expected from the positions of heavenly bodies. The result is a table of predicted times and levels of high and low water. Considerable variation from the tables may result from short-term phenomena (happenings) such as strong winds blowing water towards land or a low barometric pressure allowing the water to rise somewhat higher than normal. Thus if you measure actual tides you might find that they differ some from the predicted levels.

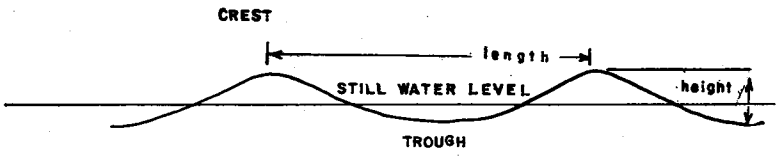
For Those Who Want to Know More——

Read the relevant books listed in the bibliography. There's a lot more interesting information! Find out about bores, tidal waves, resonance tides, and other tidal phenomena.

When the Moon is at the zenith, directly overhead, is that when high tide is? Find out why not. Find out how and where Guam's tide tables are made.

5 Waves

Here's what an 'ideal' wave at sea looks like:

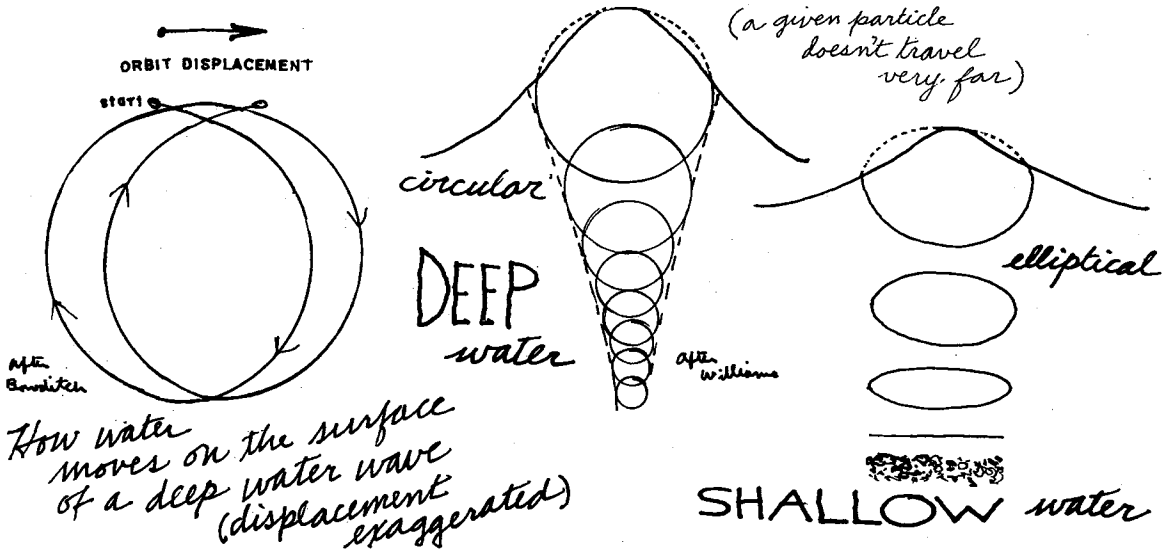


'ideal' wave

A wave of the sea always breaks in front of its base, and that portion of the crest will then be lowest which before was highest.

Leonardo da Vinci

Types of water particle orbits



How water moves on the surface of a deep water wave (displacement exaggerated)

As they approach the shore waves take on a different shape. What's important to beaches is that waves begin to break when the depth of the water is less than half their length. Ocean waves around Guam crash on reefs, away from beaches. Then smaller waves form inside the reef and may eventually reach a depth where they too break, possibly forming smaller waves. These eventually swash or gently lap against the shore to form interesting pictures on the strand.

Activity 6 Patterns in the Sand

This is best done in the morning on a clean beach after a high tide.

First relax. Then look for patterns on the sand. Sit down or lie down and watch them form. Draw some in your notebook and describe how they are made, or how you think they are formed.

6 Drift Algae

Many plants live in the sea and get washed up on beaches. Most of them are microscopic. The ones that are big enough to see are generally called seaweeds. Most seaweeds are algae, though the marine flowering plants may also be included.

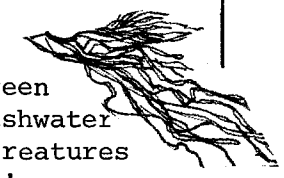
Algae are a very big diverse group. Most of the land plants you are familiar with——like grasses, shrubs, trees——have a vascular system (internal plumbing,——i.e., veins). It is this thick, tubular tissue that makes land plants stand up. Without this tissue, algae are usually soft. Although they're very valuable in marine ecology, they aren't spectacular as beach drift. Treat yourself to their many living forms underwater!

Algae are divided into 5 main groups. Here are some examples you may find on the beach:

Bluegreens

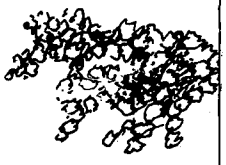
These algae don't look like much. They're often slimy because of jelly-like stuff around the cells. If you slip on a green-blackish rock, it's probably covered with bluegreen algae.

Greens:



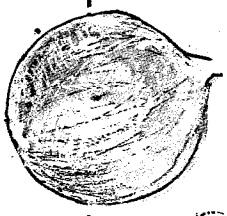
Enteromorpha (lumot tasi) - is a mass of hollow green strings living below the water's edge where there's freshwater runoff. It provides a hiding place for lots of beach creatures and food for many fishes. People too can eat it but it's tricky to wash and sometimes not safe because of polluted water.

Caulerpa - grows in 3 directions——like a vine along the sand, down into the sand with what look like tiny roots, and upward in different shapes. Some (ado') look like bunches of little grapes, while other species look like tiny palm fronds or twisted burs. The grape-like bunches are especially good to eat; fresh, or as a fina'denne'-like relish, or with oil and vinegar or soy sauce.



Halimeda (chaiguan kanifes) - is the source of much beach sand. It gets calcium from the water and lays it down like plaster on its cactus-like shape. When the plant dies and gets rolled around, this lime is broken down into sand. You can probably find both a large and a small species of this genus in beach drift.

Valonia - looks like a green egg or a green and silvery glass ball that's poppable. It's not common in beach drift but so curious that we'll mention it. This alga has a lot of nuclei but no cell walls between them so it could be a big single cell. That liquid inside isn't seawater, it's a liquid that the cell puts there itself.



Browns:

Padina (chaiguan flores) - has rounded 'leaves' that look something like a brown-and-white-striped loose head of lettuce. Like Halimeda, it also lays lime on itself. It's the only brown alga that does this. You can tell it's partly calcified because it feels stiff.

Turbinaria (chaiguan kalaktos) - grows thick heads of stiff bur-like 'trumpets' pointing outward. It holds its shape, so it's easy to recognize in the drift.

Sargassum (chaiguan lachon) - is another thick brown alga. It may grow into long strands buoyed up by tiny air-filled balls. It can float and often gets washed ashore. Take some with you when you go reef walking. Throw it on the reef, and watch for fish to come and eat it. The Hawaiian name for this alga, 'kala', is the same as for the unicorn fish (Chamorro: tataga') that feeds on it.

Reds:

There are many kinds of red algae, most of them more brown or purplish than red. They are named for the red pigment they contain, even if it is masked by other colors. Once in awhile you'll find some beautiful red alga that has been washed over the reef. Put it in freshwater and you'll soak out the brilliant red pigment.

More commonly you'll find Gelidium, Laurencia and other kinds of red algae that look like tangles of brownish noodles. Some are edible and very good.

Encrusting red algae look like smooth rocks, or a cement which holds things together.

Red coralline algae make up a lot of the reef.

Goldenbrowns:

Mostly single-celled, so they're hard to see. When lots of them are there, the water may have a goldenbrown cast. They sometimes form loose masses of living cells that you can see but might mistake for rusty-looking froth or slime. Look up more under 'diatoms'.

Activity 7 Glimpsing the Microscopic Marine World

Materials: Microscopes, slides, droppers, etc.

Get a concentrated sample of microscopic marine life. This can be done in a number of ways:

a) Centrifuge some seawater. Then take your sample from the bottom of the container.

b) Collect a bucket or large beaker of seawater. Set it in a corner of the classroom for a month or so. The organisms in it will multiply and grow and water will evaporate. You will get a concentrated sample of plant and animal plankton. You can see some of them without a microscope.

c) Get the help of an animal like a clam that filters things out of the water. Look in its stomach.

Use a microscope. In your notebook draw your sample. See how many kinds of creatures the class finds.

You might want to draw your specimens on small pieces of paper and make a collage of them for the wall.

Activity 8 Seaweed Mountings

Dried mounted seaweeds make lovely wall hangings.

All you need: Seaweed(s), flat pan, wax paper, newspapers, glue, plant press and dryer or paper towels and heavy book or corrugated cardboard and twine, herbarium sheets or other non-glossy heavy paper.

Choose unbroken plants, maybe from underwater. Fine thin ones make the nicest mountings. Remove any sand. Place in a pan of water. Slide the paper under the alga in the water and 'float' the plant onto the paper, helping it to take a spread-out natural shape. Carefully pull the paper out of the water with the alga on top. Let drain. Cover plant with wax paper and place it between newssheets in a plant press and dry in a plant dryer; or if the alga isn't very thick, place it between paper towels in a heavy book or between corrugated cardboards tied tightly together and set up so the wind will blow through the corrugation tubes.

An alga usually sticks to the paper with its own mucilage (glue) when it dries. If it doesn't, glue it to the paper. Make a frame for your mounting and hang it on your wall or present it as a gift!

7 Marine Flowering Plants

These are a group of special plants that have vascular systems (plumbing) and flowers like land plants, but they grow submerged in shallow marine waters. You can tell them from seaweeds because they have definite root systems.

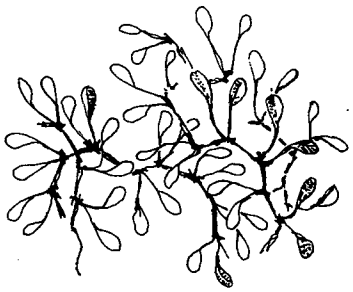
Three kinds grow around Guam——Enhalus, Halophila, and Halodule. You may find the strap-like leaves of Enhalus (chaiguan tasi) washed up in the drift.

