INSTANT Wind FORECASTING

3rd Edition

Alan Watts

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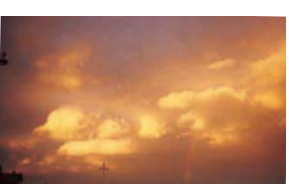


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Instant Wind Forecasting is a book that prompts questions – and provides some answers – as to what the wind may do in different circumstances. It does not pretend to cover all situations – if such a book could be written it would be vastly bigger than this – but I hope that it will help many people who need a deeper insight into the way the wind behaves than is provided by weather forecasts.

During the long hot summer of 1967 I put together a book which became known as *Instant Weather Forecasting*. At the time, I did not think that a book which tabulated what the weather might do from the look of the sky would be a great success. However, it has been in continuous production ever since and has been translated into many languages.

Possibly its success is due to the visual appeal of its 24 full-page colour pictures of the sky, but it could also be due to the tables that suggest what might happen and then leave readers to decide whether it will or it won't. These tables are based on well-known meteorological principles and so have stood the test of time.

All my life I have sailed boats and as a meteorologist-cum-sailor have always sought to understand why the wind does what it does.

So, not long after *Instant Weather Forecasting* proved popular, I thought of the much more difficult idea of writing a book of tabulated information laced with photographs to help sailors decide what might happen to the wind. It seemed natural to call that book *Instant Wind Forecasting* and, while not, inevitably, as popular as *Instant Weather Forecasting*, it also has been in print in several reissues for some 27 years.

Now I will not make any pretences about this. I know that the wind forecasting one might do from this book would often be anything but instant, but compared to other, more wordy, tomes on the subject I hope it will in part live up to its name. I have tried to make it a practical book to supplement and amplify the forecasts. Whether you get your forecasts from radio, TV, fax, newspapers or internet you will never get the degree of detail you need for sailing, or indeed, many other sports, pastimes or even work. Forecasts only give the general trend for the wind's direction and speed and the actual wind may be very different due to the proximity of hills, valleys or coast.

Since yacht racing is so wind-intensive, with every shift being of great importance, the book is aimed primarily at dinghy, board and deep-keel sailors, but it also has something to say to motorboat skippers, hang- and para-glider pilots, and to golfers when the wind is swirling around the fairway. The information on sea breezes may be of use to anyone going to the beach, especially if they intend to fly kites. It can also be useful to ornithologists and entomologists studying the flight patterns of birds and insects. The section on the special winds of the Mediterranean can be

helpful to those who already live there or those wishing to get the best out of a holiday or charter a yacht. The American Great Lakes provide unusual wind effects, some of which have been given a special section.

Sailing helmsmen cannot expect to get a race-winning idea out of this book every time or even most of the time. What I hope they will get is an idea of what to expect in order to be ready for a wind shift – whenever it comes; for the time at which a wind shifts is subject to uncertainties that may amount to tens of minutes at best and at worst hours. Yet 10 minutes of indecision may easily lose a dinghy race.

There are some big shifts, such as frontal or sea breeze shifts, over which nature has built tell-tale clouds, and what these normally look like has been emphasised in the text. In fact very few major shifts occur without some signs in the clouds above. The problem for the non-meteorologist is how to recognise those signs.

With the aid of photos and cross-references I hope that many forecastable situations have been covered. There are many days when the wind blows from one quarter and stays there. These days are usually associated with extensive layer clouds and are largely ignored here. Instead I have covered the days when the wind will shift, either long-term or short-term and the shifts can, in some way, be predicted. Only familiarity and use will show which pages are most useful for a specific situation.

Instant Wind Forecasting is *not* a textbook on the wind. There is very little deep explanation here – just enough to make it understandable. I hope this approach will appeal to all those who are daunted by long-winded explanations. Perhaps then, knowing that something may happen, the interested observer will keep a weather-eye cocked on the sky to see if he can detect when it will happen. Even today, when so much more is known than in the past, understanding the wind is the most neglected part of the spectrum of sea-going knowledge among small-craft sailors.

Instant Wind Forecasting demands very little in the way of meteorological knowledge. Try using it and do not give up even if it does not seem to work very well at first.

This new edition has been completely reworked with more pictures and the tables of the old edition have been preserved but reduced in length. New sections on micro wind shifts and the special winds of the Mediterranean have been added and we have used colour throughout. I hope you like it.

Alan Watts

To use *Instant Wind Forecasting* find the section that will help you to determine the probable trends in the wind and then fine-tune the details until you think you have a more definite idea of what it is likely to do. (Remember, there are so many types of wind and weather that no book, however detailed, could hope to cover them all.)

In thinking about the layout I have tried to make the book practical by suggesting as far as possible what can happen – and that has not been easy. However, there are some certainties. What will the reader definitely know about the situation? He will know where he intends to be with respect to the coastline. He will have – or should have – an idea of the kind of weather in which he will be sailing because weather forecasts on the Internet now look forward to as much as a fortnight ahead. That may be too far for one to have any confidence in the predictions and they will not give details such as the position of fronts, but the general run of the isobars will be given. Take a shorter period of, say, seven days and there will be more confidence. Come down to three days and you can begin to really believe it.

However, when you are on the spot, many things you want to know will lie outside the remit of the forecast. For example, the forecast will usually not allow for the way the wind is dictated by the juxtaposition of land and water. This is why the tabulated information in these pages has been separated into zones to seaward and to landward of the coastline.

There are many photos in this book chosen to illustrate certain days and places where useful indicators can help you to recognise how the wind will behave. On the spot, the feel of the day and the look of the sky are there to be sampled but there are times when very little useful information can be inferred. These are often days which are overcast or maybe wholly sunny – ones where the look of the sky offers no recognisable clues. However, that does not prevent us from recognising the days when we *can* clothe the blanket forecasts with useful details.

Wind shifts

Every day produces wind shifts and this book concentrates on those days which are likely to show more-or-less predictable shifts and whose sky signature is easily recognisable. For example, fair days with cumulus (Cu) cloud have been especially well covered as they often exhibit a short-period pattern of gusts and lulls accompanied by veering and backing shifts in direction. The bigger the Cu grows, the more likely it is that the airstream will be populated by sizeable shifts. However, when these heap clouds grow into showers – or even thunderstorms – then other rules apply and there is a special section on these.

We cannot neglect the fact that sometimes strange patterns appear in the cascade of increases and decreases of wind speed and their accompanying backs and veers. Such patterns are termed *abnormal*. The normal pattern goes with heap clouds and is the most usual way in which the wind tends to vary within itself. You will often find that abnormal variability goes with winds that have an easterly component.

The above are of most importance to racing dinghy and board sailors; it is longer-period shifts that occupy the minds of cruising and offshore racing skippers and tacticians. Thus some hints on divining major shifts in the wind such as those that accompany the passage of fronts are given even though it is often very difficult to foresee when such shifts will arrive. A case in point is when the forecast has promised a cold front. The text books will tell you that there will be a veering shift as the front passes and quite often this is the case but at other times, when fronts are older, or have travelled a long way overland, the shift may not come all at once as the cloud-wall of the front arrives in several stages. However, on the whole, there will be veering shifts when fronts pass. If there aren't, don't expect any quick clearances.

Local winds

Because it so often affects the coastwise and inland waters in spring and summer, the sea breeze has been given much prominence here. Sea breezes take over great swathes of coastline when they are at their strongest and may travel as much as 50 miles (90km) inland before they run out of steam. Unless otherwise stated, the tables are written with the coasts of Atlantic Europe in mind but many of them will also apply to North America. In the Mediterranean, sea breezes are stronger and can replace local moderate or even fresh winds in a way they would not possibly do in more northern latitudes.

If you are looking for more information as to what the wind might do, then *The wind's day* (pages 41-43) may be helpful.

Example 1 You want to sail a dinghy on a creek or estuary that is within a mile or two of the main coastline (the beachland zone). You expect

to set out in the morning and come back later in the afternoon.

Look at *The wind's day* (page 41)to remind yourself of what winds *might* blow. Match your day to one of those in the section. Days with Recognisable Wind Patterns and read the relevant entries. If the weather looks different, then experience can help to fit your day to one of the chosen situations.

Suppose the morning conditions are mainly blue skies in which Cu clouds may develop later. Look at page 90 for the times of the day involved to obtain more details of the likely wind changes. Then, for more specific information, consult the section Local Winds. If you are racing, the micro wind shifts likely to be encountered can be found on pages following 64.

Example 2 You are planning to cruise coastwise when the weather is apparently fair, but the forecast warns of troughs of low pressure crossing the area. While still in harbour you can assess the strength of the wind at sea (page 12) and add the likely gusts (page 14). You can also assess the likely wave height (page 17).

Watch the weather and decide where you are in the weather scene by using the photos to recognise the skies ahead of troughs or fronts. Passing fronts and troughs mean permanent wind shifts later (page 27). It might mean a really big blow developing (page 30). In any case, listen to the forecast and see what it says. If you cannot, then use all the aids that this, or any other book, provides to assess the likely trends. If it appears to be not too bad for you and your crew, then go – and good luck.

Useful information

Cloud type abbreviations

Cu	Cumulus	As	Altostratus
Sc	Stratocumulus	Ac	Altocumulus
Cb	Cumulonimbus	Ci	Cirrus
St	Stratus	Cs	Cirrostratus
Ns	Nimbostratus	Cc	Cirrocumulus

Conversions

Pressure 1 millibar (mb) or hectoPascal (hP) (same unit) = 0.03 inches of mercury

Note The words *sea breeze* and *land breeze* have been used to make it clear that the meteorological systems are being referred to and not just any wind from the sea or land due to other causes. Also *off-shore* and *on-shore* winds means respectively from the land and from the sea whereas *offshore* means out over the sea.

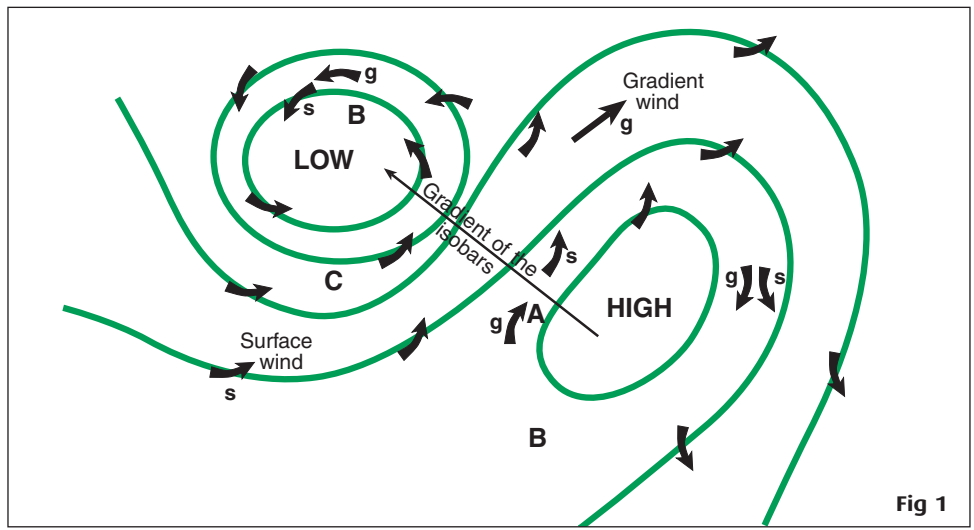

Fig 1

How to judge wind speed

Judging wind speed is difficult. It depends on where you are when you attempt to make an estimate. Hints on this are given on page 10. The estimated speed is assumed to be the mean speed. On to that you have to add the gusts (page 14). Once the preserve of the professional meteorologist, the masthead anemometer is now almost a standard fitting for cruising and racing craft, and is calibrated in knots. A dinghy helmsman will not have such a device, so his criteria are based on observation of flags etc and a force is all that he can expect to estimate. Dinghy crews will often be able to read a clubhouse anemometer before they go out, but will have to add extra wind speed to compensate for clearing the land.

What winds do

Wind blows from where pressure is high to where it is low (Fig 1, page 4). It does not go directly down the 'gradient' of pressure (A–B). Because of the rotation of the Earth, wind spirals out of high pressure regions into low pressure ones (B).

In the northern hemisphere the wind blows to keep low pressure on its left (C). (In the southern hemisphere this is reversed.) This produces the practical rule:

Stand with your back to the wind and pressure is low on your left. (In the southern hemisphere stand facing the wind.)

These rules apply most strongly to the temperate latitudes. In the tropics the winds tend to move more directly from high to low pressure. This book concerns the temperate latitudes and most of what is said will apply to either hemisphere. It is written for the northern hemisphere, but corrections for the southern hemisphere are given where appropriate.

Gradient wind This blows around pressure systems (arrows marked g in Fig 1). The *isobars* (lines of equal pressure) are similar to contours of height. So we speak of the 'gradient' between isobars. The closer the isobars the 'tighter' the gradient and the stronger the gradient wind. There will be fresh to strong winds at (C) where the isobars are closely spaced but less wind at (A). The gradient wind blows along the direction of the isobars.

Surface wind This is the gradient wind that has been modified by friction of the surface (arrows marked s). The greater the friction the more the surface wind differs in speed and direction from the true gradient wind. However, there is rarely more than a 45° difference between surface and gradient wind directions except when local winds blow. Surface wind is angled in towards low pressure and differs from the gradient wind by 10–15° over the sea and 20–30° over the land. While the angle over the sea is usually about the same as the value quoted above, that over the land can be larger or smaller than 20–30°.

In this book the word 'gradient' is used to describe the surface wind when it is caused by pressure systems and not local winds or topography.

Local or coastal winds

These will modify the rules given above.

The most important coastal winds are sea breezes by day and nocturnal winds by night.

The wind regime of a coast is governed by the pressure gradient wind and modified by:

- The diurnal variation in wind speed.
- The sea breeze–nocturnal wind system.

Diurnal variation means the normal change that occurs at almost all land stations through 24 hours. This is covered in the table on page 42. There is also some diurnal variation over the deep ocean and in winds with a long sea fetch, but it is small compared to that over land or in winds with a long land fetch.

Sea breeze – nocturnal winds These winds swing off the sea by day and off the land by night. Such a simple statement covers a multitude of variations, some of which are covered in the tables. Other local winds are:

Coastal slope winds Cold air that cascades down steep mountain slopes close to the sea. (The Mistral and Bora of the Mediterranean are examples.)

Downdraught winds These accompany thunderstorms and heavy showers especially when they occur on coastal slopes.

Katabatic winds Cooling air that flows downhill, especially at night in settled weather.

Anabatic winds Hillsides heat up in the morning, warming the air which rises.

Mountain and valley winds These blow up the valleys by day and down at night.

Coastal slope and downdraught winds may accompany poor weather, but katabatics and anabatics, sea breezes, land breezes, and mountain and valley winds are mainly phenomena of settled weather.

Admiral Beaufort's Scale of Wind Speed was fine for men-of-the-line, but needs modifying for small craft use.

Beaufort number	*General description*	*Limit of mean speed (knots)*	*Land signs*	*Dinghy criteria*
0	Calm	less than 1	Smoke rises vertically. Leaves do not stir	Sails will not fill. Racing flag will not respond. Flies and tell-tails might just respond
1	Light air	1 to 3	Smoke drifts. Wind vanes do not respond	Sails fill. Racing flag may not be reliable. Flies and tell-tails respond. Crew and helmsman on opposite sides of craft
2	Light breeze	4 to 6	Wind felt on the face. Leaves rustle. Light flags not extended. Wind vanes respond	Useful way can be made. Racing flag reliable. Helmsman and crew both sit to windward. Spinnakers may fill
3	Gentle breeze	7 to 10	Light flags extended. Leaves in constant motion	Helmsman and crew sit on weather gunwale. Spinnakers fill. Racing dinghies of 14ft (4m) or above may plane
4	Moderate breeze	11 to 16	Most flags extend fully. Small branches move. Dust and loose paper may be raised	Dinghy crews lean out. Twelve-foot dinghies may plane; longer dinghies will plane. The best general working breeze
5	Fresh breeze	17 to 21	Small trees in leaf sway. Tops of tall trees in noticeable motion	Dinghies ease sheets in gusts. Crews use all their weight to keep craft upright. Genoas near their limit. Some capsizes
6	Strong breeze	22 to 27	Large branches in motion. Whistling heard in wires	Dinghies overpowered when carrying full sail. Many capsizes. Crews find difficulty in holding craft upright even when spilling wind
7	Near gale (American usage: moderate gale)	28 to 33	Whole trees in motion. Inconvenience felt when walking against wind	Dinghies fully reefed. Difficult to sail even on main alone. This is the absolute top limit for dinghies – other than *in extremis*
8	Gale (fresh gale)	34 to 40	Twigs broken off trees. Generally impeded progress on foot. Rarely experienced inland	Dinghies may survive if expertly handled in the seaway on fore-sail alone
9	Severe gale (strong gale)	41 to 47	Chimney pots and slates removed. Fences blown down etc	Not applicable
10	Storm (whole gale)	48 to 55	Very rare inland. Trees uprooted; considerable structural damage	Not applicable

Deep keel criteria	*State of sea*	*Local wind criteria near shore and on landlocked or inland water*
Boom swings idly in the swell. Racing flags and anemometers will not respond – flies and tell-tails might just	Sea mirror-smooth. Calm enough to preserve shape of reflections of sails, masts etc	Local wind-making forces totally dominant. Sail close to shore for thermals
Sails just fill, but little way made. Racing flags and vanes may respond but cup anemometers may not. Flies and tell-tails respond. Spinnakers do not fill	Scaly or shell-shaped ripples. No foam crests to be seen on open sea	Local winds still dominant. Sea breezes will set in forenoon; nocturnal winds at night. The wind may already be a local one. On lakes, rivers etc anabatic or katabatic winds
Wind felt on the cheek. Controlled way made. Spinnakers and sails generally fill. Racing flags and anemometers respond and are reliable	Small short wavelets with glassy crests that do not break	Local winds can easily influence this wind speed. Sea breezes set in by midday. Usual upper limit to nocturnal winds. Mountain and valley winds achieve this speed and more
Good way made. Light flags fully extended	Large wavelets. Crest may break but foam is of glassy appearance. A few scattered white horses may be seen when wind is at upper limit	Sea breezes set in against this speed but usually not until afternoon. Allow earlier time in southern latitudes. Nocturnal winds do not often modify a gradient that is blowing at this speed in evening and early night
Best general working breeze for all craft. Genoas at optimum	Small waves lengthen. Fairly frequent white horses	Stronger local winds influence this speed. Sea breezes may set in in late afternoon, usually too strong for nocturnal winds to modify greatly. However, allow for effects of high ground near the shore
Craft's way somewhat impeded by seaway. Genoas near their limit. Spinnakers still carried. Yachts approach maximum speed	Moderate waves. Many white horses	Upper limit to winds that can be modified by local influences except in southern latitudes. Sea breeze effects only serve to shift the direction of winds of this strength – if at all
Edge of yacht gale force. Cruising craft seek shelter. Reefing recommended to meet gusts when cruising	Large waves form and extensive foam crests are prevalent. Spray may be blown off some wave tops	Not normally influenced by local wind effects
Yacht gale force when most cruising craft seek shelter. Racing yachts may just carry spinnakers. Reefing essential	Sea heaps up and white foam from breaking waves begins to be blown in streaks along the wind	Not applicable
Gale force in anybody's language. Only necessity or ocean racing keeps craft at sea. Set storm canvas or heave-to	Moderately high waves of greater length. Edges of crests begin to break into spindrift. Foam blown in well-marked streaks along the wind	Not applicable
Unless ocean racing – and sometimes even then – craft seek deep water. Run towing warps etc. This may be survival force for most	High waves. Dense streaks of foam along the wind. Crests begin to topple, tumble and roll over	Not applicable
Almost the utimate for yachts. Only chance is in deep water and with sea room to run before it or possibly lie to a sea anchor	Very high waves with long overhanging crests. The whole surface of the sea takes on a white appearance. Tumbling of sea heavy and shocklike. Visibility impaired	Not applicable


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To assess what the wind will do you need to know how it is behaving. Here are some tips for obtaining a reliable wind speed and direction.

The most reliable reading of mean wind speed and direction comes from an anemograph (a chart of the variations) (see page 70).

You can use the anemometer on the clubhouse or the masthead anemometer on a yacht at anchor, or tied up in a nearby marina. It is useless to look at the dials for a couple of seconds and to decide that what they show is the wind speed you require. Normally you will not get a reliable mean wind in less than 3–4 minutes observation due to gusts and turbulence. On days of abnormal variability (see page 70) you ought to note the speed and direction every half minute or so over a period of 15 minutes. If that is too much trouble, then be content with knowing the wind direction only to within 20–30° of its mean value. If it is showery, the most reliable guide to the mean wind is obtained when the skies are mainly blue between the showers.

If you have no anemometer, you can observe the racing flags on beached dinghies in the open or the race pennants on a starting-box mast. While ashore look into the wind and see if there is a free run. If so, accept that the observed speed and direction are the correct ones over the land. Speed will have to be assessed in the open using the Beaufort Scale (pages 6–7).

Are you clear of obstructions to the wind?

If an upwind barrier of trees, buildings etc is apparently less than or the same height as your thumbnail held upright at arm's length, you are outside the wind shadow of the barrier. As you approach it, the effect of the barrier progressively cuts the wind speed until the barrier fits the distance from thumb-tip to first finger-tip of the outstretched hand held at arm's length. At this distance you may have as little as 20 per cent of the speed in the open. Closer to trees you have 20 per cent more, but with solid buildings etc you have practically no speed at all.

Mean wind

For sailing dinghies the mean wind has a speed and direction you meet very rarely, compared to speeds and directions that are different from the mean. Something about anemograms will be found on page 70 but here we will just note that the wind spends most of its time shifting backwards and forwards about a so-called *mean direction* and all of its time rising above and sinking below its mean speed. This book will help you to distinguish between those days when the wind is very variable about its mean direction (see pages 64–73) and when it is not. Once you have recognised that the airstream is variable, you will sail on the instant wind and, as far as possible, make your tactical moves in accordance with the ideas given on those pages. If not, you adopt the age-old dictum when sailing to windward – tack when headed by the wind. It's a pretty chancy business and often you are induced to tack by an ephemeral shift that hurries by and leaves you far worse off than before. Such is the sailing life.

Photo 1 (page 8) In a run of disturbed weather, with winds approaching or actually gale force, among the normal waves (whose heights are given on page 17) there will occasionally be a rogue wave.

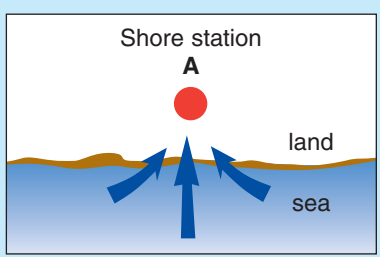
Photo 2 (page 9) At the other end of the spectrum there are days, especially on inland waters, when you have to pray for any sort of wind.

Photo 3 Force 4, perhaps a bit more, when flags are fully extended. Always try to gauge the wind speed from the highest indicators – a masthead or club anemometer if you have one. There is cumulus cloud so remember that this moment might be a lull – or a gust.

Most weather stations are ashore so the wind speed given by a weather station as the 'actual speed' is the speed over the land. This is nearly always less than the wind at sea. It may be less by as much as a factor of 5, although such a difference is rare and only occurs with light winds. The most likely wind speed at sea, both by day and by night, is given in this table, assuming that you get an actual wind speed from a coastal weather station (one within 2–4 miles (3–7km) of the coastline).

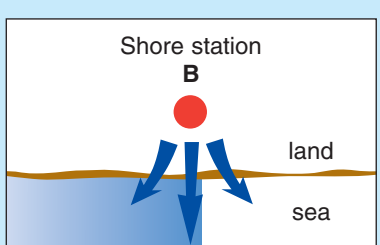
Note When winds are from the sea, there is less difference between wind speeds at sea and those recorded by coastal stations – especially by day. The greatest differences between land and sea speeds occur when winds are blowing from the land at night. The above speeds refer to winds at a standard height of about 33ft (10m) which is reasonably close to sailplan height of a typical cruising yacht. If a station is exposed on the coast and about 150ft (45m) above sea level, reported speeds must be dropped by a factor of 25 per cent.

Photo 4 Sometimes the wind can get very strong even under blue skies. This can happen after fronts have passed, or on the edges of anticyclones when depressions are trying to muscle in. It is natural in certain regions of the Mediterranean.



Winds from the sea

Wind speed quoted by shore station (A)		*Wind at sea in knots (force)*			
Knots	*(Force)*	*By day*		*By night*	
0–10	(0–3)	1–14	(1–4)	1–18	(1–5)
11–16	(4)	12–18	(4–5)	19–27	(5–6)
17–21	(5)	22–27	(6)	27–33	(7)
22–27	(6)	31–38	(7–8)	34–42	(8–9)
28–32	(7)	36–42	(8–9)	45–50	(9–10)



Winds from the land

Wind speed quoted by shore station (B)		*Wind at sea in knots (force)*			
Knots	*(Force)*	*By day*		*By night*	
0–3	(0–1)	1–10	(1–3)	0–12	(1–4)
4–6	(2)	10–16	(4)	12–18	(4–5)
7–10	(3)	14–20	(4–5)	15–22	(5)
11–16	(4)	17–22	(5)	17–26	(5–6)
17–21	(5)	23–30	(6–7)	26–33	(7)
22–27	(6)	30–38	(7–8)	33–42	(8)
28–33	(7)	38–46	(8–9)	40–50	(9–10)

Gusts are faster winds brought down to the surface. They are not impeded by surface obstacles unless you are very close to those obstacles.
Lulls are surface winds that are impeded by surface obstacles.

