CHAPTER SIX

THE SEA

'The sea! How many stout hearts thrill and manly bosoms swell at the sound of that little word, or, rather, at the thought of all that it conveys! How many there are that reverence and love thy power and beauty, thy freedom and majesty, 0 Sea! Wherein consists the potent charm that draws mankind towards thee with such irresistible affection? Is it in the calm tranquillity of they waters, when thou liest like a sheet of crystal, with a bright refulgent sky reflected in thy soft bosom, and the white ships resting there as if in empty space, and the glad sea-mews rippling thy surface for a brief moment and then sailing form the blue below to the deeper blue above, and the soft song of thy wavelets as they glide upon the shingly shore or lip among the caves and hollows of the rocks? Or is it in the loud roar of thy billows as they dash and fume and lash in fury on the coasts that dare to curb thy might? ~ that might which, commencing, mayhap, in the torrid zone of the south, has rolled and leaped in majesty across the waste of waters, tossed leviathans, as playthings, in its strength, rushed impetuously over half the globe, and burst at last in helplessness upon a. bed of sand! Or does the charm lie in the yet fiercer strife of the tempest and the hurricane, when the elements, let loose, sweep round the shrinking world in fury; or in the ever-changing aspect of thy countenance, now bright and fair, now ruffled with the rising breeze, or darkened by the thundercloud that bodes the coming storm. Ah, yes! methinks not one, but all of these combined do constitute the charm which draws mankind to thee, bright ocean, and fills his soul with sympathy and love. For in the changeful aspects of thy visage there are talismans which touch the varied chords that vibrate in the hearts of men. Perchance, in the bold whistle of thy winds, and the mad rolling of thy waves, an emblem of freedom is recognised by crushed and chafing spirits longing to be free. They cannot wall thee round.

They cannot map thee into acres and hedge thee in, and leave us nought but narrow roads between. No ploughshare cleaves thee save the passing keel; no prince or monarch owns thy haughty waves. In thy hidden caverns are treasures surpassing those of earth; and those who dwell on thee in ships behold the wonders of the mighty deep. We bow in adoration to they great Creator; and we bow to thee in love and reverence and sympathy, 0 Sea! '

From the book 'UNGAVA' by R.M. Ballantyne

SEA FEVER

I must go down to the seas again, to the lonely sea and sky,
And all I ask is a tall ship and a star to steer her by;
And the wheel's kick and the wind's song and the white sail's shaking,
And a grey mist on the sea's face, and a gray dawn breaking.

I must go down to the seas again, for the call of the running tide,

It is a wild call a.nd a clear call that may not be denied;
And all I ask is a windy day with the white clouds flying,
And the flung spray and the blown spume, and the sea gulls crying.

I must go down to the seas again, to the vagrant gypsy life,
To the gulls way and the whale's way where the wind's like a whetted knife;

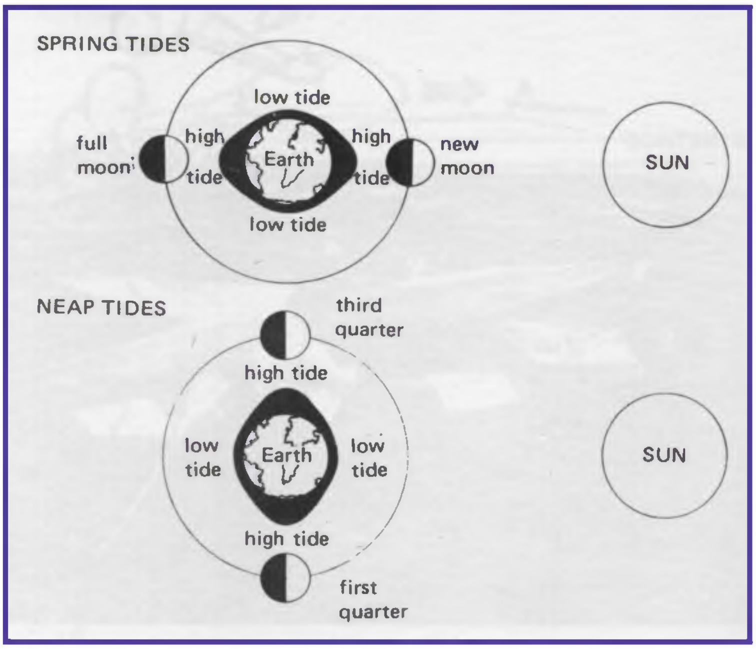
And all I ask is a merry yarn from a laughing fellow rover,
And a quiet sleep and a sweet dream when the long trick's over

John Masefield

BALLANTYNE, best known for "CORAL ISLAND' has written many books about early Arctic exploration, Arctic natives and their culture, and the extract from one of these books which I have used to kick off this chapter, for me, sums up so neatly my own feelings about the sea. About seven tenths of our planet is covered by water, most of which, is sea water. As you all know the sea is not stationary but is constantly in motion, motion caused by the sun/moon and by the weather. The sun causes thermal currents as well as assisting the moon to cause tides. The weather, specifically the wind, causes waves.

TIDES

The tide is the more or less regular movement of the rise and fall of the sea resulting from the pull of the moon and sun on the huge masses on the Earth. This movement is not the same in all parts of the world. In some oceans the cycle of the tide extends over a whole day. On the coasts of western Europe this cycle extends over a little more than twelve hours. These tides are known as SEMI-DIURNAL. There are also places where tides scarcely exist as in the Mediterranean. Tides cause a rise and fall in the depth of the water as well as causing strong variable tidal streams. Briefly, the sun and moon exert a pull on the waters of the earth
causing a rise in their level in one part of the earth and a consequent fall in another. The moon has a greater effect than the sun because it is much closer to the earth.



The rise and fall of the tide is greatest when the moon and sun are in the same straight line with the earth ~ either when both are on one side of the earth or each is in opposite sides of the earth. These are known as Spring tides. The rise and fall of the tide is least when the moon and sun are at 90 degree from each other in relation to the earth. These are known as Neap Tides. Put another way. Spring tides occur at times of full and new moon and Neap tides occur at the moons quarter. Because the earth rotates on its own axis and the moon rotates around the earth, there are two High waters and two Low waters in one LUNAR DAY, which is 24 hours and 50 minutes. A lunar day being the time it takes for the moon to appear to pass over the same line of longitude. You have to understand that the Earth rotates once every 24 hours. The Moon revolves about the Earth once every 28 days. Therefore the moon will appear to pass over the same line of longitude in 24 and 1/28 of 24 hours, i.e. 24 hours 50 minutes. A fact which complicates lunar tides is that the Moon does not remain in the sky directly above the Equator. Instead, because of the tilt of the Earth's axis, it appears to move 28 degree north and south of the Equator. The levels of high tides may vary accordingly.

DYNAMIC THEORY OF TIDES

We all know that Isaac Newton discovered the law of gravity which states that the gravitational attraction between two objects is directly proportional to their masses and inversely proportional to the square of the distance between them. This law explains why the gravitational attraction of the sun for the Earth is about 150 times that of the Moon. The huge mass of the sun more than makes up for its much greater distance. But the Moon is the primary cause of tides. Why?

The answer is that the difference in attraction for water particles at various places on the Earth is far more important than the overall attraction. This is due to the Moons proximity (239,000 miles) bringing about a big difference in the gravitational attraction from one side of the Earth to the other.

Let me explain. The water on the side of the earth nearest the Moon is some 4,000 miles closer to the Moon than is the centre of the Earth; the water on the far side is yet further by another 4,000 miles. The sun is so far away from the Earth (93 million miles) that a few thousand miles makes little difference so that the suns gravitational force, although far greater, affects one side of the Earth no more than the other side. You should imagine the Earth rotating constantly inside a fluid envelope of ocean, whose watery bulges are supported by the moon. This concept considers the tide wave as standing still while the ocean floor turns beneath it. Thus most points on earth experience two high and two low tides a day.

Tides are in fact the longest waves commonly dealt with by oceanographers having a period (the time in seconds for a wave crest to travel a distance equal to one wave length - a wave length being the horizontal distance between adjacent crests and a crest is the high point of a wave) of 43,000 seconds (121 hrs 25 minutes) and a wave length of half the circumference of the Earth. The crest and trough of the wave are the high and low tide. The wave height is called the RANGE of tide, but since it is measured only in places where it is influenced by the shape of the shore, it varies greatly from place to place.

The exact gravitational force acting upon a point on the Earths surface can be worked out mathematically. Yet movements of the tides do not fall exactly in line with the predictions. All sorts of oddities occur. For instance, at places along the same coast a few miles apart the levels of the same hole may be completely different. More strangely the tides are not at their highest when the Moon is exactly overhead. There is a time lag, known as a LUNAR INTERVAL, between the moment the Moon passes overhead and the moment high tide occurs. The lunar interval may be as much as 6 hours. These deviations are due partly to the interruption of land masses and partly to the fact that once moving, the sea has an energy of its own and does not immediately change course when a new force is exerted.

