Guide to Passage plan and execution

www.bluewatermiles.com

As a skipper and a good seaman, you should always ensure that a passage is properly planned, executed and monitored so that you can navigate safely from berth to berth taking into account all possible scenarios en route.
The below materials are applicable to all passages, especially longer ocean passages where you have to consider all eventualities and be self-sufficient as much as possible. With experience, you will be able to say which elements you can skip for shorter trips and when you need more attention.
Detailed guidelines for voyage planning can be found in SOLAS chapter V, Annex 25 of IMO Resolution A.893(21). The Marine and Coastguard Agency (MCA) says it is a legal requirement to make a passage plan in proportion to the trip to be undertaken. After all, it should maximise sailing enjoyment and minimise risk.

Things to consider in the Passage Plan

- Routing choice: rhumb line vs great circle vs weather determined. A great circle only makes sense if you are sufficiently far from the equator and not sailing along meridians (directly North-South). Most of the time optimizing for optimal weather conditions is the best choice.
- Overall distance and expected time on the sea (min, max).
- Time to go: there may only be a short window of opportunity for making a passage, or it may be that you have a few months period in which to complete it but either way they are going to be some restrictions on the best time to go. For ocean passages, you should leave port with a favourable weather window for at least three days to get clear of land. After that, keep a watch on GMDSS high seas forecasts, GRIBs and (if available) synoptic charts to get good warning of sustained bad weather.
- Paper charts and navigation materials (e.g. pilot books, sailing directions, routeing guides). MCA doesn't approve chart plotters as a primary means of navigation except for big ships!
- Navigational aids en route (e.g. lighthouses, buoys etc.).
- Landfall: make a description of the coastline and any identifiable features that can be used. Mariners who have escaped all former dangers of the voyage are often shipwrecked upon some sudden rock, coral reefs or shoal at the entrance of their destined harbour.
- Pilotage into and out of start and end ports (or anchorage) as well as a port of refuge. It needs to be easy for someone to use, and this should include straightforward places to approach in case of unforeseeable complications.
- Man-made hazards: shipping lanes, oil fields, fishing areas, military zones etc.
- Natural hazards: fog-prone areas, magnetic anomalies, ice, small islands, races, reefs, banks, shoal water, seamounts (underwater mountain ranges), e.g. 30m depth may sound ok, but if it is surrounded by waters over 3000m deep it could cause steep seas in big swell. Adjust your ocean route to allow 10 miles between you and any seamounts/shallows that come within 30 meters of the surface, and 2-5 miles from races and other hazards.

- "What if" scenarios (contingency plan): port of refuge and alternative routes in case you can no longer execute your planned passage, alternative means of navigation (celestial navigation) if you cannot use GPS etc.
- Climate conditions, prevailing winds and other wind directions expected based on pilot charts to take advantage of prevailing winds and ocean currents.
- Weather hazards (e.g. fog en route). For example, do you need extra water because you are sailing in the tropics or extra clothes because you are in the Arctic.
- Currents and tides: areas of strong current and tide predictions noted in order to make the best use of favourable currents, tidal streams and heights of tide. Tide is the king in areas with large tidal ranges.
- Search and Rescue facilities: not just because you might need them but you might be required to help in SAR operation.
- GMDSS, weather observation and forecasts for routing and sail plan decisions.
- Communication: short (vhf, mobile phone) and long-range (satellite phones, SSB).
- Appropriate sails on board. Sail plan for heavy weather (e.g. storm jib, trysail vs deep 3rd or 4th reef on the main) and downwind sailing (e.g. poled-out headsail, gennaker, asymmetric spinnaker).
- Constraints from consumables such as fuel, electricity, gas, water, and food. Remember that too little wind can be as much, if not more problematic in ocean sailing than too much. Calculate how much you need and how much you are able to generate en route. Once you are "unplugged" from shore, you have to be self-sufficient.
- Vessel suitability: condition and state of the vessel, its stability (distribution of weight, e.g. distributing water bottles on each side of the boat, using smaller tanks so that water cannot quickly flow from one side to the other), equipment and limitations.
- Crew suitability to undertake the passage: provision of a competent and well-rested crew.
- Method and frequency of position fixing, including primary and secondary options.
- Information ashore: letting someone knows where you will be sailing and at what time you will be arriving. Optionally, reporting the voyage details to the Coastguard via RYA SafeTrx.
- Required documentation for the countries you wish to visit (good to have photocopies as well):
    - ✓ Valid passports for everyone on board, with visas if necessary. When applying for visa, make it clear that you will be on a yacht as the visa requirements might be different.
    - ✓ Crew list with the following information: name and surname, date of birth, nationality, document number, expiration date, country of residence, date of embarkation.
    - ✓ ICC (International Certificate of Competence), at least for the skipper.
    - ✓ Certificate of Registry, or Small Ships Registry Certificate.
    - ✓ Value Added Tax (VAT). All private yachts owned or used by EU residents must be VAT paid if they are used in EU territorial waters. Non-EU residents may own and use a private yacht VAT-free on a temporary import basis for up to 18 months. Documentary evidence should be carried at all times as you may be asked by customs of the vessel's VAT status anytime. Documentary