The difference between mean wind speed and the speed of the gusts is greater when:

1 Sailing on landlocked waters
2 Heap clouds (Cu and Cb) clouds are about
3 Sailing in the morning rather than the afternoon
4 The speed is about force 5 (17–21kt). The difference is less for lighter and stronger winds

The difference is less when:

5 You are at sea and clear of the land
6 Conditions are meteorologically stable, ie layer clouds (and no heap clouds) with poor visibility, compared to the excellent visibility enjoyed with a Cu airstream
7 Sailing at night (including the evening and the period around dawn).

Gusts make the wind strength experienced by the yacht feel stronger, for it is the recurrent gusts that have to be fought and overcome. So a *mean gust speed* is the strongest wind that regularly occurs; and a *maximum gust speed* is one which will occur occasionally in any run of the wind. Figures for both of these can be given taking into account the factors (1) to (4) given above.

Mean wind speed as measured or forecast	7–10kt (force 3)	11–16kt (force 4)	17–21kt (force 5)	22–27kt (force 5–6)	22–27kt (force 6)	28–33kt (force 7)	34–48kt (force 8–9)
Mean gust speed to expect	force 4	force 5	force 6–7	force 7–8	40–47kt (force 9)	48–57kt (force 10)	
Maximum gust speed to expect	force 5	force 6	force 7	force 9	force 9–10	force 11	

Gustiness at sea (when the wind has a sea fetch of over 50 miles) does not differ much between day and night and therefore, as gusts are difficult to detect at night, you should allow only sufficient sail to comfortably contain the maximum gust speed.
Thunderstorms produce very intense gusts that follow some pre-storm wind conditions. Because of the way storms are constructed we have some guidance:

Wind condition before storm	
Wind away from or across path of the storm (not usually above 20kt)	Expect gusts of 25–30kt
Wind towards the storm (not usually above 10kt)	Expect gusts of 30–50kt

Really bad storms can produce 60kt or more at their leading edges.

A curious attribute of thundery situations is that a storm 100 miles away may induce gusts in an otherwise benign airstream. The most likely time for this is at night. The gusts may not exceed 25–30kt, but when the average wind is 5–10kt, that is a dangerous increase.

Photo 5 Gustiness is very marked on rivers and other inland waters because the gust air comes down over the shoreside shelter in marked contrast to the lulls where speed is reduced by it.

Wave height depends on:

- Wind strength
- Duration – the time that the wind has blown within 30° of a given direction
- Fetch – the distance wind can run from the nearest sizeable land mass.

Example The wind is estimated to have blown at about force 6 for 4 hours from a direction where the land mass is 100 miles away. What should the wave height be? Answer: 14ft (4m) from the figures given in the table, but it takes 10 hours to develop this height so the waves will not be 14ft (4m) yet.

Photo 6 The biggest seas usually come with cyclonic weather of long duration. The sky here is typical of the almost-permanently cloudy skies that go with the poor weather of depressions. There are occasional breaks but they are short-lived. Treat a cloud-line, like that in the centre of the picture, with respect – it may mean a sudden increase in wind speed and/or a marked shift in direction.

Coastal waters (depths of 150ft or less)

Fetch (nautical miles)	5	10	20	50	100	200	500
	Force 3 (7–10kt)						
Wave (feet)	–	1	2	3	3	4	4
Duration (hours)	–	3	5	10	18	24	48
	Force 4 (11–16kt)						
Height (feet)	1	2	3	5	6	7	7
Duration (hours)	1½	2	4	6	12	24	48
	Force 5 (17–21kt)						
Height (feet)	2	3	5	8	10	11	12
Duration (hours)	1	2	3	6	11	22	48
	Force 6 (22–27kt)						
Height (feet)	2–3	4	7	11	14	15	16
Duration (hours)	1	2	3	5	10	18	48
	Force 7 (28–33kt)						
Height (feet)	3–4	6	10	16	20	22	24
Duration (hours)	1	1½	2	5	8	18	48
	Force 8 (34–40kt)						
Height (feet)	4–5	8	14	22	27	28	30
Duration (hours)	1	1½	2	4	7	15	36
	Force 9 (41–47kt)						
Height (feet)	6	10	18	28	35	38	40
Duration (hours)	1	1	2	4	6	12	26
Most probable maximum wave height in storm							
Duration (hours)	1	3	6	12	18	24	36
Multiply figures above by	1.18	1.28	1.33	1.4	1.42	1.45	1.47

Photo 7 During a long run of cyclonic weather, fronts and troughs pass, leading to clearing skies in some cases and more cloud and showers in others. Here a cold front passes eastward (we are looking south over Prinsted Harbour – an arm of Chichester Harbour east of the Solent) and leaves only high cirrus cloud. There has almost certainly been a change in wind direction and speed as the front passed. You have to expect more bad weather soon, as is usually the case with cyclonic weather.

Oceanic waters (more than 600ft deep)

Fetch (nautical miles)	5	10	20	50	100	200	500
Force 3 (7–10kt)							
Wave (feet)	–	–	1	2	2	2	2
Duration (hours)	–	–	4	7	13	24	48
Force 4 (11–16kt)							
Height (feet)	–	1	2	3	4	4	4
Duration (hours)	–	2	3	6	12	22	48
Force 5 (17–21kt)							
Height (feet)	1	2	4	6	8	8	8
Duration (hours)	1	2	3	5	11	18	48
Force 6 (22–27kt)							
Height (feet)	3	4	7	10	13	14	14
Duration (hours)	1	2	3	5	10	18	36
Force 7 (28–33kt)							
Height (feet)	4	6	10	16	19	20	21
Duration (hours)	1	2	2	4	8	12	30
Force 8 (34–40kt)							
Height (feet)	5	8	14	23	27	29	30
Duration (hours)	1	1	2	4	6	12	30
Force 9 (41–47kt)							
Height (feet)	8	12	20	33	40	42	44
Duration (hours)	1	1	2	3	6	10	24
Force 10 (48–55kt)							
Height (feet)	9	14	27	45	52	56	60
Duration (hours)	1	1	2	3	5	10	24

(*The figures are based on graphs appearing with* 'Forecasting Wind-generated Sea Waves'. *Darbyshire and Draper*, Engineering.)

How to recognise cyclonic weather

- Much cloudiness with periods of rain, drizzle or showers, mixed with more continuous rain.
- Breaks occur to reveal much upper cloud, only to close in again with low overcast.
- Winds are cool and 'heavy' with moisture.
- Troughs of low pressure rotate about an almost stationary low centre and bring a continuous succession of frontal situations.
- In summer, heavy thunderstorms may be induced in the circulation.
- The poor cyclonic weather may persist for days, only gradually improving.
- Visibility can often be poor – amounting to fog when cloud is low and in rain or drizzle.

Surface direction	*Wind was...*	*Low centre should...*	*Wind shift in next few hours should...*	*Weather now should be...*	*Expect...*
East (often not above moderate strength, can be quite light)	More S and has backed E	Lie to SW of position and track to S of position	Remain E or back further to NE. Some increase in speed	Deteriorating from fair with increasing high cloud (possibly as in photo 8 or 9). High or medium level cloud moving in from S. If likely to be thundery then sky like photo 19 or 21	More cloud. Lower base. Rain or drizzle. If base does not become low then centre probably moving 100 to 200 miles south of position
South-east (not often above moderate and sometimes lighter)	W or SW earlier, now backed around to SE	Lie to W and probably track across position or to N of position	Remain SE or veer slightly S if wind gets up	Increasing high cloud perhaps as photo 9 or 29. If like photo 9, then see page 30. High cloud should move in from SW or W. See above for thundery lows	Increasing cloud of warm front or occlusion type, see photo 8 and 10. Rain and low cloud
Southerly	Possibly W or SW now backed to S	Lie to NW and track to N of position	Remain S possibly go SSE – even as far as SE before veering later	As above. High cloud should move in from W or NW	As above
South-west to west	NW or W	Lie to N of position and track some distance from position	Be frontal shifts (ie veers) at cold fronts or an occlusion. New direction probably W to NW	Cyclonic type but relatively warm with poor visibility and low cloud. If low cloud broken then much high or medium level cloud, often in islands about the sky. Such higher cloud should move from around SW or W	Change to more polar air with Cu or Cb (shower) cloud. However, sometimes this phase is slow to arrive

Forecast or actual weather
The centre of low pressure lies close enough to the sailing area for the latter to be fully dominated by the low.
Winds When these are forecast as 'cyclonic' they will vary when a low centre passes close across the area. We can expect the following changes (see table), usually depending on the wind direction ahead of the encroaching depression. The text-book depression is not very common in summer. Winds will rarely advance to full gale and most cyclonic weather will come with winds of force 4 or less.

Photo 8 (page 22) Cyclonic systems that come and go relatively quickly often show signs in the sky like these. We have a high veil of bright cirrostratus cloud as a backdrop to gathering lower clouds of a coming warm front or occlusion. However, the wind should be backing into the south and may be increasing. The dark cloud skein across the picture is the remains of the fair-weather cumulus you have just enjoyed.

Barometer	*Later...*	*Remarks*
Has probably been falling, but not steeply. If fall is steep then low is probably going to track across you. In this case expect wind increase – even temporary gale	Cyclonic shifts, ie backing to N or NW in rear of departing low centre. Improving slowly to fairer, cooler conditions. Increasing visibility	The lows can be steered along the lengths of waterways, eg as occurs along the English Channel. Most lows tend to move from W to E. They can move 'retrograde' when caught in the massive circulation of vast 'blocking' anticyclones. If such odd movement occurs, wind sequence is likely to be E to NE or N to E or SE. If low centre tracks directly across position then typical sequence is SE – temporary calm or light variable – picking up from a westerly point
Falling moderately (about 1–2mb per hour). Steep fall (about 3mb per hour) indicates developing depression and up to gale force winds (1mb = 0.03in mercury)	Cyclonic shifts. Veering on passage of fronts or troughs to SW or W and eventually NW as low centre clears away	This direction is the typical one ahead of depressions passing to the north of the sailing area. It is common over much of the US and Europe
As above	As above	This direction is also typical ahead of temperate latitude lows
Probably has been falling, but is now steadier. If still falling, expect very poor weather for a time	Fairer conditions after clearance of fronts and following showers (if any). In this later phase expect sky as in photo 4 or 7	On a maritime seaboard the SW wind is wet and humid. It produces much cloud. On a continental seaboard the SW wind can be warm and dry but also at times has the warmth and humidity of southern seas

Photo 9 (page 23) This is the classic sky ahead of strong to gale-force winds. Recognition points include high cloud (cirrus) stretched in parallel lines or banners across the sky. As yet the cloud is too thin to have stopped the thermals that create the cumulus below. Very soon the Cu will die as the upper cloud thickens.

Surface direction	*Wind was...*	*Low centre should...*	*Wind shift in next few hours should...*	*Weather now should be...*	*Expect...*
W to NW	SW	Have passed away to the E	Be frontal shifts from W to NW or even N. However, these may have already passed. Then shifts come with showery troughs (photo 24). If still low cloud and rain, then expect clearance and veering wind	Rain and showers for a while as the cold front clears – then sky opening up to high cloud and Cu (low) cloud. If front has cleared then weather now is probably clear and cool with Cu or Cb clouds. High cloud behind a clearing cold front should move from SW for real improvement (photo 7)	If wind remains W as fronts and troughs pass, the change to cool polar air will be delayed. If sharp veering shift occurs as front passes, expect cool air and showers. If latter already exists, expect slow relaxation to fair conditions
N to NE (the latter is unusual when associated with lows)	1) W to NW	Be to the SE having tracked from N or NE of position	Show little change, but can increase to fresh or more for considerable periods of time	Bright skies and big showers (see photo 31). No great change when high cloud tracks from N. If tracks from E then expect slow deterioration, to low cloud and rain or drizzle	Slow change from showery to fair
	2) SE to E	Have been to the S and now be tracking NE away from position	Continue to shift cyclonically (back in this case) as centre tracks past. No great increase in wind speed on most occasions	Overcast with periods of rain or drizzle (photo 7)	Only slow clear-up to brighter conditions – say, next day

Barometer	*Consider later...*	*Remarks*
Has been lower than now. Should show a rise, but not too fast. If rises very sharply then expect strong wind later – and perhaps not many hours later	Fairer conditions with good visibility, cessation of any showers, lightening, possibly backing, winds	A ridge of high pressure, sometimes only of a day's duration, frequently follows the passage of a low. Backing wind is often an early sign of the next depression. The barometer climbing steadily is a good indicator of a ridge that may last a few days – or sometimes a few weeks
Probably shows little change. A slow rise must ensue for the change to fair conditions	Wind to stay in this quarter if a sizeable anticyclone grows to W. Wind will back as a weak ridge passes. Then expect another low	The low-producing N or NE wind is often almost stationary in the vicinity. Weather therefore will depend on time and place
Falling somewhat at first, but then slow rise as low passes away	Rather indeterminate conditions to follow. However, any showers should be light. There can be thunder with this sort of low on this kind of track	

Winds that shift from one direction to another and stay there for many hours (half a day, or a day, or longer for instance) are called 'permanent'. Permanent shifts occur:

- slowly and more or less continuously when they are due to shifting pressure patterns;
- rapidly and usually once and for all when due to passing fronts.

Type of shift	*Usual cause*	*Weather before onset of shift*	*Signs closer to the shift*	*Later signs*
Slow backing	Approaching trough of low pressure	Fair with very little high cloud. Often Cu clouds. Typical skies (see photos 2, 3, 13)	Ci above the lower cloud (see photo 9). Barometer that may have been rising now steadied or falling. Often very good visibility	Veil of high cloud above dying lower cloud. Barometer should now be falling
Frontal veer (possibly sharp)	Passage of a warm front	Warm front: low cloud, continuous rain, moderate visibility. Previously deteriorated in the normal way with warm fronts	Lowest cloudbase. Steady rain in most cases. Barometer may show signs of arresting its fall	Immediate sign is passing trailing wisps of cloud almost on the deck. Lightening sky behind the murk
Frontal veer (probably sharp)	Passage of a cold front	Cold front: warm sector weather with much cloud, at all levels. High humidity. Poor visibility, even fog	Unusual for no form of break before an active cold front clears across. However, sudden showers mixed with rain makes cold front suspect	Immediate signs: darker cloudline. Trailing low cloud moving in from windward. Clouds moving in contrasting directions. Sudden showers and rain
Frontal veer (normally not sharp)	Passage of an occluded front	Same signs as for a warm front approaching. However, there can be holes in the cloud sheet (photo 6)	Same as for warm front but there is no warm air phase and so rain of warm front changes to showers of cold front	As for warm front and cold front combined, but effects are not so marked. Pressure steadies off at front and then rises
Frontal veer (often weak and sometimes not greatly evident)	Passage of an old, weak, warm front or occlusion	Occluded front: as for warm front	Build-up of cloud sheets as seen ahead of more virile warm fronts but light rain or drizzle may only fall	The shift comes where the low cloud sheet breaks to open skies. Sometimes there will be some formless low cloud (see photo 6), as the shift comes
Frontal veer (often weak and sometimes not greatly evident)	Passage of an old, weak, cold front or occlusion	Cold front: cloud bank arrives overhead, rain and showers but not intense. Possibly only bank of Sc	Some low cloud, possibly sea fog, but poor visibility in any case. Darker, deeper, cloud line on horizon	The shift will start under the cloud line and continue for a time. There should be a change to Cu clouds and clearer air. Cooler

Use this page to anticipate coming wind shifts that are due to pressure systems and fronts. It is mainly for yachtsmen at sea, but can be useful to small-water helmsmen. The shifts will be clockwise (veers) when across fronts and almost invariably anticlockwise (backs) ahead of fronts, troughs and occlusions. (In the southern hemisphere this is reversed.)

Photo 10 (page 28) When a major warm front is approaching, then the sky of the previous photo is gradually replaced by denser darker altostratus clouds into which the sun gradually disappears. The wind should have backed into the south by now and rain will not be too far away.

Most likely wind pattern before shift	*Tactical hints*	*Remarks*
W or NW light to moderate. Possibly fresh at sea. For other less likely directions (see previous page)	If beating into a backing wind pattern stay on port tack as far as possible. If running, choose port tack if possible	The most prevalent backing shift that lasts for hours is ahead of approaching troughs of low pressure. However, the wind will have to veer later and such veers come at the passage of fronts
SE to S. Moderate to fresh. Possibly gale	Beating on port into a veering shift heads you so choose starboard before the shift and be prepared to round up if the shift is sudden	The shift at a warm front is not often as marked or as sharp as at a cold front – however, as with all things meteorological you cannot be too dogmatic about it
SW moderate to fresh, can be gale. The more virile the whole weather regime, the more virile the front and the shift that comes with it	Allow for the truly active front to produce a shift of as much as 90° or more. When sharp the shift is under the leading lowest cloud edge	Allow for the anticyclonic situations where the warm air arrives and no cold air comes for days afterwards. Use the forecasts as well as observation
More difficult to assess than for the warm front but usually around S. Wind speed can be moderate or even less when the occlusion is old	Tactics as for cold front but expect the whole shifting phase to occupy a relatively long time – possibly an hour or two	The shift at an occlusion is like a rather extended form of the cold front. Occlusions near centres of depressions are far more likely to produce intense shifts than others
Can be any one of many different directions. Wind, however, will not usually be strong and may be less than 10kt	Almost invariably any form of front will produce a back ahead and a veer behind it, but the shift may not be at all marked (10–20° say)	Old fronts are very prevalent over land areas. However, old fronts can be found mixed up with many extensive anticyclones. Thundery warm fronts, as in photo 33, may occur in summer
Above remarks apply but the weak cold front is more likely to obey the rules for cold fronts than is an old occlusion	Above remarks apply and advice can be a modified form of that for the active cold front	Above remarks apply. The cold front is likely to become thundery in summer and so rejuvenate into a potentially dangerous weather system

Photo 11 In a run of cyclonic weather, a major trough passes at sunset. The clearing sky behind the trough illuminates the clouds that are moving away to the east. The falling rain creates a rainbow to add to the beauty of the scene and its promise of a fine night.

Very rapid wind increase (less than 3 hours) from force 3–4 (10–15kt) to force 6–7 (25–30kt) is rare following a run of fair weather. The big gales of the summer take as much as 24 hours to develop. Lesser 'yacht gales' usually take between 6 and 10 hours. In any case, anticyclonic (fair) weather has to deteriorate, as in the first case looked at below. For sky sequences, see photos 9, 10, 6 sometimes 8.

On the other hand, when the weather is already bad, or has been bad and there is a respite, the wind can increase to danger levels in a much shorter time. A secondary depression is usually to blame.

Type of weather	*Previous history*	*First signs 24–12hrs ahead of force 6*	*Later signs 18–6 hrs ahead of force 6*
Anticyclonic. Typically half cover of Cu. Moderate to good visibility. Sea slight to moderate	A run of cyclonic weather, of which this spell is a respite, eg the weather was poor yesterday or the day before and it has now improved *or* A run of fair weather which now shows signs of breaking down, eg sunny, light wind the day before yesterday, some high cloud yesterday, increasing cloud today. Possibly thundery tendency	High Ci cloud, typically moving from NW. These clouds forming into long, teased-out banners resembling a flying white mare's tail. Often no sign in the wind nor in the barometer that a large vigorous low is coming. Aircraft make dense persistent vapour trails	Increasing high cloud. Milky veil of Cs cloud (photo 9 or 29), giving haloes about sun or moon. Wind backing from typically W towards S. Barometer shows steady fall over last few hours. Obvious motion in the Ci that is passing overhead, or has passed, denotes strong wind later. In northern hemisphere high cloud (Ci) must advance from left of surface wind for significant deterioration. In southern hemisphere it must advance from right
Cool, showery, cyclonic with a seaway and much heap cloud	Recent passage of a front or trough, ie rain and/or showers in a belt that has passed on. Barometer has been low, is now rising	If weather is to improve behind a retreating depression, weather should be showery and remain so for a day or two (photos 26 and 34). Suspect another blow if showers, occurring now, die out rapidly with time	Rapid rise in the barometer. Rapid drop in previously high wind speed (say from force 6–8 to force 3–4). Some layer clouds in upper sky. If showery weather is to persist then there should not be much upper layer cloud

On the edges of an anticyclone that has persisted for some time and refuses to give way, the wind can grow to gale force as a depression encroaches upon it. Winds can then be gale force under fair skies. The weather does not in any way look like photo 6 but more like 14 or 30.

Note The signs are for normal temperate-latitude cyclones and not tropical cyclones.

Short range signs, 8–2hrs ahead of force 6	*Immediate signs, 4–1hrs ahead of force 6*	*Remarks*
Wind very definitely backing into the S. Barometer falling at increasing rate. Sun disappearing into gathering grey cloud layers. Build-up of cloud should be steady without major breaks in the sequence. Long period of swell running in from a quarter between direction of high cloud movement and surface wind	Wind speed picking up to fresh. Backing phase steadying off. Low cloud beginning to form under higher grey sheet cloud (see photo 10). Possibly some rain. Barometer falling rapidly. If more than 8–10mb (0.2–0.3in) in last 3hrs then gale confidently anticipated. Expect marked wind increase with onset of rain. Look for approaching cloud line that looks low and solid. Wind often comes with that line (see photo 6)	When fair weather is going to deteriorate then it does so fairly slowly after a run of anticyclonic weather. It does so moderately rapidly if after a short anticyclonic spell between passing lows. It does so rapidly and sometimes without much warning if immediately behind a passing depression when the barometer has tended to rise sharply. 'First rise after low foretells a stronger blow' (see section below)
Wind backing rapidly. Barometer steadying off or even falling again. Heap clouds dying out under encroaching layer clouds. Long swell running across the immediate seaway. Possibly confused sea	All signs of another frontal depression with wind from typically S or SW, low cloud. Rapid advance of leaden sky. Barometer falling fast. Wind rising	When signs of more bad weather soon follow retreating bad weather then it usually means a secondary depression. The signs listed are for this form of marked and rapid deterioration. It is often made dangerous because of the rapidity with which the wind rises, by the cross sea that develops and by the fact that it is normal to assume that better weather is sure to follow bad

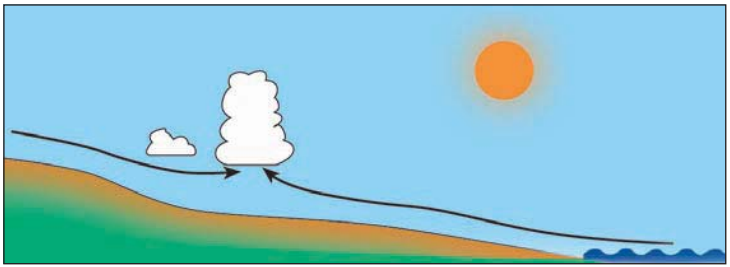
Whenever the winds drop to less than light to moderate then local winds frequently take over. Sea breezes and land breezes are the best-known local winds of coastal regions but in hilly districts anabatic and katabatic winds are prevalent and bend the wind direction far from the forecast direction. In regions of mountains and valleys lake winds are very well known, having a daily routine of wind shifts that can be quite predictable.

An additional local effect is the way winds are steered by topography and only local knowledge will enable you to predict how the coastal promontories and bays, or inland hills and valleys, will affect the forecast wind. The following is a summary of the most common local winds and their effects.

See numbered diagrams on pages 34–35.