HIGH AND LOW TIDES

The level of the water in the open oceans rises and falls by only about two feet. In shallow lakes it may be as little as a couple of inches. But where the deep ocean basins come in contact with the shallow continental shelves, there is an enormous decrease of space and water can only accommodate itself by piling up along the coasts. This level may rise 40 ft or more. When tides flow in river estuaries they are slowed by the very shallow water. The flood tide can flow faster than the ebb tide so that the level of water rises faster than it falls. In some rivers the level changes so rapidly that a single huge wave advances upstream - A TIDAL BORE. One of the best examples in the U.K. is the Severn Bore in the west country.

The Severn Bore

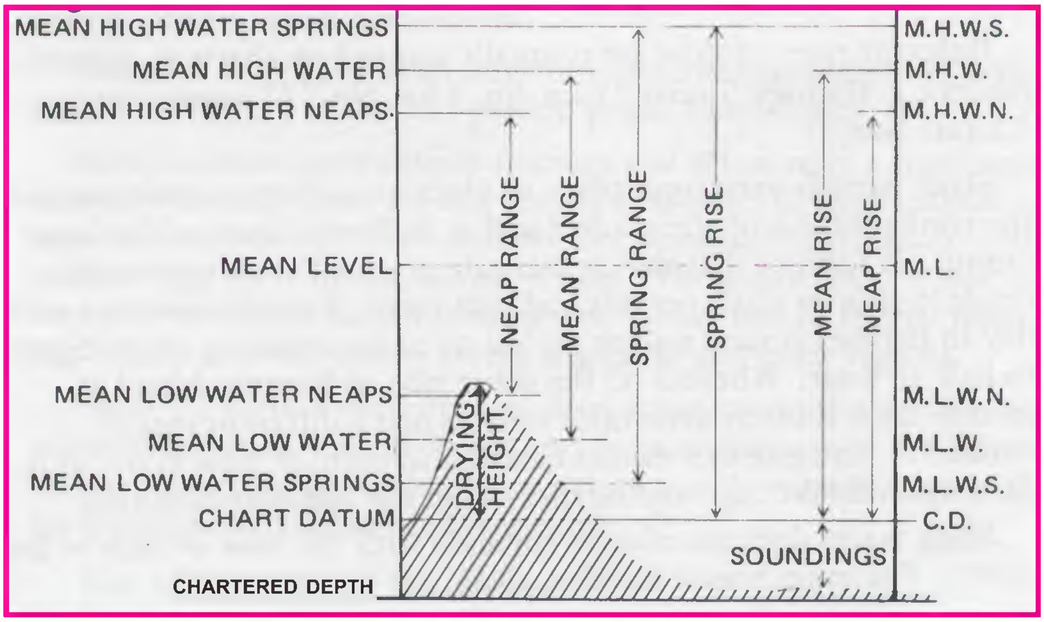
It is on this Bore that I believe Frank Goodman holds the record for the longest run on one wave.

Should you place a measuring pole upright in the sand below the lowest point at which the tide falls and drew on a graph the different heights of water observed during the course of one day a tidal curve is obtained roughly in the shape of a sine curve. You will note, during your patient observation, that the tide rises for 6 hrs 12 mins on average. This is the rising or flood tide. When the water reaches the highest point on the measuring pole the level remains constant for a short time. This is high water slack tide. Then the water level drops as the sea falls again for 6 hrs 12 mins on average. This is the falling or ebb tide and will eventually reach low water slack and the cycle beings again. The duration of a cycle is therefore, as I have said above, on average 12 hrs 25 mins. Thus the times of high and low water are some fifty minutes later each day.

SPRING TIDES, NEAP TIDES

If you continue to observe your measuring pole for a month you will note that the difference in height between high water and low water varies from day to day. Tidal movements vary and the TIDAL RANGE varies. Let us remind ourselves as to why. Variations in movements are related to the relative position of the Earth, Moon and Sun. When the three bodies are in a straight line with each other we experience Spring Tides and maximum range. The range of the tide is the difference in height between successive High and Low waters. Spring tides therefore occur around the times of full and new moon. Subsequently the movement diminishes and the range is less pronounced. When the sun and moon are out of line and come round to form an angle of 90 degrees with the Earth, so that the tidal range is at its least, we are experiencing Neap Tides. The neap tides correspond with the first and last quarter of the moon. Then the movement and range increases until the next Spring Tide. The complete cycle lasts about 14 days.

Finally the range of the tide varies from one Moon to the next, the greatest ranges being experienced at the time of the spring and autumn equinoxes. The equinoxes occur when the sun crosses the equator. At this moment the length of day and night is equal throughout the world. When the Sun and Moon are at their lowest angle the forces generating tides are greatest. Therefore when the New or Full Moon has a low declination or angle near the line of the equinoxes (21st March and 23rd September) when the Sun's declination is zero. Spring Tides will be of greater range than usual. These are called the EQUINOCTIAL SPRING TIDES. The range of the tide also varies considerably from one point to another depending on the sea bottom and the shape of the coast line. It is also worth noting that the range at maximum spring tide is six times greater than the range at lowest neap tide and also, whatever the range is at a given spot the level of the sea is always the same at HALF TIDE. This half tide level is called the MEAN LEVEL and is an invaluable reference (see diagram on following page).



It is possible to obtain a rough approximation of the height of tide between High and Low Water by using the THE TWELFTHS RULE. This rule relies on the fact that the tidal curve is very like a sine curve. From it we can deduce that from one slack water to the next the sea rises or descends by:-

1/12 of its range in the 1st hour
2/12 of its range in the 2nd hour
3/12 of its range in the 3rd hour
3/12 of its range in the 4th hour
2/12 of its range in the 5th hour
1/12 of its range in the 6th hour

By dividing the range by 12 and the time interval between two slack waters by 6, it becomes fairly easy to reckon the depth of water from hour to hour. You must remember that the interval between two slack waters is on average longer than 6 hours, that is the tide time is different from clock time. However, no notice is taken of this unless the time interval, between two slacks is very different from the average (which is the case in the English Channel for example where the time interval can be less than five or more than seven hours). The Twelfths Rule can really only be applied in the open sea with any reliability. The rise and fall of tides in estuaries is often determined by other factors of a local nature, like the restrictions and constrictions imposed by the coast line and sea bed. Strong winds are also responsible for heaping up the water. When high spring tides coincide with strong winds blowing in the same direction the effect may be to increase the level of high tide by 10 ft or more.

TIDAL STREAMS

Tidal Streams are the horizontal movement of water due to the vertical rise and fall of the tide. Tidal Streams should not be confused with currents. I will explain the nature of currents in a moment. So the rise and fall of the tides causes tidal streams. These streams, their direction and rate of flow can be discovered by consulting a Tidal Stream Atlas, tidal information on charts and from Admiralty Sailing Directions. I have included a page from the Irish Sea Tidal Stream Atlas which you will note bases its' tide times on High Water Dover.

These streams, their direction and rate of flow can be discovered by consulting a Tidal Stream Atlas

The rate of flow of the tidal stream is dependent on whether the **tide is making**, i.e. increasing up to Springs, or **taking off**, i.e. decreasing towards Neaps.

TIDAL DIAMONDS

As well as Tidal Stream Atlases, you can use Tidal Diamonds as displayed at (usually) convenient spots on the chart. Each one encloses a letter and by referral to the appropriate letter in the Tidal Information Table, usually in the bottom right hand corner of the chart, you can gauge what the speed and direction of the tide is going to be at your area of operation relevant to the current state of the tidal phase. If the diamonds are well spaced out and there is not one in your vicinity, then a little extrapolation will be required. Of course you are also going to have to extrapolate if your activity falls between Spring and Neap tides. See also Pages --- and ---.

As a rough guide we can use the THIRDS RULE. You will not be surprised to learn that there is a direct relationship between the range of the tide and its speed. From the TWELFTHS RULE you will remember that during the 3rd and 4th hour (approximately half-way between high and low water) the range increases (if rising tide - decreases if falling tide) by 3/12 ths of its range, hence this is also the time of greatest speed of the tide. All things being equal, and do remember that things are rarely equal when making a guestimate of tidal behaviour using these Rules, the tide is maximum half-way between low and high.

The Thirds Rules goes like this:-

During 1st hour of tidal rise (or full) the speed of the tide will be 1/3 rd of its maximum speed.

During the 2nd hour the speed will be 2/3 rd of its maximum speed.

During the 3rd and 4th hour tidal speed will be at its maximum.

During the 5th hour the speed will be 2/3 rd of its maximum.

And during the 6th hour the speed will be 1/3 rd of its maximum.

Using a 4 knot tide as an example:

Hour				**S peed of Tide**
1	=	1/3 rd of 4	=	1 1/3 knots
2	=	2/3 rd of 4	=	2 2/3 knots
3	=	3/3 rd of 4	=	4 knots
4	=	3/3 rd of 4	=	4 knots
5	=	2/3 rd of 4	=	2 2/3 knots
6	=	1/3 rd of 4	=	1 1/3 knots

Having explained the Thirds Rule I have to tell you that in WILLARD BASCOM book 'WAVES AND BEACHES' says 'The maximum current velocity comes about at the same time as the maximum change in the height of water. Since these relationships depend largely on the local conditions NO GENERAL RULE applies '. My own experience does not usually coincide (Waves & Beaches is an American book) and I do use the Thirds Rule to give me an estimate of the tidal speed.