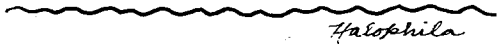
Guam doesn't have extensive seagrass beds. Around the high islands of the Carolines, however, they form with mangroves a double filter zone between land and reef. There, first mangrove, and then seagrass beds settle out runoff sediments from the land. In the reverse direction, seagrasses form resilient dikes which soften waves rolling in toward the mangroves.

Mangroves and seagrass beds are productive communities important in the nutrient flow between the land and reef. Seagrasses are eaten by dugongs and green sea turtles, and provide hiding places and feeding grounds for fish. Many small marine organisms settle on their broad flat blades which become serving plates for many fish.

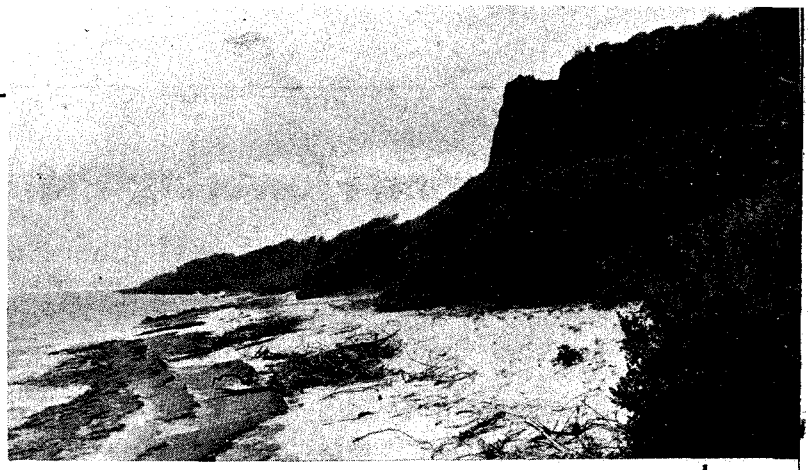
If you are fortunate, you may one day witness a seagrass flowering festival. This event seems timed to the tide. Male Enhalus flowers are shed into the water and float about like tiny white-skirted dancers. Some contact floating female flowers still attached to the parent plant. After pollination, the ovary is pulled underwater to the base of the female plant where the fruit matures.

During a big seagrass flowering festival, there are thousands of the tiny white flowers skimming along on the water. If you join them in their dance on an incoming tide, you find more and more swirling together as if they all were converging on little mounds of still-exposed sand for a main event. Eventually rising tide and winds will wash you ashore amid great drifts of spent, slightly soiled dancers.





8 Plants of the Beach



Beach plants are tough. They live in hot Sun, winds, shifting sands, often little freshwater, and lots of saltwater.

They may grow low and have tip branches that break off, offering low resistance to strong winds.

Or they grow tall and have flexible trunks to bend in the wind, like ironwood and coconut palms. Most have thick waxy or hairy leaves and salty sap, helping them live in Sun and salt spray which would desiccate (dry out) other plants.

Harsh conditions assure one thing: little competition for a place on the sand. The same species growing on the shores of Guam live on islands throughout the Pacific. How do they get there? These residents of the land's edge produce floating seeds. Typhoon waves which remove beaches from beneath the trees throw back their seeds upon reformed beaches, and reconfirm the power of life.

Here are some common species of the beach strand. Alongside them grows another hardy group, plants of coastal rocks and cliffs. Behind them grows the characteristic beach forest. The forest is beyond the effect of ordinary wave action, so we will leave it for another time.

Ipomoea pes-caprae

Pantropical Alalak tasi, Beach morning glory

Alalak tasi is a true pioneer, often rooting in bare sand. It first sends down a deep taproot. Then when conditions are favorable, it grows out over the sand. When conditions are harsh it may die back till only the part nearest the root is alive, waiting for a chance to extend itself again.

This vine is a member of the same genus, Ipomoea, as a number of other wild species of morning glories on Guam, also sweet potatoes, I. batatas, kamuti, and kangkong, I. aquatica. It produces beautiful rosy funnel-shaped flowers, mostly in the morning. (One Ipomoea, the moon flower, produces big white flowers at night.) The big glossy leaves of alalak tasi differ by having a distinct cleft at the tip. This is what earns the species name: 'goat-foot'. The seeds are borne in round capsules and are black and a little fuzzy.

Activity 9 Wilting Morning Glories

Collect 1-m sections of as many species of Ipomoea as you can find in a half hour. Compare the thickness and other characteristics of leaves and vines of alalak tasi with other species. Lay the sections of vines out separately on the sand.

Make a 4-column chart in your notebook. In the first column, draw an outline of a typical leaf of each species. In the next column, describe the leaf (size, thickness, waxiness, hairiness, sap, etc.). In the third column describe what happens to the leaves with time on the sand under the Sun. Assign numbers to the species as they wilt (#1 wilts first, #2 next, etc.). Then in the last column, describe the place where you found the vine. How do the conditions in this place (its normal habitat) relate to its wilting time?

Some 'Sea Beans'

Many kinds of 'sea beans' can be found in beach drift. Some come from Guam, and some have floated here from distant shores. Here are 4 of the most common ones.

Vigna marina

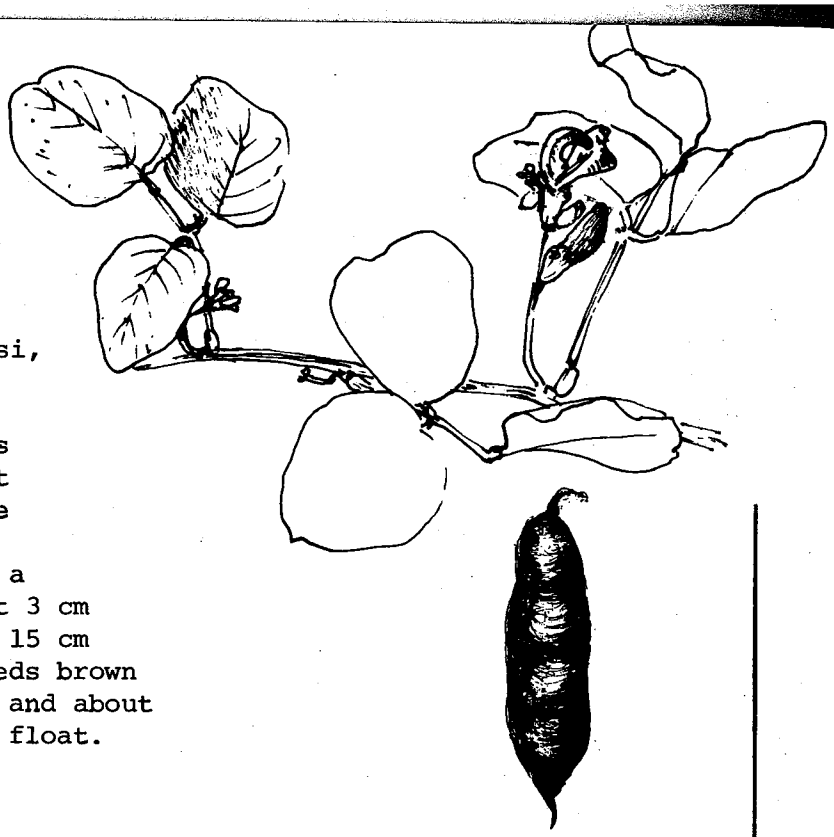
Pantropical Akankang manulasa

This vine often grows with the beach morning glory. It has glabrous (no hairs) trifoliate leaves (each leaf has 3 leaflets), yellow flowers about 1.5 cm long, thick pods about 5-7 cm long by 6-7 mm wide, seeds oval, brown, about 6.5 mm long.

Mucuna gigantea

Tropical Gayetan, bayogon dikike, sea bean

A slender high climbing vine. Leaves trifoliate. Flowers pale green, about 4 cm long. Pods about 15-20 cm long by 5 cm wide, 2-winged, flattened, with golden hairs. Seeds are large, compressed and round or squarish.



Canavalia maritima

Tropical Akankang tasi, sea bean

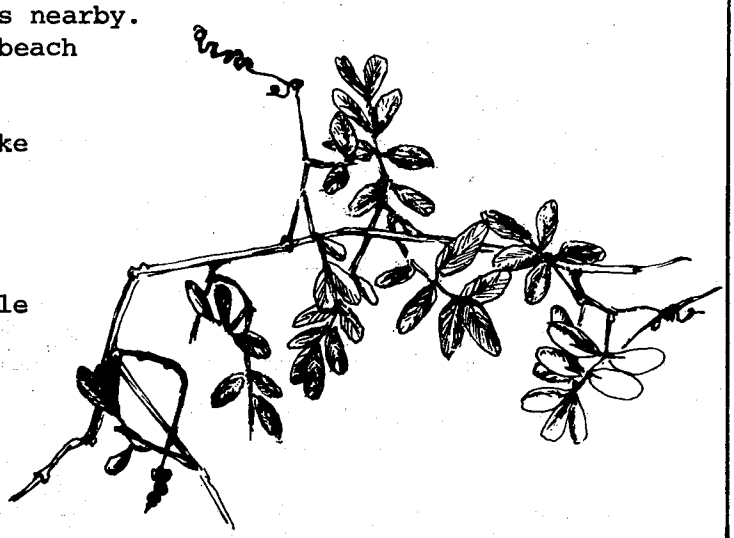
Akankang tasi also has trifoliate leaves, but the leaflets have fine whitish hairs. The flowers are pink with a white blotch and about 3 cm long. Pods are about 15 cm long, 2.5 cm wide, seeds brown with darker marblings and about 1.8 cm long. Usually float.

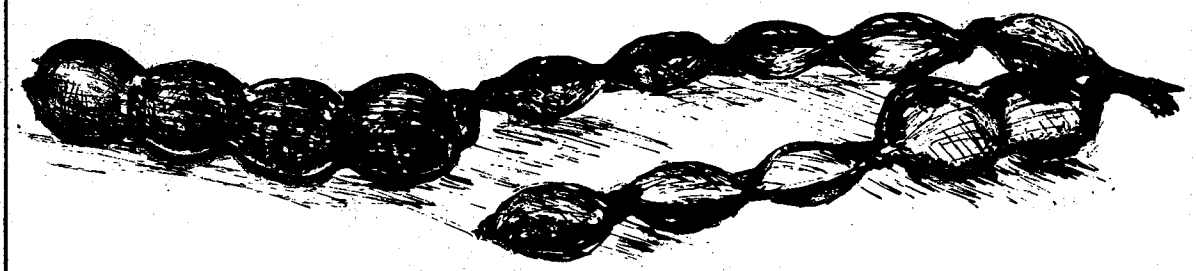
Entada pursaetha

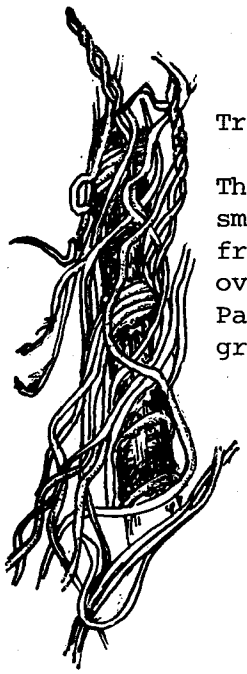
Bayogon dankolo, snuffbox bean, 'hotbean'

This massive vine grows in forests. Its giant pods are up to 1 m long and hold dark brown seeds 5 cm or more across, an exciting find in beachdrift! Look for it especially on beaches that have rivers nearby. It gets from forest to beach by floating downriver.