		Requirements	*Time or period*
1	**Sea breezes** Light to moderate winds that blow from sea to land by day	• Land warmer than sea • Light morning winds • Less than half cloud cover	Morning or early afternoon to early evening near coast. Spread inland (if at all) during afternoon and evening
2	**Land breezes** Light winds that blow from land to sea by night	• Sea warmer than land • Light or calm evening winds • Clear skies	Dusk to dawn. Sometimes after dawn, especially in autumn
3a	**Katabatic winds** Winds that sink downhill in fine settled weather	• Slopes cooler than plains or valleys • Light or calm evening winds • Clear skies	Whenever slopes become shaded – afternoon or evening continuing through the night
3b	**Anabatic winds** Winds that flow uphill in fine, settled weather	• Slopes warmer than plains or valleys • Light or calm morning winds • Clear skies	Whenever upper slopes, peaks etc come into sun leaving lower slopes in shade. Early morning, continuing until lower terrain feels the sun
4	**Föhn winds** Dry, warm winds in the lee of mountain ridges	• Lee side of mountain barrier • Stable gradient wind directed to flow over barrier • Weather too fine, visibility too good	Föhn storms may last some hours. Föhn conditions may last several days
5	**Mountain-gap winds** Winds that cascade through openings in mountain barriers, eg: Mistral – Rhône valley and environs Levanter – Strait of Gibraltar	• Cold, large-scale airmass that breaks through gap in mountain barrier • Constricting valley from mountain gap • Relatively very warm sea	Lasts for several days at worst

Speed/force	*Season*	*Places*	*Special effects*
4–14kt on most coasts. 14–24kt North Africa and some Mediterranean coasts	Spring, summer (autumn and sometimes winter in Mediterranean)	Beaches, coastal plains, sometimes inland up to 50 miles (80km). Hills upwards of 1,000ft (300m) do not stop it	Cloud cleared from coastal regions. Sea breeze fronts form
1–6kt. Stronger where valleys funnel wind	All year, but mainly autumn and winter	Coastal plains. Inland hills help by adding katabatic wind	Provide coastwise sailing on otherwise calm nights. Sometimes produce coastal showers in early morning
1–6kt. Strong where valleys funnel wind	All year, particularly spring and autumn	Mountain and hill valleys, plains at foot of hill slopes, coastal plains and when backed by hills	Drain very cold air into valleys in winter. Form frost hollows. Fill valleys with morning mist or fog
A few knots	Any time of year, particularly spring and autumn	Mountain and hill slopes, lochs and lakes etc	Help to provide lake and valley winds
Mainly 14–20kt, may be gale force. Rise very rapidly	Mainly winter for storms but all year. Possibly 30–40 times per year. Prevalent in spring	North side of Alps, east of Pennines, Grampians, Scandinavian mountains, east of Rockies (Chinook)	Produce warmth, dryness, break cloud, adverse physiological effects. Storms frequently preceded by lens-shaped clouds. Often exceptional visibility
May be strong to gale. Mistral exceeds 33kt on 30 days per year; exceeds 21kt on 100 days per year	Mostly winter and spring but can be all year	Mistral: Rhone valley on to Gulf of Lions but felt from Perpignan to Genoa	Gusty wind often under clear skies. Trees set permanently to SE in lower Rhone valley



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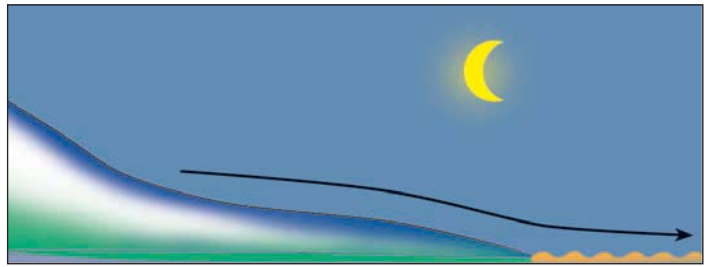

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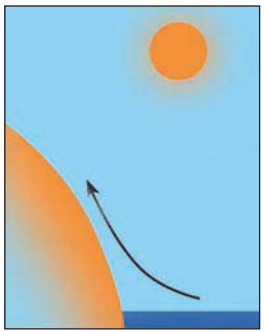

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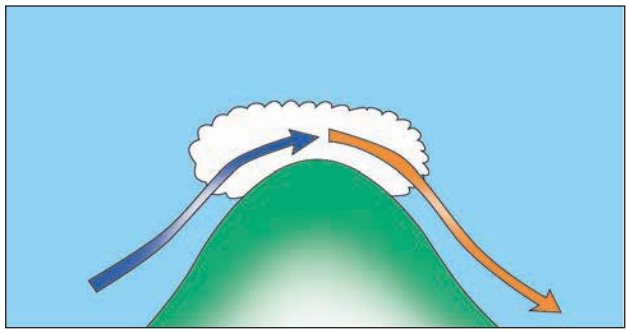

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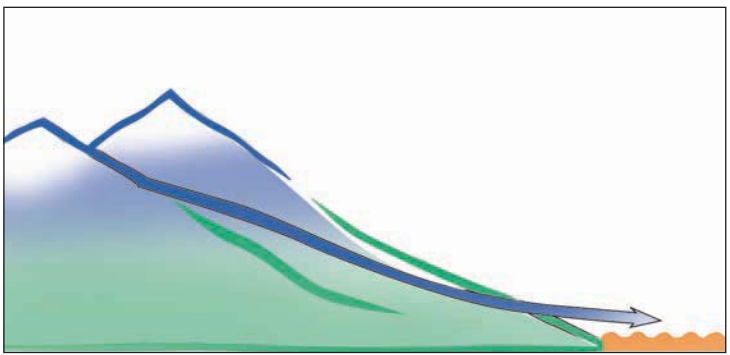

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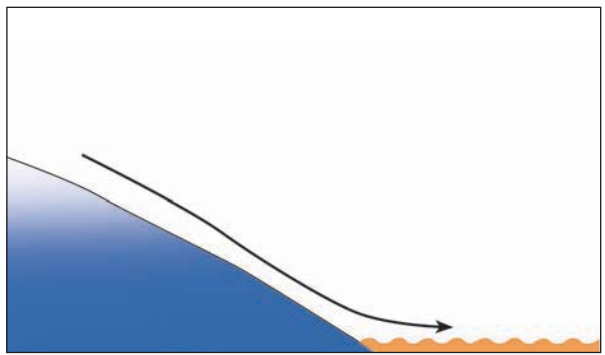

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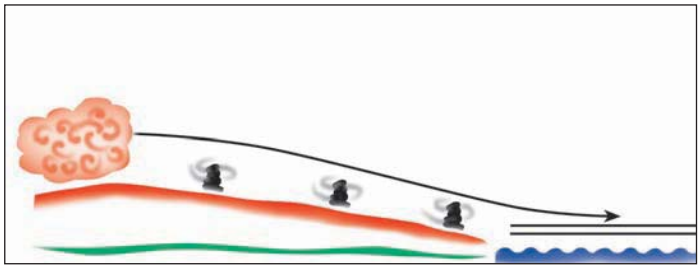
Fig 2



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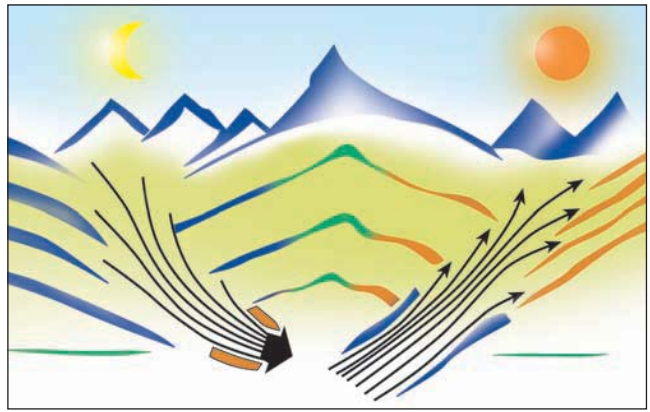

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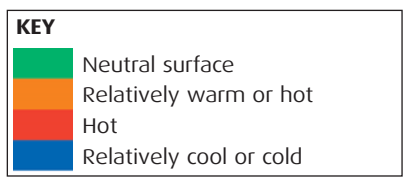
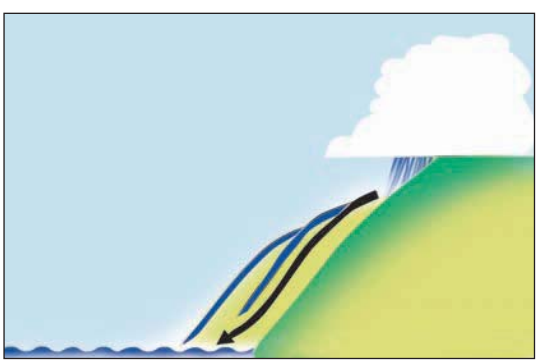


Fig 2



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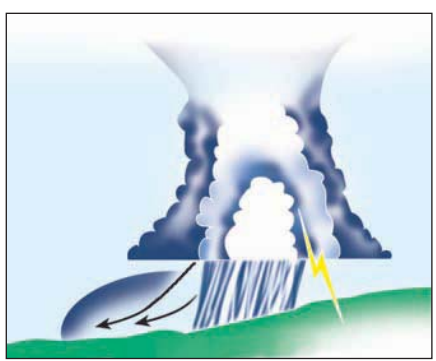

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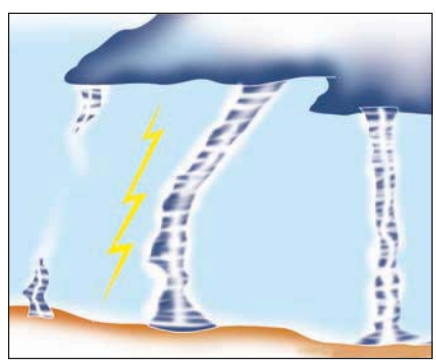

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		Requirements	*Time or period*
6	**Coastal-slope winds** Winds that blow off steep cold coasts on to warm seas, eg Bora – North Adriatic and North Caucasian shore of Black Sea Vardarac – Aegean	• High snow-covered mountains descending directly to relatively warm seas • Cold, unstable airstream directed from land to sea	Normally lasts a day or two
7	**Desert winds** Winds that blow off desert areas and are thus warm, dry and hazy. Often carry dust. Scirocco – Mediterranean generally	• Hot, arid desert with much cooler flanking sea • Cyclonic large-scale winds	Last for several days
8a	**Mountain winds** Winds that flow down mountain valleys to the plains	• Plains warmer than valley • Light evening winds • Little cloud or clear • Aid of katabatics	Midnight to early forenoon
8b	**Valley winds** Winds that flow up mountain valleys from the plains	• Valley warmer than plains • Light morning winds • Little cloud or clear • Aid of anabatics	Midday to late afternoon
9	**Lake winds** Winds that blow along and around the edges of steep-sided lakes	• Steeply landlocked lake, fjord etc • Steep sides so that different parts catch sun at different times • Light or calm winds	Morning anabatic winds flow up warmed sides. Afternoon katabatics flow down. Along lakes depending on which end is in sun and shadow
10	**Downdraught winds** Winds caused by rain or hail showers on nearby slopes	• Large Cb clouds especially over hills • Unstable airstream often with good visibility • Slopes from hills to valley bottom or lake	Any time in mountainous areas, but particularly afternoon or early evening
11	**Thunderstorm winds** Winds caused by downdraught currents under advancing storms	• Thundery conditions • Obviously bad thunderstorm on way • Thunderstorm coming up against sultry wind	Any time but usually afternoon or evening
12	**Rotating winds** Tornadoes, waterspouts	• Very unstable conditions • Sultry thundery weather • Intense thunderstorms nearby	Mainly late afternoon of sultry days

Speed/force	*Season*	*Places*	*Special effects*
Strong to occasionally gale over coastal waters	Winter and spring. Maximum Dec–Jan; minimum June	North shores of Adriatic, sometimes whole Adriatic coast. North Caucasian shore of Black Sea	Sometimes gusty gale in 10-mile (15km) wide strip of coastal water under clear skies
Moderate sometimes strong	Mainly spring but also summer	North African coast across Mediterranean	Can lead to extreme heat under scirocco conditions. Can damage vegetation. Also produce muggy warmth on north shores of Med
3–10kt maximum just after dawn	Any	As below – Swiss Alpine valleys, Wisper valley into Rhine etc. Permanently over glaciers (glacier wind)	Intense frost pockets in winter half of year
2-5kt	Any	Mountain valleys, hill valleys. Valley wind tendency wherever plains sharply cooled	Help to clear valley mist and fog
1–5kt around edges. Often calm in centre with reversal of direction from one side to the other	Mainly spring to autumn	East–west rather than north–south oriented lakes	Produce light breezes. Clear overnight mist or fog. Sometimes produce backbones of cloud along lake centre
Suddenly from calm or light to strong to gale, gusty	Mainly spring to autumn	Lakes and valleys with steep slopes towards direction of unstable airstream	Produce prodigious and sudden squalls. Suddenly very cold. Hail etc arrives after wind has cascaded down hillside. Wind may come but rain or hail need never reach own position
As above. Wind from direction of storm, 30–40kt is usual maximum but can be more in US	Mainly spring to autumn	Over land, especially in hilly areas where cloudburst may occur with flooding	As above but big storms may go on for hours
Incredible wind and pressure effects from tornadoes, less with waterspouts	Mainly hottest part of year	Tornadoes preferentially form over hill ridges parallel to wind	Unusual but destructive when they occur. Most prevalent in central US but also occur in Europe and Mediterranean, sometimes under clear skies

To understand local wind effects we can take the main coastline and divide the adjacent sea and land areas into 'wind zones' parallel to it. The diagram (right) shows the extent of the zones and the names we give them.

We need these zones to describe sea breeze and nocturnal wind effects in particular. The sea breeze is a complex wind, but can be understood and rules established if you can first position yourself in one of the zones.

Offshore zone: where ocean racers and deep-water passage makers sail, but very few dinghies or small cruisers are found. The wind is dictated by the gradient wind direction and the shifts are due to changing pressure patterns. However, when conditions are right, sea breeze effects extend into the offshore zone.

Coastwise zone: where most coastal passage makers are found. Sea breeze effects reach this zone on many days when they are active over the coast itself. It is on the edge of the realm of the nocturnal wind and will only rarely have an effect on 'steered' winds this far out.

Inshore zone: where dinghies which sail off the beach, or compete on an Olympic-type course, or which are just outside for a spin, will be found, also many small cruisers and power-boats. It is also the zone with a maximum chance of wind shift at most times of the day or night. Here sea breezes are born and from this zone they extend their influence seaward and landward with the day. Steered winds will be prevalent here when close to the shore itself. Nocturnal winds will reach their maximum strength and frequency in this zone.

Beachland zone: the area that lies directly inland from the shore. It includes coastal creeks and harbours that probably contain most of the sailing fraternity's activities. It is often a coastal plain with backing hills and the latter may be 10 or more miles inland. Here is where the sea breeze will blow if it is going to. Sometimes it never gets further inland than this zone, athough it is more normal for it to get 15–20 miles (20–30km) inland on most occasions when the strength of the gradient wind allows it to blow at all (photo 25: frontispiece).

Like the inshore zone, there is a maximum chance of wind shift in the beachland zone, both from sea breeze and nocturnal wind effects as well as other causes.

Coastal zone: is far enough inland for effects borne on onshore sea winds to have established overland characteristics (such as gustiness) not possessed over the sea. It is also where the sea breeze frontal system will have had time to organise itself when sea breezes set in against offshore winds. Other effects, like showers formed over warm coastal sea that arrive over cooler land at night, will not have died out in the few miles from the coastline, but on the whole the coastal zone is land and is not affected by the adjacent sea.

Inland zone: is the true land where sea winds have lost most of their oceanic characteristics; also the zone into which sea breezes penetrate only when conditions are good, although the seaward side of the zone will often have sea breezes. It will also experience the curious alternations between calm and fitful wind that are to be found under sea breeze fronts that have reached the limit of their penetration. When conditions are good, the sea breeze system will penetrate inland for tens of miles, possibly 50 miles (75km) on the best days. The inland zone is dominated by land winds or sea winds that have developed the convection currents so often found over the land in daytime.

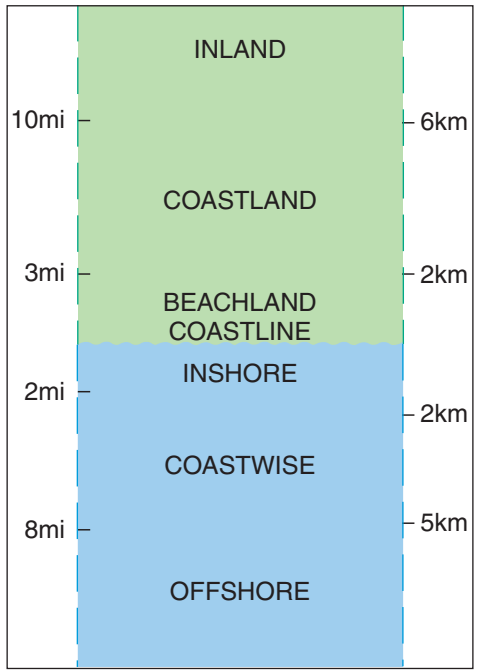

Photo 12 As the air stills and stabilises with evening, so katabatic winds begin to blow downhill and may be revealed, as here, by a tell-tale smoke plume from someone's bonfire.


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Anyone who drifts about in almost flat-calm conditions in the morning knows he can expect some wind by the afternoon. This is because of the normal change in wind speed that occurs with the day and is called the *diurnal variation*.

The diurnal variation follows the sun. When the sun is high, so is the wind speed and when the sun begins to go down, so does the speed of the wind. Wind speed on the coast tends to be lowest just after sunset and just before sunrise.

Low cloud – particularly of the cumulus type – also tends to follow the same patterns. Clear cool mornings develop Cu by the afternoon, but the Cu tends to die with evening and there is often a clear night. In settled weather, high clouds also tend to increase with the day although they may not follow the normal rules.

Both the increase in wind speed and cloud are linked to the heating of the land by the sun. No similar variation occurs over the ocean. In the lower layers of the atmosphere wind speed increases with height. Friction slows the wind near the surface. When Cu clouds form, it shows that the lower layers are being mixed so that faster wind from aloft can speed up the wind at sea level. So the wind is bound to increase when Cu forms and when Cu dies, the mixing stops, friction takes over and the wind mutes.

You can see that the wind's day is dictated firstly by local heating or cooling of the land (Fig 2). This makes the speed rise with the day and fall at night. It also makes the sea breezes blow near the coast; lake winds and mountain and valley winds blow inland both by day and by night. Near the coast, the nocturnal wind blows by night.

The wind's day is also dictated by the gradient wind speed. Too much gradient wind and local winds are over-ridden, although the diurnal speed change is evident even in sustained gradient winds as strong as force 6–8. However, winds caused by travelling pressure systems rise and fall at odd times that do not fit the diurnal variation. Such unusual increase or decrease of the wind indicates that the pressure pattern is changing locally.

I have compiled a table (following pages) aimed at those days when most yachtsmen are happy to be out, when there is not too much wind and some sunshine, or at least broken skies. To use the table choose a time and place and see what influences there may be on the wind. Then check the more detailed sections that follow for further information.

Photo 13 The multi-coloured sails of windsurfers resting before the start of a major race. The flags show that there will be some wind from an inland direction and the mass of cumulus clouds approaching from the right indicate that the wind will have normal variability. However, the coastline is off to the left and there might just be a sea breeze whose odd shifts and calms will frustrate all the competitors.

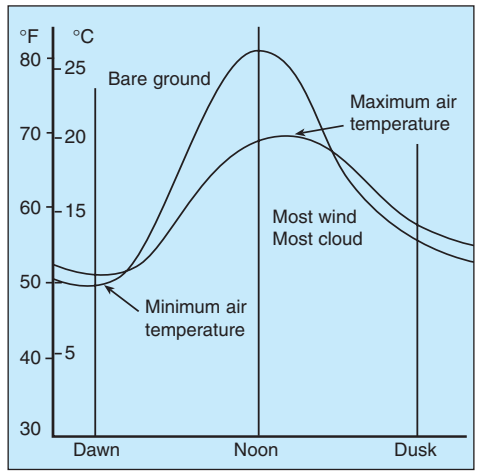


Fig 2

These examples relate to temperate latitudes with wind strengths between calm and 15kt; in the summer half of the year, eg April to October inclusive.

- 'Morning wind' refers to the wind that gets up after dawn but before sea breezes blow.
- Choose time and place and see what the wind might be doing.
- Fresh winds are not much modified by local wind effects other than steering by topography.
- Moderate winds are on the edge of being altered by sea breezes and not usually at all by nocturnal winds.

Inland zone more than 10 miles inland	Dawn calms or time of lightest wind speed	Overnight inversion breaks over the land and wind appears at the surface.			Gradient wind blows and increases to maximum by 1500hrs Sea breeze blows on the best sea breeze days
	Valley winds blow from mountains			Valley winds blow towards mountains	
Coastal zone between 3–4 and 10 miles inland	Dawn calms or time of lightest winds	Morning wind may pick up from calm	Morning wind (gradient wind) established and increases with time. Sea breeze shifts occur when morning is calm		Gradient wind blows but sea breeze can replace it. Sea breeze blows if morning wind 8kt or less
Beachland zone to between 3–4 miles inland	Dawn calms or time of lightest winds. Last of nocturnal wind	Morning wind or sea breeze drift if flat calm	Morning wind if over 8–10kt Sea breeze shifts if 1–5kt		Gradient wind if 12–15kt. Sea breeze blows if morning wind lighter than 10kt (sea breeze conditions must obtain)
	Any strong wind is gradient				
MAIN COASTLINE	**04** Local solar time (24hrs)	**06**	**08**	**10**	**12** **14**
Inshore zone to about 2 miles offshore	Dawn calms. Time of lightest wind if from landward	Morning wind if from land. Otherwise maintains gradient	Sea breeze calms when light or gentle wind from landward. Sea breeze begins to blow by end of period if land wind less than 4–6kt		Sea breeze blows or other wind direction shifted towards land. Onshore winds increased by sea breeze effect. Fitful calms if morning wind 10–15kt
	Still nocturnal wind?				
Coastwise zone between 2 and 8–10 miles offshore	Gradient wind (from seaward or landward). Nocturnal wind (landward only)		Gradient wind blows but some sea breeze 'holes' in the wind on inshore edge of zone		Sea breeze picks up and blows unless gradient too strong (12–15kt)
		Morning wind from landward picks up and probably shifts			
Offshore zone more than 10 miles offshore	Gradient wind probably light if from landward		Gradient wind is only possible wind unless morning absolutely flat calm. Then onshore drift possible by end of period		Sea breeze may produce calms and then shift later in period on good sea breeze days

Note Winds due to intense systems like thunderstorms, tornadoes and hurricanes, though rare, can occur at any time of day or night and take over any existing wind regime.

Sea breeze can blow up to 40–50 miles inland on some evenings. Otherwise gradient wind will blow but decreases in speed			Katabatic winds blow in hilly districts (photo 12). Otherwise gradient wind will blow. Lighter than during the day. Increasing gradient often means stronger wind by tomorrow			
Thunderstorm winds at their most probable			Valley winds blow from mountains			
Sea breeze may blow. Calms can be due to sea breeze fronts. Gradient wind if above 15kt			Gradient winds lighten. Calms follow daytime sea breezes before onset of nocturnal wind. Latter pick up by end of period		Nocturnal winds blow but falter by end of period sometimes leading to dawn calms. Gradient winds blow at their lightest	
Sea breeze blows for a time but falters and may go calm by end of period			Early night calms or light winds. Nocturnal wind by end of period (if stronger than gradient wind) (photo 18)		Nocturnal winds blow at their strongest (gentle to moderate) but falter towards dawn. If stronger then gradient wind – any onshore wind is gradient	
			Nocturnal winds blow more strongly on steep coasts			
16	**18**	**20**	**22**	**24**	**02**	**04**
Sea breeze still blows at first, then falters. Coastal calms, picking up to gradient wind if any. Any increasing wind is usually gradient			Early night calms or light winds. Nocturnal wind by end of period. Any wind other than nocturnal wind is gradient wind		Nocturnal winds blow at their strongest. Any wind off the sea is gradient. A more than gentle wind from the land means gradient + nocturnal	
Sea breeze falters and dies to fitful calms. Followed by gradient wind if any			Gradient wind or nocturnal wind by end of period		Nocturnal wind blows at a few knots. Otherwise gradient wind (but at its lightest). Dawn calms occur towards end of period	
Sea breeze occasionally blows and falters to temporary calm. Otherwise gradient wind			Gradient wind. A very light gradient can become switched to nocturnal wind on clear nights. Normally, however, only gradient wind			

Almost without exception, coasts experience sea breezes (daytime winds from the sea).

The beachland and inshore zones (where the majority of people sail) experience most sea breezes. When the wind is from a point inland, or even parallel to the coastline, then extensive wind shifts occur. The important tactical situation to recognise is the one when a sea breeze frontal system will be formed (see page 52).

In the tables that follow it is assumed that the typical sea breeze day is involved. Hints on possible variations are given but not every sea breeze is predictable in time or place. However, *some* are and by following the hints on days and wind speeds it should be possible to recognise those days that are almost certain to produce a breeze.

A sea breeze day is one where nature conspires to make the breeze possible. It has bright blue skies early and for best results Cu clouds develop. The wind is less than 8kt over the land (10–12kt over the sea) and big shifts come when the morning wind blows from land to sea. (Photos 14 and 23).

Sea breeze fronts, like miniature cold fronts, form between a light or gentle wind blowing off the land in the morning and the sea breeze starting to blow from the sea (see Fig 3, page 46). Such a front is recognised by a line of cloud along it (see photos 16 and 17). On dry days it may form the only cloud in the vicinity of the coast. On other days when Cu clouds form readily, the sea breeze front divides the coastal sky in half. To seaward it is usually quite cloudless, to landward there are fleets of Cu clouds. The sea breeze fronts on sea breeze coasts form more or less continuous lines parallel to the coast and move inland at about 3kt at first, increasing to 6–8kt in the afternoon. Thus the front rolls back the offshore wind, producing wind shifts that are amongst the widest experienced. They may indeed be 180° shifts and occur almost instantaneously, the light wind from the land suddenly being replaced by the somewhat stronger breeze from the sea.

At other times the onset is not so sharp and there is a calm patch between the two winds. For example craft can be at the same time:

- Running before the breeze on the seaward side,
- Running before the wind in the opposite direction on the landward side or
- Listlessly becalmed under the sea breeze front itself.