COMPUTATION OF RATES
Inside the front cover of Admiralty Tidal Stream Atlas is a COMPUTATION OF RATES TABLE and use of this will help you provide a fairly accurate estimate of the speed of the tide at a given point at a given time and date - given that the wind has not blown constantly over the area to speed up or slow down the speed.

You require three bits of information:
(i) Range of tide, (For example,at Portsmouth which is appropriate for the Isle of White -see Tidal Atlas for Solent on next page) which is found in TIDE TABLES.
(ii) Speed of tide at Spring's in chosen area.
(iii) Speed of tide at Neap in chosen area.

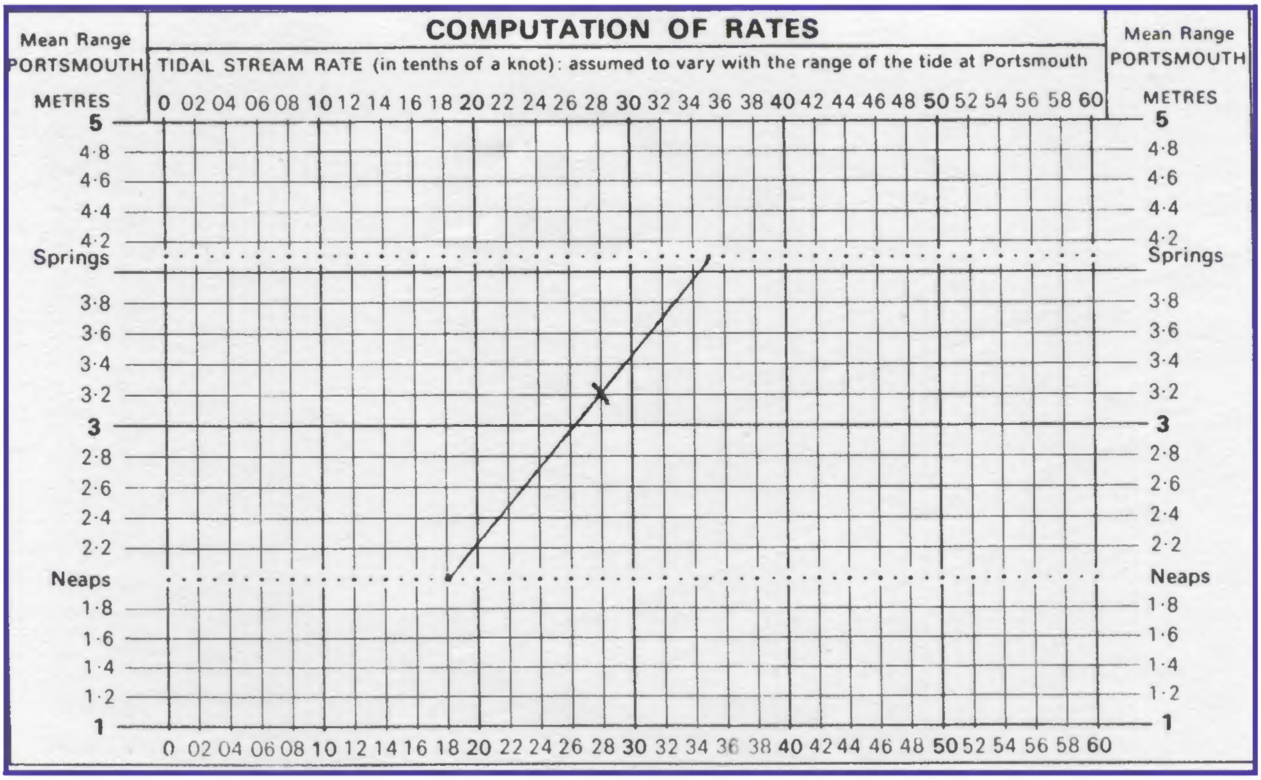
In the extract from Admiralty Tidal Stream Atlas 'The Solent and Adjacent Waters' at the southern tip of Isle of Wight you will see

18.37

Let this be our 'chosen area'.
18 = 1.8 knots (remember I knot = I nautical mile per hour)
37 = 3.8 knots

It is written 18.37 for brevity. This is telling you that Neap Tides run at 1.8 knots and Spring Tides at 3.7 knots.

Turning now to the Table 'Computation of Rates' we plot 1.8 along the Neaps dotted line and 3.7 along the Springs dotted line and then join up these two points



I can tell you that the range of the tide on our chosen day is 3.2 metres. Following the 3.2 horizontal line to our 1.8/3.7 line and reading off from the vertical line we see the TIDAL STREAM RATE (in tenths of a knot) is 2.8 knots. The main anomaly to the general use of the TWELFTHS (range) and THIRDS (speed) rule is it does not. apply out in the open sea where the tidal streams do not oscillate to and fro in a straight line but travel in an ellipse. There is no true slack but merely a falling off in rates at the extremities of the ellipse.

Slack periods of tide vary from place to place according to coast line and the configuration of the sea bed and it also varies at different times of the lunar month. It follows that the greater rate attained at Springs would result in shorter slack periods and vice versa. For instance, on a calm day in Bardsey Sound a slack period on neaps could be anything up to half an hour. Whereas on the other side of Ramsey Island at Springs, slack is often detectable only as just a different sort of confusion and one can almost hear the screech of 'tidal tyres' as it does a handbrake turn and hurtles in the opposite direction. Slack water does not always coincide with the time of high or low water. The reason for this, again, is the restrictions and constrictions imposed by the coast line and sea bottom.

So remember, the Tide Tables are mathematically correct but environmental factors like wind, high or low atmospheric pressure may speed up or slow an incoming or ebbing tide and affect its' height.

It was sometime around 325 BC that Aristotle wrote, ***'it is even said that the many ebbings and risings of the sea always come with the Moon and upon certain fixed times'***. In effect he was telling us that when planning a sea kayaking trip we should not underestimate the gravity of the situation!!

Times are G.M.T. Add Summer Time

COWES

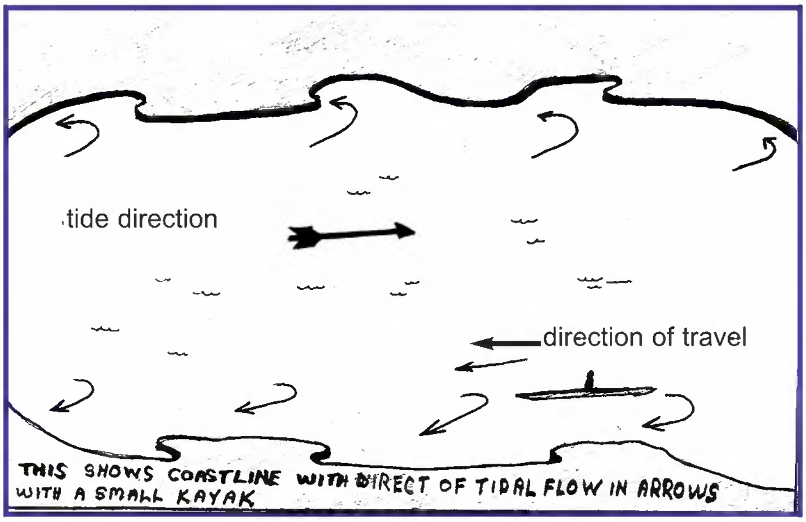
JULY

D. of M.	D. of W.	Morn h m	Hgt m	Aft h m	Hgt m
1	S	06 10	3·5	18 43	3·7
2	M	07 05	3·5	19 32	3·7
3	Tu	07 59	3·5	20 19	3·7
4	W	08 49	3·5	21 05	3·7
5	Th	09 38	3·6	21 49	3·8
6	F	10 23	3·7	22 30	3·8
7	S	11 04	3·8	23 07	3·9
8	S	11 41	3·9	23 40	4·0
9	M	—	—	12 19	4·0
10	Tu	00 14	4·0	12 52	4·0
11	W	00 49	4·0	13 26	4·0
12	Th	01 26	4·0	14 02	4·0
13	F	02 08	4·0	14 45	4·0
14	S	02 56	3·9	15 35	4·0
15	S	03 50	3·8	16 34	3·9
16	M	04 57	3·7	17 47	3·8
17	Tu	06 21	3·6	18 56	3·7
18	W	07 29	3·6	19 57	3·8
19	Th	08 32	3·7	20 53	3·8
20	F	09 30	3·8	21 45	4·0
21	S	10 29	4·0	22 35	4·0
22	S	11 30	4·0	23 22	4·1
23	M	—	—	12 29	4·2
24	Tu	00 08	4·1	13 12	4·2
25	W	00 53	4·1	13 49	4·2
26	Th	01 38	4·0	14 25	4·1
27	F	02 22	4·0	15 07	4·0
28	S	03 10	3·8	15 53	3·8
29	S	04 03	3·7	16 47	3·7
30	M	05 09	3·5	17 49	3·6
31	Tu	06 21	3·3	18 47	3·5