evidence might include: original invoice or receipt, evidence that VAT was paid at importation, and/or invoices for materials used in the construction of a "home-built" boat.

- ✓ Clearance papers from Customs and Immigration from the previous port of call when crossing borders (not needed within EU). A dated receipt from your departure port may be a useful alternative. If you arrive from abroad, you should obtain entry clearance at a Port of Entry (ports where one may lawfully enter a country). Regulations and requirements may vary, and it's advisable to consult the customs and immigration authorities of the specific countries you plan to visit. In theory, a yacht registered in the EU doesn't need to report to Customs if arriving from another country within the EU Schengen area. Non-EU registered yachts should report arrival without delay. As a non-EU citizen travelling within the Schengen Area by boat, you generally do not need to clear immigration controls when moving between Schengen member states. On entering the Schengen area from a non-Schengen country (or when leaving the Schengen area for a non-Schengen country), you should obtain immigration clearance via the port authorities. If your passport is stamped on entry into the Schengen area you will need to ensure it is also stamped on departure otherwise in the eyes of the immigration authorities you may never have left.
- ✓ Stores list if applicable, which should differentiate between opened and unopened items. In practice, very few countries are interested in stores other than alcohol but fresh fruits and vegetables should always be mentioned to prevent the spread of pests.
- ✓ Cruising permits if applicable (issued to visiting yachts in the USA, Canada, some Caribbean islands, and other countries around the world).
- ✓ VHF and other radio licenses and operator's certificate if applicable.
- ✓ Insurance papers – most marinas will not allow boats to berth without at least third-party insurance. Best if the certificate can be in the language of the countries visited.
- ✓ Bill of Sale to prove legal ownership of the vessel.
- ✓ Vaccination certificates if applicable.
- ✓ Bills of Health and pratiques acquired en route if applicable.
- ✓ Charter documents if applicable.
- ✓ Ensign warrant for British yachts, if applicable.
- ✓ Security and Firearms certificate, if applicable.

Things to consider on Passage

- Maintain a logbook.
- Obey COLREG rules, e.g.:
    a) Keep a proper lookout by all available means (binoculars, radar, VHF, AIS, charts) and do not assume the other crew sees you!
    b) Identify the other vessel as soon as possible (position, course, speed, intentions, and type based on navigation lights and day shapes).
    c) Take successive bearings of converging vessels to avoid collision situations. Close to land you may judge the other boat's relationship to the land beyond ("making and losing land" technique).
    d) Make your boat as visible as possible. At night, show navigation lights in the proper combination.
- Do not rely only on GPS when close to coasts and hazards. A good navigator will never rely on one source of information. A second source of positional information should be used to check and verify the boat's position relative to the danger (e.g. fixes with marks, radar). Performance instruments and cockpit chart plotters are excellent aids for navigation, but they should be backed up with paper charts, lookout, and traditional skills.
- Use a tracking tool to see how accurate your electronic chart seems to be. The tracking tool also allows to follow the track out again if you have to leave in a hurry or in bad weather.
- You can only be as accurate as the charts you carry! Check the date of soundings and the expected level of accuracy of your charts.
- Be careful when using vector charts as they will show different levels of detail depending on the zoom. By using an incorrect scale, you may remove potential hazards from the screen (eg. a tiny island or reef in the middle of the ocean).
- Entering position / waypoint information on paper charts is prone to errors. Check the inputted position by verifying its bearing and range to a centre of a compass rose on the chart.
- When using GPS, check the position accuracy using a dilution of precision parameter (HDOP) (should be around 1.4). If satellites are too close together, the HDOP is poor.
- Keep a record of how much fuel, gas and water has been used. You can turn off the electric water pump at sea to avoid a scenario that a leak is developed and the water is poured into the bilges.
- Perform drills regularly. After exiting the marina with a new crew, practice tacking, gybing, reefing, mob and motor handling.
- Create a deviation table for steering compasses – if you sail on a boat, you do not know.
- Recharge batteries every day.
- If you have a generator-driven watermaker on board, top up tanks every day.
- Check food stores on a daily basis for damp or mould.
- Make sure that the crew is well-fed, warm, dry and rested between watches.