This bean is used to make bayogo bean dolls and other handicraft. If you rub it against a hard surface, it gets hot and makes people jump. Some kids call it 'hotbean'.







Cassytha filiformis

Tropical — Agasi, mai'agas

This curious vine doesn't seem to have any leaves (they are small scales), but you can find small flowers and roundish fruit which gets white when ripe. It grows in a tangle over other plants and sometimes extends over bare sand. Parts of the vine are green, and parts are orange. When it grows out over sand, it is bright orange.

Mai'agas is at least partly parasitic, getting its nourishment through little 'suckers' by which it attaches to other plants.

Cassytha is related to the avocado tree, but is so different that some botanists put it in a subfamily all by itself. It resembles the parasitic vine Cuscuta or 'dodder', but the two are not related.

Some islanders use this vine for medicine and as food.

Scaevola taccada

Tropical Asia and Pacific — Nanasu

Nanasu is one of the most characteristic and common strand plants. It is a large shrub with thick, light green leaves and soft wood. This plant is easy to identify by its 'half flower'. It's really all there but looks as though it's been cut in half. The fruits are roundish and green when young, and white when ripe.

The mature fruit contains a juice like the water in your eyes. Some islanders use it as an eyewash. It grows right where it's needed to soothe eyes irritated by salt spray! The inside of the stem is spongy. Some people cut it out, dye it, and use it for making decorations.

Scaevola is well-adapted to beach strand conditions. It has a strong root system, thick leaves, and a rounded growth habit. It also has leaves at the ends of long, flexible branches. Strong winds may bend these branches, and break off the tips. This reduces resistance of the plant to the wind and lessens its chances of being uprooted. After the storm, new leaves sprout and the bush may grow back a little more tangled than before.

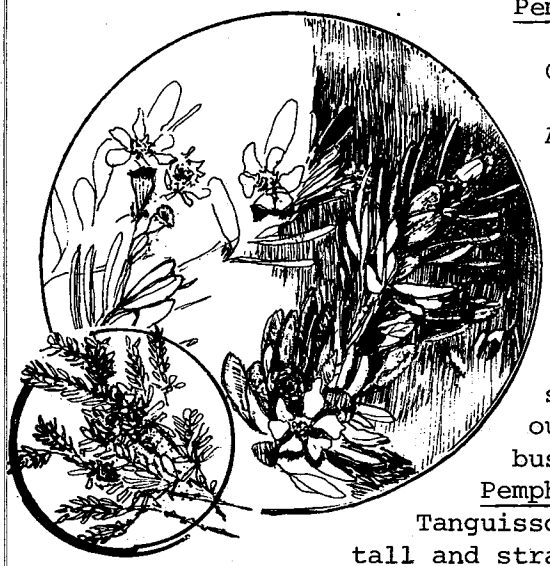
Messerschmidia argentea

Indo-Malayan-Pacific — Hunek

This lovely little tree has large thick leaves covered by silvery hairs. The twigs are thick and have large old leaf scars. Small flowers are borne on curved stalks in large panicles. The fruit is tiny and roundish.

Like nanasu, hunek gives a rounded profile to the winds. On exposed beaches it is low and mound-like. On other beaches, it grows taller and looks like a bonsai tree. The leaves cluster at the ends of branches which may break off in storm winds. Unlike nanasu, it maintains a strong trunk. Rather than grow back more tangled, it complements existing growth and maintains its symmetry.

Pemphis acidula

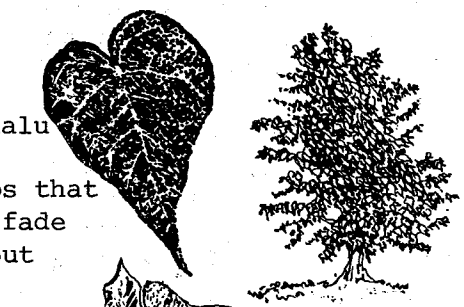


Old World Tropics — Nigas

A real 'old salt', nigas is a hardy coastal plant. Not a true sand beach plant, but it may be around, with roots firmly anchored in coral crevices. Typhoons may remove upper parts but the gnarled roots will sprout again. Some beach plants hold their place on shore by bending or having soft branches that break off in strong winds. Tough nigas crouches low and hangs strong. On a wind-swept coast it may grow from low flat plants right out on spray- and wave-swept rocks, to low mounds, bushes and small trees further back. A clump of Pemphis is a living wind sculpture. Accordingly, near Tanguisson Point on Guam's leeward coast, it grows 3-4 m tall and straight.

Nigas leaves are kind of salty-sour, like pickles and capers, fruit of another coast plant. People and green sea turtles eat them. The durable wood is used in woodwork, spears and fishhooks. A favorite use of nigas on Guam is as decorative driftwood. Few plants match it in reflecting life amid forces of Sun, wind and sea.

Thespesia populnea



Paleotropical strand plant — Banalu

A small to medium-size tree. Heart-shaped leaves with tips that point down. The flowers are yellow with a red center and fade to pink-purple. They are like pago (Hibiscus tiliaceus) but don't open as wide.

The fruit is 5-lobed and round. It has a yellow sap. Seeds are silky-pubescent (fine-haired).

Make a banalu stamp in your notebook: cut a fruit in half, let the sap flow out some, and stamp it on paper.

Barringtonia asiatica

Widespread paleotropical Puting

This particular Barringtonia is a medium-size to large tree with very big leaves at the ends of branches. The large fragrant flowers have a heavy white calyx and many many long stamens, white at the base and pink at the ends. If you arrive late at the beach, you'll find that the petals and stamens have fallen to the ground and the calyx and pistil remain on the tree. Why would it help this tree (or species) to drop most of its large fleshy flowers before the heat of the day? The fruit is square in cross section, and sort of heart-shaped in long section. It has a thick husk. Puting usually grows in protected rocky places and not on the strand itself. We're putting it here because the seeds are often found in beachdrift.

These seeds as well as other parts of the tree contain a saponin and are sometimes used to drug fish.

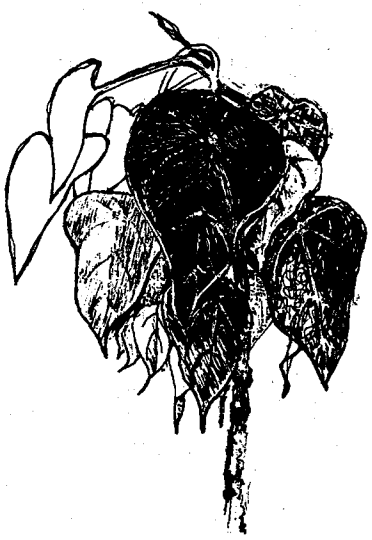
Hernandia nymphaeifolia

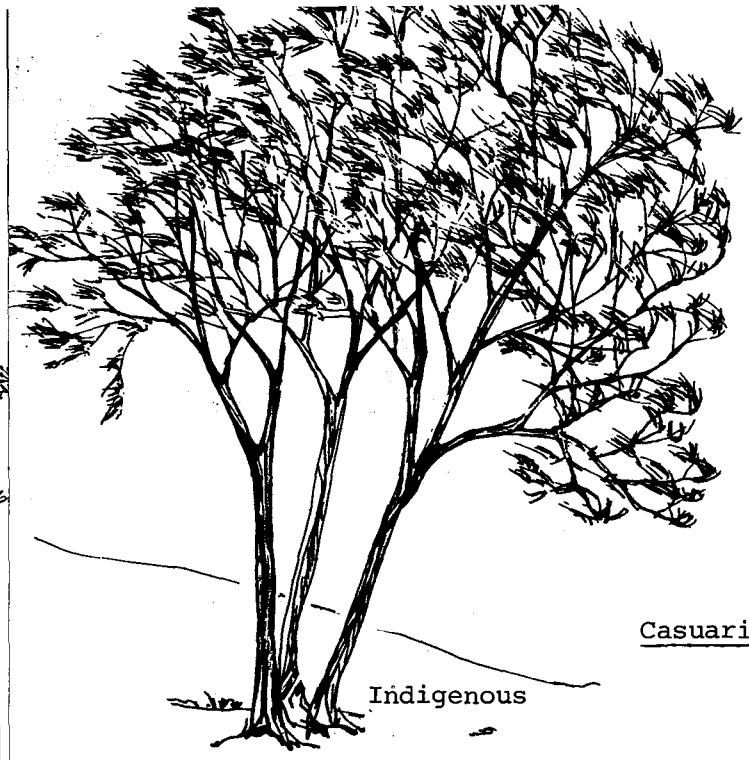
Paleotropic Nonnak

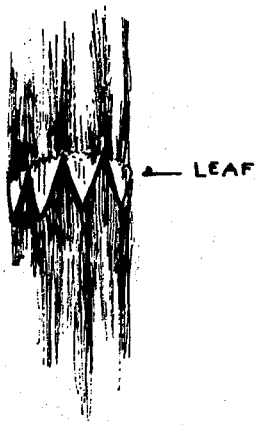
A noble medium-size to large tree with a buttressed trunk. The leaves are peltate (the petiole attaches to the bottom of the leaf). Usually there's a red spot where the petiole meets the leaf. The whitish flowers are in clusters. The fruit is in a pink, refreshingly fragrant, lantern-like hollow ball with a hole in one end.

This tree grows somewhat back of the beach strand but is included here because its 'pink lanterns' and seeds may be found in beachdrift.

The sap may be used to remove hair.