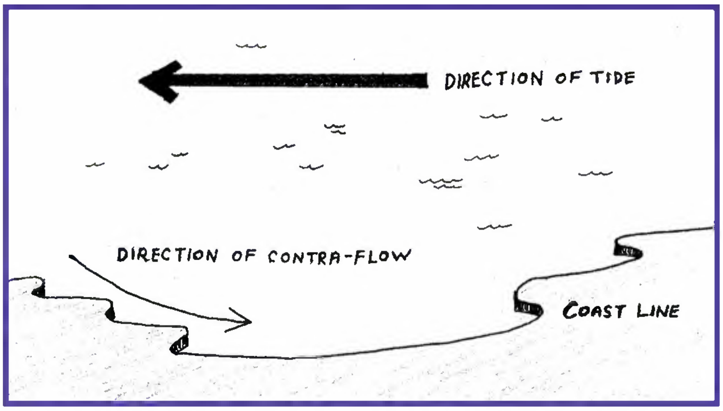
AUGUST

D. of M.	D. of W.	Morn h m	Hgt m	Aft h m	Hgt m
1	W	07 19	3·3	19 40	3·5
2	Th	08 15	3·4	20 31	3·5
3	F	09 07	3·5	21 19	3·7
4	S	09 58	3·7	22 04	3·7
5	S	10 44	3·8	22 44	3·9
6	M	11 22	3·9	23 17	4·0
7	Tu	11 54	4·0	23 46	4·0
8	W	—	—	12 24	4·1
9	Th	00 21	4·0	12 54	4·1
10	F	00 59	4·1	13 31	4·1
11	S	01 41	4·0	14 13	4·1
12	S	02 29	4·0	15 02	4·0
13	M	03 22	3·8	16 02	3·8
14	Tu	04 33	3·7	17 24	3·7
15	W	06 15	3·6	18 46	3·7
16	Th	07 26	3·6	19 48	3·7
17	F	08 28	3·7	20 44	3·7
18	S	09 31	3·8	21 40	3·9
19	S	10 47	4·0	22 34	4·0
20	M	11 42	4·1	23 19	4·1
21	Tu	12 24	4·2	23 53	4·2
22	W	—	—	12 48	4·3
23	Th	00 29	4·2	13 06	4·2
24	F	01 06	4·1	13 39	4·1
25	S	01 45	4·0	14 15	4·0
26	S	02 25	3·9	14 55	3·9
27	M	03 10	3·7	15 39	3·7
28	Tu	04 04	3·5	16 38	3·5
29	W	05 23	3·3	17 56	3·4
30	Th	06 40	3·3	19 00	3·3
31	F	07 39	3·3	19 55	3·4

I have spent some time with speed or rate of flow of tide and with its range. I am sure you do not need convincing that, when your paddling speed is about 3 or 4 knots having the tide with you is of paramount importance. On the other hand you may wonder about the need to be too concerned about tidal range. Drawing so little draught as a sea kayak does and consequently requiring only shallow water to float, does it matter that much that the sea level goes up and down. It mattered greatly to Mike and Jonathan, and me too for that matter as I had previously navigated our crossing of the Wash off the Norfolk coast between Boston and Hunstanton. Several hours out and we ran out of water. We tried paddling round the mud banks but eventually we had to portage them. Thick slimy mud up to our knees. I was not allowed to forget this 'error of judgement'. By the time we eventually cleared the mud the tide began to change, and so did the wind and Hunstanton refused to get an inch nearer as we paddled furiously into a darkening sky. This particular trip had a happy ending but it could well have been dicey.



Understanding tidal behaviour is important to us as paddlers. This understanding is particularly useful when circumstances force you to have to paddle against the tide. Several years ago I volunteered to undertake some B.C.U. coaching award assessments at Plas y Brenin, one of our better known Sports Council Outdoor Pursuit Education Centres in North Wales. It was agreed (I had had a couple of pints in their new bar at the time) to circumnavigate Island of Anglesey. No matter how we juggled our departure point or departure time we had, at some stage, to paddle against the tide. We chose to do so through the Menai Straits the narrow and fast piece of water between the Island and the mainland. We chose this area to meet an on-coming tide because we banked on the tide having a contra-flow along the shore. Certainly the speed of tide in shallow water along the shore line is slower than it is out at sea, as the frictional resistance of the land and shallow sea bottom slows it down. Consequently paddling against the tide is best done in shallow water along the beach and when using the tide as it flows in your favour paddle out in deeper water away from the beach. My own local water, the Solent, between the Isle of Wight and south coast of England, runs quite fast on Springs and when I have had to paddle against it I have kept close to the shore to use the contra-flow in the bays. You may have to travel further but it is often quicker.



TIDAL CALCULATIONS

Before going on to talk about other behavioural features of the sea as caused by weather, tides and currents, I will now provide you with an explanation as to how to calculate tidal behaviour better than I did on my Wash crossing. I will be covering this in greater detail when I discuss navigation, but for now a short treatise on how to find the times of low and high water on any given day and time of day.

It is as simple as looking it up the information in a TIDE TABLE.

Refer now to the extract from the Tide Tables for COWES, Isle of Wight, 1990 on Page 173
On 2nd of July, a Monday, the table says that at Cowes at 0705 it is High Water and the height of the tide will be 3.5 metres above Chart Datum.

CHART DATUM

Is the level below which soundings shown on the chart are measured? See the diagram on Page 169.The height of the tide at any time is the distance of the sea level above (or even occasionally below) chart datum. Some Tide Tables will show the time and height of tide of Low Water. Our example only displays time of high water. No matter, extrapolation is easy when you remember that low water comes 6 hours and 12 mins after high or roughly between the two high waters given in the table.

To find the actual depth of water you add the height of tide at the time in question to the depth of water shown over your area of operation on the chart.In the British Isles chart datum at all ports have been amended to approximately Lowest Astronomical Tide or L.A.T. This is simply the lowest level which can be predicted to occur under average meteorological conditions, not necessarily the extreme lowest level as induced by extreme weather conditions.

Back now to our extract from Cowes tide table. Before leaving the 2nd July we should note the time of the next High Water is 1932 hrs and the height will be 3.7 metres - an increase of .2 m since the morning tide, indicating that each subsequent tide is getting higher or moving towards Spring Tides. Indeed you will see this is the case and each tide does get higher up to the 8th and 9th of July when it reaches 4 metres. It remains at 4 m until 14th July when it starts to drop, tide by tide, until it reaches its lowest at 3.6 m.

This rising and falling towards Springs and Neaps can be shown graphically. Here is an extract from H.M. Coastguards Calendar for July 1990. You will note that it is based on tidal heights at Dover and will consequently not match up exactly with the Cowes Tide Table.

HIGH WATER DOVER

DATE	DAY	AM TIME	AM HEIGHT	PM TIME	PM HEIGHT
1	SUN	0520	5.4	1744	5.5
2	MON	0627	5.2	1852	5.4
3	TUE	0733	5.3	1955	5.4
4	WED	0832	5.4	2051	5.5
5	THU	0921	5.6	2139	5.7
6	FRI	1003	5.8	2220	5.8
7	SAT	1040	6.0	2257	6.0
8	SUN	1116	6.2	2333	6.1
9	MON	1151	6.3		
10	TUE	0008	6.1	1228	6.3
11	WED	0045	6.2	1306	6.4
12	THU	0121	6.1	1342	6.4
13	FRI	0159	6.1	1419	6.3
14	SAT	0240	6.0	1501	6.2
15	SUN	0327	5.9	1550	6.1
16	MON	0424	5.8	1651	6.0
17	TUE	0530	5.6	1800	5.8
18	WED	0645	5.6	1914	5.8
19	THU	0802	5.7	2027	5.9
20	FRI	0912	5.9	2134	6.1
21	SAT	1012	6.2	2231	6.3
22	SUN	1102	6.5	2323	6.5
23	MON	1147	6.6		
24	TUE	0010	6.5	1229	6.7
25	WED	0050	6.5	1307	6.7
26	THU	0128	6.3	1345	6.6
27	FRI	0206	6.2	1423	6.4
28	SAT	0244	6.0	1504	6.2
29	SUN	0327	5.7	1546	5.8
30	MON	0414	5.4	1638	5.5
31	TUE	0515	5.1	1749	5.1

Time Zone GMT Times and Heights of High Water at Dover

You will note that HW at Dover on 2nd July is 0627 GMT (Greenwich Mean Time - of which more in a moment) and at Cowes it is 0705 GMT - a difference of +38 minutes. This difference remains virtually constant (changes are also dependent on times of H.W. and spring/neap tides - but are OK as a rough guide) and as a consequence, once we know the time of HW or LW at one place we can add or subtract the difference to get the time of HW or LW at another place. This is known as the TIDAL CONSTANT SYSTEM.