- Every crew member should drink at least a litre of water for each 4-hour period (dehydration is a major problem in the sun when you are exerting yourself).
- Check the weather forecast regularly and listen to navigational warning updates.
- Be aware of the developing weather (squalls, changes in wind, clouds, waves, bird flight patterns etc.), without a passive dependence on outside sources of weather information.
- Golden rules of heavy-weather:
    a) If you can, don't go if heavy-weather is predicted.
    b) Keep clear of any potential lee shore.
    c) Avoid areas prone to breaking waves (e.g. sea mounts, harbour entrance on ebb, etc.).
    d) Prepare the boat and crew before the heavy-weather hits.
    e) Don't beam reach when wave heights equal or exceed the beam of the boat, especially in breaking sea.
    f) Reef early. Don't be caught over-canvassed.
    g) Balance the sail plan for the wind angle you want to maintain.
    h) Don't leave the boat until the boat leaves you.
    i) Get underway once conditions moderate.
    j) There is no one right way of handling storm at sea. There is only what works for different boats and their captains in different storms.
- Stay away from lee shore: if the wind is blowing onshore (toward the land), stay much farther offshore than you would in an offshore wind blowing toward the water. Even if you are not in danger of being blown onto shore, the wind will be unpredictable up to a mile to windward of a lee shore as it begins to rise over the land, and the waves will be steep and may break.
- If the boat speed drops to 50% of the hull speed, the boat is under-canvased and needs more sail area to drive through the waves, even if that means sailing at a higher angle of heel than normal.

$$Hull\ speed\ [kt] = 1.34 \times \sqrt{\text{LWL (Waterline length)}}$$

- When sailing downwind rig a preventer to avoid main boon from swinging across the deck during accidental gybe
- Check stowage daily to ensure gear is not working loose.
- Inspect the racor filter for water every week or so (water ingress through deck fittings is the usual culprit).
- When motor sailing check engine cooling regularly (throwing cooling water overboard).
- Check engine oil regularly.
- Do a deck walk every day to ensure things are running fine (sails, rigging, etc.) and there are no signs of wear and chafe. Look for trouble and things that are not quite right in order to uncover and correct problems before they become serious.
- On longer passages adjust lines every now and then to avoid chafe (e.g. once or twice a day).

- Check bilges at least once per day.
- When nearing land double-check the boat's position and progress on the paper chart and the plotter, and start asking questions such as "Am I seeing all the lights, or are some obscured? Is that really the harbour I want to enter, or a false cove?" Peel all eyes for buoys, lighthouses, and signs of shoal water such as a change of colour or larger waves. As you enter a channel, systematically check off landmarks, buoys, and other aids to navigation.
- Don't make assumptions and don't cut corners near land or when the visibility is poor or the sea is rough. Give all buoys a wide berth and stay well outside shoal areas both in- and off-shore.
- Use all your senses: if you smell pine trees, you are probably approaching a shore. If you see a buoy leaning, there's current flowing in the direction of the tilt. If you feel rougher water, a shoal is nearby. Generally, waves begin to noticeably slow down and change their characteristics when the water depth is roughly half the wavelength. For example, if you have ocean waves with a wavelength of 200 meters (period of ~12sek), they would start to slow down and grow in water that's approximately 100 meters deep.
- Sail on the most favourable tack first. The wind direction is rarely steady over a long period of time so try to use good conditions when they exist.
- Assign the best steerer to the wheel in tricky situations.
- Maximize VMG (Velocity Made Good) to reach waypoints as quickly as possible.
- Alcohol and sailing don't mix. Even a can of beer will scramble the pilot's calculations.
- Keep your head and don't panic: when in doubt, stop or heave-to to think things through.
- Agree on common visual signals for communication in situations where it might be hard to hear other, e.g. coming to a buoy, anchoring, heavy weather.
- Get a clearance form from your last port of call as you may need it when you arrive in a new country.
- For longer passages, make sure all crewmembers have a valid passport and visa for the destination country. Collect passports from all crew members to make sure you can officially release them to immigration office when you reach your destination. You may not be allowed to leave without checking out all the crewmembers you arrived with.
- In many countries you can recover VAT on purchased items as the tax is intended only for goods that are going to be used within the country so keep records of all purchases.
- A friend or relative who is joining you for a time on the boat makes for the safest and most efficient delivery of spare parts. If you want to ship spare parts, put an invoice on the outside of the package and label it "Spare parts for yacht in transit" to avoid taxes and other fees.
- When you reach your destination after a long passage, clean up and inspect the boat within 24 hours or arrival in a new port to return the boat to a passage-ready condition as quickly as possible. Delivering spare parts might be time-consuming so plan ahead.
- All banks and patches should be avoided in swell conditions. It should be remembered that the depth of water is reduced by half the height of the swell and that the swell increases in height as the water gets shallower. Entering a shallow harbour entrance in a swell should only be attempted on the flood and near HW.