To be sailing or racing on waters just inland from the land and to recognise the sea breeze front advancing from the coast is to have advance knowledge of a wind shift, the final direction of which is often almost precisely known as it frequently comes from a direction some 20° to the left of the direct onshore line. It is also a wind without useful tactical wind shifts (see page 68).

Coastal wind shifts due to sea breeze influence occur on many summer days. Examples are when fresh winds blow nearly parallel to a coastline. These are too strong to be fully shifted to blow on shore, but a shorewards cant occurs as the day progresses.

On-shore morning winds on sea breeze days are reinforced by the breeze and it is prudent to allow for the wind speed to double during the afternoon. The wind may also shift more nearly to the onshore direction.

Sea breeze coasts are mainly east-facing and south-facing with extensive coastal plains backed by low hills. Here the sea breeze frontal systems form most readily and move furthest inland. Sea breezes are also drawn from far to seaward. With prevailing westerly winds, many sea breeze frontal situations must occur on these coasts, thus there is also a strong probability of daytime wind shifts.

Sea breeze wind speed is 10–15kt at maximum in latitudes of about 40–60°N, but may reach 25–30kt in sub-tropical latitudes.

Sea breeze afternoons are when the breeze will slowly alter its direction to blow more from the left of the onshore direction.

Sea breeze evenings are often calm or very light, but later a nocturnal wind will set in from the land (see page 56).

Sea breeze effects to seaward

The sea breeze inshore comes earlier than anywhere else. Here the wind from the land falls to calm in the forenoon before the sea breeze gets going. Shifts occur here that may not be experienced a few miles to seaward or inland.

The sea breeze coastwise usually starts slowly and later than inshore – perhaps by early or even late afternoon. The wind goes calm before picking up slowly from seaward.

The sea breeze offshore is more rarely experienced in temperate latitudes, but is prevalent in lower latitudes.

Photo 14 A typical sea breeze day looking up an estuary on the south coast of England. Here is a morning with all the ingredients for a sea breeze before midday. In fact, the craft on the lower right show that the breeze has already reached them. The cumulus further inland shows that the convection necessary for a sea breeze front to develop is already there.

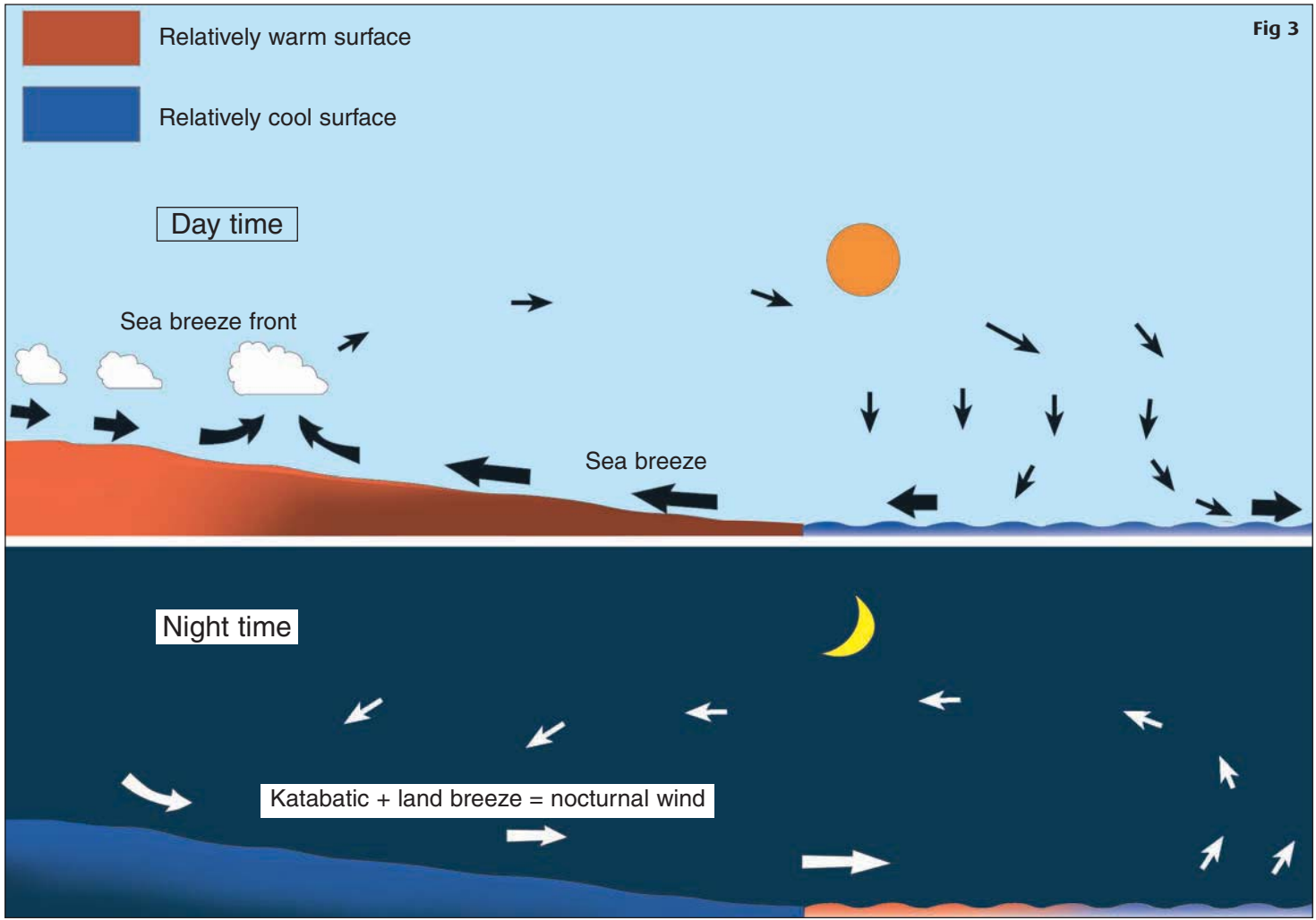

Relatively warm surface
Relatively cool surface
Day time
Sea breeze front
Sea breeze
Night time
Katabatic + land breeze = nocturnal wind

Fig 3

Photo 15 (page 47) Further inland you have to wait for the sea breeze to arrive. This is a coastal creek some 2 miles (3 km) from the main sea coast, which lies in the direction we are looking. In the distance the cumulus cloud has died out and, as the wind is light, this is a sure sign of a breeze on its way.

Wind from the land

The table below shows the type of shifts that sea breeze effects produce in the various zones parallel to the coastline. On this page are the variations that usually happen to a wind that blows from the land to the sea within an arc of 70° either side of the direct line inland from the main sea coast.

Wind in the morning from the land	
Inland	Sea breeze shifts occur middle of the afternoon and into the evening, if at all. On good sea breeze days (light winds and Cu clouds) sea breeze front advances from coast as long as sun provides power and convection can continue. Morning shifts are due: **1** to establishment of gradient wind. **2** to local thermal influences. Other afternoon shifts may be due to local storms, showers etc. Evening gradient wind re-established after a quiet period.
Coastal	Sea breeze shifts early afternoon to late afternoon. Off-shore wind rolled back and reversed behind a calm zone (sea breeze front) (see page 46). Early shifts can be establishment of gradient wind after dawn calms or in flat calm, anabatic drift to inland hills. Evening gradient wind re-established only after calm period in most cases.
Beachland	Sea breeze shifts late forenoon or early afternoon. Calm areas formed during establishment of sea breeze front over beach and move inland. Sea breeze cannot pull in from seaward until sea breeze front forms and moves. Many sea breeze effects in this zone. Normal loss of sea breeze to a calm evening but can re-establish gradient suddenly.
COASTLINE	
Inshore	Morning wind calms and then pulls back towards beach in early forenoon if morning wind is light, in later forenoon if gentle wind (see page 52). The most likely zone for wind shifts due to sea breeze effects. Gradient not usually re-established before evening after calm period.
Coastwise	Sea breeze shifts spread into zone in early afternoon to late afternoon. Wind usually goes calm for a period and then pulls in towards shore. This calm zone moves out towards offshore as day progresses. Gradient re-established in evening and calm period.
Offshore	Sea breeze shifts in middle afternoon to early evening but only in light weather. Event is fairly rare in temperate latitudes. Less rare further south. Light on-shore breeze can be established up to 20–30 miles offshore. Light airs in evening or near calm followed by re-established gradient wind direction.

Wind along the coast

On this page are the shifts that usually occur when the morning wind is within 20° either side of the main sea coastline. The events are those associated with sea breeze coasts that are only indented by headlands and inlets, bays etc to a depth of about 10 miles and have a flattish hinterland that rises to coastal hills. Other venues, where high ground comes close to the sea, where coastline takes a sharp turn for tens of miles, where lagoons, etangs etc go many miles inland, may not obey the rules. On-shore wind direction is not covered as only predictable effects are a swing to more on-shore and an increase in speed.

Morning wind within 20° either side of main coastline direction

Sea breeze shifts middle of the afternoon to early evening. A swing of direction more from seaward can be carried into this zone but only in light to gentle winds. Any such tendency will revert to gradient wind again by evening. Other influences on the morning wind are as opposite.

Sea breeze shifts occur early afternoon to late afternoon. Light to gentle morning wind shifts move towards seaward direction and increases. If moderate wind there can be a shift, but not marked.

Sea breeze swings off the sea during forenoon or early afternoon. Light wind swings in and increases in strength. Gentle wind swings slowly to normal sea breeze direction but may not get there fully. Moderate wind may come in from 40° to seaward of coastline direction but often much nearer to coastline direction.

Sea breeze swings off the sea in early forenoon if light wind; later forenoon if gentle wind; afternoon if moderate wind. Wind shifts to sea breeze direction, either all at once or in a series of swings. Complex shifts occur when wind moderates.

Shift occurs to more directly on-shore at inshore edge of this zone in early afternoon to late afternoon. Only rarely does effect extend to offshore zone. If wind moderate then possibly no effect at all.

Only light to gentle morning winds see the effects translated 20 miles out and then not before middle afternoon to early evening. Possibility of shift more directly landward as day progresses but early evening return to gradient wind direction.

To assess the possibility of a sea breeze from forecast or actual conditions, first choose your sailing area. ⬇ means that a sea breeze is probable (↓ that it is possible) so move down to the next section. Then assess actual or forecast wind speed; next, cloud cover and finally, if sea breeze has proved possible with the combination of conditions, from the wind direction assess the way the breeze may set in.

Sailing area	*Offshore*	*Coastwise*	*Inshore*	*Beachland*	*Coastal*	*Inland*
Distances in miles	10 miles off (**a**) **No**	3–10 miles off ↓	0–2 miles off ⬇	0–4 miles inland ⬇	4–20 miles inland ↓	20 miles inland (**b**) **No**
Wind speed (assessed at about 0900)	Force 0–2 Calm to light 0–6kt ⬇	Force 3–4 Gentle to mod 7–16kt ↓		Force 5–6 Fresh to strong 17–27kt (**c**) **No**	Force 7–8 Gale 28+kt **No**	
Cloud cover	Sunny (fine) ⬇	Sunny periods Bright periods (**d**) ⬇	Sunny intervals Bright intervals (**d**) ↓		Cloudy (**e**) **No**	Overcast (dull) (**f**) **No**
Wind direction (assessed at about 0900)	From mainland ⬅ sea breeze frontal system	Parallel to main coastline sea breeze frontal system if force 0–2 Shift to seaward if force 3–4			From seaward ➡ increase in strength and possibly shift more from seaward	

The above establishes the prospects for or against a sea breeze. Forecast or actual weather conditions may assist or hamper the establishment of a sea breeze. If the above shows, in the forenoon, that the sea breeze is likely then check below:

Weather	*Small Cu clouds*	*Showers*	*Thunderstorms*	*Fog/poor visibility*	*Rain/drizzle*	*Increase in high cloud*	*Increase in wind*
	If over coast then the Cu assists	Inland can assist if not fierce. Over coast may kill sea breeze.	In forenoon and early afternoon sweep away sea breeze which can return later.	Hinders sea breeze. Sluggish coastal calms.	Kills sea breeze. Slackens it if light intermittent.	Damps sea breeze at first. Kills it later if continuous cloud build-up.	Blows away sea breeze if force 4 or more.

Notes
a Possible landward drift on calm mornings. Maybe moderate by midday in low latitudes.
b Inland drift on calm mornings is not sea breeze, but plains wind.
c If in lower latitudes just possible. So continue to next section.
d 'periods' = more sun than cloud; 'intervals' = more cloud than sun.
e If warmth can be felt through cloud and wind is already calm to light, then breeze can come. If very light, allow for thin cloud to clear on summer mornings.
f If overcast on coast, but it looks bright inland, then sea breeze can be drawn in when wind light.

Photo 16 Inland from the coast you may often see the sea breeze front coming. Here we are about 15 miles (24km) from the coastline towards which we are looking. We can hardly discern the sea that lies beyond the coastal hills because of the haze, typical of conditions around sea breeze fronts. In this case there is very little cloud either side of the front which means that the front itself is very easy to see.

Having decided from the previous page that there is likely to be a sea breeze, it is tactically important to know when it might arrive. So you must recognise the signs accompanying its onset. Sea breezes rarely set in against off-shore winds that are above 8–10kt mean speed at about 0900–1000 LST (Local Solar time) in latitudes of about 40° and 60° (wind speed measured over the land). From observations made on the good sea breeze coast of southern England one can conclude that sea breezes should occur by the given LSTs on most similar sea breeze coasts.

Time by which sea breeze should have occurred

	Wind speed, wind off-shore. Measured at about 0900–1000						
Zone	*Calm*	*1–2kt*	*2–4kt*	*4–6kt*	*6–8kt*	*8–10kt*	*10–14kt*
Inland	Landward drift at any time	50 miles inland by 2000–2200 40 miles inland by 1900–2100 30 miles inland by 1800–2000 20 miles inland by 1600–1700		On the best sea breeze days and on good sea breeze coasts			
Coastal	*(Usual times for 10 miles inland from the main coastline.)*						
	1200–1300	1300–1400	1400–1500	1400–1700	Not normally possible		
Beachland	*(Usual times for 3 miles inland from main coastline. Subtract about 1–2 hours for the coastline itself.)*						
	1000	1100	1200	1300–1400	1500–1600	Not normally possible	
COASTLINE							
Inshore	*(Usual times for between 1½ and 2 miles out from main coastline. Add about 1 hour for coastline itself.)*						
	0800–0900	0830–1000	1000–1100	1100–1200	1200–1400	Often no true breeze but off-shore wind reduced in afternoon	
Coastwise	*(Usual times for about 10 miles from main coastline.)*						
	0900–1100	1100–1200	1300–1400	1400–1500	1500–1600	Often no true sea breeze but wind reduced in afternoon	
Offshore	*(Usual times for about 20 miles from main coastline.)*						
	1000	1300–1500	1500–1700	Wind reduced sometimes but usually no sea breeze		Usually no effect	

The previous table suggests when the sea breeze front could arrive. Use the hints below to recognise it when it does come.

Landward zones

Here are signs of the approaching sea breeze front, under which is the shift to the on-shore breeze. Very dry airstreams may not have clouds along the sea breeze front to mark it and make the shift visible.

Zone	*In the early forenoon look for...*	*In the next few hours look for...*	*The sea breeze front is marked by...*	*Ten to twenty minutes before the shift...*
Beachland *and* **coastal**	Cu clouds which first develop over inland hills but later spread seaward. Allow for any cloudy-bright or misty mornings breaking up to Cu and heat	Signs of Cu not surviving over coastline and sea (sunshine on cars, boats, buildings etc near coast itself). Cloud overhead remaining well broken – half cover or less. Off-shore wind will increase somewhat as morning progresses but lightens with approach of sea breeze front	A darker, deeper line of Cu clouds parallel to main coastline and advancing inland. Wind lightening to calm. Gulls, swifts or other soaring birds under cloudbase. Contrast of bright sun conditions on seaward side of the front	Wind progressively lightens. Some puffs from landward interspersed with calm and then puffs from seaward. Eventually sea breeze front moves inland leaving venue in breeze and bright sunshine
Inland	Cu day without much wind. Sea breeze takes time to travel so for 'early forenoon' above read time given in previous table. Cu can get quite extensive inland and still the breeze will come	Any signs to seaward of unusual amount of sunshine through haze layer below cloudbase	As above	As above

Seaward zones

The sea breeze system tends to make clouds disperse over coastal waters, so making it difficult to recognise the onset of the calm that sets in (sea breeze antifront) and the breeze that follows it. Below are a few suggestions.

Zone	*In the early forenoon look for...*	*In the next few hours look for...*	*The sea breeze antifront is marked by...*	*Sea breeze gathers momentum ...*
Inshore	Cu clouds that first develop over inland hills and then spread seawards. The Cu shows convection, necessary for a vigorous sea breeze system to develop. Broken higher cloud or any cloud that allows sun to get to the land will be allied to a sea breeze	Signs that the off-shore wind is lightening – certainly it should not be increasing markedly. Cu clouds tending to die out so that it becomes sunnier	Off-shore wind falling to calm. Curious shell-shaped catspaws round a craft due to sinking jets. These darken the water just as wind does, but there is no horizontal wind yet. Clear sky overhead. Fitful and often very light puffs towards shore	When sea breeze front forms over beach. Look for bigger darker Cu forming line over beach. Then expect the slight on-shore drift to pick up soon to a 4–6kt or more on-shore breeze
Coastwise	As above	Can be as above on landward side of zone and conditions will spread seawards with time	Above signs progressively later, the further from shore	This zone needs the real sea breeze front to develop before it can expect breeze

Photo 17 (page 54) Typical cloud along a sea breeze front inland. The day is more humid than that of the previous photo and so there are more cumulus clouds and they are bigger along the front itself. The coast is off to the right where there is little or no low cloud as we expect with sea breeze front conditions. So the breeze will be blowing from the right and the morning wind from the left. Expect calm or just fitful winds under the front.

Photo 18 (page 55) The kind of evening when a nocturnal wind is almost certain to blow. This is a backwater not far from the sea and it is flat calm under clear skies – perfect conditions for a land breeze plus katabatic drift off the coastal hinterland. We can expect some wind from the land by midnight.

Statistics show that on average in the summer-half of the year most coastlines experience winds off the land during the night. So inshore and coastwise cruising craft should expect, and make use of, the nocturnal wind. The table below shows how to forecast its onset from the strength of an opposing wind, ie a light to gentle wind from sea to land. It is essential that land cools below sea temperature. Thus late summer and autumn are preferred.

Coastal geography	*Forecast or actual weather at sunset*	*Wind speed at sunset*
Flat coastal plain backed by hills	Clear sky with normal visibility. Sun sets visibly, ie little obscuring low cloud. Any low cloud should be dispersing. High clouds should not show signs of rapidly increasing. In other words, every sign of a fair night	Calm or light air 0–3kt
As above (note that this and higher speed of wind can be replaced by nocturnal wind when steep hill and mountain slopes back the coastal plain)	The above weather regime that allows radiation to cool the land and the hill slopes is essential. If coast faces E or S then sun has left the nearer hill slopes a long time before sun sets in summer. Thus early katabatics are to be expected	Light breeze 4–6kt
Big hill ridges backing the coastal plain but within a few miles of it. However, mountains further back will provide moderate nocturnal winds and keep them going into the early morning. Possibly as late as the early forenoon	All the radiation stops must be out if this wind speed is to be affected. Cool clear nights are possible candidates so long as wind is not tending to increase	Gentle breeze 7–10kt
Only coastal-slope winds as experienced in the Mediterranean can really influence this wind speed	A clear night and this wind speed at sunset must preclude nocturnal wind except as an additive to an already off-shore wind	Moderate breeze 11–16kt

Prospects for nocturnal wind	*Sailing tactics*	*What can prevent it?*
Almost certain to occur. Expect present wind to lighten still further to temporary calm if it is now on-shore; then slowly to pick up from landward by midnight. If wind now off-shore, expect some lightening at first but no full loss of wind before nocturnal wind picks up with the night	Seek the shore as far as is prudent to achieve maximum advantage from nocturnal wind. Allow for 'holes' in the wind off cliffs and local high places and for local enhancement of strength through funnelling out of estuaries and coastal valleys etc	Forecast of gathering wind during the night. Such wind may not become evident for some hours and then may arrive suddenly, sweeping away any nocturnal wind that has occurred. Gathering cloud over the land, cutting off radiation to the sky
Can occur because the wind over the land lulls with the night and so land breezes and katabatics can take over. Expect nocturnal wind late, ie after midnight	As above applies but the 'sunset' wind should stay longer. Changeover calm period or shift to nocturnal wind should come some hours after dark	This wind speed may be the commencement of a 'gradient' wind. Look for signs of encroaching cloud, fall of barometer etc. If so, present wind may strengthen with the night and no nocturnal wind occur
Cannot usually occur with normal coastal plain shoreline. However, if 'sunset' wind is blowing on-shore, the wind over the land will be less and even this speed cannot fully rule out the chance of a nocturnal wind later in the night. However, if it occurs allow for it being swept away again before dawn or just after. If wind already off-shore then it will probably strengthen during the night	There is enough speed here to keep the present regime going for a long time – possibly all night. It is touch-and-go with this wind speed whether there will be any marked shift with the night. If there is it usually means a change of speed as well; dropping if wind is on-shore, increasing if wind is already off-shore	Simply, this speed can keep nocturnal winds out. However, coastal slope winds from steep sides close to the shoreline can easily upset the normal run of events
Very little prospect unless wind drops with the night. Check the forecast	Sail as you will. A wind from the land will strengthen near the shore so stay there. If already off-shore then go anywhere	What conditions will allow a nocturnal wind? A gradient wind that lightens rapidly with the night

I can only give hints about wind shifts; each site must be judged by its form of shoreline and the direction of the wind with respect to the shoreline and the state of stability of the airstream (gusty or not). Local wind shifts are caused by objects obstructing the wind or to local heating and cooling in light airs. Most of the remarks apply to all wind zones.

Type of shoreline	*Causes of shifts*
Flat or gently rising, some trees but mainly open. Usually backed by coastal plain or other flattish hinterland. If in doubt use these comments for small-water shores	Local thermals or sinking jets of air in calm or light air conditions Steering (more parallel to the shore) of wind that is already somewhat parallel to the shore Refractive bending to bring wind more directly off the shore when its direction is already close to perpendicular to the shoreline Steering of off-shore wind (0–15kt) by shore topography when conditions are meteorologically stable, such as in the evening–night–early morning, or days with total cover of low overcast St cloud. Any form of Cu cloud gives a day where the local steering effects are less noticeable
Steep-to shores and those closely backed by cliffs etc. See also pages 103 and 105 for lake winds	Local thermals as above. There can also be more extensive anabatic winds towards slopes in the sun and katabatic winds from slopes that have lost the sun Steering, which along steep shores is very marked. Refractive bending, that is very likely to affect katabatics flowing from the shore Mountain and valley winds (make local inquiries); see page 36 Thunderstorm winds (downdraught or falling winds)
Wooded shores that are unavoidable and lie in the path of the wind. Also sheds, ships, houses etc which you have to closely approach	Barriers to the wind. These may alter direction but most importantly they cut speed. Tree-lined banks with some gaps in them produce lowest speed at 5 tree heights (h) off. Wind returns to near normal at greater than 20h. Dense woods and close-packed buildings have lowest wind speed close to them. Wind then climbs back to normal value beyond 20h Gaps between dense barriers increase speed and alter direction. Wind across the waterway compressed between barriers must spread out when released and so fans across the waterway

Sailing tactics and comments

Hug the shallows with centreboard well up to catch the odd thermal puffs that are drawn towards a heated shoreline of mudflats or sand and shingle. This is flat-calm sailing. Further offshore there are often complementary sinking jets of air that darken the water with a mirage of non-existent wind

Wind on-shore – tack before you are forced to do so by the shallows
Wind off-shore – hang on right into shore

Wind on-shore – hang on
Wind off-shore – tack off the shore

Look for gaps and valleys down which the wind will come, or up which it must go. Gusts over-ride the topographic steering so gust air will come from somewhere near the gradient direction (the direction the low clouds are moving); when the gust dies the wind will revert to being steered by the terrain

Find on-shore wind along sunlit shore in morning; find off-shore wind along shaded shore in evening (katabatics at this time but not anabatics). For example, if waterway is orientated N–S, cant towards W shore in the forenoon and E shore in the afternoon

Wind will tend to blow along enclosed waterways one way or the other, even when the gradient is at a wide angle to the axis of the waterway. Steering of wind by the terrain is very marked and may be dominant on lakes and rivers set between high ground

In general, winds flow up valleys to mountains by day and from the mountains to the valleys by night

Thunderstorms produce extreme downdraught gusty winds that fall down slopes on to the water below. Very dangerous when they occur

Fit top of thumb (above knuckle) at arm's length to wooded shoreside to judge 20h. Keep this distance off and still have 80 per cent of undisturbed wind speed.
Avoid minimum wind speed at 5h, this distance can be judged by fitting distance between tips of thumb and forefinger of outstretched hand at arm's length to shoreside trees etc. There is more wind close to a shore half-fronted with trees than at 5h

Where gaps between dense barriers occur allow for increase of wind speed by funnelling

Photo 19 It is a warm, rather humid, day. The wind is moderate easterly and the cloud is globular but chaotic. It is the form of cloud called altocumulus floccus caused by instability in the medium layers and therefore often runs ahead of thundery outbreaks. It is the kind of day when the wind quality is the one we have called abnormal.