When using this system we come across STANDARD and SECONDARY PORTS. The system is simple. It depends on the time difference between these ports being constant so that knowing what time High or Low water is at any port means that by adding or subtracting the known time difference at another port we can deduce the activity of the tide at this port. For example, if we know that on 2nd July the HW at Dover - a Standard Port, is 0627 we can refer to the TIDAL CONSTANT TABLE, or in the case of the illustration THE TIDAL DIFFERENCES ON DOVER TABLE and on looking up Cowes we see it shows we need to add 29 minutes to find HW at Cowes, i.e. 0656 which is only 9 minutes out from the time shown on the actual TIDE TABLE for Cowes, - an acceptable difference.

Should we need to know the time of HW or LW between ports it is simply a case of extrapolating or

TIDAL DIFFERENCES ON DOVER

Port	Time diff.
ENGLAND, SOUTH COAST	
St. Mary's	+6.07
Newlyn (see Penzance)	
Penzance (Newlyn)	+6.05
Porthleven	+6.02
Helford River (Ent.)	-6.00
Falmouth	-5.58
Truro	-5.50
Mevagissey	-5.40
Fowey	-5.40
Looe	-5.38
Plymouth	-5.28
River Yealm (Ent.)	-5.22
Salcombe	-5.23
Dartmouth	-5.00
Torquay	-4.53
Teignmouth (Appr.)	-4.56
Exmouth (Appr.)	-4.48
Lyme Regis	-4.38
West Bay: Bridport	-4.56
Portland	-4.23
Weymouth (see Portland)	
Lulworth Cove	-4.33
Swanage	†-2.21
Christchurch (Ent.)	†-2.01
Lymington	†-0.41
Yarmouth (I O W)	†-0 36
Cowes (I O W)	+0.29
Calshot Castle	+0.39
Southampton (1st HW)	-0.01
Hamble	+0.30
Wootton (I.O.W.)	+0.25
Ryde (I.O.W.)	+0.29
Portsmouth	+0.29
Langston	+0.30
Chichester (Har. Ent.)	+0.27
Littlehampton (Ent.)	+0.19
Shoreham	+0.10
Brighton	+0.03
Newhaven	+0.05
Rye (Harbour)	-0.02
Folkestone	-0.12
Dover	—
Deal	+0.15
Ramsgate	+0.20

Port	Time diff.
ENGLAND, EAST COAST	
Margate	+1.00
Whitstable (Appr.)	+1.36
Grovehurst Jetty	+1.32
R. Medway:	
Sheerness	+1.36
Tilbury (Gravesend)	+2.03
Greenhithe	+1.30
London Bridge	+2.52
Southend (Leigh)	+1.30
R. Crouch:	
Burnham-on-Crouch	+1.28
R. Blackwater:	
Maldon	+1.43
Bradwell	+1.11
West Mersea	+1.07
R. Colne:	
Brightlingsea	+1.05
Colchester (Wivenhoe)	+1.12
Walton Backwaters	+0.42
Harwich	+0.50
R. Stour: Mistley	+1.15
R. Orwell: Ipswich	+1.10
R. Deben:	
Woodbridge	+1.17
Orford Haven	+0.26
Southwold	-0.58
Lowestoft	-1.33
Great Yarmouth	-2.08
Blakeney (Bar)	-4.42
Wells-Next-The-Sea	-4.11
Hunstanton	-4.42
King's Lynn	-4.36
Wisbech (Cut)	-4.44
Boston	-5.08
R. Humber: Grimsby	-5.20
Hull	-4.52
Bridlington	+5.52
Scarborough	+5.37
Whitby	+5.11
R. Tees (Ent.)	+4.57
Hartlepool	+4.47
Seaham	+4.42
Sunderland	+4.40

taking a mean average between the two. For example, on the Isle of Wight the table shows COWES HW to be 29 mins after HW Dover and just along the coast YARMOUTH HW to be 36 mins after HW Dover. Half-way between Cowes and Yarmouth we would add 31 minutes to the Cowes HW difference (36 - 29 = 7, half of 7 = 3 1/2) to get 32.5 minutes. This is only an example. In reality we would not bother with such a small time difference; it would be of no consequence. Prevailing winds and/or atmospheric pressure alters the time of high and low water all the time.

GMT and BST

GMT - Greenwich Mean Time - is the time we keep in the U.K. between OCTOBER 28th and MARCH 25th. During this period the sun passes over the Greenwich Meredian (the line of longitude of 0 degree) exactly at midday. If you like it is true time.

Between March 25th and October 28th we have BST or British Summer Time which is GMT plus 1 hour. The clock change is now actually made on the last sunday of October and of March to match Universal Time as used by computers.

One way of remembering whether clocks go back or forward is to use the season Spring and Fall (American for Autumn). The clock "Springs forward' and 'Falls back' so on March 25th at midnight the clocks springs forward and we add an hour. Tide Tables and Almanacs take no account of BST, all their calculations are shown as GMT so between March 25th and October 28th we must add one hour to the times shown in the tables to get current clock time.

So that is the 'ins and outs' of tides. You will have to refer to this section later when I cover navigation as rather than cover what tides are and then later discuss the computations of tidal flow I have kept the subject together.

CURRENTS

We have already determined that TIDES are movements of water caused by the gravitational attraction of the Moon and Sun. Currents on the other hand are defined as an onward horizontal movement of water caused by factors other than gravity. Some currents are transient features and affect only a small area such as a beach. These are the oceans responses to local, often seasonal, conditions. Other currents are essentially permanent and involve large parts of the worlds oceans. These currents are the response of the ocean and atmosphere to the flow of energy from the tropics and sub-tropics to the sub-polar and polar regions. Because the air over the tropics receives more direct rays of sunlight it is warmed more than the air at higher latitudes. The warmed tropical air rises and is replaced by cooler air from the north or south. This movement driven by the sun and guided by the rotation of the Earth, causes the major winds.

Near the equator the air is relatively still (the Doldrums), but not so far to the north and south of the equator the Trade Winds blow westward, that is they come from the east. At higher latitudes between 49 degrees and 50 degrees the winds blow eastwards, that is, they come from the west. It is worth understanding at this juncture that when giving tides and winds direction to describe them that TIDES flow to and WINDS blow from, so that an easterly tide means the water is moving to the east and an east wind means the wind is moving to the west. I shall be saying more about the nature of which when I discuss weather. Back to the Trade Winds and those east winds between latitudes 40 degrees and 50 degrees.
A question that should be entering your mind is why do the winds blow west and east when the pressure difference is between the equator and the two poles. Surely the air should simply move south from the North Pole and north from the South Pole to replace the warm air rising at the Tropics.

THE CORIOLIS FORCE

It is this Force that is responsible for the winds moving, not north and south, but in fact deflected to 60 degree to the perpendicular. The Force is the result of the Earths' west to east rotation. This results in winds and ocean currents being deflected to the right in the Northern Hemisphere and to the left in the Southern Hemisphere. The combined results of the three forces; the Suns' heat, the Coriolis Effect and winds, bring about a clockwise circulation of ocean currents in the Northern Hemisphere and a counter-clockwise circulation in the Southern Hemisphere. It is the Trade Winds that furnish the initial impetus by the equatorial currents. These flow close to the surface towards the west until they encounter a land mass that turns them away from the equator. The water masses flow to the north or south and eventually close the loop forming huge eddies that rotate clockwise in the Northern Hemisphere. Each ocean has these great jets of water. In the Atlantic there is the Gulf Stream and Benguela Current.

DEEP SEA CURRENTS

Whereas surface currents owe their motion principally to energy supplied by the wind, deep ocean currents are set in motion when surface waters become cooler and denser than the water below and thus begin to sink. Sea water changes density in two ways. By an increase in dissolved salts and through a decrease in temperature. When salt water freezes the salt is squeezed out of the water and surrounding unfrozen water becomes considerably saltier. In the oceans, near the poles, two deep-sea currents are triggered by the increased saltiness of unfrozen water, which becomes the densest coldest water of the entire oceans and slides down off the continental shelves into the deepest pockets of the ocean floor.

For the globe as a whole the ocean is the great stabiliser of temperatures and is able, within limits, to maintain an equilibrium of life on the Earths' surface. Sea water is an excellent absorber and radiator of heat. Owing to its enormous heat capacity, sea water can continue to absorb great quantities of solar radiation without becoming unbearably hot and, conversely, it can lose much of its heat without seemingly becoming too cold. Because of these qualities sea water acts as a gigantic heat storage battery for the Earth. For example, temperatures in the English Channel vary from 8 degree C (47 degree F) in winter to 16 degree C (61 degrees F) in summer. Through the agency of ocean currents and the atmosphere, heat and cold may be distributed over thousands of miles. The ocean plays the most. important role in this, since unlike the atmosphere which is susceptible to sudden or excessive fluctuations of temperature, the oceans change temperature at a comparatively slow rate and therefore dominate the air. Meteorologists have learned that long-range weather forecasting needs to reckon with the prevailing pattern of adjacent ocean temperatures. One of the best examples of the overall influence of the oceans on climate is in the contrast between the Arctic and Antarctic regions.In Antarctica the land mass is surrounded by seas of uniform coldness which prevents any warming influence reaching its interior lands. Only the hardest life can survive this climatic rigor in-spite of long hours of summer sunshine. In contrast the Arctic has no immediate land mass at the pole and the influence of the warm Atlantic penetrates right into the Arctic region creating an environment a few degrees warmer which enables the Arctic to support a wide variety of plant and animal life at very high latititudes - the equivalent of which in the south is barren ice-desert.

