Sail handling on *Endeavour*

HM Bark *Endeavour* replica under plain sail in fair weather en route to Newcastle Maritime Festival in 2008. ANMM photograph

The *Endeavour* replica is a fully functioning, educational museum whether alongside our wharf or making a passage, says crewmember **Anthony Longhurst**. Not a day goes by without someone learning something. Here he tells us what many thousands of sea miles have taught us about 18th-century, square-rigger sail handling.

When many people first see our *Endeavour* they question how the ship sails, with her bluff bow pushing along so much water. In addition, many believe that square-rigged ships can only sail downwind and must be slow and uncomfortable. The reality is surprisingly different.

When putting to sea on the replica, the first thing we notice is the comfortable motion as she steadily rolls, pitches and scends (rises again) on the swell. The masts swing in wide, gentle arcs against the sky, whispers of wind fill the billowing canvas. She heels over comfortably as the helmsman puts a bit of helm on to check her tendency to gripe (turn or 'round' up into the wind – what sailors call 'weather helm'). This only takes one or two spokes of helm. The helm is eased again as she settles on her course once more.

The hard work of setting the sails is soon forgotten once we sit back and admire the beauty of the vessel under full sail. There is the creaking and sighing of the ship's timbers, the slight rapping of reef points against their sails far above and the occasional slap from a wave striking the weather bow. Below decks nothing can be heard other than the creaking hull and the gurgle of water passing along the ship's sides, leaving the rudder in small whirlpools trailing astern.

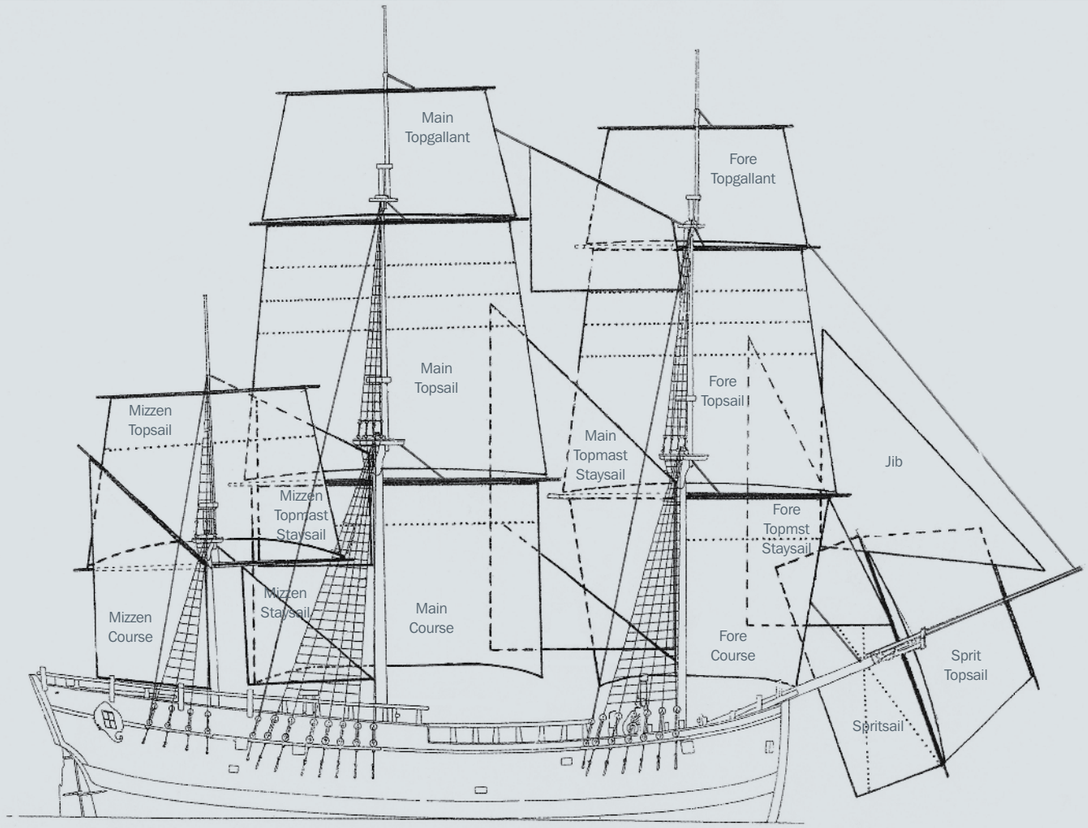
There were very good reasons why the British Admiralty and James Cook chose this old coal-hauler, built in Whitby on England's north-east coast, for a long voyage to the South Seas. The original collier, the *Earl of Pembroke*, was built to be managed by a small crew, strong and seaworthy enough to survive the rough, shallow North Sea and occasional groundings, nimble enough to get in and out of coastal ports, capacious enough to carry a viable cargo – or in Cook's case, supplies for her large complement not just of sailors but of scientists and marines. She was everything they were looking for.

The Royal Navy did a great job in recording the hull and construction details for 20th-century replica builders. The rigging has been scaled to the Admiralty specifications and tables relating to vessels of her size. Instead of hemp rigging and sails, however, the replica has manila standing rigging, and for durability and rot resistance uses polypropylene running rigging and Duradon sail cloth (a polyester woven with the appearance and feel of natural canvas). It also uses modern antifouling paint instead of 'White Stuff' – a mixture of oil, rosin and sulphur or brimstone – applied over sacrificial planks or deals of fir. But notwithstanding these differences, we can conclude that the replica and the original ship behave quite alike under sail, since the hull shape and rig are as identical as modern day practices and research can allow.