Weather in the Mediterranean can be dangerously unpredictable. The holiday-brochure view of continuous sunshine and fair winds is not borne out by experience. Admittedly summer tends to that norm but spring and autumn can bring very bad weather indeed.

Depressions move into the western Med mainly through the Strait of Gibraltar and the Gironde Gap, but they are also prone to form in the Gulf of Genoa and move off southeastwards.

Intense thunderstorms, waterspouts and tornadoes, as well as mountain-gap gales, are some of the hazards of the Mediterranean theatre. Furthermore this inland sea is surrounded by mountains and enjoys high temperatures so local winds dominate the area. A summary of the main regional Mediterranean winds is given below (Fig 4). To these must be added very strong sea breezes that can reverse offshore winds of 20kt or more, especially on the North African coast. Such sea breeze effects – especially in the Adriatic – can stem strong to gale force winds like the Bora during the middle of the day, leading to the strongest wind not being in the afternoon but in the morning and evening. Understanding the winds of any particular Mediterranean area is a question of local knowledge and local experience. So consult the locals!

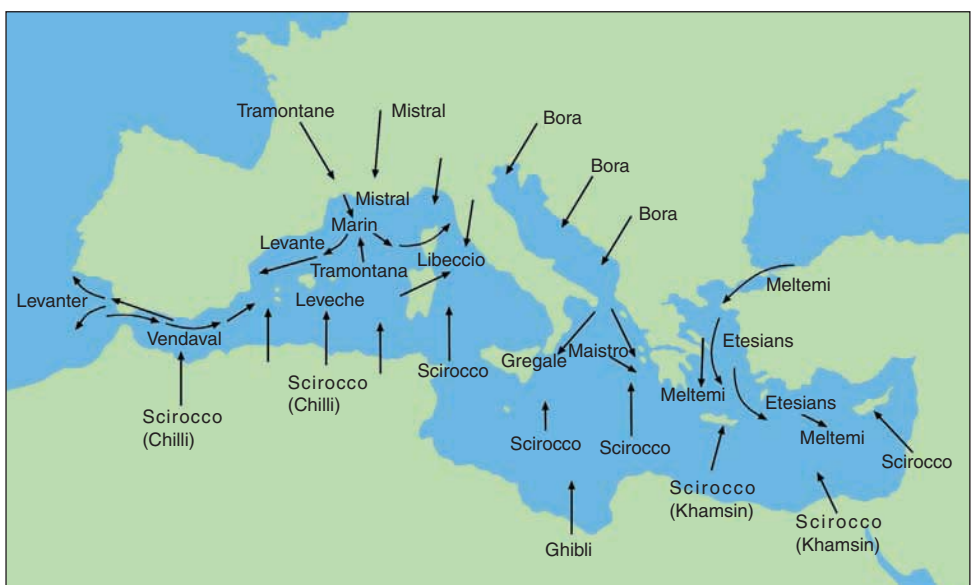


Fig 4

Regional winds of the Mediterranean

Names and regions	*Characteristics*	*Season, place, time etc*
Mistral French Riviera	Cold, dry and often strong. Sometimes vicious squalls. Lasts on average 3½ days, but can be a fortnight or hours	Most likely in March, least likely in October/November. Average number of days between Perpignan and Rhone: 113 per annum at 20–30kt; 31 per annum at 30–40kt
Maestrale Gulf of Genoa	As above with violent gusts in and around ravines	Max speed c 1000 in summer; c 1200 winter. Gale force on 10–15 days per annum on coast
Maestral S France & Spain	Often brings fair or fine weather, Usually no rain, snow etc	As above
Tramontana Ballearics	Showery in autumn and winter. Like maestral, mistral that has lost its bite	As above
Bora North shores of Adriatic	Cold strong NE wind through Trieste Gap and over mountains. Cold and dry like mistral. Gale force gusts appear out of blue. Further down Adriatic, showers and thunderstorms	Most frequent midwinter, least in June. Can be local or extend across whole Mediterranean. Sudden gales. Max speed at 0700–1100hrs and 1800–2200hrs. Minimum speed mid-afternoon
Vardarac Aegean	Cold, strong outflow through Dardanelles and Varder Gap	Mainly cool season. May extend to Matapan and Crete
Tramontana (when N) **Greco/Gregale** (when NE)	Dry and clear, often cloudless	Bora over Apennines; extends across Tyrrhenian Sea to Corsica and Sardinia
Gregale Central Med, Malta, Ionian Sea	Strong NE winds but not cold as heat gained from sea. Weather as for bora	Cool season. Average 1–2 days. Not in July at Malta. Gale on about 2 days a year
Maistro Greek west coast Ionian Sea	N to NE winds otherwise as Gregale	
Etesians Aegean, Rhodes, Turkish coast	Cooling NE winds in north Aegean. N in central and south Aegean. Dry. Good vis, continuous blue sky. Locally gale-force between islands	Start late May, early June as podroms (forerunners). Main etesians set in after couple of weeks. Very regular. Can extend across whole Med

Names and regions	*Characteristics*	*Season, place, time etc*
Meltemi Turkey	Locally gale-force between islands	As etesians
Levante East Spain	Long fetch NE winds onto Spanish coast. Squalls and accompanying bad weather	Mainly autumn to spring when these can be levante gales. Can be extended; bora, then strong to gale with heavy rain
Levanter Strait of Gibraltar	Easterly wind of Strait	All year – strongest in winter. Can blow for 10 days without respite
Vendaval Strait of Gibraltar and Alboran Channel	Westerly (or SW) wind of the Strait. Heavy rain, low cloud, poor vis. Violent squalls and thunderstorms	Mainly cool season. Most frequent October/November and February/ March. Extends to Balearics
Lebeccio Italy and surroundings	W or SW winds of Italian sea areas. Violent squalls and seas off Corsica. Very hot and dry squalls in summer	Common to west of Italy all year. Strong in winter. May extend to Adriatic. Dangerous on Istrian coast
Scirocco Mediterranean	These are winds from desert areas of North Africa. Produce very high humidity at Malta with fog and low cloud. Warm and moist in Gulf of Genoa. Water level may rise 13ft (4m) before scirocco gales at Genoa	Average 5 days a month on N African coast. Temp may rise to over 38°C (100°F). Occasional gale with bad dust storms. Ghibli most frequent in spring. (See Fig 4)
Chili Morroco, Algeria, Tunisia	As above	As above
Khamsin Egypt	As above	As above
Leveche SE Spain	SE to SW dry and dust-laden winds	Mainly late spring and early summer
Marin Gulf of Lions	Warm and moist, much low cloud, rain and poor visibility	Almost as frequent as mistral

Wind quality

The 'quality of the wind' describes how the wind varies as it blows. It always has a mean direction and speed; when the forecast says 'westerly, force 4' it refers only to the mean wind direction and speed. But sailing boats never get a steady wind and to them the mean wind is only useful as a guide. It is the wind's quality that has to be sailed through as it shifts and changes speed. Winds that have quality are either tactical or non-tactical.

Tactical winds must show some form of recurrent pattern so that a measure of anticipation of the shifts can be made by the helmsman. The shifts must also be of sufficient duration in each phase of the pattern to make it advantageous to tack on them. In practice that means a minute or two or more in each phase of the pattern.

Normal wind quality comes from *gust cells* (Fig 5). These are separate entities moving in the wind field and usually capped by Cu clouds. Meteorological considerations lead to a veered (clockwise) shift, and a gust at the head of a gust cell under the leading edge of the capping Cu cloud. As the cloud passes, the veered phase relaxes in speed and backs (anticlockwise shift) until the wind has lulled under the trailing edge of the Cu element. The next gust cell follows the lull with a gust and a veer and the pattern repeats. Gust cells can occur even in dry airstreams where no Cu clouds result, and in fact most airstreams show some aspects of the normal shift pattern. It is, however, at its maximum effectiveness when there are Cu clouds and the wind is about force 3–5.

The gust cell pattern is over-ridden when Cu clouds grow big enough to produce *showers*. Then the wind will back ahead and veer behind the passage of the big Cu or there may be a line of them stretched across the wind. The shift pattern is then of 15–30 minutes duration and each shower has its own shower cell of wind shift below it.

(In the southern hemisphere 'veer' and 'back' are reversed.)

On days when temperature inversions exist and convection is inhibited, an *abnormal shift pattern* is engendered in the wind. The attributes of the abnormal pattern are covered on page 73. The gust cell idea now cannot be used, but the abnormal pattern (as well as having tactical attributes that are the exact opposite of the normal) is high in the scale of variability.

These are the basic tactical wind patterns that can be recognised. Others may exist but recognising them is far more difficult.

Non-tactical airstreams are those in which no recurrent pattern occurs. The largely random shifts have to be met and countered each on its merits and anticipation is largely impossible. Also in this group are the very steady wind streams that include sea breezes and land breezes. An increase in wind speed from moderate to fresh can turn a tactical airstream into a non-tactical one, because the size of the turbulent eddies in the wind begins to swamp the convective eddies that formed the gust cells.

Opposite is a table that gives a scale of variability applicable to shift patterns with which the helmsman has to contend.

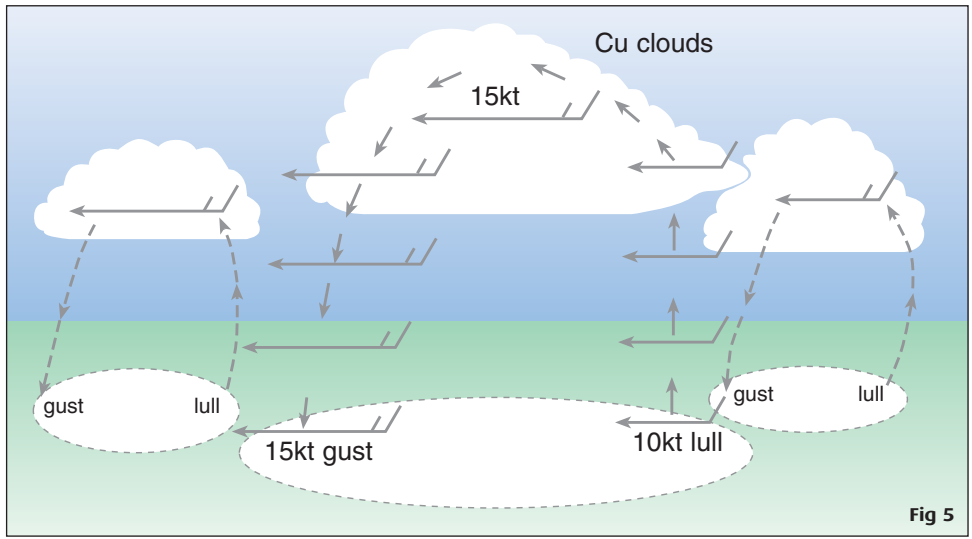


Fig 5

Scale of variability

Variability tends to be maximum **1** in the forenoon and **2** in winds with a land fetch.

Category	*Description*	*Particularly associated with*
High	Shifts are wide, ie possibly 60°–90° between extreme directions. Often abnormal variability (see page 73)	Warmth, mainly clear skies but poor visibility – days with sunshine and islands of upper cloud – sultry conditions ahead of thundery outbreaks – period before onset of sea breezes against the morning wind – E wind directions
Moderate	Shifts are 30–40° or less and often half this at sea with a sea fetch. Usually normal tactical variability	Cool polar airstreams and good visibility – Cu, or Cb and passing showers – sometimes clear skies in a dry airstream – NW wind direction is typical
Low	Shifts are small and usually random in time. Flow may be almost without turbulence in the evening and during the night	Overcast days – continuous rain sometimes mixed with showers (but not showers and bright periods as above) – evenings and nights of settled weather – very early morning before sun can heat land. When sun takes effect expect onset of high or moderate variability – any direction
Random	Shifts are dictated by wind speed and degree of atmospheric stability. Fresh winds can have moderate random variability – scale increases with increasing 'lumpiness' of skyscape	Low overcast and cyclonic weather generally – above moderate winds but wholly cloudy airstreams show random shifts with lighter winds – no sign of 'organisation' in the airstream as occurs with Cu clouds – S or SW wind direction

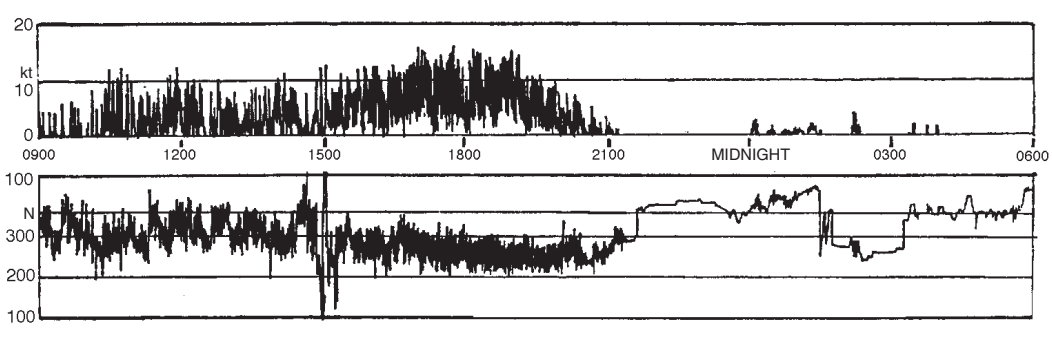


Fig 6 This anemogram shows what may happen to the wind over beachland waters on a day when a sea breeze occurred temporarily late in the afternoon. Through the morning and most of the afternoon the variability is high and the shift pattern is highly abnormal. Then, around 1400 LST, the variability becomes extreme. The latter is very rare and has not been given a category in the table above. After this the variability decreases into the evening but at about 2000 the variability became high for a short while before becoming low until after midnight.

The reaction to a shift pattern of any scale is dictated by the necessity to tack on heading shifts. This technique is applicable in all variable airstreams provided you are prepared to be caught out now and again by turbulent eddies that only last long enough to settle on the new tack and then shift back again, demanding a new tack. The tactical airstreams to be described can be visualised in their variability and therefore some form of prediction is possible. Thus, instead of tacking on ephemeral headers you tack to the phase of the pattern you envisage coming along next.

Photo 20 (page 66) Stratocumulus is a cloud of stable situations and a type under which any gust and lull pattern is very jumbled. There is very little hope of getting into phase with a pattern of shifts unlike the cumulus days illustrated in photos 5 and 13.

Photo 21 (page 67) Closer to the onset of thunderstorms than photo 19, there is more low and medium-level cloud and in the background, through the haze, we see the tops of thunder clouds. The sky still has the chaotic look of photo 19 and the haziness is a normal accompaniment to thundery outbreaks. The wind quality will again be abnormal but under the cumulonimbus there will be heavy and squally gusts.

The normal tactical airstream is one associated with convection currents and thus with Cu clouds. Its tactical attribute is that the wind tends to veer as it gusts and backs when it lulls.

Recognition points	*Typical variability*
Blue skies populated with small Cu clouds; photos 1 and 5 are good examples. Wind is not too strong, ie mean speed of less than 15–18kt is normal. Shift pattern is still there in stronger unstable airstreams but the pattern is not so well marked. Includes days with Ci cloud (photo 9); but not Cu below gathering medium level cloud (photo 8); nor turbulence cloud that looks like Cu (photo 6), when the wind is strong	Moderate – something like a 4min-gust lull sequence. Sharp speed increase when wind gusts accompanied by a veered shift. Wind holds veered direction for 1–2min then shifts progressively to the backed direction with corresponding fall of speed into the lull. (*Note* 4min sequence is typical. It may be 3min or as long as 8min.)
Big Cu clouds whose depth is greater than their base height from the ground (assess using thumb as a yardstick on an isolated cloud some way away) or clouds may be already producing showers. First as in photo 24, later as in photos 26 or 31	Longer period sequence as clouds grow in individual size. Big Cu brings same shift pattern as above, but probably bigger gusts and variability bordering on 'high' when wind less than 12kt. Shower clouds bring a 20–30min shift pattern. The wind often backs ahead of showers and veers behind them. It is rare for showers to come in an even sequence. They come in batches with long, clearer periods between
Cu grow below a higher layer of cloud (see photo 9). Upper layer shows that Cu cannot grow deeply and so little chance of showers	Moderate – the wind speed is usually fairly low, and veer and gust, back and lull pattern when present will be less distinct than when Cu develops in blue sky or under much higher clouds
No low cloud at all. Which can occur when the airstream is too dry to form Cu clouds. Beautiful weather but not a strong tactical airstream	Low – or sometimes moderate to high, but abnormal, shift pattern. It is easy to detect which. When Cu cannot form, the convection currents are inhibited and so is the shift pattern. It is often a poor version of the Cu airstream. Visibility is often poor
Sc, ie a layer of low Cu lumps merged together	Low but usually normal when the Sc layer is permanent. When such a layer breaks up with the sun's heat the pattern may be abnormal (photo 20)

Ignore days with layer clouds (especially at low level), cyclonic skies (see page 20) and any sky where there is no sign of convection currents, ie no cumuliform clouds (heap clouds). These will probably have a shift pattern but it must be assessed on the spot and may well be random, especially under the first form of sky mentioned.

Recognise the shift pattern...	*Tactical action*
1 By wind speed. If now in a lull, a gust must follow. Gusts appear under leading edges of major Cu cloud elements. So look out for Cu clouds arriving overhead. A blue gap means a gust soon and a veer of wind. Wind will be around the mean speed and direction under middle of Cu elements, and will be backed and will lull under the trailing edges and in the blue break behind **2** From reaction of other craft to windward, heeling to a coming gust etc **3** From gust 'splash' marks on the water	When beating go onto starboard tack if practicable in the gust half of the sequence and revert to port when wind backs. Hold port tack into and through the lull, but be ready to resume starboard tack when wind next gusts. You have perhaps 150 seconds of veered wind so waiting for 10–20 seconds to check that the first stab of the gust is not just a turbulent eddy will not lose you much and may gain a great deal. It is less easy to assess when to tack back on to port, but consider doing so after a couple of minutes have elapsed on the starboard tack. (In the southern hemisphere, port and starboard are reversed)
1 By the coming cloud elements. Cu clouds must be deep to produce showers (see photo 26 where depth of cloud is 5 or 6 times the distance base to ground). If big Cu clouds without any showers, expect enhanced pattern as above (photo 24) **2** If these grow into showers then each becomes a wind-making entity in its own right. Expect heavy gusts when shower starts and a backed wind direction; 10–15min of bluster and downpour and then a further period with wind veering and precipitation dying out. Relatively low wind speed in the blue break behind (photo 31)	As above when beating and the clouds are lumpy and large, but not producing showers. Allow for a good plane under the leading edges when off the wind. When running allow for veer in the gust by assuming port tack (gybe?). If big Cb shower cloud prepare to meet a 20–30kt gust under leading edge and expect to have to weather it for at least 5–10min. Remember to reverse the tactical rules above when big showers bring backing winds ahead and veering winds behind them
Much more chance of a mixed up shift pattern with some normal and some abnormal shift sequences. However, look for the individual Cu elements below the upper cloud; there will be a normal pattern of shift with them. Between clouds the shifts are less determinate	Less useful as a tactical airstream and it will probably pay to tack on headers rather than try to divine the shifts to come. If a pattern emerges then use it
By shift pattern. If the direction shifts widely but stays in the phases of its shifts for a period that may be measured in tens of minutes, turn to the next pages, for this is an abnormal shift pattern. If the shift pattern is rather indistinct – if you cannot really see what it is doing – then it is probably normal verging on random	Take it as it comes. Before the start of a race try to get off on your own and sample the shift pattern
By shift pattern. It is difficult to give rules about this type of cloud cover as so many things can affect the surface wind speed and direction	As above

The way the wind shifts in speed and direction from moment to moment can be studied using anemographs. An anemograph is a mechanical or electrical device connected to a wind vane for direction and an anemometer for speed. The resulting charts are called anemograms and Fig 7(a), showing 10 minutes of a brisk northerly, is a good example. It was taken during the middle of the morning on a day when the sky probably looked something like photo 5.

We see that the mean speed was 20kt (top of force 5) but that it was in fact only rarely this speed, spending most of its time below and above it. On one occasion (1058–1059), the wind gusted to 30kt (force 7) but at other times (1056.30s and 1059.70s) it lulled to a mere 12kt (lower side of force 4).

However, looked at by and large there were three distinct phases of speed. Over the first 3 minutes the wind was stronger than average but this was followed by 5 minutes of much less variable lulled wind. Then, after half a minute or so of much gentler wind the speed suddenly gusted up and stayed strong but very variable (1104.30s onward).

Of the two, the direction trace is the most variable, often swinging to NNE and back to NNW. Again we can detect phases when, on the whole, the wind is veered (shifted clockwise) or backed (shifted anticlockwise) to the mean direction. There is a distinctly backed phase over the 2 minutes 1103–1105, and a veering phase from then on. These phases are associated with gust cells generated by the up-and-down currents that have to be there for heap clouds to form. The small variations are due to turbulent eddies in the wind. These are what make the wind vary from second to second.

This veering and backing, gusting and lulling is typical of days with heap clouds and is the normal pattern of variability. On days when there are low layer clouds or at night the wind is much less variable. Typical conditions associated with evening, night and early morning are shown in Fig 7(b). This is a southerly of about 15kt mean speed.

Fig 7(c) illustrates two things referred to in the text. It shows the anemograms of a day when a sea breeze sets in but also illustrates how strangely variable abnormal wind patterns are.

All these anemograms were drawn at Thorney Island which forms part of Chichester Harbour, just east of The Solent. The anemograph was some 3 miles inland from the main coastline of southern England where sea breezes are habitual. The month was June – the time of maximum sea breeze force and so maximum frequency of sea breeze.

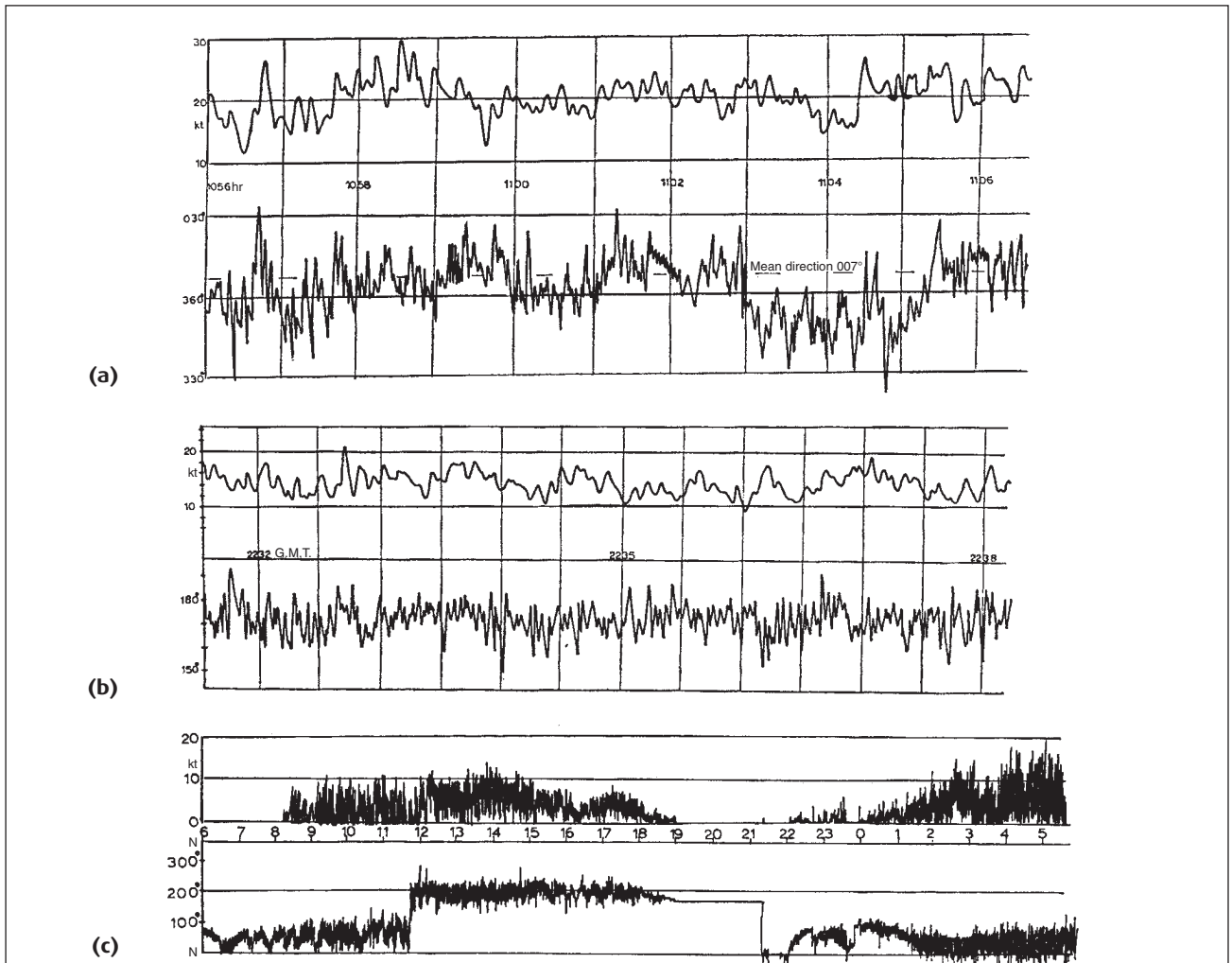
On the direction trace we see the north-easterly wind suddenly swept away just before midday by the southerly sea breeze. The NE wind is abnormally variable going close to N at 0630 and staying there for 20 minutes before gradually shifting over the next hour towards E. Then it more rapidly backs to N again before taking another half hour to shift back to E. This pattern of sharp backs and slow veers is repeated right through the morning until the breeze arrives. It is this strange behaviour that we are calling abnormal. The sea breeze, when it comes, is always less variable than the wind it replaces.