COASTAL CURRENTS

There are usually many reasons for coastal currents such as wind, prevailing off-shore ocean circulation, local temperature differences under water and prevailing surf waves. Because so many forces influence the flow it is impossible to predict with any accuracy the liklihood of coastal currents without talking to local fishermen and kayakers. It is rare for these currents, where they are to be found, to be of any significance to us as kayakers. It is the wind and tidal streams that are of concern and tidal streams, as we know, are predictable.

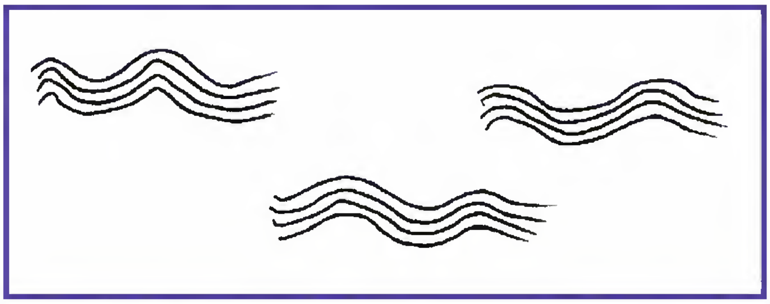
TIDE RACES AND OVERFALLS

Some time ago now, whilst attempting a circumnavigation of the Island of Anglesey with two friends, Keith and Robin, we were fast approaching the Trearddur Bay area along the south west coast on an ebbing spring tide. It was late afternoon and the light was fading. Ahead I knew lay the overfalls of PENRHYN

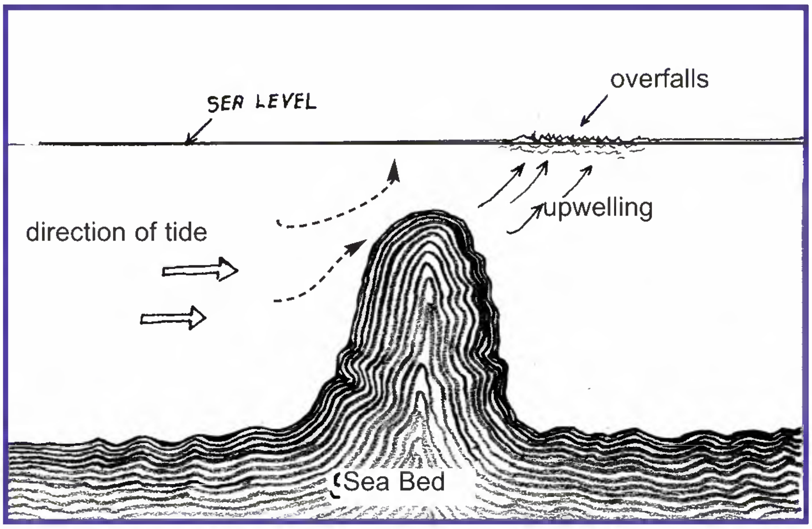
MAWR. I had often played around in them whilst running courses from places like Plas y Brenin. As we steamed ahead I could see the white water of breaking waves on the horizon and soon I could hear the noise as it grew louder and louder. Long before we were actually in the overfalls the waves were appearing large, quite large in fact. Once among this turbulent and breaking confused sea it was clearly each one for himself. Soon we were through and into quieter waters as we seemed to skid around South Stack and head on for the Skerries flashing its light in the distance on the far side of Holyhead Bay.

It was not many years previously that Ray, Frank and I negotiated the infamous Gulf of Conryvrekan that lies between SCARBA and JURA on the west coast of Scotland and, though exciting, was not half as much so as Penrhyn Mawr on this particular occasion. The lesson is that it is not always possible to be certain about what to expect. Let us see why and examine in some detail the anatomy and behaviour of tidal races and of the overfalls they cause. As the tidal streams move along the coast they often become constricted by the topography of the land below the sea and along the coast itself. Given that the coast lay in a straight line with an adjacent deep sea then we would hardly notice the rise and fall of the tide. No coast line runs for very long in a straight line. There are bays, headlands, peninsulas, rocky outcrops and offshore islands. The sea bed is forever undulating with shallow and relatively deep areas along the shore. It is this changing topography of coast line and sea bed that impinges on the tidal streams.

Take a river. It may meander for miles with hardly a ripple. The river is deep and the banks smooth. Suddenly the river shallows and as a consequence the water runs faster. As the river becomes shallower still and rocks interrupt the flow of water then the water is seen to rush on by creating waves, many of which are breaking, creating white water and much noise. It is a rule of hydrodynamics that water behaves predictably whether it is contained in a bath or in an ocean and what happens in the river happens also at sea. Often tidal races are noticeable only by your kayak speeding along with less effort than usual. On the other hand they can be demonstrated by anything from a small patch of ripples to an area of 50 square miles or more of heavily breaking seas.



This disturbed water is so affected by the state of the tide and wind that at different times the same race can be negotiated in safety by a kayak or only by risking group capsize. In some areas it will be possible to paddle a few miles out to clear the outer- edge of a race. In other areas paddling out ten miles may be insufficient. Identifying tidal races from charts is usually easy enough. The topography of the coast is clearly shown and where the sea depth is decreasing and headlands protrude out, - and usually there are islands laying off headlands, - then you can be fairly certain you will find these symbols over the area of sea affected.



Whilst actually on the water and looking for signs of overfalls, a progressive increase in the height of the standing waves until the water deepens towards the tail of the shoal.

Here the standing waves are still roller-like and rounded but progressively higher and steeper until they become unstable and break on a line which marks the transition to the overfalls. The next few waves, though hollow, frequently retain the long form and parallel organisation of the rollers at the bottom of the glide, and may break simultaneously across a wide front. In the body of the race order soon gives way to chaos as hollow, breaking waves lurch and topple this way and that, collide, rebound, mount one upon another and collapse in foam and tumult. In contrast to its abrupt beginning the race peters out gradually; the waves subside leaving only a swell which spreads radially outward form the disturbance which caused it.

Downstream of the race lies another zone of turbulence quite different in character. Here the surface is domed and dimpled by currents that run in all directions wheeling, dividing, coalescing, welling up from the depths, diving down again under a lip of spume. Apart from a few patches of ripples at the margin of eddies, the general appearance of this final stage is rounded but pock-marked. Oily rather than glassy it resists the formation of wind ripples. In the downstream reach the disturbance finally disappears in a residual swell. Tidal races are more complex and variable than this rather simple model, but the same basic structure is there, energised in proportion to the strength of the stream and interacting in each of it parts with wind, sea and swell.

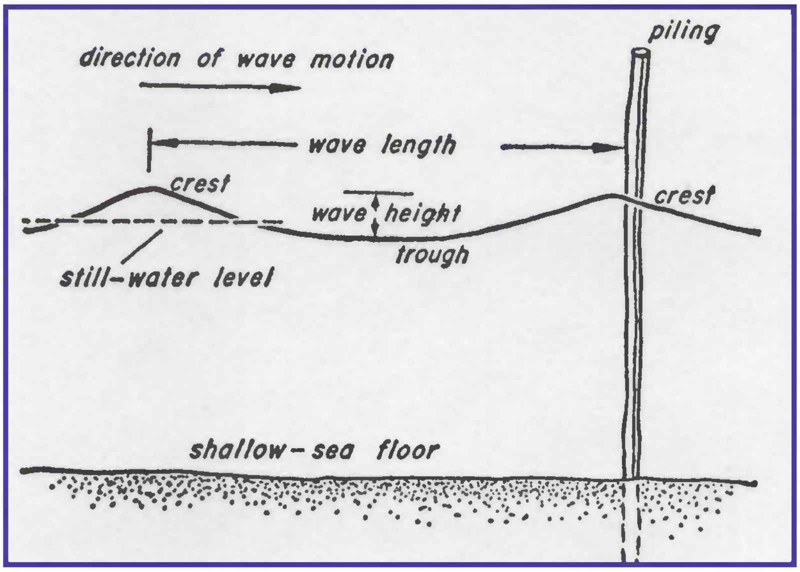
EFFECT OF WIND ON TIDAL RACE

The wind often becomes noticeably stronger when entering a tide race. Opposition of wind and tide creates an increase in the apparent wind, and as the tide velocity is usually higher in races than the surrounding sea, this increase can be quite marked. The wind strength can also increase as the wind and tide race move in the same direction, but the effect is less noticeable. It is wind against tide that increases the height and steepness of the sea and its tendency to break.