- But not that you cannot have big waves in shallow water if the area is extending for many miles offshore, except for the places where the sea is directly meeting slowly shallowing sea bottom. Among other things, this is one of the reasons that you will not experience big waves in shallow seas and lakes.
- When crossing an ocean East to West or West to East, you will be crossing many time zones. The time zones change by an hour every 15 degrees of longitude. There are two main options to consider for the ship's clock:

    1. (Simplest) Keep the ship's clock to UTC and accept the variance of sunrise & sunset times. Ignoring the time zones altogether and living by UTC will make time management on board straightforward. This system should work well with a 24-hour (non-rotational) watch system as the sunrise & sunset times will shift naturally giving a possibility for different watches to experience different phases of the day.
       The only little trouble is the meal time change in relation to the phase of the day (morning, noon, evening). Nothing to worry about if you just eat when you are hungry. But if you have a fixed schedule for the meals then perhaps shifting the meals slightly forward or back at the start of the trip will reduce the impact.
    2. Adjust the time as you progress across the ocean. Change the ship's clock by an hour with every 15 degrees of longitude change (subtract 1 hour when going west and add 1 hour when going east). Always record UTC as well as ship's time in the log to avoid any confusion.

  Regardless of the ship's time you choose, keep all navigation to UTC to keep the log consistent and make the celestial navigation trouble-free.

Consumables Management

Water

- Drinking water and cooking (highest priority): 3L / day / person (you may need to account for more in the tropics). You can keep all drinking water in bottles or jerry cans to have an independent water source in case of water tank issues (e.g. leak, contamination), especially if you do not carry a watermaker.
- Personal hygiene: 1L / day / person.
- Cooking and dishwashing: 2L / day / person (could be replaced with seawater if needed).
- Showers if planned (e.g. every 3 days): 15L / shower / person.
- Carry ~30% extra water to allow for delays.
- Watermaker: extremely efficient devices nowadays, e.g. 20-100L/h. You can top up water tanks and empty bottles / jerry cans every day. A small hand-operated emergency watermaker makes also a potentially life-saving addition to the grab bag. Very small boats have completed trans-oceanic passages thanks to equipment of this sort.
- Water is precious. If the seawater floating around the boat is clean, you can use it for:
    - Washing dishes, possibly rinsing them in fresh water if you must. For rinsing you can use a spray bottle or a pressurized garden sprayer.
    - Taking shower – rinse with fresh water to make sure sea creatures don't grow on you. Rinsing could be done with a spray bottle to better control the amount used.
    - Boiling carbs - salt water is very salty so mix with freshwater, say half or third in a pot.
    - Washing vegetables like potatoes and carrots before cooking.
    - Boiling eggs - you will need to leave them slightly longer, as salt water boils quicker.
    - Wiping down deck and benches, except any areas of varnished wood.
- Having a salt water tap installed in the galley is a brilliant idea – be it a remote anchorage or the open sea.
- Make sure that the salt water is strictly restricted to the galley – getting salt watr in any other part of the inside of the boat is to be avoided at all costs.
- If the worst comes to the worst and you do run out of water, the following methods can help collect additional water:
    - Catch rainwater from sails, bimini, sprayhood or directly by just opening the water inlets and building a small dam to make sure the water flows into. Use a simple and cheap tea strainer for coarse filtering. In some parts of the world, unless you can effectively filter the rainwater, it might be best to keep it in jerry cans and use it for washing rather than drinking.
    - Heat seawater in a pressure cooker to collect evaporated fresh water.
- Take a hand-operated syphon pump if you plan to visit remote areas: useful for filling tanks from portable containers.