The accompanying speed trace also shows odd behaviour. It often falls to calm for periods measured in tens of minutes before shooting up occasionally to touch 10kt. Again this is typical of abnormal wind behaviour.

We see that on the whole the breeze is stronger than the wind it replaced and is opposed to it in direction – the sea breeze front situation. The breeze then follows the diurnal variation in speed, being maximum at around 1400, before falling to calm in the early evening.

Chichester Harbour is backed by the South Downs and has a well-established nocturnal wind regime. When the nocturnal wind sets in soon after 2100, it again shows abnormal behaviour but there must have been a change in the pressure pattern during this period because the NE wind comes back over night much more vigorously than it had been the previous morning. Otherwise the night wind would have grown to a few knots reaching peak speed soon after midnight and falling away to calm by dawn.

By dissecting the small changes in the wind in this way we learn a great deal about the way it behaves and can then sometimes steal a march on its vagaries through knowledge of what it has done in the past and so may be doing now.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300°
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100°
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Fig 7

Photo 22 Photos 19 and 21 are typical of skies ahead of the kind of thundery outbreak where a front has become unstable and so the storms will have bases a mile or more above the ground. This photo shows the sky just before the storms erupt, crossed by linear waves. The surface wind will usually be from your left as you face the coming bad weather and there can be unpredictable gusts.

The abnormal tactical airstream often occurs on warm summer days when, despite the heat, Cu clouds do not readily develop. We cannot discount them being seen somewhere in the sky but this airstream is likely to look like photos 19, 27 or 28. The cloud is often high and well broken up. It may seem a little thundery and the visibility will not be very good. It will often be warm or hot for the time of year and the wind will not be much above 10–15kt and often less.

Recognition points

Not as easy to recognise as the normal airstream because it is associated with a low, inversion of temperature (at or below 3,000ft (1,000m)). Clouds may often form readily in the lower layers to make it recognisable. It is often associated with skies like that in photo 14.

Mornings of warm sultry days with poor visibility. The wind will not usually be above moderate.

Always consider this type of variability in the morning before or around 0800–0900 LST on sunny or fair days. Also when the inversion re-forms in late afternoon or early evening. Consider it also in the hour or so before a sea breeze front moves in against a wind off the land. It will not always be there but it can be looked for (see page 71)

Typical variability

High to moderate (see page 65). Increase–decrease sequence often 5–8min having corresponding backing with the increase and veering with the decrease. (Compare the normal shift pattern.) An easterly, for example, may spend a minute or more progressively shifting to, say, SE while its speed falls to a low value. It will probably then spend several minutes in this direction before shifting back progressively to, say, NE and increasing in strength to moderate. The whole sequence may last as long as 15–20min but 8min is more typical. A full 90° between phases of the pattern is probably extreme variability and perhaps 60° is more typical. In any case the shifts are so large that they cannot be ignored. It is often a phenomenon of the forenoon before the sun is high.

Before a sea breeze front comes in (see pages 50 and 52) consider that the wind will have phases of, say, 5–10min of back and increase in speed followed by a similar period of veer and decrease. Sometimes, however, the normal shift pattern occurs, ie veer and increase, back and decrease, but the 'spikiness' of the shifts will not be like the gust–lull sequences of the normal airstream. When the sea breeze front has passed inland, expect a random airstream without much variability

Recognise the shift pattern...

By the variability and the changes in wind speed. Also by the kind of day. It is usually not a very 'fresh' day, rather humid and visibility is not at all good. The windspeed may drop almost to zero for minutes on end in some extreme cases. Watch the wind ashore and note how fitful it is. You may have wind from one direction for some minutes, then there suddenly seems to be little or none but a sensitive wind vane or a flag shows that the wind has markedly shifted. Watch on and off for 10min or more if you can. You will then be able to recognise if this is truly an abnormal wind pattern and act accordingly.

Before a sea breeze front. There should be only small amounts of Cu and not necessarily near you when sailing near the coast. When the front does arrive the shift to sea breeze may be prolonged and very frustrating

Tactical action

Think of the wind as two winds, one of which continually replaces the other. The phases of the pattern demand that one tacks to them because their extreme shifts are so wide. It is a kind of 'square-wave' pattern where, despite large shifts measured in seconds that must, if possible, be ignored, one can spend some minutes on starboard tack when the wind is lightest and most veered. Then as the wind inches its way back to the other phase of the pattern, a point is reached where it is essential to tack on to port for the backed, stronger component of the pattern. This is a difficult wind to handle as it is always prompting one to tack on headers because there is such a large variation in 'turbulent' shifts. However, these short period shifts must be largely ignored – reacted to, but not tacked on – and the major parts of the pattern visualised and made the basis of your tactical strategy.

Make the most of the tactical shifts before the sea breeze arrives. Under the sea breeze front expect frustrating puffs and calms. After the sea breeze comes in, forget wind tactics and, if the wind shifts, tack on headers

Photo 23 (page 74) The sky is blue, the wind is light but the puffs of cumulus show there is convection going on. Perfect conditions for the onset of sea breezes. If the wind at the moment is on-shore the sea breeze effect will enhance it as the day progresses, leading to a moderate wind which can be gusty by the afternoon. If the wind is off-shore or side-shore, the breeze, when it comes, will be stable and wind tactics are out.

Photo 24 (page 75) The big, solid, Cu elements can only be formed by strong convection currents. Therefore under them there will be a normal gust-cell pattern of gusts and lulls. Look for a gust under the leading edge of any cloud elements and a lull under the tail. This way you can make use of the pattern. In this picture the open sea lies a mile or two behind us so there may yet be a sea breeze.

Main recognition points: Clear early with normal or below average temperatures for the time of year. Usually sunny and bright. Any higher cloud is usually thin and well scattered. Cu clouds develop in the forenoon over land. They should show no marked vertical development and have flat bases and rounded tops.
Possible dangers: Offshore, moderate morning wind can grow to fresh or even strong by afternoon. Showers might develop with strong gusts. Otherwise a benign airstream.

Sailing venue	*Time (LST)*	*Look and feel of the day*	*Sailing assessment*
Inshore zone with off-shore wind. (coastwise and off-shore variations in columns 7 and 8)	0800–1200	*Early*: clear and often cool for time of year. Good visibility for time of day *Later*: Cu clouds develop over the land and drift over the sea. Or Sc clouds tend to break to Cu as morning progresses. Or higher cloud sheet breaks up with morning, leading to sunny periods when some Cu should appear	A sea breeze morning if wind less than 10–12kt. (See page 50 for mode and times.) Wind will slacken, possibly to calm if less than moderate. If more than moderate expect increase, but some slackening is possible during the middle of the day. As off-shore wind early, slight seaway and expect this to slacken if sea breeze calms set in later.
Inshore zone with sea breeze or off-shore wind	1200–1800	Clear skies and sunshine if sea breeze blows. Cu may be visible inland. If no sea breeze, due to wind strength, then Cu cover at maximum and some sunny periods during afternoon. Good to excellent visibility unless industrial or other smoke sources ashore	If sea breeze has developed, expect steady on-shore breeze for the afternoon. Expect breeze to veer as afternoon progresses. Breeze will slacken towards end of period. Slight seaway at first but growing with duration of sea breeze. When sea breeze still developing in first part of period expect calms and fitful airs. Odd periods of wind from almost any direction. If wind speed has grown during the morning so that no sea breeze occurs, and there are no signs of sea breeze calms, then off-shore wind for rest of day. Small seaway because of short fetch
Inshore zone with calm or off-shore winds	1800–0800	Usually a clear evening. Cu over land may temporarily return to inshore zone but dies out with sunset. Often a clear night with risk of cloud again by dawn. Seaside town lights shining on cloud indicate change in the entirely fair situation. The cloud may be St (ie fog off the ground) that could mean fog on the sea later	Time of very little wind in fair conditions but nocturnal wind should aid passage making by midnight. Expect to lose nocturnal wind by dawn on many coasts. Sea should be slight, visibility good. Be suspicious of any new wind that springs up overnight from new quarter (other than off-shore)

The forecast will say something like: fair or fine with long sunny periods; winds light and variable; sea breezes around coasts; average temperatures; good visibility. Or: mainly fair with sunny intervals; risk of a shower during the afternoon; wind light to moderate; good visibility.

These two forecasts will cover most fair weather days, although wind strength may be higher.

(In southern hemisphere 'veer' and 'back' are reversed.)

Photo 25 (frontispiece) Where sea breezes are habitual, the coastal trees will cant landwards under its influence. This example is on the cliffs near Salcombe in South Devon, England. The sea is a short distance away to the right.

Photo 26 Shower clouds will bring their own wind patterns. We must expect a gust under the leading edge of a big cumulus cloud such as this. There will almost certainly be a wind shift at the same time, but as the cloud and rain pass, we can expect the wind to go back to what it was before the shower struck.

Wind quality	*Expect...*	*Variations for coastwise zone*	*Variations for offshore zone*
Possibly random shifts at first. Becoming normal variability (see page 68) with Cu development. Curious wide, indeterminate shifts as sea breeze develops late in period. If sea breeze sets in then expect steady non-tactical airstream	Sea breeze to continue if it has already set in unless an odd cloud bank, or shower cloud etc comes along. If wind has calmed to fitful patches and Cu is not increasing, then sea breeze should start. If wind still from shore by end of period but slackening in speed, expect sea breeze during afternoon. If wind has increased to moderate or fresh then no sea breeze and present wind should continue	Look and feel of day as for inshore zone. Sea breeze effects can reach limits of this zone when morning wind is very light. Can be late afternoon (if at all) when morning wind is moderate. Assess onset by calms as for inshore. No true sea breeze? Can have shifts and lightening of the existing wind. Most other remarks as for inshore zone	Sea breeze only when morning wind is very light and clear with Cu ashore. Some shift or lightening in mid or late afternoon if wind less than 10kt offshore. Otherwise present wind to continue
If sea breeze has set in then steady non-tactical airstream. If sea breeze still developing (early part of period) then indeterminate shifts. If gradient wind continues from shorewards then normal and perhaps moderate variability	Sea breeze to continue if it is already blowing but to veer and slacken perhaps to calm by end of period. Sea breeze that has produced calming over inshore waters can set in for a short while late in afternoon; then return to off-shore wind. If all the sea breeze forces can do is reduce the speed of a moderate to fresh off-shore wind, then expect increase again with evening	Sea breeze usually does not show up in this zone until middle of period, so wait for signs. If clear skies above and Cu over land expect sea breeze effects to come. Early return to gradient wind further from the shore. Some shift towards off-shore even in moderate to fresh coastwise directed winds. Most remarks for inshore zone refer also to this zone, but sea breeze effects occur later further from the shore	If sea breeze has not shown by 1600 then it probably will not. Possibly some shift to onshore in coastwise directed winds. Otherwise this zone is unaffected by inshore forces
Evening shift patterns are often random although there can be moderate visibility. Overnight shift pattern is muted version of daytime one	Nocturnal wind by midnight if a clear night. If calm, then night wind will only be a few knots from shore. If wind already off-shore then nocturnal wind adds to offshore gradient wind and can become moderate or more. Expect slackening of wind by dawn but some pick-up as sun rises appreciably	Calm evenings may see nocturnal wind reaching this zone. If gradient already returned to off-shore direction, expect increase with the night. Possibly more fitful gusts by dawn	Most unlikely to be any coastal influences

Photo 27 More organised than the pre-thunder cloud of photo 19, these lines of altocumulus show the air at their level is unstable. The lines of Ac with their turreted tops are for obvious reasons called altocumulus castellanus while at the top of the picture is the woolly-sheep-like altocumulus floccus. These clouds lie along the wind direction at their level and if that wind comes from the left of the surface wind then we can expect thunderstorms to break out some time later.

A day of showers and bright periods with variable wind and squally gusts.

Main recognition points: Cool and clear early; rapidly developing Cu clouds that can grow to the dimensions of those in photo 26 with showers. Wind often NW; force 3–6.

Possible dangers: Moderate morning wind grows to fresh or even strong by afternoon. Intense gusts and showers. Occasional thunder.

Sailing venue	*Time (LST)*	*Look and feel of day*	*Sailing assessment*
Coastwise and inshore with off-shore wind	0800–0900	Cool and clear early. Ragged Cu that develops early denotes possible showers later. Often permanent wind shifts when nocturnal wind influence wanes and, later, when land inversion layer breaks. Good visibility for time of day	Variable wind from early morning, possibly widely variable. May already need to sit out and so expect hard sailing later. Consider shifts due to shoreside topography. Do cliffs extend wind shadow to your position? Shoreside refraction?
ditto	1000–1200	Day remains cool out of the sun. Cloud amount increasing in lower layers. Wind speed increasing	Often moderate wind so wind and sea will make for a wet sail in dinghies. The seaway may make it difficult to recognise considerable wind shifts that can occur. Expect big gusts and perhaps a wetting as Cu clouds build into showers
ditto	1300–1700	Often fresh with gusts to 25–30kt. This is time of maximum wind speed but least variation in direction. However, showers will produce their own regime of variation. Some risk of isolated thunderstorms (photo 32)	Times of hardest sailing. Long dinghies will continually plane, short dinghies will frequently plane especially in gusts. There will be many capsizes in the gusty conditions. Allow for downdraught winds if there are showers over steeply sloping shores
ditto	1800–sunset	Coolish evening. Some lowering of visibility but no marked fall. Shower and other low clouds tend to reduce in size and form, Sc eventually dying out altogether. There can be Cu with silver linings against the setting sun	A calming of the wind and a steadying of the gust–lull sequence lead to more displacement sailing for dinghies. It is unusual to have good planing conditions in the evening. Tendency to establish abnormal wind shift pattern comes with establishment of inversion over the land
Coastwise and inshore with off-shore wind	Night Sunset to dawn	Clear skies, stars bright like jewels. Little seaway and a restful land wind without much variation. Later (towards dawn) possible showers over coastwise waters. Very often an increase in ragged Cu even if no showers develop	Very rarely a time for dinghies to be out. Coastal passage makers seek inshore zone if prudent as max nocturnal wind there. Wind should be perhaps force 2–3, sometimes 4, but stronger night winds from the shore should be treated with suspicion. Increasing gradient wind?
Offshore or coastwise with on-shore wind	Day or night	Much heap cloud with smaller ragged Cu between. Major passing showers. Cool, often blustery. Good to excellent visibility	Least wind behind showers, most under cloud leading edges and in precipitation
Inshore with on-shore wind	1000–1700	Cool airstream with much heap cloud and occasional showers. Good visibility	Seaway at maximum for the conditions because of long sea fetch. Major cloud elements tell when shift pattern is imminent

Land Area Forecast will probably say something like: Fair or fine early, becoming showery later; some showers may be heavy. In severe cases it may mention thunder although that does not mean a thunderstorm, just an occasional clap with a passing squally shower. Showers will die out overnight.

Sea Area Forecast can either mention continuous showers (no change with day or night) or no showers.

Photo 28 The onset of high cirrus clouds often means a deteriorating weather situation. However, some forms are more prognostic of coming bad weather than others. These sheaves, though spectacular, may or may not mean anything because, while the main elements are in line – a sign of coming trouble – there are other streaks in different directions. So you need to keep an eye on the situation.

Wind quality	*Diurnal variation*	*Expect*	*Remarks*
Abnormal pattern possible at first, reverting to normal gust-cell pattern as sun is higher	Time of lowest speed of the day but must increase	If wind already moderate then it will increase. If less than moderate, consider sea breeze influence	This is the low speed time. Conditions will deteriorate
Early forenoon may be abnormally variable. Should become normally variable as Cu clouds build and develop into respectably-sized elements. Shower cells later	Time of increasing speed and variability at first. Lowered variability later	Gradient wind to be established by this time. If wind more than moderate at beginning of period then little change in direction. If moderate or less, expect some slackening and shift due to sea breeze. Showers can sweep away sea breeze 'calms' and re-establish gradient wind	This is the time of day and these the zones where sea breeze influence will be most marked. A full sea breeze may not be established, but a sea breeze shift of some magnitude can occur
Gust cells with least directional but maximum speed variations. Shower cells with maximum intensity. May revert to abnormal pattern by end of period	Time of max wind speed. Time of max showers and strongest gusts. Time of min variation in direction, except when close to windward shores	Continuation of early afternoon conditions during the period up to 1700–1800 LST but shower frequency decreasing towards evening. Increasing direction variation towards end of period	The wind can be relied on to maintain its established pattern in the afternoon. There are exceptions but they are rare
Normal gust cells of afternoon tend to change to indeterminate shifts or abnormal pattern. Some tendency towards laminar flow	Time of strongest calming influences on the wind. Gust–lull sequence muted. Shower cells should have died out by end of period	Calming period to continue through the evening and after dusk, but if wind continues to blow from the land nocturnal wind will reinforce it. So expect increase of wind from the land with the night	This is a period when coastal waters are likely to have indeterminate shifts and very light periods
Quality will depend on airstream and not on any other factor. Wind may be gusty in the afternoon and will become more turbulent with the day	Little change in type except for possible wind increase. Some change of direction near to the beach	Coastal effects will not extend this far out when wind is on-shore	No effects. Wind should be dictated by the pressure pattern, ie should be gradient wind
Wind quality is that of sea. If air cooler than sea then normal, but low variability, see page 65. If air warmer than sea, variability could be abnormal	No great change with the night except for effects mentioned under column 3	The effect of nocturnal wind influence against light on-shore evening winds is unlikely to extend very far into this zone	No effects worth mentioning

Photo 29 The sun goes down behind an advancing veil of cirrus and cirrostratus (ice-crystal clouds); the vapour trails are dense and persistent; the last vestiges of the day's cumulus disperse. There is a front on the way so you must expect more wind and probably rain or drizzle during the night and maybe into tomorrow.

Main recognition points: Because temperate latitude sea temperature cannot be excessive, a hot or warm airstream must have an origin in the sub-tropics. Thus, expect layers of cloud together with sunshine, poor visibility or sea fog.

Thunderstorms formed over a land mass can move over the sea, but few storms originate over the water.

Typical morning situation 0800–1000 LST	*Ways of recognising change*	*Wind changes to expect*
Warm and humid. Poor visibility and often fog on coasts if not at sea. Wind from a warm quarter (usually a southern quadrant), typically moderate or less. Deck heads and deck hands may sweat	Signs of change are wrought in higher clouds. Clouds of the high or medium levels, as in photos 21 or 27, must move from hot land mass and obey the rule that they come from left of the surface wind* direction, eg East coast of US: medium level clouds from W over warm southerly. English Channel: medium level clouds from S over warm easterly. Such orientations breed thunder. Be suspicious of backing and increasing wind in sultry conditions (*right of surface wind in southern hemisphere)	If it remains sunny, or if there are sunny periods over the land, allow for a sluggish sea breeze (inshore and coastwise but perhaps not the latter) that may not start until afternoon. If thundery-type cloud thickens then surface wind will usually increase and perhaps back a little. When thunder heard, storms within 10 miles. When sky like photo 21 or 22, then allow immediately for gusts to 30–40kt (possibly more), torrential rain and hail etc. Storms ashore draw in air from seaward + sea breeze? = moderate or more, on-shore wind. Most intense storms move up against a wind they are sucking into themselves. So wind that sluggishly shifts towards coming bad storm means intense thunder squalls later *from* the direction of storm
Typical situation dusk to midnight	*Ways of recognising change*	*Wind changes to expect*
Depends on events of the day. **1** No storms and no sea breeze: probably remaining warm and humid, and keeping gradient wind **2** Visibility still poor: St cloud may form over adjacent sea. Always risk of fog; avoid shipping lanes **3** Sea breeze by day (inshore and coastwise, or maybe only the former): evening coastal calms or very light wind from any quarter not offshore, can become nocturnal wind **4** Storms that have now stopped or receded: cooler, gradient that may be locally bent by storms. Often considerable cloud in medium and high layers. However, St is possible as a formless sheet of foggy cloud, possibly only a few hundred feet off the deck	Difficult to recognise signs of change at night. Remarks above apply to night as well but coastal thunderstorms are usually phenomena that die with the night. Lightning and thunder heard: storms within 10 miles. 'Summer lightning' (no thunder heard) storms more than 10 miles away. Storms come from direction in which medium level clouds move. (As, Ac drifting across moon?) Over adjacent coast? Could well die over sea unless upper storms (lots of cloud-top lightning strokes). Nocturnal wind can generate coastal showers and storms late in the night with attendant gusts	If light evening wind (or calm) then nocturnal wind, but not if St forms over the land (watch for coastal town lights loomed on low clouds). However, wind after inland storms often comes from shorewards and may look like nocturnal wind. Consider return to gradient direction (forecast?) later in night. If storms persist over local sea area consider wind changes as above

The forecast will probably say something like: Mainly fair, thunderstorms (or risk of them) later (usually afternoon or evening), visibility poor, sea fog, wind light to moderate at first, becoming fresh for a time later.

Photo 30 It is fair over the coast now but what is that brewing out over the sea? They look like shower clouds but note how the cloud elements do not have much substance. It is likely that these heap clouds will stay at sea because they probably only exist above a warm tidal stream and will come to nothing. If you are sailing under them, expect some variable winds.

Expect later...	*Remarks*
If no storms develop, existing gradient wind should continue into evening and night. If no storms, and a sea breeze develops, then expect light evening in-shore wind or even calm, when visibility will be very poor. If storms ride in across the surface wind direction, after they have passed expect wind from same direction. If intense storm comes towards its wind, expect light to moderate wind in rear, to come from left of line of advance of storm. Very sluggish nocturnal wind in light, fair, night conditions	Storms are of two kinds. Surface storms bend surface wind to themselves and move towards their own wind. Upper storms occur along fronts and usually move across the surface wind. Later such storms may descend to near the surface. Waterspouts occur in association with intense thundery activity as do tornado storm spouts, but where and when they occur cannot be predicted. They are more likely off Florida and the Gulf States than further north. Waterspouts are mainly whirlwinds of vapour but tornado spouts could swamp a cockpit, even if the intense winds – up to 200kt – could be countered. Luckily it is very rare for a yacht to meet such conditions. Hurricanes are not included here. Unnatural warmth and skies that look thundery precede them, but only the hurricane warning service can give precise information. Besides, hurricanes and yachts do not mix!
Passage of a thundery trough leaves a new wind situation. Expect tomorrow's wind to be veered on today's when upper storms pass. Can still be warm with low visibility. Surface storms produce new cooler conditions tomorrow (forecast?). If cooler airstream, then probably a Cu day (see page 76) with gradient from a direction veered to today's direction	The wind tomorrow can hardly be the same as today if thunderstorms occur widely. Upper storms are formed on warm fronts and winds veer when they pass. Surface storms that form in lines across the wind are usually on cold fronts and winds again veer when they pass. A thundery occluded front can have appearance of both kinds without respite. Tomorrow must then be cooler with probably a return to good visibility and fleets of Cu. Persistent warm days without storms do occur and then gradient wind can be modified by nocturnal wind at night unless gradient too strong. No storms, despite heat, means anticyclonic tendency

Photo 31 A line of heavy heap clouds approaches, accompanied by some wild-looking cirrus above. This is a (possibly thundery) trough, ahead of which the wind will back and increase, and then, when the blustery showers have passed, most likely revert to the direction it had before the trough struck. Such troughs typically pass in half an hour to an hour. However, sometimes the coming mass of cloud is the leading edge of a cold front with possible squalls.

Main recognition points: Mainly fair, anticyclonic weather now and in immediate past. Upper sky beginning to cloud over – usually from a westerly point. Wind showing signs of backing towards a more southerly point.

Possible dangers: Increasing wind in the next 6–12hrs – possibly a sharp blow. Chance of squalls later and bad weather generally.