WAVES

> ***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 wantoned with thy breakers, - they to me were a delight; and if the freshening sea made them a terror, 'twas a pleasing fear, for I was at it when a child of thee, and I trusted to thy billows far and near, and I laid my hand upon thy mane.***
> ***--As I do here.***
>
> *Lord Byron*

The sea surface is rarely still. Waves cross its surface continuously carrying energy. Any disturbance such as a pebble dropped into the water or a submarine landslide can generate waves. Wind and earthquakes are the most important wave generators. It is waves caused by wind that concern the sea kayaker. Winds cause waves which range from ripples less than a centimetre high to great storm generated waves more than 30 metres high. To study the physics of waves let us look at a simple group of waves; a group of waves or series of waves being known as a wave train. Let us watch a wave train as it passes a fixed point. We see a regular succession of crests - the highest point of the wave, and trough - the lowest point of the wave.



The wave height is the vertical distance from the crest to the trough. The wave length is the horizontal distance between either two successive crests or two successive troughs.
The wave period is the time between one crest (or trough) passing a fixed point and the next one, usually expressed in seconds.

Wave period is easily measured and is frequently used to classify waves

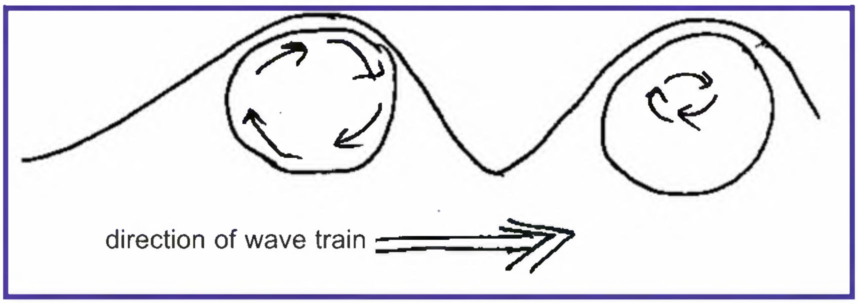
$$\text{WAVE SPEED} = \frac{\text{WAVE LENGTH}}{\text{WAVE PERIOD}}$$

Wave steepness is the ratio of wave height to wave length

$$\text{WAVE STEEPNESS} = \frac{\text{WAVE HEIGHT}}{\text{WAVE LENGTH}}$$

It is worth noting that a piece of wood floating on the water surface moves forward on each wave crest and backward in the wave trough. After the passage of each complete wave the piece of wood returns to its initial position thus demonstrating the cyclical nature of waves.

For a result let us look at the anatomy of a wave in deep water. A wave in shallow water is distorted by the sea bed - hence the need to study a deep water wave. Water molecules at the top of a wave moves round the top of the wave in the same direction as the wave train is moving. These molecules continue to move round the outside edge of the wave to reach the trough before starting upwards to reach the crest again.



The surface particles describe a circular orbit exactly equal to the height of the wave. The particles below the surface ones describe a smaller circle whilst those nearer the centre of the wave describe a slightly flattened orbit (see figure above).   Earlier, in order to demonstrate the cyclical nature of waves, I said that a piece of wood bobs up and down on the crest and troughs of successive waves, maintaining its position on the top or bottom of each wave. Of course we know that the wind will blow our piece of wood along from one crest to another. But I have to tell you that even if there is no wind blowing to influence the piece of wood, it will be imperceptibly moving forward because all waves are in fact moving very slowly forward away from the originating cause of the waves. This movement is called MASS TRANSPORT.

We used to suppose that the water returned to its original position after each wave passed, but now we find that when waves are steep the orbital circles of the water particles do not exactly close. The water itself is transported by the passing wave form, although its progress is very slow compared to the wave velocity. This actual motion of the water is proportional to the square of the height of the waves and is much more pronounced at the surface than a short distance down.

SEA SWELL
When the wind stops blowing or it changes direction, the sea it caused continues to travel on as swell. The experienced surfer will not worry too much about local wind conditions to bring him good surf. If the weather map shows storms out at sea, even at some considerable distance away, he knows the ensuing swell will travel towards his favourite beach bringing good surf. I will come to waves in shallow water in just a moment. First I want to consider waves or swell in deep water.

Deep water is defined as water deeper than half the wave length and its length preserves the relationship to its period given by the formula L = 1.56 P2, where L is length in metres and P is the period in seconds. As period can be measured reasonably accurately by timing the passage of crests past a buoy, for example, the length, which is very difficult to estimate, can be calculated. As the speed in knots of a swell wave in deep water is, for practical purposes, three times the period in seconds, we can give some values to the sort of waves that are likely in summer off the Atlantic coasts of Europe. See table below:-

TABLE showing the lengths and speeds of swell waves of different periods in water deeper than half the wave length.

PERIOD (In seconds)	LENGTH (In metres)	SPEED (In knots)
4	25	12
5	39	15
6	56	18
7	76	21
8	100	24
9	126	27
10	156	30
11	189	33
12	225	36

Without the energy of the wind to sustain them the waves of a swell gradually decrease in height but their period and length continue to increase, although at a diminishing rate: thus they become less obvious but more faster as they travel away from the wind source. If the wave system as a whole advanced at the speed of individual waves it would provide an almost, infallible warning of the approach of strong winds. We cannot rely on this because each leading wave in turn is 'eaten' by its successors which absorb its energy. This process can be clearly observed in the wash of ships passing through smooth water. The. group of waves in an area of swell advances at half the speed of the individual waves which comprise it. The arrival of a swell is always worth observing and if a note is made of its direction and period, then subsequent alteration can be observed and added to other evidence about its possible origin and development.

WAVES IN SHALLOW WATER

So far I have discussed ideal waves in deep water which are quite unaffected by the sea bed. As waves approach the beach and the depth of water is less than 1/2 the wave length the wave has reached what is known as its critical depth. It is at this depth that the sea bed influences the orbital motion of the wave. The wave period remains unchanged but. the wave length is shortened. As a result the wave height increases and the wave crests become more peaked. The wave steepness increases until it reaches a critical value about 1/7 th. At this point the wave crest peaks sharply, becomes unstable and breaks. Waves usually break when the water depth is 1.3 times the wave height.

Energy from a breaking wave frequently causes a new set of smaller waves to form. These waves also break when they reach shallow water. Thus the surface zone may have several sets of breaks depending on wave conditions and near shore bottom configuration. It is interesting to note that when waves break they expend their energy through the turbulence of the water and by washing up on the beach. In these final stages the waves' energy is changed to heat energy. If this heat energy were not thoroughly mixed with large quantities of sea water, it would cause an appreciable temperature rise in the surf zone. On a steep sloping shore the crest of the breaking wave overhangs and falls in front of the wave and is known as a ‘plunging breaker’. On a gentle slope, the crest sharpens and the foam spreads down over the front of the wave forming a ‘spilling breaker’ In shallow water the waves, unlike those in the open sea, become an actual shorewards movement of water carrying in driftwood, etc. It is on open beaches which are gentle sloping that produce spilling breakers which are ideal for surfers.

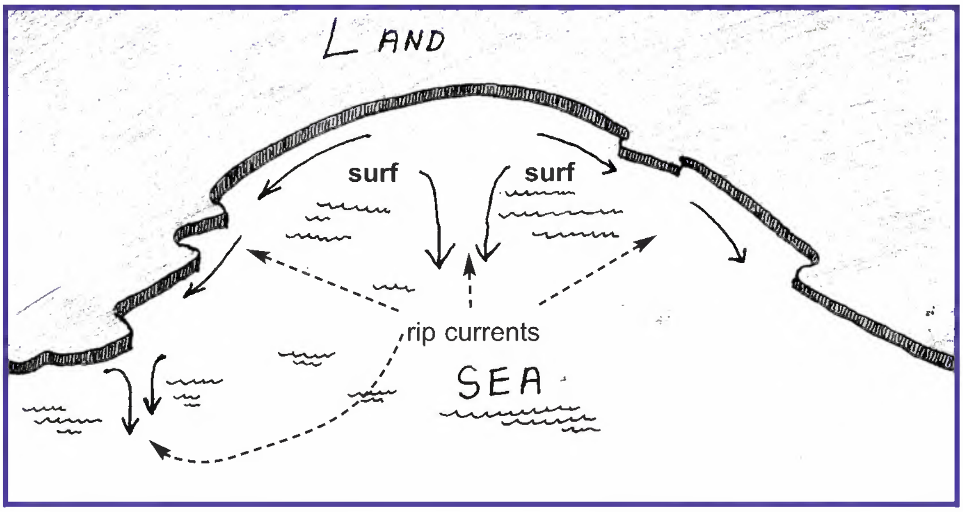
When the depth of water falls to 1/10 th of the deep water wave length, the increase in height becomes very marked and the progressive de-acceleration causes 'crowding' with steepening and narrowing of the crests. Retardation of the troughs steepens the wave fronts more than their backs (as opposed to deep water waves where the front of the wave is determined by wind direction - remember my diagram on an ideal wave - the face of a wave approaching the coast is the front) and the wave is ready to break at any moment. At a depth equal to 1/25 th of the deep water wave length the relationship between length and period disappears, the waves' speed becomes dependent on depth alone and it breaks. Sudden shoaling can cause a wave to break in any depth once it has entered water less than half its wave length deep, and swells may break over rocks 20 metres below the surface.