Food

- Keep cooking simple and easy.
- Prepare a menu plan for the whole trip and stock according to that.
- Carry ~30% extra food in case the passage takes more time than you estimated.
- The more fresh food you can vacuum-pack and freeze, the better.
- Store vegetables and fruits in netting so they are well ventilated.
- Keep as much packaging off your boat as possible, especially cardboard boxes to avoid cockroach eggs.
- Have a plan of what you are going to eat if a freezer / refrigerator breaks down (e.g. tins, bread, sweats, ….). Vacuum packing could potentially keep the food fresh even if the freezer fails.
  Example: https://bluewatermiles.com/docs/provisioning-checklist.pdf

Gas

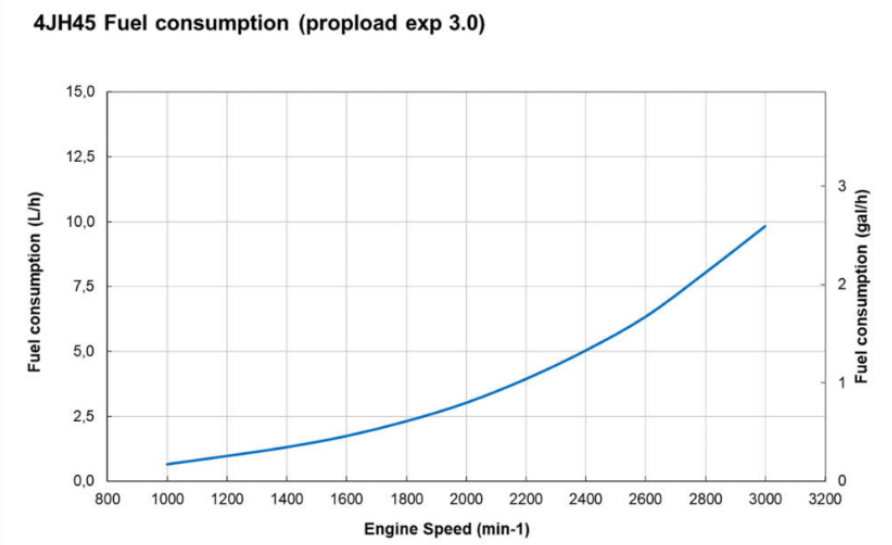
- On average 1 cylinder (2.75kg) per week / 6-7 people.
- It can be difficult to get gas bottle replacement en route because there is no standardization for gas bottle fittings around the world. GasBOAT systems provide kits to enable safe connections between a variety of connectors and bottles.
  Depending where you are bottles may be filled with either propane or butane or by a mixture of the two. Propane should always be used at higher latitudes because butane does not vaporize below 0^{o}C. Propane is stored at a higher pressure than butane so it is perfectly safe to put butane into a propane cylinder, whereas it is very dangerous to put propane into a butane bottle. With this in mind, most blue-water cruising yachts carry propane cylinders.
- Carry extra cylinder(s) in case you will not be able to get a replacement, the passage takes longer than expected or you have to desalinate seawater.
- Consider what food you would eat, if you did run out of gas (tins, sweats, bread, …).

Fuel

- Know how much fuel your engine uses per hour. Check the manufacturer's website, eg. Janmar.
- Estimate much you are going to use it and where you can top it up.
- Leave enough fuel for the passage to top up batteries, get through calms and some fuel for the final approach into port and emergency situations.
- Divide your fuel into thirds. Use a maximum of one-third of the fuel on the first half of the voyage, one-third on the second half, and hold one-third in reserve for emergencies.
- Try to keep the tanks topped up to minimize a chance of stirring debris and minimize condensation inside the tank. If possible.
- Try to avoid carrying extra diesel in tanks on deck as they can be a liability in rough conditions and the diesel bug can proliferate in the warmth and light.

Example:

Input	Range
Engine: Janmar 4JH45 (45HP), run at 1800RPM, speed 5KT Usage per hour: 2.5L (depending on sea conditions) Fuel capacity: 200L + 20L (in spare canister) = 220L You will have to make your own judgment if that amount of fuel is enough for your particular passage.	With engine only: ~3 days / 440NM With the engine used only to top up batteries (3h / day): 29 days With solar power generator and engine to top up batteries (1.5L / day): 49 days Assuming that you only use 50% of fuel for power generation (the rest from alternative sources, e.g. wind turbine), you could sail for 25 days and have fuel to make 180NM on the engine.