Sailing venue	*Previous history*	*Weather now*	*Sailing assessment*
Main coastline facing S or SE. Wind now SW to NW	A period of fair weather with Cu clouds by day and clear skies at night (photo 14 or 8). Not much high cloud before, but more has encroached in recent past. Wind typically W or NW moderate or less. Has begun to back towards SW or S or shows tendency to do so (photo 9)	Ci invading upper sky. Cu, if any, beginning to shred and die out. Often very good or exceptional visibility. Wind should have backed somewhat, perhaps now SW to S and some signs of increasing speed	Easy conditions, with a small seaway due to land fetch, can change to difficult conditions with growing seaway as wind develops sea fetch and increases. (For wave height estimate (see page 17)
Same as above but coast faces E or NE	As above	As above	Unless wind backs to SE (east-facing coast), waters will be sheltered and above remarks about land fetch apply. If wind does back off the sea, then above remarks on sea fetch apply to E coast
Same as above but coast faces W or SW	As above	As above	Present on-shore wind (often with Cu clouds and sometimes with showers) will remain onshore as wind backs, so expect sea conditions to become more lumpy. Allow for cross sea as new wind direction generates waves
Same as above but coast faces NW to W	As above	As above	On-shore wind (if any) will soon go offshore and may temporarily fall lighter. Present seaway will be replaced by less lumpy one and it can be quite smooth inshore at first

Forecast will probably say something like: Mainly fair at first but becoming cloudy later; rain probably spreading during the outlook period; winds light to moderate at first but backing southerly later and increasing to fresh. (This page only refers to changes in the period when the sky is first clouding over. See pages 26 and 30 for later.)

Wind quality	*Diurnal variation*	*Expect*	*Tomorrow*	*Remarks*
Moderate, usually normal variability at first under Cu. Becoming rather random as upper cloud cuts off sun's heat. However, may still have considerable shifts in it. As wind swings from off the sea, any normal variability will be lower in the scale. Yet increasing wind will bring larger, random, turbulent eddies	As described on pages 41 and 48 when wind off the land. No noticeable variation when wind comes off the sea (unless another coast is not more than 50 miles distant)	More cloud. Frontal weather. Wind to increase from southerly direction. Rain later	Only the forecast can help here. The most likely event is showers but it could be foggy, or low cloud and muggy warmth. It depends how fast the weather moves	If clouds increase but wind stays doggedly where it is, then usually not much change
Under influence of land, winds should remain variable but become more random in shift pattern as the sky clouds over	Usual variation when day only partly cloudy but this can be over-ridden by winds of the low	As above	As above	
Normal variability if Cu or Cb off the sea. Random turbulence of fairly low variability if wind off the sea, under full cloud cover and with increasing wind. If abnormal variability, see page 73 (this applies to above cases as well), then allow for a thundery trough or gusty heavy showers later	Should be little or none	As above	As above	
Often Cu or Cb off the sea at first, so normal variability. As wind backs Cu will die out and shift pattern will become indeterminate	Daytime turbulence and convection currents when the wind comes off the land. If shift spans the evening period then wind will be very slow to pick up and can be quite light at first	As above	As above, but if warm air tomorrow then wind will probably be off the land or parallel to it. If showers, today's wind pattern can be repeated, although probably more virile than today	

Main recognition points: Clear early with normal or below-average temperatures for the time of year. Often a sunny and bright morning with little low cloud; what there is may be mist patches lifting out of hollows etc. Any higher cloud is usually thin and well broken. Cu clouds develop in the forenoon but not too early, ie after 0800–0900 LST. Often rapid development later, see photo 13. Visibility good.

Sailing venue	*Time (LST)*	*Look and feel of the day*	*Sailing assessment*
Beachland zone with off-shore wind Coastal and inland zone variations in columns 7 and 8	0800–1200	Early: Clear and often cool; good visibility; occasional mist patches that quickly clear. Later: Cu clouds develop, first over slopes in the sun; may remain individual on best days, or flatten and spread into Sc layer, which often thins later. High cloud sheets tend to break as morning progresses	A sea breeze morning if wind less than 4–6kt at about 0800–0900. See pages 48–49 for mode and times. Expect wind to slacken – calm patches by mid-morning ahead of sea breeze shift. If wind 5–9kt at 0800–0900 expect a sea breeze afternoon. Wind shift or wind 10–15kt: sea breeze slackening the gradient wind around middle of the day is only likely possibility (except in lower latitudes). More than 15kt no great change with the day
Beachland zone with sea breeze or off-shore wind	1200–1800	If sea breeze blows then usually clear skies to seaward of sea breeze front. Cooling, steady sea wind. If sea breeze front in vicinity then heavy Cu clouds and odd wind shifts (photo 17). Local haze. If moderate or more offshore wind then usually Cu fleets or Sc layer and warm. Moderate visibility	If sea breeze has developed, then steady, but often slowly veering wind for the afternoon. Tendency to slacken towards coastal calms by end of period. Morning wind of 5–9kt often yields in afternoon to onset of sea breeze. Short duration with possibility of return to off-shore wind at first sign of sea breeze slackening. Odd wind shifts before onset. Moderate to fresh off-shore wind may be shifted if good day, but no true sea breeze
Beachland zone with light winds or calm or off-shore wind	1800–0800	Usually a clear if hazy evening. Any low cloud dies out. Often a clear night with bright stars. Any low cloud at evening or early night may mean trouble	After sea breeze day, evening is typically calm, or light winds. Nocturnal wind is likely by midnight, see page 56. Gradient wind (above sea breeze by day) may come from new quarter at evening and be the wind for the night. A depression encroaching? See page 20
Beachland zone with on-shore winds	Dawn to dusk	Cool morning early and often ragged sea Cu that becomes Sc over land. If cloud cover early allow for its breaking later with sun's heat. If clear early, sun's heat can generate cloud later	Early morning wind is gradient (cannot be nocturnal wind because of direction). If broken skies then sea breeze adds to wind strength. Strongest mid-afternoon, lessening with evening. Wind direction can be shifted by effect of strong sea breeze to be more directly onshore. Allow for a gusty blow in afternoon if early wind is gentle to moderate. If more, think about safety later in day
Beachland zone with on-shore winds	Dusk to dawn	Cloud from the sea at dusk likely to remain for night. However, the airstream should either be Cu from the sea or clear. If nocturnal wind blows then usually clear of low cloud over land, but much ragged Cu or Cb over inshore and coastwise zones	Wind from the sea at night can have entirely different feel to wind off land – more like daytime wind. Allow for gusts and eddies. If above 7–10kt unlikely to change. However, nocturnal wind effect can reduce or reverse light on-shore night winds. Calms between phases of the shifts

The forecast will say something like: Fair or fine with long sunny periods; winds light and variable; sea breezes around coasts; average temperatures. Or: Mainly fair with sunny intervals; risk of a shower during the afternoon; wind light to moderate to fresh. It may mention lifted fog patches in the morning. Otherwise good visibility.

Photo 32 Sometimes thunderstorm clouds can build in quite strong winds. Here we see the anvil of a major storm spreading out over a sea whipped into big waves by a force 5–6 wind. The strongest gust wind will be under the rain-stalk on the right of the picture.

Wind quality	*Expect...*	*Variations for coastal*	*Variations for inland*
Early: often random shifts. When Cu develops: normal shift pattern, see page 68. Before sea breeze front arrives often abnormal for a time, see page. 73. Wide shifts in vicinity of the front but can pass rapidly and wind from landward suddenly becomes wind from seaward, see pages 45–49. Sea breeze current is usually non tactical	Sea breeze to continue if already set in, unless odd-looking cloud banks, showers, overcast come along. If wind still offshore by end of period, but slackening, sea breeze may be imminent. If wind still offshore by end of period but increasing, then little breeze. Max sea breeze force mid afternoon, so possibly some shift later	Sea breeze frequently does not reach this zone before 1200. Often morning of mixed wind patterns that may increase. Expect afternoon sea breeze, especially beyond a range of coastal hills. If wind greater than 10–15kt and no depth in the Cu then probably no breeze	As coastal, but sea breeze effects come correspondingly later, if at all. Therefore unlikely to have sea breeze in this zone in this period
Normal: when Cu and offshore wind persist. Abnormal: when late sea breeze front hovers. Odd shifts: when sea breeze front virtually overhead, calms and fitful shifts. Non-tactical sea breeze current when latter established	Early part of period: if no sea breeze yet but other conditions are right, look for sea breeze front, see page 52. Sea breeze front in middle of afternoon leads to odd calms and curious shifts in beachland and nearer coastal zones. If moderate–fresh then expect diurnal loss of speed with evening. There is often a shift of direction at this time	Time for sea breeze to invade coastal region and blow through it in early period. (For times etc see page 52.) When morning wind 6–8kt sea breeze front can hover in this zone	Time for sea breeze to appear inland. (For times etc see page 52.) When morning wind 6–8kt sea breeze front can hover in this zone. Only best sea breeze days find front 30–40 miles inland by end of period
Sea breeze non-tactical stream falters and dies. Odd shifts as evening wind takes over but then indeterminate shift pattern. Nocturnal wind will be steady and surface-hugging. Shoreside shift pattern dictated by topography	Light airs evening following sea breeze day. Increase in high cloud with filaments in many directions means fair weather tomorrow. Filaments and banners in one direction means likely deterioration (see pages 26 and 27)	Sea breeze can continue to blow lightly until dusk. If not, almost or total calm. If sea breeze swept away by another wind, that often will be the wind for the night	Best sea breeze days find front advancing inland until about 2100–2200. Evening calms. Nocturnal wind usually only in seaward side of this zone
Quality in this zone depends on nature of airstream and not land mass. However, there will be normal variability with Cu airstreams from the sea, but land heating produces random gusts and turbulent eddies	Often little change in wind type except for diurnal variation. Approaching night should have similar wind direction. However, consult forecast for likely changes	Remarks in column 4 apply to coastal zone as well as beachland	Similar to beachland zone
Nocturnal wind from the sea can have normal variability made more noticeable by being largely devoid of turbulent eddies	Light evening on-shore wind can be nullified by nocturnal wind, but allow for return to onshore by dawn	Similar to beachland zone	Similar to beachland zone

Photo 33 One summer Sunday afternoon, an intense thunderstorm front moved across the English Channel from France. There were sudden gusts of such intensity that almost every dinghy sailing off the coast of southeast England capsized. This is the threatening cloud that came just ahead of that outbreak and should be compared with photos 22 and 23.

A day of showers and bright periods with variable wind and squally gusts.
Main recognition points: Cool and clear early; rapidly developing Cu that can grow to the proportions shown in photo 24 by late morning or afternoon with showers. Typical wind NW force 3–5.

Possible dangers: Mean wind speed doubles in heavier gusts, especially when associated with showers. Many capsizes on sheltered waters as gusts ignore shoreside hamper. Occasional thunder.

Sailing venue	*Time of day (LST)*	*Look and feel of the day*	*Sailing assessment*
Beachland and coastal with off-shore wind. *Note:* Apart from sea breeze effects, most of the information applies also to inland venues	Early forenoon 0800–0900	Cool and clear early. Some mist pockets may exist and clear as foggy cloud that converts to Cu. Ragged Cu early denotes showers later. Early morning wind often seems quite strong. Usually good visibility. Not much high cloud	Variable wind from early morning. Anticipate permanent wind shifts: 1 when overnight off-shore wind influence wanes; 2 when sun breaks the overnight inversion layer; 3 when sea breeze influence increases
As above	Forenoon 1000–1200	Day warms up in the sun, but remains cool in the shade. Cu cloud cover increases but should remain broken for showers to follow. If Cu spreads to cover whole sky then no showers and diminished gusts	Can expect to get wet from both rain and spray. If showers occur then allow for big gusts as they strike. If wind less than moderate, anticipate sea breeze slowing the wind and perhaps a marked sea breeze shift. Showers will sweep away such influences
As above	Afternoon 1300–1700	Showery airstreams usually make force 4–5 by afternoon. There should be blue breaks between showers. However, minor troughs produce extended showers sometimes preceded and succeeded by clearer weather. Risk of thunderstorms but these should be isolated and passing	Often tough sailing. Gusts at maximum but possibly not as noticeable as morning gusts because afternoon mean speed higher. Expect capsizes in dinghies. Allow for wind increase (see page 12) on leaving harbour. Days when showers die out early, or form late, can allow sea breeze effects
Beachland and coastal with off-shore wind	Evening 1800–sunset	Showers die out but thunderstorms can continue. Usually clearing skies. Wind speed falls rapidly. Gusts die. Some fall of visibility but not marked	Wind can fall very dramatically in speed and shift direction somewhat. If showery morning and sea breeze afternoon, anticipate evening calm on sheltered waterways
As above	Night Sunset to dawn	Clear skies; bright stars; cool night especially on the water (see page 56)	If calm after sunset allow for nocturnal wind. Leaving harbour with gentle to moderate wind expect increase when clear of land
Beachland and coastal with on-shore wind	Forenoon and afternoon	Airstream must be cooler than the sea for showers to form. Thus seaborne showers most likely in beachland zone on coasts with a northerly aspect. In coastal and inland zones showers can form over the land even though none over the sea. Visibility good apart from showers	There are many possibilities. Wet, cool, showery air off the sea is uncomfortable for sailing. Usually a lot of cloud whose amount varies only with state of the airstream and nothing else. Further inland on rivers, reservoirs etc gusty showers or much Cu with moderate variability
As above	Evening and night	No diurnal variation in on-shore showery airstreams, so showers continue through the night. Generally cool and wind does not appreciably decrease in evening. Showers may even enhance over beachland before dawn	Allow for sometimes invisible showers and their gusts. No showers now does not mean that the night will be wholly dry. If leaving sheltered harbour or estuary allow for wind increase and gusts

Land Area Forecast will probably be something like: Fair or fine becoming showery later; showers may be heavy (in severe cases they can mention risk of thunder), showers will die out overnight. (Excludes coasts with on-shore winds where showers can continue throughout the night.)

Despite forecast, if no showers materialise in your area then you may be in a shower shadow (in lee of hills) or the air aloft subsides as a whole and prevents the showers building. The latter may mean rain later if cloud increases aloft, or fair weather if upper sky remains mainly blue.

Photo 34 We are close enough here to the edge of a thunderstorm to be in imminent danger of a sudden blast of cold air from the direction of the storm; this is most likely to be found in the roll-cloud on the left.

Wind quality	*Expect...*	*Remarks*
Abnormal pattern (see page 73), possible at first reverting to normal pattern (see page 68) as sun rises higher. For variation with time of day see Diurnal variation on page 42	Wind strength increases, usually marked when Cu forms – it may not have formed at this early time. When Cu does form expect wind to shift closer to gradient (forecast?) direction	This is the characteristic weather immediately behind a depression. It may go on for days or revert quickly to fair (with risk of another depression)
Can still be abnormal if sun has not broken overnight inversion layer. However, this airstream will have normal variability on most occasions. Normal pattern as soon as Cu clouds develop	Formation of Cu shows convection currents that bring the gradient wind to the surface. Bright mornings without too much Cu or Cb cloud can induce sea breeze-slackening of wind near the coastline. If wind is 8–10kt or less from the land, sea breeze can occur over beachland, but any showers will normally re-establish gradient wind	If the airstream that ought to be showery is not and there are no signs of large Cb clouds, and if wind is less than 10kt then see page 53. If more, this page applies
Under Cu: gust cells with least direction variations but maximum speed variations. Under Cb (showers): shower cells with maximum intensity. Spring and autumn: expect a return to abnormal variability by end of period	Continuation of early afternoon conditions with wind increase to maximum at mid afternoon. Then a general slow decrease in speed with a marked slowing by end of period. If wind does not fall with onset of evening then expect increasing gradient wind	Beachland and seaward side of coastal zone are liable to have sea breeze shifts in this period even though conditions seem to be biased against them
Normal gust cells of afternoon tend to change to indeterminate or abnormal shift pattern. Tendency to laminar flow in creeks with extensive mudflats at low water	This is the period when the wind mutes most strongly. Fall in speed with clear skies may be enough to make later increase due to nocturnal wind effects quite evident. However, such effects occur in next period unless strong katabatics from shoreside slopes are present	There ought to be gradient wind from the land during this period but sometimes there are calms or indeterminate shifts in these zones
Light winds will have indeterminate variability. Stronger winds can carry on an undulating gust-lull pattern	If gradient has continued from land in previous period expect wind to continue for most of the night. Greatest chance of no wind is at about dawn. Allow for katabatics from local slopes close to the coastline	Moonlight sailing is not usual for dinghies, but cruisers may need this night information
Gusty shifts will be normal, but variability will be fairly low. Showers enhance gust speeds but should bring veered direction in northern hemisphere (backed in southern hemisphere)	Showers to continue through the day, but if they do not, look for signs of developing higher clouds – depression encroaching? Other possibilities include the subsiding air in developing anticyclonic weather that damps out showers. Low wind speed (6–12kt) and coastal hills can induce big showers and sometimes thunderstorms	Many on-shore weather regimes are possible, eg clear over the sea – cloud builds over the land. Sea breeze effects can make coastal belts cloud-free even with on-shore winds
At night variability is relatively high and gusts associated with showers (and sometimes even without showers) continue. However, nocturnal wind influences act against the on-shore wind, so allow for reduced speed and more stable conditions after midnight	Showers in the evening to continue through the night, possibly with breaks but enhanced at times. With evening, wind of less than 10kt slackens in middle of night. Possible pick up by morning but further inland wind will have night-time lulling usually experienced overland	On-shore night winds can produce many different effects over the land. Only a few can be covered and here we have concentrated on the airstream which develops showers over the sea and sweeps them inland

Photo 35 Inland waters surrounded by steep slopes and occupying valleys, as here, will have their own local winds. The wind will be steered along the length of the lake or reservoir, and gusts, which we can just see rippling the water on the right, will be very prevalent and often unpredictable. You are likely to have cloud cover.

Main recognition points: History of heat and perhaps an extended spell of fine weather that has now grown overhot and humid. Much more cloud aloft than hitherto. Poorish visibility – heat haze. Wind may come from an unusual quarter, eg E when prevailing winds are westerly or from some other quarter, such as S or SW when weather oppressive.

Typical morning situation, 0800–1200	*Ways of recognising change*	*Wind changes to expect*
Warm or close, often with little wind at first. Cloud, as in photo 27, drifting in on high or medium level winds. Usually not much low cloud in early part of day. Hazy or poor visibility. There may be fog on the coast itself	If upper cloud moves from left* of gradient wind, anticipate thundery rain or thunderstorms by late afternoon if not before. A likely pattern is that medium level cloud will diminish during the middle of the day and then new forms will increase to wholly overcast. Allow for the surface wind being sea breeze, when the rule above will not apply. * 'Right' in southern hemisphere	Sea breeze? (See pages 45 on.) If moderate or fresh, expect gradient to persist with some backing. If wind backs as cloud increases, expect deterioration. Wind increasing into the afternoon. If thundery rain or thunderstorms arrive, expect intermittent gusts. Gusts can become very strong (30–50kt) when sky grows to look like photo 22. When storm line passes expect cooler, moderate or fresh wind from direction in which medium clouds were drifting this morning
As above	If gradient wind blows more or less parallel to direction in which upper cloud moves – the cloud form tends to set in lines along the wind at its level – then, although there may be changes in the amount of cloud, no great weather changes should occur. (Applies to southern hemisphere without change)	More chance of sea breeze as cloud tends to decrease. When wind is moderate or fresh expect persistence of morning pattern through the day. However, should the surface wind back*, it can bring the above deteriorating situation. * 'Veer' in southern hemisphere
History of frontal cloud now breaking and decreasing. Now somewhat cooler than of late. Sky may resemble photo 9. This applies when the clearance occurs at any time of the forenoon or early afternoon	If upper cloud comes from the right* of the gradient wind direction, cloudiness should decrease. Cu clouds should develop but remain relatively small at first * 'Left' in southern hemisphere	Sea breeze is more probable as both sunshine and Cu development aid sea breeze. If moderate or fresh, wind should have veered* or be veering soon to a new permanent direction. Speed will increase with the day. * 'Backed' in southern hemisphere
Typical afternoon situation, 1300–1500		
Morning was warm but there is now increasing high cloud. Any morning fog has lifted but visibility is still not very good	Very definite thundery sky encroaching overhead from left* of morning wind, ie the wind before the sea breeze, if any. Expect thunderstorms or thundery rain. * 'Right' in southern hemisphere	Present wind regime should be invaded by new forces. If storms are coming then increasing tendency for wind to go towards storms when less than 10kt already. If 15–20kt or more expect to remain more or less in present direction followed by a sudden, savage, takeover by storm winds when they threaten overhead. Great cold gusts from direction of the nearer storm centre
Cloudless afternoon with a cooling sea breeze. Some upper cloud perhaps, but not at all threatening as was the previous situation	If beachland or coastal, look inland for sight of storms developing over hills. Sea breeze feeds such storms. The downdraught winds sweep away the sea breeze	Continuing sea breeze now, but if storms develop, downdraught winds from inland will sweep sea breeze into the sea by, or during, the evening. Then cold wind from the land, perhaps for rest of the night. If thunder heard, possible strong wind from that direction soon

Wind quality	*Remarks*
Usually abnormal and sometimes highly variable (see page 73) particularly when light. Random in fog or when fog is lifting into rather formless masses of low cloud. Tending to become normally variable if Cu develops (see page 68)	These days do not necessarily result in thunder but they often presage a breakdown in present fine spell. The situation depicted is that of an encroaching front forced into being thundery by surface heating. It is most likely to occur in summer when fronts approach over a heated land mass
Often abnormal with moderate variability. Very often becoming normal with afternoon. Cu cloud development is accompanied by a change to normal shift pattern	The morning may look and feel just like the above but nothing much happens because the upper and surface winds need to be crossed to one another before change is indicated
Possibly random now but can be normal or abnormal at this early hour. Most likely to become normal by afternoon if Cu develops. Cu does not have to develop in very dry airstreams	Probably an old cold front or occlusion is passing. When the sky is observed immediately after the front has passed, it will not often look like the text books. There is often very little cloud at low levels and that above is broken up. However, some connected linear features may still exist in the cloud aligned across the wind. Whether cloudy or not there is nearly always a veer* of wind when the front passes. * 'Back' in southern hemisphere
Because of convection currents, afternoon winds are far more likely to be normal than abnormal. However, if day is very hot and still no sea breeze develops, then abnormal pattern can persist. If sea breeze has set in, present random or other shift pattern will be replaced by the regime of the storms, should they develop	The hot, hazy morning may have foretold thunder, but nothing happened. It is far more likely to occur as the day wears on
Sea breeze means random non-tactical shifts, but near to developing stormline expect strange shifts with early tendency to blow towards storms and then later from them	The sea breeze that develops on these hot humid days is often sluggish. It may be slow to develop, slow to move inland and even then only blow gently. However, if storms develop on inland hill ridges these can give the sea breeze a sudden jerk in the afternoon or early evening

Waves on fronts

With the development of computer technology, forecasting depressions and fronts has become very good, as long as you accept that a 3-day forecast chart will not be as accurate as a 24-hour chart. However, one weather system that may temporarily keep weather poor and is not always easy to predict is the *frontal wave*.

A frontal wave is a mini depression and on the weather map appears as shown in Fig 8 – a kink in an otherwise straight front; cold fronts are particularly prone to such systems. Waves run along fronts just like the analogous wave that can be induced in a stretched rope anchored to a stanchion and given a flick; they move quite fast – in strong wind systems as much as 50–60kt.

The wave slows the clearance of the front and so retains the cloud and the rain which was expected to pass.

In Fig 8(a) (at time zero) you are at A and the cloud of the cold front is just clearing. You now expect fair weather. But, disappointingly, the clearance disappears, the cloud and rain return and the barometer begins to fall. By dotting in where the front would have been were it not for the wave we see that the wave temporarily makes part of the front that was moving one way as a cold front, move back the other way, so becoming a warm front, while that part of the front that is trailing on the tip of the wave is still a cold front but is now displaced.

In Fig 8(b), typically an hour later (but it can be shorter or longer), the NW (in this case) moderate wind has become light and variable and may even come from some unexpected points such as E. You may not realise it but you are close to the tip of a cold front wave.

After another hour in Fig 8(c), the windward horizon is once again showing signs of clearance and the wind of 2 hours ago has come back. The barometer is now rising again, if only slowly. The wave has passed and this time you can expect a clearance.

Thus, waves keep the weather deteriorated for longer than expected. They also produce winds that, close to the wave-tip, try to blow directly into the centre of the small, travelling low. The speed with which the wave moves will not allow this movement for long and unexpected wind shifts are short-lived.

Depressions start as waves like this and, given many hundreds of miles of undisturbed front, may well develop into big depressions. However, waves on relatively short lengths of front will usually pass and die.

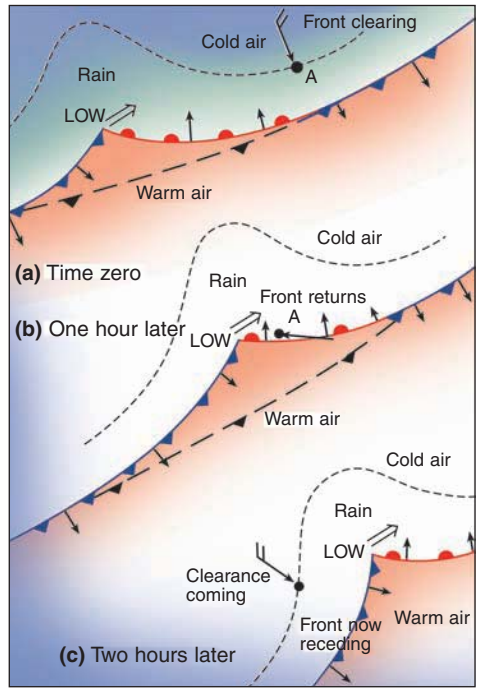


Fig 8

Photo 36 All is suspiciously calm at this moment but when mountains surround a sailing venue sudden changes often occur. There is some stratus cloud just forming over the highest point of the mountain. It could mean that the calm will soon be swept away. *Photo: J.F.P.Galvin.*

Because there are so many possibilities, a hypothetical lake (see page 104) has been chosen to illustrate the different winds that can be encountered. It is assumed to have high ground on three sides and low plains to the south. Effects characteristic of lakes with rising ground on only one side are also covered (see below). The diagram can be rotated to represent a lake whose open aspect does not lie to the south.