BACKWASH, UNDERTOW and RIPS

Its force spent, the wave retreats. This is known as backwash. Part of its water moves beneath the advancing waves and this is known as the undertow. Undertow can be quite strong, particularly on a steep beach. There have been several occasions when I have had to land on a steep beach with a dumping surf and have clambered from the cockpit to wade the final few feet to prevent damage to the kayak only to be whisked off my feet by the strong undertow.

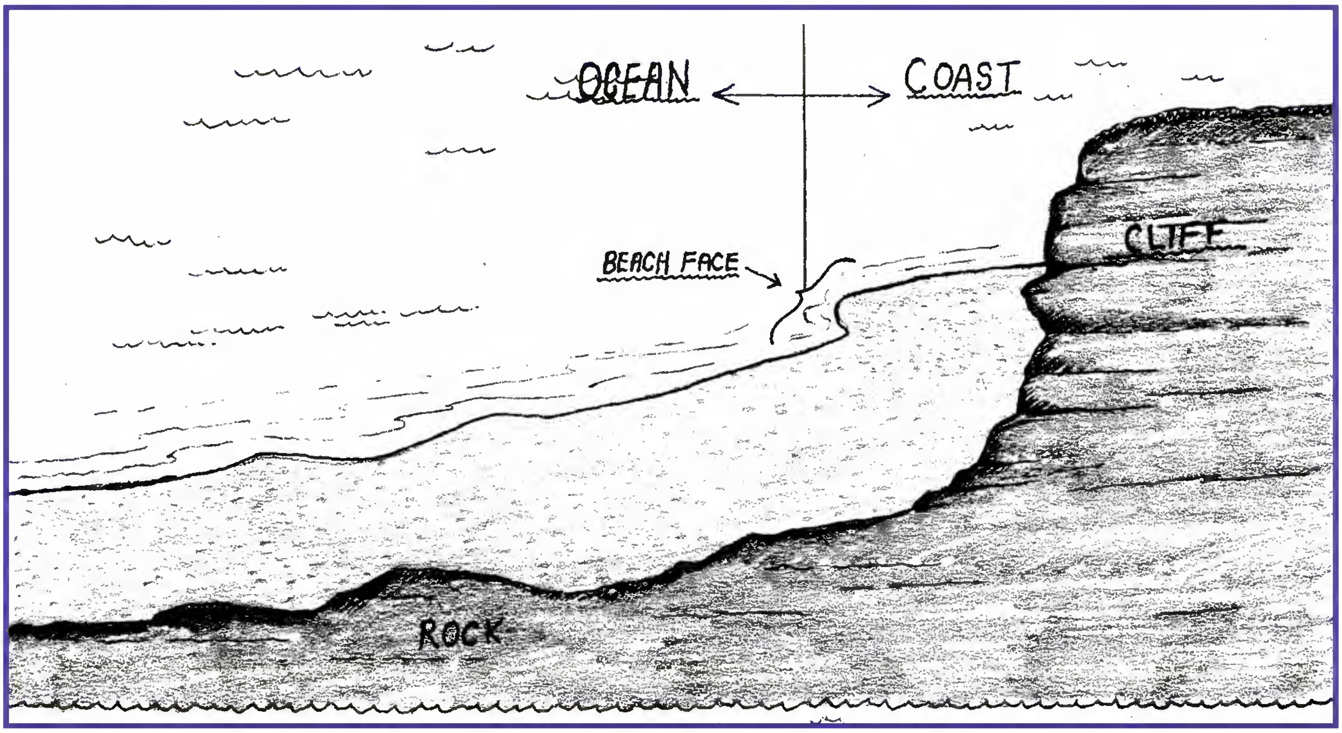
Rip Currents are fairly fast narrow streams of water running out to sea from surf zones. As the surf comes in so the water the surf waves bring in needs to escape. It usually does so in fast narrow streams at specific places where the surf is weakest. Before surfing on a. beach previously unknown to you, it is wise to identify the rip currents. You will notice narrow channels where the surf is somewhat a little more subdued than the surf either side of the channel. Closer inspection will reveal a rip current taking water back out to sea. Should you capsize and take a swim among the surf normally your kayak and yourself will be flushed back up to the beach. If on the other hand you find yourself being caught by a rip and moving away from the beach all you do is swim parallel to the beach and out of the rip channel so that the surf waves push you back up to the beach. Rip currents are also present at regular intervals along straight uninterrupted beaches. Along such beaches the surf usually alternates between regions of high surf and regions of low surf. Expect an outward flowing current in narrow regions offshore where the surf remains consistently weaker. Rip currents can reach speeds of 2 or 3 knots or even more on an ebbing tide. Beyond the surf zone the rip currents weaken and turn parallel to the beach as it moves back to the beach with the surf.

Finally, a word about waves shallowing and breaking as they approach sand bars some way off the beach itself. Bars of shingle or sand are often found at the mouths of river estuaries and may even be exposed at low water. These bars are usually formed by sand and shingle being scoured, lifted and carried by the river and receding tide only to be dropped where the sea becomes deeper. As the water deepens the transporting currents fan out and reduce in velocity and consequently drop the large amounts of sediment to form bars. Those embankment like deposits, over which the outermost end is surrounded by water, are called spits. Bars and spits form wherever there is a supply of sand, a transporting current and a dumping ground. These shallowing 'dumping grounds' are notorious for breakers, especially as the tide is rising or falling over them to bring the critical depth. How often have we watched in wonder at the fury of breaking waves over these bars, especially when the wind is blowing encouragement. They can be exciting playgrounds for



kayakers but watch the breakers don't swallow you up and spit you out!!

THE COAST



I wanted to include a short section on the land aspect of coasts; to say something about the formation of beaches, bays, headlands and cliffs. Many sea kayakers have an interest in topography and geology. I have been dragged miles by enthusiastic 'rock-buffs' to examine interesting stones or rock formations. Stan Chladek, one of North America's more adventurous kayakers(!) is one such 'culprit' as we divert here and there along the north shore of Lake superior in Canada.

Our own coastline here in the U.K. is varied and like all other coasts, if we can interpret what we see, a fascinating story emerges. So before closing this chapter on the sea, I shall include this short description of some of the major coastal features. The crust of the earth is slowly but constantly shifting. Sometimes it is not so slow in its shifting. As I write Mount PIMATUBO in the Phillipines is blowing its stack in a dramatic and frightening manner. But going back to the normal. The continents act much like great rafts of rock, floating on the viscous interior of the earth. Consequently, if a load is added to the top of one of these continental rafts - as is happening in the Phillipines as Mount Pinitoba pours out huge amounts of lava or as is happening in the Antarctic as huge amounts of ice press down on the earth - then the raft will sink a little and the sea level will appear to rise. By the same reasoning, as erosion removes mountains and large ice sheets melt, the raft rises. For example, a number of bays used on the Alaska coast as harbours a century ago are now raised and too shallow to be navigable.

Coasts are often classified according to whether they are rising or sinking, that is whether erosion of rock or deposition of sediment is having the upper hand. An illustration of a sinking coast is quite often a very irregular shoreline with narrow beaches among a high rocky topography. On the other hand a stable coast line that has not moved up or down is marked by an almost continuous line of sandy barrier islands and the mainland is a series of shallow bays and lagoons. Thus the basic geology of a coast depends on its history of motion relative to the ocean. If there is plenty of sand and the coast remains stable then beaches become a major feature of the coast. Most coasts have a more complicated geological history. Relative to sea level they have at various times risen and fallen, each time retaining some features left from the previous situation. Since the marine processes are usually interrupted before they are completed, there are only a few good examples of their finished, work. Thus we are forced to observe changing situations and guess at how the process started and how it will continue. We should try and imagine what actually causes the changes and the rate at which they are taking place. This is one best clue as to the future. To help us, let me start by defining a shoreline, a coast and a beach.

A shoreline is the linear area of contact between sea and land.

A coast is defined as an area of land, often extending well inland, which makes up an overall feature or characteristic.

A beach, on the other hand is a relatively small feature whose limits are defined by the effects of waves. A beach is an accumulation of rock fragments subject to transportation by wave action. They may be made up of any kind of rock material ranging from boulders to fine sand. The colour of the sand tells us of its origins. Light coloured sand derives from granite rock which breaks down into quartz and feldspar. Black sand is formed by the breakdown of dark volcanic rocks.

Here in the U.K. many of our beaches are composed of small flat stones called shingle. Single is formed from the destruction of sea cliffs made or sedimentary rock.