Casuarina equisetifolia

Indigenous

Gagu, ironwood,
Australian pine

This tall tree looks like a pine but isn't. It produces fruits that look like tiny cones but aren't. It looks like it has pine needles but doesn't. It's an example of convergent evolution——unrelated species in different parts of the World developing into similar-looking plants or animals.

Gagu is a flowering plant. What look like pine needles are really green branches. The true leaves are very tiny triangles that circle around the joints of the branches.

Children sometimes play a game with these branches. One pulls the branches apart, then carefully puts them together again. The other tries to guess where the separation was.

In a way, this tree is 'related' to a big, flightless Australian bird, the cassowary. Cassowary 'feathers' are flexible, thin and drooping, like branches of the tree. Early European visitors to Australia noted the resemblance. The tree was given a name similar to the bird's, which is Casuarius.

Ironwood is flexible and tough. When typhoons hit, the trees bend with the wind. Tips of the branches break off and there is less resistance to the wind. After the typhoon, the tree may look like it has mange, but it is still standing and will soon grow back its long needle-branches.

Fallen branches form a soft mat under the trees. The mat seems to inhibit growth of other plants. This leaves the area clear for sitting or lying on the soft mat, except for those sharp little cone-like female catkins, which contain seeds, and all the little crawly things hiding in the mulch!

Activity 10 Crawling Things Here and There

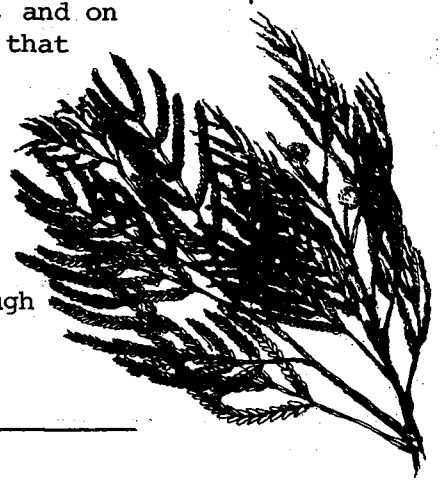
Materials: Quadrat markers (these can be made out of clothes hangers pulled into squares or circles). Bug collecting equipment (optional——fingers will do, or forceps can be made from bent coconut leaf midribs or grass stems). Jars of alcohol (optional ——depends if you'd rather look at moving or non-moving crawlers). See boxes (nice but also optional).

Divide the class into two groups. These two groups can then work in teams of 2-4. One group places quadrats on the mulch under Casuarina trees, and the other places quadrats on the mulch under other trees. The groups collect all the insects and other animals they find within the quadrats. Then the two collections are compared. Which harbors more crawly things? Are the insects and other life found in gagu mulch the same as or different from those found in the mulch under other trees? How do the conditions under gagu trees differ from under other trees? Does this relate to the life found there, and if so, how?

A Special Beach Tree

It's about time we mentioned Guam's small rare native tangantangan, Leucaena insularum variety guamense. (Not to be confused with the very common tangantangan here, Leucaena leucocephala. See Savanna, Old Fields, Roadsides pages 36-38. L. leucocephala was brought in after World War II to help keep Guam's soil from eroding into the sea. It's been doing a very good job, too.) Every part of the native tree is smaller than on the introduced species.

Before Typhoon Pamela in May of 1976 there were three small but healthy stands of the little tree on Guam beaches——just south of Togcha Cemetery, just north of Talofofo Bay, and on Cocos Island. For weeks after the typhoon it seemed that Pamela had wiped them out.



Today (March 1977) we see that the two stands on the east coast are making comebacks. The trees now are just several inches tall, but there are lots of them. Did they arise from old roots or sprout from seeds? It looks as if these two beaches will once again be generously populated by this delicate-looking but tough tree! How are the specimens on Cocos Island doing?

28

Cocos nucifera

Pantropical — Coconut, niyok

Graceful coconut palms leaning over sand beaches and peaceful lagoons are the very symbol of the beach strand, so we will now consider the coconut tree.

Like the seeds of other plants of the beach strand, coconuts float. Tests show that coconuts will sprout even after floating in saltwater for 4 months. While they probably could have floated to islands, it's much more likely that coconuts were brought to islands by people. They're too important a plant to be left to chance drifting. Guam's first coconuts were probably brought by the ancient Chamorros.

Coconuts generally grow just behind the strand plants rather than right out on the beach, though they often lean out over it. The root system of a coconut tree goes down about 1 m, or, in areas of good soil, down to 5-10 m. Although coconuts can't grow in waterlogged soils, they can grow near sand beaches even if their roots are covered by saltwater once in awhile——as long as it drains off.

If left alone, coconut groves tend to become very dense as young trees grow up beside their parents. This could be one reason they lean out over the beach——to get Sun. The growing tip is sensitive to light and will grow toward it. If lots of other trees are behind it also looking for light, a tree will lean out over the beach where no other tall plants compete for light. Trees growing nearest the beach strand maintain a somewhat precarious balance. They lean out into the free Sun, trying to get away from the shading of the trees behind them. They mustn't lean too far, lest they topple. Their roots, though extensive, are anchored in shifty sand and they are exposed to strong winds. If a big typhoon doesn't happen for a long time, these trees may grow tall and lean way over the beach. Then along comes a really big blow and down goes the king of the beach. In the months that follow, up comes the next prince to take his place farthest out in the free Sun. You may be surprised by how tall beach coconut trees are on other Pacific islands. It means they don't have the typhoons that Guam does.

We know more about coconut trees than other beach trees because coconut palms are so much more useful. The nuts ripen in 9 or 10 months, germinate a few months later, and grow into trees that flower in 3-8 years. They bear generally at about 6 years, producing around 40 coconuts a year.

Here's an illustration showing some of the many uses of this marvelous tree.

Leaf stopper
(gas escapes
during fermentation)
Salad or Lumpia
(tree must be killed to get it)
Decorations, Toys
Sap (toddy)
Heart
Sweet rice
wrapping
Fresh drink
Unopened flower bud
New Leaf
Fans
Tuba (fermented)
Young
Leaf
Pudding
Boil for
molasses
Sour for
vinegar
Baskets
Hats
Spin for
palm sugar
Distill for
aguayente
Use to
make rice
cakes rise
Thatch
(Mature leaf
"Gauze"
Noose for
catching
river shrimp
Medicine
"tea bags"
Leaf
Midrib
Tongs
Sandals
Decoration
stems
Young Nut
Sterile injection
medium
Coconut water
Trunk
Orchid post
Spoon meat
House post
(soak in seawater)
Notch and stack
for pig pen
Ahu
Old flower
spray -
Kindling,
removing
intestine
from roast
boxfish
Tiki
Fast thatch,
baskets
Brooms
Roots - medicine
Braid for
torch
Copra
Soap
Oil
Old Leaf
Mature Nut
Meat
Copra cake
Animal feed
Husk
Shell
Chips
Floor polishing
samba (skuiyi)
Sprouted Nut
Charcoal
Grated - Kelaguen
Fuel
orchid mulch
Oil
Handcrafts
Candy
Mattress stuffing
"Apple" snacks
Squeeze for coconut milk
Oily meat
Husk - Twine, rope
Pudding
Butter
Fishing float
Utensils
Sauce
Oil
String
dispenser
Planter
Polynesian sashimi
"Peanut butter"
Scent with ilang-ilang for hair oil

If you want your favorite 'manha' (green coconut with tender meat) tree to be as productive as possible, don't hack steps on the trunk. Being a monocot, the coconut has vascular bundles (plumbing) scattered throughout its trunk. A cross section would look like this:

A coconut tree can't form wood and bark like dicot trees, so its wounds remain.

Some people tend to cut steps on alternate sides of the trunk. That's worse than one-above-another steps because side and side steps cut through the veins on 2 sides. One step above the other cuts through only one section of plumbing. If you need to climb a tree often, make a ladder, or better yet, climb island style by making a loop of rope or pago bark, putting your feet in it, and hopping up. Lots of islanders can do this——even without the rope. Coconut tree climbing's a great sport!

Activity 11 Storytime

Write a story about a beach tree. Begin with its journey to Guam, floating or in a canoe of ancient people. Tell of its struggles to live on the beach where it settled, then how it finally establishes itself and begins to produce seed-children. These spread around to other beaches and islands, most dying but the lucky and hardy ones surviving on other beaches. What messages does your tree send to its faraway children as the wind blows through its leaves? What messages does the wind bring back about the faraway shores? Tell of the frightening days when your tree is chopped at or threatened by a bulldozer clearing a place for a hotel or recreation area. Tell of your tree's good years when it grows to be the biggest of its kind, bravely reaching farthest out on the beach for the free Sun, so beautiful that people

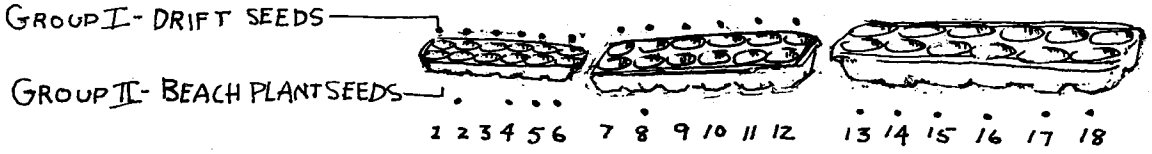
admire it, even though they don't realize the chance it is taking. Finally tell how your tree perishes in a spectacular typhoon, to be missed by people, but itself content with its glorious struggle and that it lived its fullest and sent its seed children, even on the waves of the last typhoon, to do the same.

Activity 12 Beach Seeds

Materials: long egg cartons (optional)

Divide the class in 2. Group One collects seeds from beach drift, Group Two seeds from beach plants.

1. The drift seeds are laid out in a numbered row, or placed in the back section of an egg carton. Seeds from beach plants are matched with the first set. Any that match are placed in the front row in front of the corresponding drift seeds, and given a corresponding number (II-2, II-4, II-5, etc.). The unmatched beach plant seeds are placed in the front row after the last drift seed. A class recorder keeps a record and assigns successive numbers.



Compare, contrast, and discuss the collections. What percent of the drift seeds could have come from the plants growing on that beach? How do seeds found on the beach compare with those you found on plants?

2. Put samples of each seed in a bucket of seawater. Which ones float? The class recorder will add this information to the chart. Are there any floating seeds for which you can't find possible 'mother' plants? Where do you think these came from? This group of seeds will be known as the 'mystery seeds'.