Source: https://www.yanmar.com/marine/product/engines/4jh45/

Electricity

- Calculate power consumption per day [Ah] for your boat.
- Check the capacity of domestic / home batteries [Ah] (assume that you can only use 30-50% of the total capacity). Know how much power you can generate on average per day [Ah] on your passage.

  Useful formulas:

$$Power\ [W] = \text{Amps}\ [A] * Voltage\ [\text{V}]$$

$$Amps\ [A] = \frac{\text{Power [W]}}{\text{Voltage [V]}}$$

$$Usage\ [Ah] = \frac{\text{Power [W]}}{\text{Voltage [V]}} * h$$

- The nominal level of charge in an open cell 12V battery (in rest):
  - 11.5V – fully discharged
  - 12.1V – 50%
  - 12.7V – fully charged
  - 13.2/4 – charging

  As a rule of thumb every 0.1V = 10% of the battery capacity. You'll shorten the life of your battery if you over or under-charge them. Ideally, store batteries charged (80-100%).

Example of average consumption on a modern sailing boat per day and 12V system:

Item	Power [W]	Time used		Daily consumption	
		Passage [h]	Anchor [h]	Passage [Ah]	Anchor [Ah]
Navigation lights	12	12	-	12	-
Anchor light	4	-	12	-	4
Interior lights	18	4	4	6	6
Chart light	3	10	-	2.5	-
Chart plotter	24	12	12	24	24
GPS	2.4	24	12	4.8	2.4
Instruments (e.g. wind)	4.8	24	-	9.6	-
Depth Sounder	6	24	-	12	-
Radar (Tx)	38.4	12	-	38.4	-
Radar (Standby)	16.8	12	-	16.8	-
Stereo radio	12	2	2	2	2
VHF radio (tx)	25	0.1	0.1	0.2	0.2
VHF radio (rx)	3	24	24	6	6
AIS	2.52	24	-	5.04	-
Autopilot	24 (moderate wind)	4	-	8	-
Bilge pump	60	-	-	-	-
Water pump	120	0.25	0.25	2.5	2.5
Toilet pump	120	0.1	0.1	1	1
Shower pump	120	0.1	0.1	1	1
Water heater	750	0	1	0	62
Windlass	100	-	-	-	-
Refrigerator with Freezer	60	10	10	50	50
Small laptop for weather forecasts	45	1	1	3.75	3.75
Sat nav (Iridium Go)	6-18	1	1	1.5	1,5
Watermaker	110	1 (30L / h)	1	9.1	9.1
Charging phones / mp3 etc.	3-7	2	2	1.2	1.2
Gas detector and solenoid controller	1.2	24	24	2.4	2.4
Stereo (2 speakers)	90	1	2	7.5	15
Total				~215	~183

Windlass is skipped as you generally only use it when the motor is running so it won't be directly using all amps out of the battery.

The Fridge power consumption is perhaps a little low for running, but probably about right for a 24hr period. The little compressor types use about 5-6Amps, but it also cycles. It is hard to get the exact amount because there are many variables affecting refrigerator consumption: climate, type and amount of insulation, ventilation of the compressor, how full it is, how many times the door is opened, whether it is top or front opening, temperature set in the unit etc.

The table is just an example so do not take it for granted. Check consumption of your items on board on the product manuals or on the internet (they are given in Amps or Watt). It's worth checking your particular brand/make and model to get an accurate result and even when you are shopping for things, you might do a comparison of different brands to get the most efficient product. For example, LED lights use a lot less power than normal lights.

Significant savings can be achieved if the boat is hand or wind-vane steered (without autopilot). However, an autopilot or wind vane is a must for short-handed sailing. The radar could be used mainly in areas of greater shipping activity, during reduced visibility and during the night in areas of tropical squalls.

Consider what you can turn off during an ocean passage. For example, do you need a chart plotter all the time?

Required domestic battery capacity:

- The minimum battery capacity should be 3-4 times the expected average load. This is because with normal batteries you can only get 30-40% of the capacity out of them. You should never let lead acid batteries get below 50% of their capacity before you charge it up again as this can limit the lifespan of the battery. As they take a long time to charge up, especially the last 15% or so. Because of this, you might find that you are only able to use 30-40% of the battery's potential. This is not necessarily true for deep cycle batteries which are designed to handle discharges of 80-100%.
- Based on the example above the required capacity should be: 3 x 215 ~ 645 Ah.
- Alternators should be sized at 25% to 40% of the amp-hour rating of the house bank. For the example above the alternator should output: 645 Ah / 4 ~ 160 Ah.