Aspect	*Thermal tendencies (quiet weather)*	
Rising ground on three sides as in Fig 9 (wooded slopes to the water's edge may preclude anabatics)	Morning	Anabatic drift to W shore and later to N.
	Afternoon	Daily increase in gradient wind usually over-rides most thermal influences, but N winds reduced in speed and S winds enhanced. E and W winds tend towards N.
	Evening	Katabatic drift from W shore.
Rising ground mainly to W	Morning	Maximum tendency to anabatic drift to W shore.
	Afternoon	Waning anabatic influence on W shore. Gradient winds from N or S quadrants steered more parallel to W shore when high ground not far distant.
	Evening	Early katabatic tendency for drift off W shore.
Rising ground mainly to N	Morning	Maximum tendency to anabatic drift to N shore late in the morning and continuing into the afternoon.
	Afternoon	Waning anabatic influence on N shore as afternoon progresses. Steering of winds from W or E quadrants.
	Evening	Katabatic drift from N shore.
Rising ground mainly to E	Morning	Little thermal influence in the earlier part of the forenoon.
	Afternoon	Some increasing anabatic drift to E shore. Steering of winds from N and S quadrants along E shore.
	Evening	Maximum anabatic tendency, but this is small compared to tendency when rising ground is to W or N.
Rising ground mainly to S	Little or no anabatic tendencies in morning or afternoon. However, slight slopes can catch sun and provide some drift to S. Equally little katabatic drift in evening and night. Allow for steering of existing wind.	

Tactical rule If beating into a wind with a topographic or thermal cant, tack towards the side that the wind cants. Example: In Fig 9, tacking up the W shore towards mark M, assume gradient wind has N tendency but tends to be NW rather than NE; wind funnels through (D) and fans. Tack towards (D) (starboard tack) and get a favourable lift for the mark. Wind will come progressively from port of the mark so tack that way. Other examples would follow the same principle.

Topographic steering (gentle, moderate or possibly strong gradient winds)	*Funnelling and fanning (gradient winds, strength above gentle)*
W winds tend to become NW or SW over lake. Wind shadow possible off W shore. N winds tend to become NW or NE. Wind shadow possible off N shore. E winds tend to become NE or SE. Wind shadow possible over NE part of lake. S winds tend to become SE or SW in extreme S corners (A) and (B).	NW winds funnel and fan into W along N shore and N along W shore. Holes may appear in the wind in the centre of lake. NE winds funnel and fan into E along N shore and N along E and W shores (remember to add thermal tendencies). SE winds preserve form until forced to funnel on NW shore. SW winds steered into S on W shore. S winds must split to funnel out NE and NW and a hole can develop off N shore. Wind increase at (C) and (D).
W winds tend to become NW in (D) and SW in (A). N winds locally enhance speed along W shore and over centre of lake generally. E winds split over central W side of lake. S winds steer and increase speed on W shore also over centre of lake.	NW winds enhance in (D); fan into N wind towards (A). Tend to W in (B). NE winds fan into E in (D) and fan into N along W shore. SE winds steer from S on W shore. SW winds fan into S along W shore.
W winds steer and enhance on N shore. Local increase over centre of lake. N winds are steered into NW at (D) and NE at (C). E winds steer like W winds. S winds tend to split in (D) and (C).	NW winds fan into W winds over (C). NE winds fan into E winds over (D). SE winds steer into E winds along N shore. SW winds steer into W winds along N shore.
W winds split into (C) and (B). N winds steer on E shore and enhance over lake centre. E winds tend to be NE in (C) and SE in (B). S winds would tend to take a curved path from (B) to (C) with locally enhanced speed over centre of lake.	NW winds funnel into (B). NE winds steer into N winds along E shore. SE winds funnel out of (B) and fan towards (C) and (D). SW winds steer into S winds along E shore or turn into W winds in (B).
W winds tend to steer along S shore and enhance in speed in (B). N winds tend to split into (A) and (B). E winds would fan out of (B) and steer into (A). S winds would tend to come from SW or SE in (A) or (B) but enhance in speed over central and N part of lake.	NW winds steer towards W winds along S shore. NE winds steer towards E winds along S shore. SE winds steer into E winds along S shore. SW winds steer into W winds along S shore.

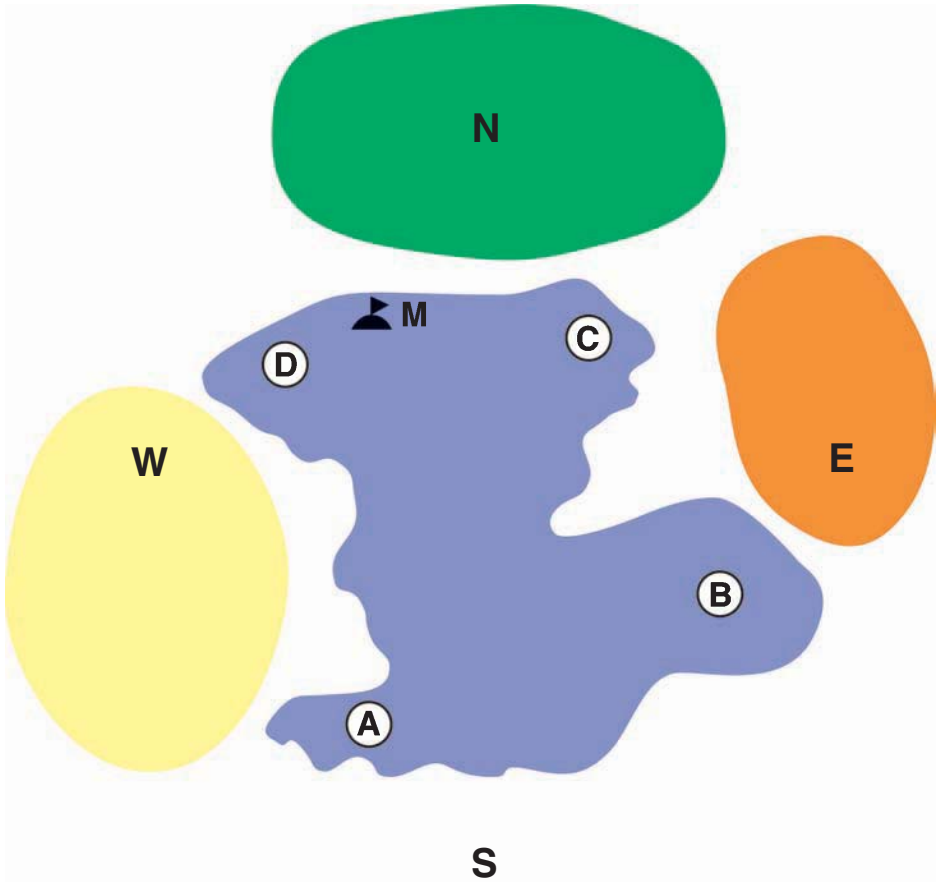


Fig 9

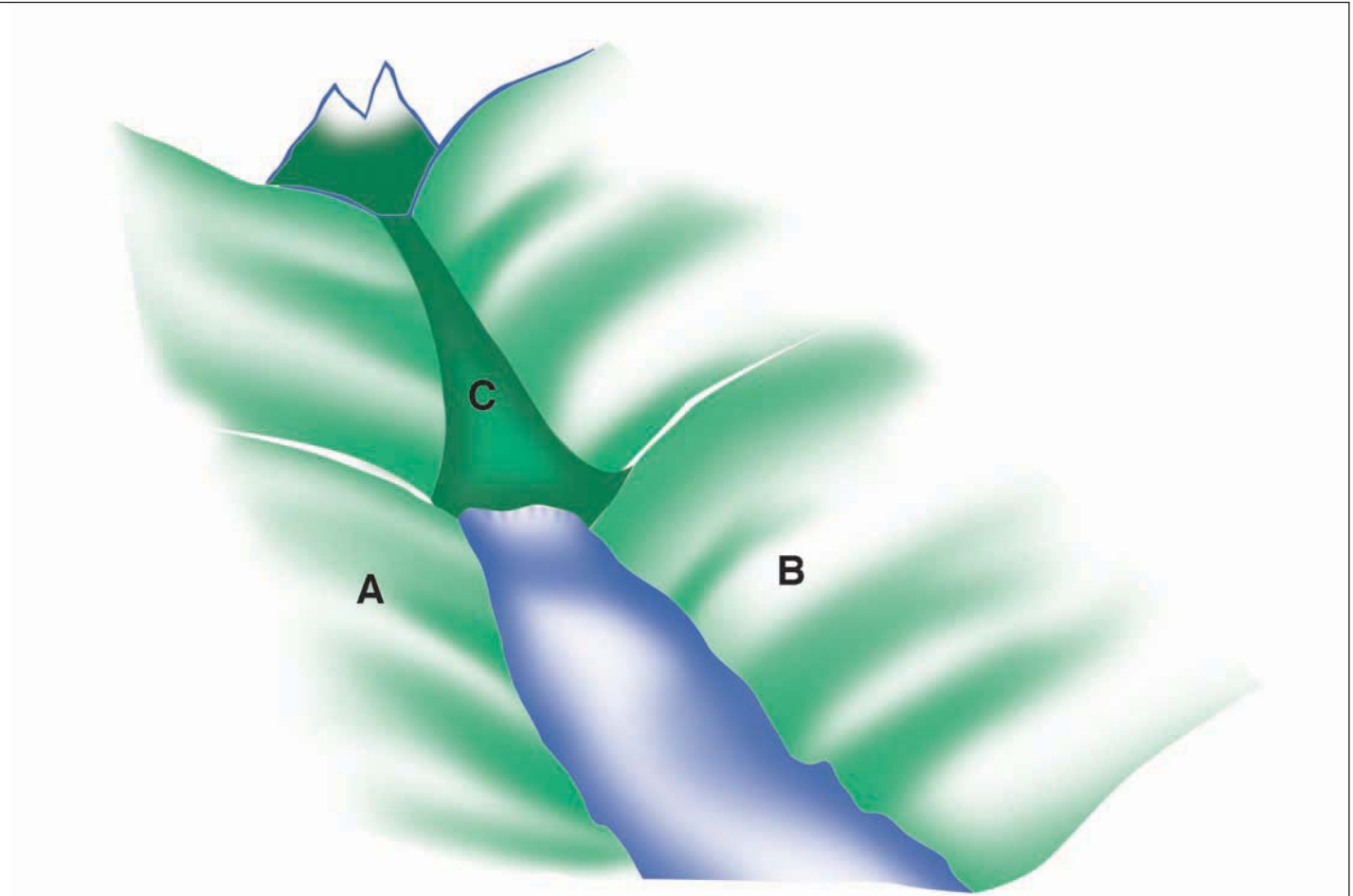


Fig 10

The hypothetical site in Fig 10 is typical of mountain lakes that tend to be long and narrow (finger or moraine-dammed lakes) and very deep in places. The lake often runs into an alluvial plain at one end and looks up a valley to mountains at the other (photo 36). The thermal and topographic winds of such lakes differ depending on which direction they point (photo 35).

Note When lakes point between N–S and E–W directions or there are other situations not apparently covered, use the principle that sunlit slopes develop on-shore drift and lately shaded ones develop off-shore drift.

When gradient wind tends to over-ride thermal tendencies then consider other possibilities. Examples include:

1 Developing Cu which deepens with the morning. Showers or perhaps thunderstorms (falling winds). Look for direction of motion of lowest cloud as indicating true gradient wind and assume later falling winds from that direction preferentially.
2 Increasing veil of high cloud with mares' tails and later halo phenomena. Gradient wind will normally back and increase. Rain belt likely to follow.
3 Continuous moderate rain now. After requisite time interval (1–6 hours) gradient wind should veer with cessation of rain.

Valley C aspect	*Morning*	*Early afternoon*	*Late afternoon*	*Evening*
North	Anabatic drift up slopes (A). Developing tendency for drift up (B). Slack tendency towards (C). Cu clouds mainly over (A).	Equal tendencies to anabatic drift on to (A) and (B). Strong tendency to (C). Cu clouds over (A) and (B).	Slack tendency on shores (A) and (B). Continuing tendency to (C). Cu clouds begin to disperse. Katabatic descent starts on (A). Anabatic ascent may continue on (B).	Katabatic drift from (A) and slack tendency on (B) lead to wind from (A) to (B). However, add continuing tendency to (C).
South	Anabatic drift up (B). Developing tendency for drift up (A). Slack tendency towards (C). Cu clouds mainly over (B).	Equal tendencies to anabatics on to (A) and (B). Some tendency to (C) but not as marked as when (C) looks north. Cu clouds over (A) and (B).	Slack tendency on shores (A) and (B). Slight tendency to (C). However, generally slacking thermal tendencies at this end of lake. Main tendency is N flow along lake. Katabatic descent starts on (B) when shadowed.	Katabatic drift from (B) and starting katabatic on (A). Wind tends to be from (B) to (A). Little tendency to (C).
East	Anabatic drift up both (A) and (B) but (A) preferred. Little tendency towards (C) at first, but developing.	Anabatic drift mainly to shore (A) so wind (B) to (A). Strong tendency to (C) so add E drift.	Slackening tendency to anabatics on (A) and (B). Katabatics may start on (B). Flow to (C) continues and so main wind is E drift.	Katabatics from (B) and (A). Flow to (C) slackens. Strong tendency to calm.
West	Anabatic drift up both (A) and (B) but (B) preferred. Slack tendency up (C) at first but rapidly developing.	Anabatic drift overwhelmingly to shore (B). Strong tendency to flow to (C).	Anabatics continue on (B) but slack, or katabatics commence on (A). Flow to (C) continues.	Katabatics commence on both (A) and (B) and flow to (C) slackens. Strong tendency to calm.

4 Warm, cloudy airstream – usually from between S and W – must be followed by veer and cold front which only forecast can usually predict.
5 Belt of heavy showers now. Expect veer and clearance followed by more showers by day.
6 Hot sultry conditions with passing belts of Ac (plus other clouds). Expect thunderstorms from same direction as Ac comes. Allow for arriving over slopes without much warning and producing up to gale force downdraught (falling winds).
7 On European lakes allow for Föhn conditions (also elsewhere when mountain range lies in gradient wind direction), ie unnatural clarity of the air and stillness followed by sudden arrival of wind from mountains up to gale force, especially when funnelled through valley constrictions.

The tendencies are those of an otherwise calm situation – even in nights with clear skies after moderate daytime winds. However, by day topographic cants and thermal tendencies can be over-ridden by the gradient wind.

Early night	*Middle of the night*	*Early hours*	*Sunrise*	*Gradient wind from...*
Strong katabatic descent from both (A) and (B). (Hug shores for wind, avoid calm centre.) Tendency for backbone of Cu cloud to develop along centreline of lake. Slack flow in (C).	Katabatics continue from (A) and (B) as for early night. Developing flow down (C), so N flow along lake.	Flow from (C) dominant as katabatics from (A) and (B) slacken to nothing.	Continuing flow from (C) but diminishing as sun climbs. Slack anabatic tendency on (A) and (B) but developing on (A) as sun climbs.	SW to SE – lake wind from S. NW to NE – lake wind from N. W or E – consider the gaps through which the wind can find its way to the lake surface.
As above	Katabatics continue as for early night. Developing flow down (C), so S flow along lake.	As above	As above	As above
Slack flow in (C). Strong katabatic descent from both (A) and (B). Katabatics also in (C) but little tendency to flow along (C). Cloud backbone possible as above.	Katabatic flow from (A) and (B) and developing tendency for flow from (C).	Katabatics tend to diminish but flow from (C) continues. Thus any wind is drift from E to W. Loses vigour nearer centre of lake.	Continuing flow from (C) to which must be added increasing tendency to anabatics up sunlit slopes.	SW to NW – lake wind from W. NE to SE – lake wind from E. N or S – consider gaps through which the wind can come to lake surface.
Strong katabatic descent from both (A) and (B). Katabatics also in (C) but little tendency to flow along valley floor on to lake. Cloud backbone as above.	Flow from (C) develops and adds to continuing katabatic flow from (A) and (B).	Katabatics tend to diminish but flow from (C) continues. Thus gentle breeze along lake is possible. But allow for it losing vigour further from the head of the lake.	Continuing flow from (C) but increasing tendency to anabatics up sunlit slopes.	As above

There will often be special winds on large lakes. These will be dominant winds when there is already very little gradient wind in the morning. The lakes version of the sea breeze is the lake breeze that can vary the wind over the shoreline on almost any summer day. It reaches 8 miles inland on 3–4 days of a typical late spring or summer month. If the forecast or actual morning wind is less than 5–8kt mean speed, then consider a lake breeze.

Will there be a lake breeze?

Remarks apply to shores with an uninterrupted and more or less straight shoreline backed by an extensive, relatively flat hinterland. For sailing, E- and S-facing shores will be preferred to W-facing. N-facing shores have least chance of lake breeze. (The information refers to the Great Lakes of North America (Fig 11) but should, with reservations, be applicable to other large bodies of inland water.)

Fig 11

Best weather type	*Look of the day*	*Morning wind from shorewards*	*Other morning wind directions*
High centred over area. Weather chart should otherwise show very widely spaced isobars. Forecast should be for slow movement of the high.	Sunny early and no more than half cloud cover by midday. Light or gentle wind. Near calm in early morning.	Same as sea breeze frontal system but less deeply penetrating. However, same early calms over shoreside waters; breeze arrives inland progressively later, ie 1030 1–2 miles inland. 1330–1630 at 8–10 miles inland. (Refers to E-facing shore. System weaker when W-facing.)	Parallel to shore or slightly on-shore. If fully onshore then lake breeze only adds to existing wind.

1 Obtain a reliable wind speed over land.
2 Use time of day in table (right) to find factor by which to multiply wind speed over land to give speed over water.

Spring and early summer (mid February–June)												
LST	0100	0300	0600	0800	1000	1200	1400	1600	1800	2000	2200	2400
Factor	2.5	2.4	2.2	1.9	1.4	1.1	1.0	1.1	1.2	1.9	2.3	2.5
Summer and fall/autumn (July-November)												
LST	0100	0300	0600	0800	1000	1200	1400	1600	1800	2000	2200	2400
Factor	2.8	2.7	2.5	2.2	1.8	1.3	1.2	1.4	1.9	2.5	2.6	2.8

What is the lake breeze season?
On average, breezes are first possible at the beginning of April, when lake breeze occurs only with almost total calm. The season is generally from mid April to mid August. Maximum effect is to be expected in June and July. There is very little chance of lake breeze from September through to March.

What is the likely direction over the lake?
Given the wind direction ashore, expect the wind to veer on average 30–40° over the lake.

Most likely type of onset near shoreline	*Evening and night*	*Weather type that inhibits breezes*
Facing the lake: If wind along the shoreline from left, expect rapid or even sudden shift when lake breeze starts up. *If from the right expect*: Slow shift to lake breeze direction. With winds of about 6–8kt a partial shift to more onshore, but no true on-shore lake breeze as with lighter winds. *If wind truly off-shore expect*: Sea breeze frontal system with calming near shore at first then onset and gradual strengthening with the afternoon. *If wind truly on-shore expect*: Reinforced speed by afternoon and perhaps some shift to more directly on-shore.	Expect calm in evening unless forecast for rapid movement of prevailing pressure pattern. Expect some nocturnal wind overnight with light wind from land guided by shore topography. Stronger where mountains come close to lake edge, ie moderate katabatics sometimes. Expect nocturnal wind to falter near dawn.	Cyclonic isobars with only occasional glimpses of the sun. (Breeze is not so likely as with anticyclonic isobars.) However, lows may move out during day to give a chance of a late breeze if wind is light and there is sunshine and reasonable visibility.

You may not wish or be able to answer all these real or implied questions – they are simply designed to prompt.

Race planning for restricted waters

Before the race

Likely gradient wind direction can be found from...	*Likely type of airstream*	*Proximity of topography*	*Possible local shifts*	*Tidal streams etc*
1 Forecaster at a local weather centre **2** Telephone pre-recorded forecast **3** Fax actual and forecast charts **4** TV forecast that also gives current charts **5** Radio forecast for inshore and offshore **6** Internet	**1** *Unstable*: Likely strength? Strength of gusts? Showers? Thunderstorms? **2** *Stable*: Strength? When will inversion break? Morning or afternoon? Any fog?	Local contour map Cliffs Promontories Valleys Islands (most important when airstream stable) Bays	Shoreside shifts Gusts over cliffs Bending over islands and promontories Sea breezes (stable) bent when coming up against high ground. Flow into bays. Holes in the wind in lee of islands.	State of tide during race Set of streams past marks and coastal inlets Streams emptying from estuaries Back eddies in bays

On the spot

Mean wind direction	*Mean wind mark*	*Type of airstream*	*Position of marks and wind direction*	*Sea breeze?*
See page 10	Try to establish a sight mark in the eye of the mean wind as far away as possible. Use as a reference for shifts.	Cu day, see pages 76 or 90. Warm, poor visibility day, see pages 84 or 98. Showery day, see pages 80 or 94.	Inshore marks: Shoreside shifts? Sea breeze shifts? Offshore marks: Sea breeze shifts or calms? See page 48.	Possible? See page 50. When? See page 52.

Help the day to go smoothly

Know the way the wind blows	*Ensure the wind later will not be uncomfortable*	*Look for possible trouble*	*Quiet mornings...*
Get the forecast the night before and in the morning.	If leaving shelter, refer to tables on pages 12 and 14. Too much seaway? See page 17.	Forecasts can be wrong. If sky and wind conspire against you, see pages 20 and 30, should you head for home?	Often mean quieter evenings. Will tide be running against you making a long haul home? Also may mean sea breezes in middle of day and sea breeze calms in evening.

Fronts etc	*If frontal shifts?*	*If sea breeze shift?*	*If very late finish*
Any fronts likely to cross area? See page 20. Shifting pressure systems? Lows, see page 26.	New wind veered to old and new wind quality, see pages 26 and 64.	Most likely new direction is 10–20° left of directly on-shore. Consider other lesser shifts in moderate winds.	Lose sea breeze? Shift back to gradient replacing sea breeze? Flat calm? Don't forget the paddle! And an anchor!

When sea breeze blows	*Review large-scale shift timing*	*Quality assessment*	*Leaving shelter?*
New tactical situation?	Cannot time fronts accurately enough, so eye to windward if frontal situation passing. Is warm front coming?	Recognise normal shift day, see pages 68 or 73 and time shift pattern. Recognise abnormal shift pattern. Assume tacking to variables paramount and other tactical considerations secondary.	Hot ashore but cool or cold on water? Any risk of thunderstorms? Possible gusts and cold deluge. Take protective clothing plus personal buoyancy.

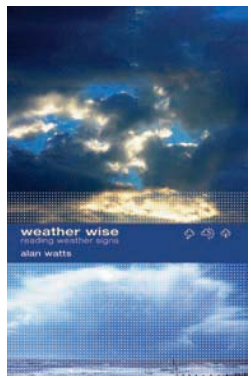
The tide	*The river*	*If you must go back early*
Don't let it leave you stranded up the creek. If you are not familiar with a drying tidal area, leave 2hrs after high water. Is there a bar across the harbour entrance? Is there an ebb tide race in the entrance?	Go upstream if you have a choice – drift home.	Sail in the morning as there will be wind by lunchtime and in the afternoon. Get back by 1700 and escape the evening calm.

Other books by the author that help amplify and explain the tables in this book.

Instant Weather Forecasting (Adlard Coles Nautical). The bestselling do-it-yourself weather forecast book has been continuously in print since 1967. Its 24 colour photographs of cloud formations and their accompanying explanatory text enable anyone to read the sky, pick up the clues and predict what the weather will do. It has been translated into a dozen languages and is now in its third edition.

Instant Storm Forecasting (Adlard Coles Nautical). Invaluable for anyone pursuing outdoor activities. Dramatic photographs of cloud formations relating to bad weather help the reader predict whether a storm is on the way, while helpful tables show how quickly winds may build up. Practical explanations about thunder, lightning, hail and more equip the reader with the understanding needed to judge how severe a storm might be, and how quickly it might arrive.

The Weather Handbook (Adlard Coles Nautical). For anyone who finds general weather forecasts frustrating because they don't give sufficient local detail, this up to date explanatory book is a straightforward guide to how to look at the sky and interpret what clouds indicate about coming weather, as well as how to combine weather forecasts with the reader's own observations to arrive at the best prediction.



Weather Wise (Adlard Coles Nautical). Ideal for all outdoors enthusiasts, from sailors to golfers, this highly practical and very accessible 'hands on' guide to the weather answers the questions many people have about the seasons, clouds, changeable weather, geographical variables and much more in an easy to understand way, with tips, hints and fact panels.