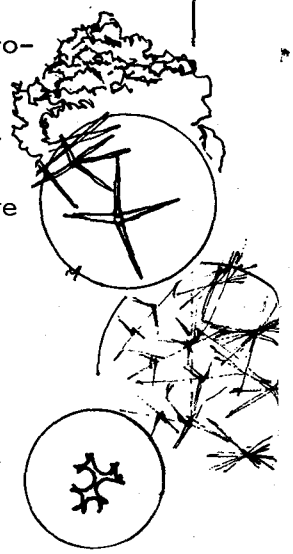
3. Germinating beach seeds: Bring the egg cartons and seed collections and some sand back to class. Set the cartons in shallow pans of water so that they are always moist. Sprinkle sand over the seeds to barely cover them. Close the cartons and check them every other day to see if any germinated (sprouted). Keep records. How many drift seeds sprouted? How many seeds collected from beach plants sprouted? What can you say about this?

If any of the 'mystery seeds' sprout, perhaps someone living near the beach can plant them to see what kinds of plants they become.

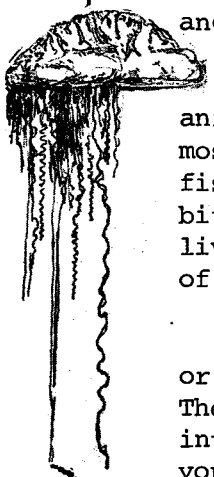
9 Invertebrates

Invertebrates are an immense group of animals without backbones. It would be almost impossible for you to learn the names of each kind. It isn't hard though to have a general name to use for most of the ones you'll find on the beach. Usually they'll be in one of these groups:

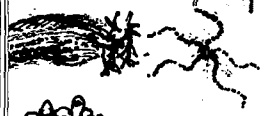
I) Protozoa - These are a really big group (about 44,500 kinds are known) of one-celled animals. You need a microscope to see most of them. One group, the foraminifera (forams), lays down a calcareous shell which you may have seen in Activity 2, Sand Analysis. Other protozoa may be seen in Activity 7, A Glimpse at the Microscopic Marine World.



II) Sponges - are full of tunnels leading to larger tunnels. The body is made up of spicules (little spikes) which you can see under a microscope if you first dissolve the sponge in dilute acid. About 4,200 kinds are known and you'll find lots of kinds washed up on the beach.



III) Coelenterates - include about 9,600 kinds of animals with stinging cells called nematocysts. The ones most likely to be found on the beach are washed up jellyfish and especially the blue Portuguese man-o-war and bits of coral. Coral is actually a skeleton laid down by living coral polyps, which are like tiny anemones, sort of upside-down jellyfish.



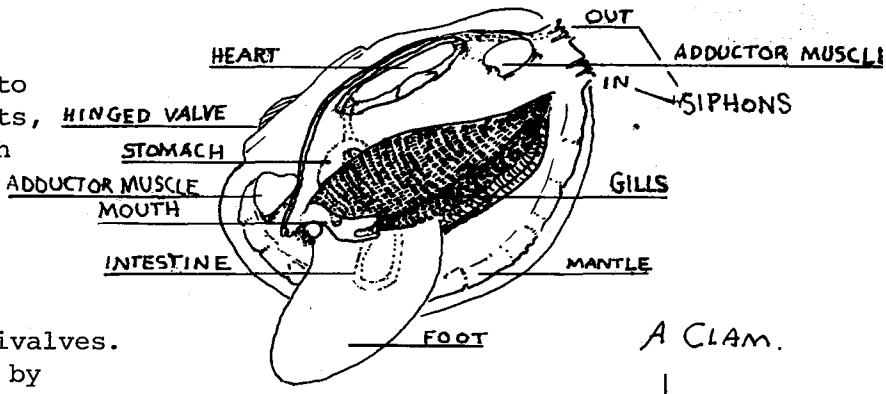
IV) Worms come flattened horizontally or vertically, or round. The round ones are either segmented or unsegmented. There are some 23,000 kinds. The ones you're likely to run into in the sand are annelids with stinging bristles. Also you can find the tubes of sipunculid worms.

V) Echinoderms are a group of about 5,700 spiny-skinned animals with bodies that are radially symmetrical. They include brittlestars (around rocks) and starfish, sea cucumbers and sea urchins. You'll find the round skeletons and spines of sea urchins ashore and generally there are cucumbers too.

VI) Mollusks are a big bunch of shell makers. In some kinds, like chitons, octopus, squid and nudibranchs, the soft-bodied living animal is a lot more apparent than the shell. On the beach, however, you're more likely to find shells than bodies. A mollusk forms its shell by oozing lime and a substance to make it harden through a special layer of its body, the mantle. Sheet after sheet is laid down and the shell grows. There is generally a thin outer protective coat over the thick middle section of shell, both of which are laid down by the edge of the mantle. The inner 'nacreous' coat which is smooth and often pearly is formed by the whole outside of the mantle. Cowries extend the mantle around the outside of the shell and so keep it smooth and shiny. The mantle also makes the colors and patterns of a shell.

Tridacnid

Seashells can be divided into 2 groups: those with 2 parts, the bivalves, and those with one part, the univalves (gastropods).



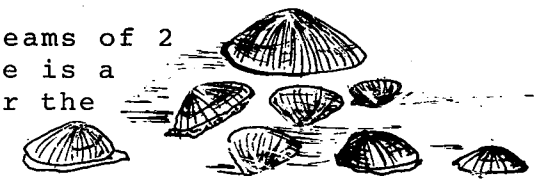
A CLAM.

Those little clams that you find by digging in the sand near the water's edge are bivalves. These clams breathe and eat by filtering seawater with their gills. You may notice them squirt out some water when you first uncover them. They reproduce by shedding eggs and sperm into the water. The fertilized eggs develop into swimming larvae that later settle down and become clams. The sand clam can move about by extending its foot out into the sand, and then swelling it so that it spreads out and anchors in the sand. Then the clam can pull itself forward.

Activity 13 Observing Sand Clams

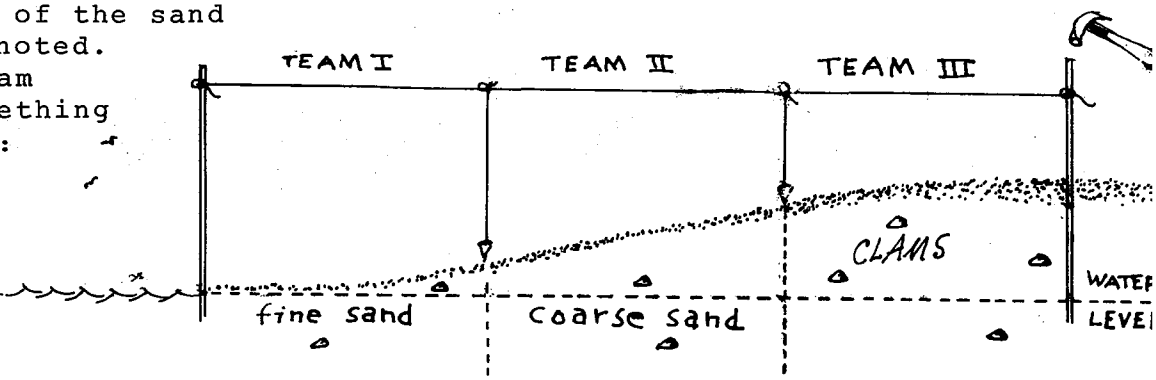
Materials (per group): 2 stakes about 2 meters long, wire or clothesline marked every 30 cm, line level (optional), 1-3 meter sticks, container for clams (bucket, bag, etc.), notebook with clam diagram, pencil, knife, epsom salts (optional).

1. Work in groups of 7-9 along the beach in areas with different kinds of sand if possible. Lay out a transect by stretching a 2-meter line between two stakes. Place one stake at the water's edge and the other directly up the beach. Allow a foot or more working space under the line. Level it with a line level or other means.



Six students space themselves evenly in teams of 2 opposite each other along the line. There is a recorder for each team or one recorder for the whole group.

One person removes the sand from a 30-cm-wide swath under the wire, looking for sand clams. The teammate measures the vertical distance from the wire to the place where the clams are found. The recorder places dots on a diagram of the transect to indicate the location and depth of each clam. Changes in the character of the sand are also noted. The diagram looks something like this:



Place the clams you find in a container. Continue looking until the number of clams you find decreases or for the time specified by your teacher.

2. Lay the clams you collected on the sand beside the trough and observe any behavior.

Each team opens a clam and observes the different body parts. Compare this clam with your diagram (from p. 33). (These little clams really 'clam up' tight. You'll have to surprise one open or slide a thin knife between the shells or place one in a solution of epsom salts to make it relax and open.)

Fill up the trough, returning the clams to the places where you found them. We could make them into soup. But if everyone collected them to eat there wouldn't be enough for students to observe. So let's share these clams with other classes that will be using this beach.

3. Combine the findings of all groups. Consider these in relation to the way these clams live and reproduce. Where were the most found? Draw dashed lines on your diagrams to indicate the water level. How high was the tide when you were at the beach? Estimate the tidal range for the beach. Do the clams 'prefer' to be above, at, or below the current water level?——the mean water level? Were there more clams in coarse sand or fine sand? How do you think the quality of sand might affect the clam's ability to get food and reproduce? Did you feel any difference in temperature at different levels? Is there any freshwater drainage into this sand? If so, at what depth? What effect might it have? Can the clams move? How fast? Do you think they could move about in the sand enough to position themselves favorably for each tide change, or only generally to the range of tides?

The univalves, (= gastropods = snails), are many and varied. A few of the common ones you're likely to find are sketched below. They have a more active way of feeding than the bivalves that sit in one place and filter the water. Gastropods go about scraping off bits of food with a file-like organ called a 'radula'.

Activity 14 Getting Radulated

If you're patient and not too squeamish, you can feel a mollusk radula. Smear some snail food (like ripe breadfruit, fish juice, etc.——what do snails like?) on your finger and lay your hand in the path of a moving African snail. If it's hungry, it'll scrape at your finger. It won't hurt, but your sensitive finger will feel the scraping.

Snails close their shells with a door (operculum). That's what those cat's eyes are that you find on the beach.

Most shells you'll find on the beach will be empty, or else borrowed by hermit crabs. For more on live mollusks and shells see the LOG unit Coral Reef and the many shell books available.

Activity 15 Observing Live Mollusks

Mollusks are easy to keep in an aquarium. Almost any aquarium or large jar will do. Place clean sand, some rocks and a little seaweed in the bottom, and fill with clean sea water.