Power generation systems:

- **Diesel engine:** run for ~2-4h per day to recharge batteries fully (assuming a decent alternator is fitted, e.g. 12V / 160Ah). This requires fuel but it is by far the most efficient power generation method available. Whatever the new, clean power systems available you can't beat a good diesel.
- **Solar panels:** ~60Ah/day - better if you have a good system to point the panels to the sun, worse if you have lots of shady spots on the panels. As an example, a 100W panel in full noon sun puts out about 8A at 12V (96W). If the full sun was hitting the panel 24-hours a day, the output would be 8A x 24H = 192Ah. Since during a 24-hour day, the panel will only put out full power for a couple of hours, the output will be much less.
  Solar panels will produce no power at all during the hours of darkness but they are useful contributor to the on-board power bank.
- **Wind power generator:** ~80Ah/day - very much a function of the weather pattern. The world's cruising routes tend to be downwind, robbing the generator of some of its power. To put that in context, a boat doing 8 knots dead downwind in 20 knots of true wind would experience an apparent wind of just 12 knots. A turbine might generate 200 watts in 20 knots but most manage only 40 watts in 12 knots of wind. For example, if you are heading to the UK from Germany and plan on beating into 20 knots or more every day, you'll get much better output than sailing downwind from the Canaries to the Caribbean. The wind turbine would be very useful once in a trade wind anchorage.
  All generators make a noise which can be detrimental to the crew as well as to any neighbours and should be taken into account.
- **Hydro generator:** ~10Ah/h (at 5kt boat speed) - Great on passage but useless at anchor. Provided you have sufficient boat speed this can keep the batteries topped up without resorting to running the engine at all. You get energy during the night, cloudy days and even when going downwind.
  There are two main types of hydro generators: the fixed transom-mounted and towed. The fixed types are easier to deploy, more efficient in terms of both power generated and reduced drag and are commonly used on offshore racing boats. The disadvantage is that the impeller is constantly changing depth and sometimes coming clear out of the water, reducing its efficiency. The traditional towed generators tend to be cheaper but are not as efficient, particularly at lower speeds, they do create some drag and are more difficult to get back on board.
- **Auxiliary power generator:** they are very reliable but this will increase your fuel consumption considerably over a long passage. The downsides of any generator are the noise, the heat and the air pollution, commonly for 2 hours each day.

What if your power generation system fails?

If you go to sea for an extended period, you need to consider a scenario where your power generation system fails, e.g. engine. Based on the power consumption table above for a modern sailing yacht, one should be able to sail for 4-6 days when radar, autopilot, chart plotter and perhaps other optional equipment are turned off. If deck reckoning and celestial navigation are used for position fixing and no electronics at all, perhaps just compass light and navigation lights, one should be able to sail for weeks.

If you only have the main engine for electricity generation and it fails, this also takes out all your power and although people have crossed the oceans without it, it would not be particularly pleasant.

Conclusion. For long passages (e.g. Atlantic crossing) you should consider at least one alternative power generation system. It would also be advisable to have a battery-powered GPS in a grab bag just in case.

Rubbish

Managing rubbish on long passages is important. A bag of food waste will soon develop an unpleasant aroma and be hard to stow if you are not mindful of it.

Below are a few best practices to employ:

- Store rubbish in double bags to avoid spillage in lockers.
- Crush bottles and cans as much as possible before throwing them away.
- Rinse all disposable food containers before putting them into a bin.
- Remove all packaging before anything comes on board.
- You can throw food scraps overboard when you are over 12 miles offshore in deep water (check the MARPOL convention for more details).
- Discard trash bags only in designated harbour facilities. Some places like small islands have very limited rubbish facilities so be responsible and mindful of how you dispose of it.

Survival Navigation

If your GPS is broken or you have no electricity on board, you should have some strategies to make it safely to the next harbour. Things are probably easier if you are in sight of land but being on the open sea without any obvious reference points makes the job more difficult. But not all is lost. Learning how to navigate with a sextant and carrying one would be a prudent and truly seamanship approach. If that is not available, you can carry on using the dead reckoning (tracing distance travelled and a course) and some alternative methods like a stick.

No Compass?