A large surface-area to volume ratio is desirable. Preferably use a container with vertical or outward-sloping walls. If you use one that gets smaller toward the top, don't fill it beyond that level where surface area starts to decrease.

An electric pump will help keep the water oxygenated but you can also bubble air through the water once a day with a bicycle pump. (Blowing in air through a straw won't help as much——why?) If you're careful not to overload the tank, you may not need to oxygenate the water.

Observe the activities of the mollusks each day. Name them and keep a comment sheet beside the aquarium so that you can communicate with others about the activities in the tank.

VII) Arthropods are the biggest group of invertebrates. They have an outside skeleton and jointed legs. Included are insects, spiders, centipedes, millipedes, and crustaceans. Sand fleas and crabs, which abound on the beach, and lobsters and shrimps are crustaceans.

Activity 16 Where Do Sand Fleas Live?

Mark off about a 1 m circle of bare sand and another where the sand is covered with drift seaweed. Pound and sift through the bare sand. Remove the seaweed and do the same thing. In which area are there more sand fleas? Why do you suppose this is?

Activity 17 Drift Seaweed Housing Areas

Search through drift seaweed. How many kinds of crustaceans and other creatures can you find there? Drift algae offers hiding places, protection from Sun, wind and birds; it provides food and hunting grounds for a big crowd. Just think of the story you could write about what goes on here!

Activity 18 Where Do Crabs Make Their Holes?

This activity is best done in the morning. Mark off circles about 2 m in diameter in loose sand and in a place where beach shrubs grow in the sand. Count the number of different-size holes in each sample area. Discuss the difference in number and size of crab holes in relation to sand stability.

Activity 19 Housing Problems for Hermit Crabs

(Hermit crabs have no hard skeleton on their abdomens so they move into empty snail shells for protection.)

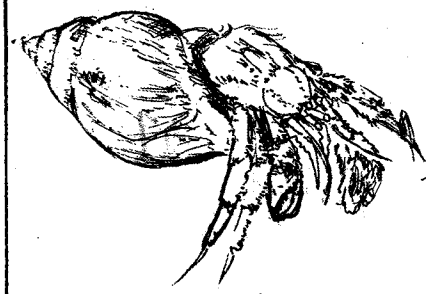
1. Put a shelled hermit crab in a tray with a number of empty shells. Leave it undisturbed. Does it show any interest in the empty shells? What does it do?

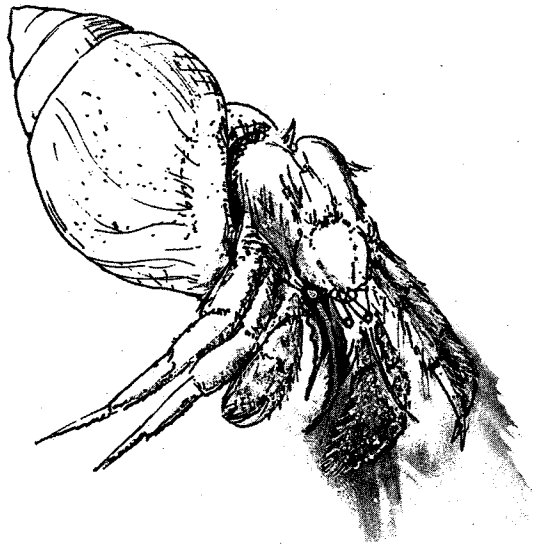
2. Remove a hermit crab from its shell. This can be done in 2 ways: a) Place the crab on a moist sponge or cloth and leave it undisturbed for a while. Then gently touch the end of its shell with a heated object. Do not frighten it with movement. It should move away from the heat. b) Hold a hermit crab in your left hand with the open end of the shell away from you. Put a drop of water on the top edge of the shell above the opening. Hold a forceps just behind the opening. Hold the shell very still and wait. When the crab comes out, grasp it behind the head and pull it gently from the shell.

Place the shell-less hermit crab in a tray. How does it act? Now put a number of empty shells in the tray. What does it do? Does it get into the first shell it comes to or does it make a careful selection?

3. Remove several crabs from their shells. Place them in a tray with one empty shell. What happens? How does the winner take possession of the shell? How do the losers behave?

Activity 20 Hermit Crab Races





1. Divide the class into groups of 6-8. Each student collects as many hermit crabs as he can within a specified time. These are put in a container and graded by size.

For Race #1, each student chooses a crab in 'Class I' (small crabs). These are placed in the center of a circle about 1 meter across and the race is on! You may urge your crab on with words but not otherwise. The first hermit crab to cross to the outside of the circle wins. The 'owners' of the 'losers' then offer reasons why their entries didn't win the race, but how their crabs are better off in other ways. For example: 'My crab has too heavy a shell to run fast, but the heavy shell protects it from being crushed by other crabs.' Or, 'My crab lost because it didn't move. It figures it's better to stay still and look like a stone so a passing bird won't take a peck at it,' etc.

2. For the next race, contestants can move to 'Class II' (bigger crabs). On the 'go' signal students place their crabs in the center of separate meter circles. They then do whatever they can think of, including touching, to urge the crabs to move fast. The first crab to move out of any of the circles wins.

Repeat this race several times with different crabs. After the races, discuss the best way to make a hermit crab move. How do hermit crabs react when touched or moved? How do they react to nearby movement or shadows? Do they get used to nearby movement or being touched? How might the hermit crabs' reaction aid their survival?

Activity 21 Footprints on the Beach

This activity is best done in the morning. Sketch 'footprint' patterns you find in the sand. Which belong to birds? Which belong to shell-less crabs? Which were made by hermit crabs? How do you know?

Activity 22 What Roamed Last Night?

Materials: large cans, digging tool, bait (crushed crab, seaweed, dead fish, etc.), board to cover can and seaweed.

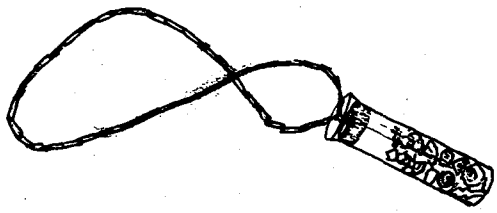
Bury the can so that its open top is level with the sand. Place the bait at the bottom of the can. Put 3 stones around the edge of the can and on them place the board so that it covers the can but leaves a place for creatures to crawl under. Camouflage the trap by covering the board with drift seaweed.

Leave the can trap overnight. The next day, check to see what fell in. Observe and count the creatures. Are there any spare parts indicating animals that got eaten? Release the beach animals and as they crawl away note the kind of tracks they leave. Compare these with those you sketched in Activity 21.

Activity 23 Miniature Wonderland of Shells

Materials: small vial with stopper, sealing glue, hairpin or paperclip or wire, chain or string, small magnifying glass (optional).

During visits to the beach, collect tiny shells and put them in a small vial. When the vial is almost full (leave some room so the shells can be moved about), insert a cork stopper. Poke a clipped-off hairpin or paperclip or other wire into the cork. Push the cork below the rim of the vial. Fill the top of the vial with glue. Suspend the vial on a chain or string and wear it around your neck or use it as a key chain. If you like, attach a small magnifying glass (or another vial filled with water). Now you can entertain yourself and others with the wonderworld of miniature shells!



10 Reptiles

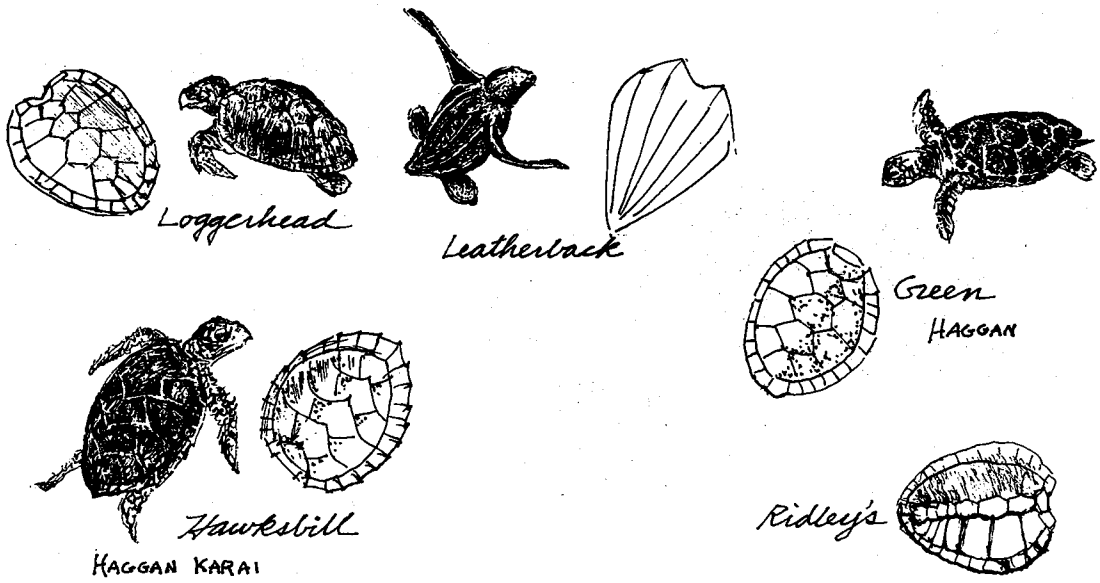
Sit quietly on a beach at dusk. You may hear the geckoes wakening. While they may be awake throughout the day, it's probably too hot to be very active. So they take a siesta, and with the fall of the Sun they begin to stir. Listen carefully and you may hear the geckoes in different coconut trees calling to each other with their click clicks. Watch. Sometimes you will see them come down the coconut trunks from the crowns——'to kiss the ground and pay respect to their ancestors', some old people say. Sometimes they move in fairly large numbers, probably to do their evening hunting and to visit.

Five species of geckoes live on Guam. You can tell a gecko from other lizards here because it chirps, has bulgy eyes, 'suction toes', and such tiny scales that it doesn't look scaly. Other lizards on Guam are skinks or anoles or monitors.

While geckoes are not really beach animals, they are certainly Pacific ocean travelers. They probably came before or with the first people. Their traveling success might be because of their hard-shelled eggs. These could be laid and get stuck in crevices and cracks in about-to-become-drift wood, and in early days, canoes. Geckoes can float. If they fall in the water, tiny air bubbles collect on their granular skin, forming a silvery life vest!

SEA TURTLES

There are five kinds. Only the green (our more common species) and hawksbill have been recorded from Guam. A few ridley and leathery turtles are known from other parts of Micronesia.

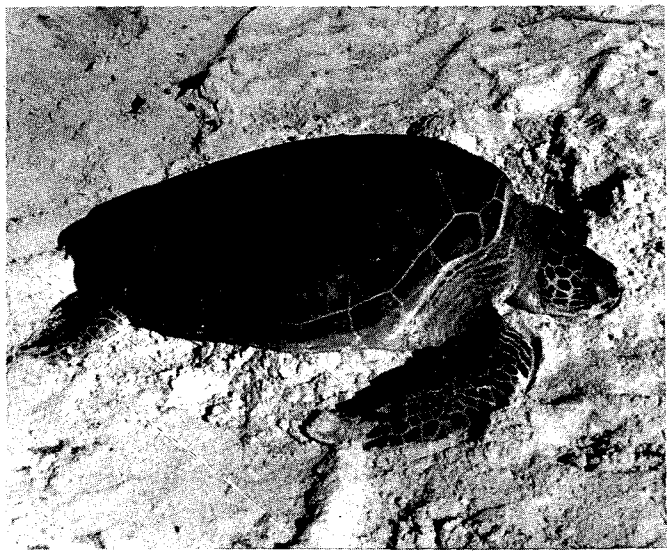


Sea turtles are remarkable animals. Though they normally swim about and eat in the ocean, like other reptiles they have lungs and must surface to breathe. (They can hold their breath a really long time though.) They lay eggs and their babies have to breathe, too, so they must come to beaches to make nests.

It's not likely that you'll meet a sea turtle on the strand. Females come only at night to certain remote beaches to lay their eggs. We believe that turtles return to nest at the same beaches where they themselves hatched. There aren't many quiet nesting beaches on Guam any more. After lumbering ashore, the female green turtle carefully digs a hole as deep as her flippers can reach. She then lays about 100 eggs and covers the nest. On the same trip she may dig other holes and fill them in without dropping eggs in them——why would she do that? Then she tiredly drags back to sea. At intervals of about 2 weeks she returns to make other such nests. Then she won't lay eggs for 2-3 years. Although the nest is covered, the path the turtle took to and from it leaves telltale marks in the sand. (If you see what you're looking at, you can tell the difference between her coming-up and her going-down trails.) If you find such trails, you might report it to Fish and Wildlife so they can do something to protect the nest and hatchlings. By protecting baby turtles on Guam we could probably help increase their population.

Turtle eggs hatch in 2 to 2-1/2 months, and the little turtles work hard to dig their way out of the nest. They then head for the low place on the horizon. Many are killed by predators as they cross the sand and begin to swim.

No one knows where baby turtles go, but tagging programs in the Caribbean show that mature turtles may travel as far as 2000 kilometers from feeding to nesting grounds. How they find their way is a wondrous thing. For more about sea turtles read So Excellent a Fishe (see p. 48).



Activity 24
Store-sold Turtles

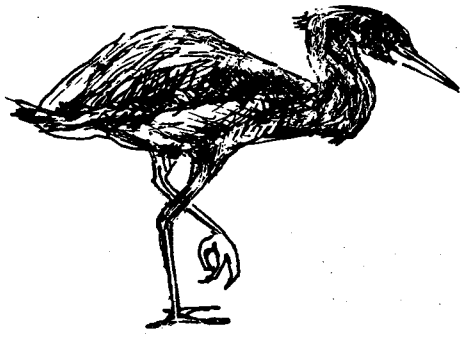
See our turtle sketches. Visit Guam stores that sell stuffed sea turtles or their shells. What species are they? If you find any leathery (not likely), hawksbills, or ridleys for sale, remind the manager that it is illegal to sell them.

11 Birds

Forest areas along beaches are good places to look for many of Guam's birds. They are an edge where birds like to congregate. Some birds make their living on the beach strand, reef flat and open ocean though. We'll now discuss these 'beachcombing' and ocean soaring birds. Shore birds characteristically have long legs for wading and long beaks for spearfishing and poking. Birds of the open sea generally have long wings for soaring and flying long distances, and webbed feet for swimming.

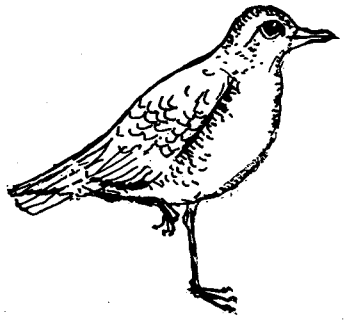
Shore and near shore birds

Demigretta s. sacra,
Reef heron, Chuchuko'



These graceful, medium to large herons are occasionally seen along water's edge of quiet beaches or on reef flats of quiet lagoons where they stand stately, spearing fish, crabs and other littoral life for their food. They are shy of people and will fly away in an arc when you approach them, crying out repeatedly, making you ashamed that you disturbed them! They may be blue, slate gray, or sometimes pure white. The young may be white to mottled. Reef herons are also found about mangroves and sometimes in Guam's freshwaters and savanna.

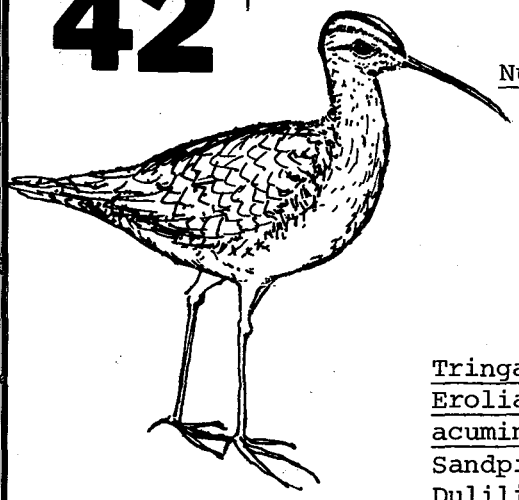
Pluvialis dominica fulva,
Pacific golden plover,
Dulili



This bird is brown when it comes to Guam all the way from the Arctic. It visits Guam during the winter months (when it's winter in the Arctic). When spring returns to the faraway north, the bird turns a beautiful gold with black markings and it flies away to return to its homeland.

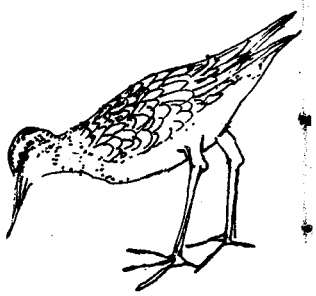
It is often seen about the beach, but also frequents open areas like big lawns and antenna fields.

42



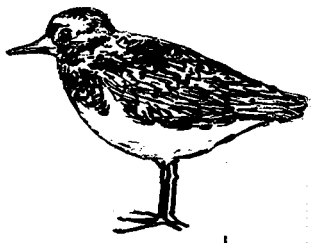
Numenius phaeopus Whimbrel, Kalalang

A winter visitor which confines itself pretty much to beaches, generally alone, wading along quiet shores where it is easily disturbed and flies away up the beach at your approach. It is fairly large and brown.



Tringa spp., Erolia acuminata Sandpipers, Dulili

Small gray-brown birds that run up and down the beach poking in the sand and shallow water. There are at least 3 species that migrate or straggle through Guam in the wintertime.



Arenaria interpres Turnstone, Dulili

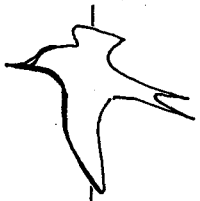
Like a sandpiper but shorter and fatter and with distinct black and white markings and red legs. It too is a winter visitor.

T e r n s

Terns have long pointed wings and generally forked tails and are very graceful in flight, flying often in pairs with constant wingbeats, seldom soaring, but sometimes hovering. They make a bright splash as they take small fishes from the surface of the water with their bills.

Terns can spot schools of fish from the air much easier than fishermen in boats can. When you go fishing, the terns will show you where the fish are! Here's a tool for identifying them:

Key to Guam's Terns and Noddy

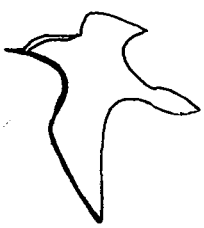


I) underparts white or pale grey

A) rump and tail white

1) head and nape white.....white tern - resident. Chunge'

2) cap or nape black.....black-naped tern - straggler.



B) rump & tail same color as mantle
1) cap and eye stripe black, underparts including nape black .....sooty tern - straggler.

2) cap white or same as mantle, no eye stripe, crown white, nape dark grey, mantle pearl grey..... white-winged black tern - straggler.

II) underparts dark, upperparts dark brown, wedge-shaped tail .....brown noddy - common, resident migrant. Fahang

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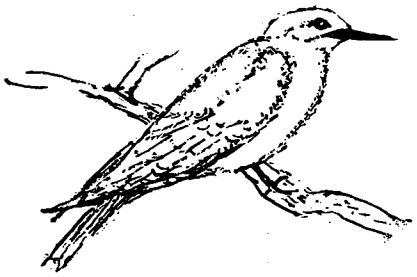
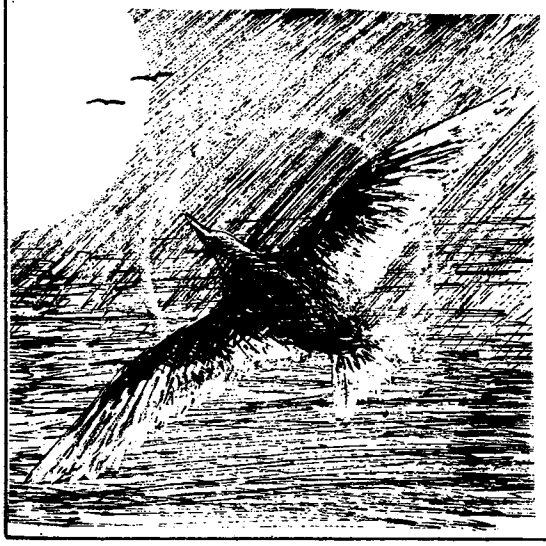
The most common terns on Guam are the graceful white terns which may be found in Casuarina and other forests along the shore as well as inland in savannas. They do not make nests but lay their eggs in the forks of trees, for instance Pandanus, or in depressions on branches, especially of breadfruit trees. It is a marvel that the young hatch without falling out of the tree! The parent bird goes fishing, and can often be seen flying inland with fish held crosswards in its beak. The young can eat live fish one after another,



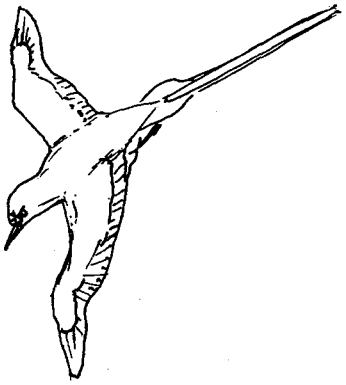
Gygis alba
White tern,
Chunge'



sometimes shaking all over after swallowing a particularly big wiggling fish! This delicate white bird with big black eyes often hovers above the place where it will land, or if you are a quiet intruder, it may hover over you for awhile, seeming to survey you.