Unlikely to happen on a boat but possible in survival on a liferaft or an unhabituated island. Steps:

1. Locate a short length of wire, a sewing needle or a pin.
2. Magnetise the needle using one of the methods:
    a. stroke needle repeatedly with a magnet (always in the same direction), for example from a speaker.
    b. stroke with a piece of silk cloth.
    c. fashion a coil around the needle and connect the ends to the positive and negative terminals of a battery or batteries, leave for 5-10 minutes.
3. Suspend the needle in some way, e.g. fill a glass or plastic vessel with water, put the needle on a piece of wood, a slip of paper or a piece of leaf.
4. The needle should rotate and indicate the magnetic N-S.
5. Use a star or sun to help you recognize which end of the needle is pointing north.

Want to calculate speed without a speedometer?

Improvise log line or use Dutchman's log. (aka spit log).

Approximate latitude

The simplest way is to find the right latitude to find us land, then sail across that line of latitude. In other words, keep latitude constant. To do that, all that is needed is a stick. Hold it vertically in front of the eye with a straight arm and line the top of the stick up with Polaris's star in the Northern Hemisphere. Then, carefully "nick" the stick at the point where the horizon intersects it. Every evening, check the stick against Polaris. If the "nick" is still on the horizon, you are at the same latitude. For this to be effective, one would have to mark the stick as soon as possible after the last reliable fix, use the same stick every time and the same person should do it.

Another method that could be employed is to improvise a quadrant using a protractor and a plastic ruler. With that, you can measure celestial objects' altitude. The easiest, at least in the northern hemisphere, would be to take the altitude of the Polaris star which is always equal to the observer's latitude (+/- 1^{o}). Another alternative would be to measure the sun at noon (sun at its highest point) but for that, you will need a table

for the declination of the sun to make the calculations.

Approximate longitude

You could establish approximate longitude from local noon (sun at its highest point) by taking a time when it happens and calculating the difference to noon at Greenwich using a conversion of Time to Arc (1 hour = 15^{o}, 1min = 15', 4sek = 1'). Applying correction from the graph for the Equation of Time (the difference between what our watch is doing and what the Earth is doing) will make the calculations more accurate.
Note that when checking the sun's height against the horizon, it is not possible to look directly at the Sun. Instead, you can use a stick and a bit of paper and mark the end of the shadow every 20 seconds or so as local noon approaches. Alternatively, make a sun shadow board.
These methods will not be terribly accurate because it is very hard to find the exact point in time when the sun is at its highest but it will give us some approximation.

Getting the approximate latitude and longitude using the methods above requires an experienced helm steering a constant course and accurate chart keeping to make it work.

Landfall

Avoid making landfall after dark if you are unfamiliar with your destination. Plan the passage to arrive in the morning, and if you are early, heave-to until dawn.

If landfall is estimated to be near, looking for seabirds and cumulus cloud formations on the horizon can be very useful. The smaller the bird, the closer land is likely to be, perhaps 30 - 50 miles distant. But of course, a single bird could always be lost and some birds venture across oceans. Clouds gather over land as the land heats up and convection occurs, causing sea breezes. A good sign!

You can and should listen to VHF radio traffic and watch for other vessels. Asking for directions for the last miles can always be done.

The top of a high radio mast will probably be the first landmark to be observed on land from the sea. Interestingly enough, they are in the same red-white colours as a safe watermark.

Seawater can give some useful information too: What does your echo sounder read? What is the water temperature? Is it shallowing? What colour it has?

The sighting of a light aircraft can give you an indication of position and, near coast and island groups, can help with landfall in the same way the sea birds and small cumulus clouds do. Watch the plane carefully: Does it seem to be losing height? Has it lowered its wheels and flaps? Is it turning into the wind, its nose down 2-5 degrees? Is it about to disappear below the horizon? Does it circle around before disappearing? Do you see any airports or airfields on the chart in the vicinity of your approximate position? Aircrafts (except search and rescue planes and helicopters) are not supposed to use marine VHF frequencies but it's always worth a try on channel 16.

Finally, while you are sailing near an unseen island you may get two warnings that it exists below the horizon. First of all, you might see evidence of a reflected swell. Second, as you pass the island, the secondary swell coming towards the bow will be replaced by another coming on the quarter. If this happens you should begin to worry a little: are you about to miss the island? What are the birds doing? Maybe there is a marker cloud on the horizon?

You can find more about technology-free navigation in the Barefoot Navigator book.