Birds of the Open Ocean

Phaethon lepturus dorotheae, White-tailed tropic bird, Fakpe



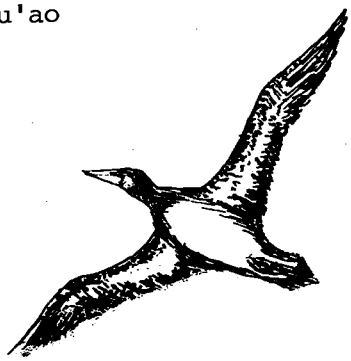
This is perhaps the most beautiful aerial resident of Guam. Besides having graceful long wings, and striking black markings, the adults have long tail feathers. They are most often seen near cliffs. Against the deep blue of the sea or sky they fly alone or in pairs. They flap their wings constantly with occasional short glides. They are now considered endangered.

They dive for fishes and squid and can float on the ocean's surface, and may be found far at sea throughout much of the tropical and subtropical Pacific.

Puffinus spp. Shearwater
Paya'ya'

Small to medium-sized offshore and pelagic birds which are all dark, or sometimes with white underparts. They have long narrow wings, heavy bodies, short tails and long slim hooked bills with paired tubular nostrils (if you should ever get really close!). These birds fly with alternate short bursts of flapping and long glides, banking low over the ocean's surface on stiff wings. They eat small fishes and squid near the surface in shallow dives and are often seen above schools of fish. There are about 4 species reported from Guam, all of them stragglers.

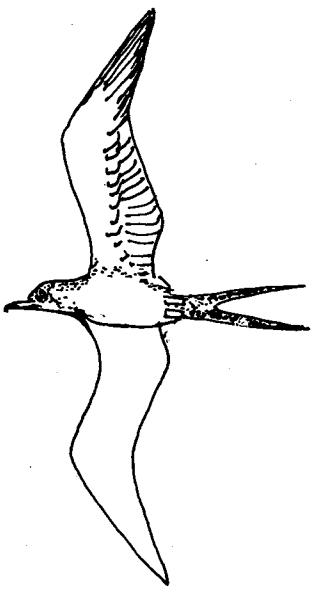
Sula leucogaster
Boobies or gannets,
Lu'ao



Large web-footed seabirds which fly gracefully over the ocean alternating a series of slow powerful wingbeats with short glides. They eat fish, catching flying fish right out of the air or else by diving into the water! Very beautiful in flight, they are awkward and somewhat comical on the ground, stepping high with their webbed feet like a skin diver walking with flippers. They smell like fish.

The brown booby flies about Guam offshore and in more remote places like Orote Point. It is mostly brown, with a white lower breast and belly.

Boobies may range up to 80 km from their home islands. Fishermen use them to locate schools of fish. To Caroline Islands traditional navigators, they are true friends. When you see them, you know you are within 80 km of land. At dusk they can be trusted to fly straight to shore, thus showing you the way.



Fregata m. minor
Frigatebirds, Man-o-War birds, Ga'ga' manglo'

Great, mostly black birds with long, angled wings and deeply-forked tails. The male is black with inflatable red throat pouch. The female has a white breast. Immature birds may have white head and breast. They are graceful fliers and soarers, a beautiful sight to see! They do not often grace Guam. Occasionally they come here when there is a storm or typhoon about their home areas in the Northern Marianas or central Caroline Islands. They effortlessly fly great distances and have been reported over 6,400 km from their nest sites. They do not land on water——their feathers are not waterproof. They catch fish from the surface or, in contrast to their majestic appearance, steal them from other fisherbirds! These birds are widespread in the Pacific and have made their way into the arts of many Pacific peoples.

Seabirds and Man

Seabirds, especially those of the open ocean, have contributed hours of flying time to the evolution of life-sustaining islands. For centuries, they've been carrying nutrients of the sea to land. They assisted the first plants on islands to grab a tenuous foothold, and then grow. This provided shelter, habitat and sustenance for other life. Seabirds thrive by the thousands on uninhabited islands. Those of long ago left a legacy of guano turned phosphate rock. People such as our Nauruan neighbors have become rich by selling island which birds built for them long ago.

Seabirds cannot tolerate man's continued presence in large numbers nor his pressure on their nesting grounds. There are fewer and fewer 'away from it all' homes for seabirds. The closest large nesting island to Guam, aside from small Anae Island off Agat, is Farallon de Medinilla (north of Saipan), which has been used as a bombing target.

A fact not known or not heeded by many is that seabirds are protected by law.

12 Beaches and Man

The beach is many things to many creatures; an edge, a home, a serving plate of the ocean, a sea buffer, a place to reproduce, hunt, live out life's dramas.

For people, beaches provide a place to forage——to cast nets, dig for clams and treasure, go crabbing. Even though Guam is supported mostly by outside money, we still need to maintain her natural productivity and an islander's freedom to live off the land and sea.

The beach is a place of refreshing windfalls. It has given us puka shells, and California redwoods for big sailing canoes. On an outer island of Truk it even provided a containerized cargo box of beer which washed ashore after a barge sank on the way from Guam to Ponape!

The beach provides a setting for legends of sea-people, like Si Sirena of Guam and the dugong and porpoise girls of Palau and Yap.

Beaches provide sand for sweetening clay soils, for babies to play in, and for mixing with cement. They also provide modern Guam with recreation areas and tourist attractions.

So appealing is the beach that many places, including Guam, feel that beaches are public domain. But, belonging to the people, beaches are subject to human greed and carelessness——what has been called the 'Tragedy of the Commons'. It's become necessary to make laws to protect them. For example, it is now illegal to remove sand from our public beaches.

Guam is now working on Coastal Zone Management. Check it out.

Activity 25 Averting the Tragedy of the Commons

What are human greed and carelessness? Give some examples in relation to public beaches. What is the collective wisdom of people? Give examples of ways that wisdom could triumph over greed and carelessness in using beaches.

As the land is man's habitation, the seashore is the edge of man's influence——a place to get away from it all, a place to be together, or alone. Because of the constantly changing assemblies at the water's edge, because of the endless lines of poetry being written ashore in gentle lapping lines or thundrous crashing waves, the beach has a cadence beyond man's power. Here a person can lose the burden of self-importance and be refreshed by a vision of expanding horizons, in the mind, and in the lands and space beyond the horizon.

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Suggested Equipment

(in order of first appearance)

Notebook and pencil (not 'suggested', indispensable)
2 liters of sand
Dye for sand
Vials of sands from different places (35-mm film containers make good 'vials' - small, tough, recyclable)
Hand lens (See box), magnifier
Watchglasses
Dilute hydrochloric acid (HCl)
Glass stirring rod
Calcareous sand beach
String 30-50 m long
Quadrat markers (e.g. clothes hangers, string, boxes, cans)
Core tubes or glass vials or shovel
Tide Tables (or page 11)
Graph paper (optional)
Felt pens (optional)
Microscopes, slides, droppers, etc., bucket, can, or beaker
Seaweed(s)
Flat pan
Wax paper
Newspapers
Glue
Plant press and dryer or paper towels and heavy book, or corrugated cardboards and twine.
Herbarium paper or other non-glossy heavy paper
1-m sections of different species of Ipomoea
Bug collecting equipment (optional——fingers will do or forceps can be improvised from bent coconut leaf midrib or grass stems)
Jars of alcohol (optional)
Egg cartons (optional)
Sand clams
Knife
Stakes 2 meters long, wire or twine or clothesline, line level (optional), meter sticks.
Epsom salts (optional)
Snail
Aquarium (large jar), pump (optional)
Hermit crabs, sponge or cloth, forceps
Vial and stopper
Hairpin or paperclip or wire, string or fine chain.

Plant Index

Animal Index

Acknowledgements

Chamorro names-Jose S. Rivera.
Photo credit, page 40 William J. FitzGerald, Jr.

With thanks to my Parents,
Frank and Marjorie Cushing,
who among many marvellous things,
brought us to live by the shore.

"The sea doth wash away
all human ills."

Euripides

"Who can number the sand of the sea,
and the drops of rain, and the
days of eternity?"

Ecclesiasticus

"The Walrus and the Carpenter
Were walking close at hand:
They wept like anything to see
Such quantities of sand:
'If this were only cleared away,'
They said, 'it would be grand!'"

"'O Oysters, come and walk with us!'
The Walrus did beseech.
'A pleasant walk, a pleasant talk
Along the briny beach.'"

Lewis Carroll

"To see a world in a grain of sand
And a heaven in a wild flower,
Hold infinity in the palm
of your hand
And eternity in an hour."

William Blake

"There is a rapture on
the lonely shore,
There is society, where
none intrudes,
By the deep sea, and
music in its roar:
I love not man the less,
but Nature more."

Byron

"Dark-heaving——boundless, endless
and sublime——
The image of Eternity.
And I have loved thee, Ocean!
and my joy
Of youthful sports was on thy breast
to be
Borne, like thy bubbles, onward:
from a boy
I wanton'd with thy breakers."

Byron

"I wiped away the weeds and foam,
I fetched my sea-born treasures home;
But the poor, unsightly, noisome things
Had left their beauty on the shore,
With the sun and the sand
and the wild uproar."

R. W. Emerson

"My life is like a stroll
on the beach."

Thoreau

"When it came night, the white waves
paced to and fro in the moonlight,
and the wind brought the sound
of the great sea's voice to the men
on shore, and they felt that they
could then be interpreters."

Stephen Crane

"I am forever walking upon those shores,
betwixt the sand and the foam,
The high tide will erase my foot-prints,
And the wind will blow away the foam.
But the sea and the shore will
remain forever."

Gibran

"The sea is the land's edge also, the granite
Into which it reaches, the beaches where it tosses
Its hints of earlier and other creation:
The starfish, the hermit crab, the whale's backbone;
The pools where it offers to our curiosity
The more delicate algae and the sea anemone.
It tosses up our losses, the torn seine,
The shattered lobsterpot, the broken oar
And the gear of foreign dead men.
The sea has many voices."

T. S. Eliot