It is when using another 20th-century necessity – the engines – that we understand that the vessel's hull shape is designed to be pulled by the sails rather than pushed from astern by propellers. Despite a number of lower fore-and-aft sails that we set to help stabilise and balance the ship when the engines are running, the helmsman must always be vigilant. The ship will yaw and dart off course with little notice, and it takes up to half a turn of the helm to correct. Motoring can be like trying to push a ball across the surface of a pool with a broom handle!

Once under sail, though, you feel as though you've stepped aboard an entirely different vessel. When balanced with the appropriate sails for the conditions, *Endeavour* leads herself with the minimum of effort from the helmsmen. At times the helm may need no adjustment for up to half an hour, and then it might only need half a spoke (1/20th of a turn on the ship's wheel). She only needs a slight breeze to make enough way to gain steerage, which occurs when making about one knot through the water. This surprises some people, since the tall rudder is very narrow, designed to create the least amount of drag. The ship can be kept on her course in as little as five knots of breeze.

The foremast is relatively close to *Endeavour*'s broad, bluff bow, stepped about six feet (1.82 metres) abaft the forefoot (where the stem post joins the keel). In later years, foremasts gradually moved further aft as vessels' bows were given a finer entry and therefore had less buoyancy to support the weight of the rig above it. With *Endeavour*'s foremast stepped so far forward, there is a great depressing force upon the lee bow. When on a beam reach (wind blowing from the side – around 90°) or close hauled (wind from a forward quarter), this tends to create weather helm by lifting the stern as the bow is pushed down. To help compensate for this the jib is set way out in front, lifting the bow and pushing the head off.



Endeavour in sail

What follows is a description of how the ship's sail plan is adjusted when sailing with a well-trained crew to compensate for different wind strengths.

0–20 knots

With the wind two points (22.5°) aft of the beam – *Endeavour*'s best point of sail – we begin with all plain sail set in winds of less than 20 knots, except the studding sails. These additional light-wind sails were used to extend the area of the larger square sails. I won't include them here, since they are generally the first to be brought in as the wind increases. They are illustrated on page 40. The total sail area shown above would equal 9,468 square feet. With the wind at 15 knots, the maximum combined pressure from all sails set on the ship is approximately 3.2 tons.

20–25 knots

All sail except the main staysail is set until the wind increases to about 20 knots across the deck (apparent wind) and weather helm starts to increase. The main topgallant staysail is brought in (handed) to ease excess strain off the main topgallant rigging and to remove some of the heel that is created by this sail being so high in the rig. The fore topgallant is then handed to ease the depression on the bow. This is preferable to removing sail aft, which is not yet the cause of the weather helm. The total sail area set at this time is 8,561 square feet. With the wind at 20 knots, the maximum pressure from all sails is approximately 5.1 tons.

25–30 knots

As the wind increases to about 25 knots apparent, the sprit tops'l, jib, main topgallant and mizzen topmast stays'l are handed and furled, and the first reefs are put in the fore and mizzen topsails. The effort of all the sails set is generally centred slightly forward of the ship's turning point (CLR or centre of lateral resistance). The CLR moves forward as the bow is depressed. The fore topmast stays'l is set from the end of the sturdier bowsprit to compensate for the loss of the jib, maintaining some lift for the bow. It is about this time that a diagonal reef is taken in the sprits'l, to keep the weather clew (lower corner) clear of the building seas. The sprits'l helps prevent the ship from rounding up. In these conditions, *Endeavour* comfortably makes six to seven knots, heeling at about ten degrees. The occasional cresting wave slaps her side and sends spray across the deck. The helm is comfortable and requires minor adjustments. The sail area is 6,313 square feet. With the wind at 25 knots, the maximum pressure from all sails is approximately 6 tons.

30–35 knots

As the wind increases to 30 knots apparent, the main topmast stays'l is handed. This is a large sail and at almost 700 square feet adds a lot of stress to the main topmast. With this the second reef is put in the fore tops'l and the main topsail has the first reef put in. By taking sail in like this, you not only control the depressing of the bow, but you also lower the sails' centre of effort, thereby reducing the heeling of the ship. The more a ship heels over, the more she is forced to round up. Depending upon the seas, it may be time to hand and furl the spritsail. The helm becomes heavier to turn and it can give a light kick as a wave slaps against it. More spray comes on deck and the rig is starting to sing as the ship rolls to windward. Sail area has reduced to 5,185 square feet. With the wind at 30 knots, the pressure in the sails is approximately 7 tons.

35–40 knots

At 35 knots, the second reef is put into the main tops'l, the fore tops'l is close reefed (i.e. the third reef goes in), and the mizzen tops'l is handed and furled along with the spritsail (if it has not been already). The mizzen course, which is what we call the gaff-rigged fore-and-aft sail, is also handed as this will now act to round the ship up, since there is not much sail left forward to counteract it. The main stays'l is set. The seas grow in time to about three to four metres, the helm requiring more attention as the ship occasionally takes a heavy roll to leeward. The wind in the rig is becoming louder and the spray from the seas comes more regularly across the decks forward. Sail area is 4,194 square feet and at 35 knots of wind, the pressure in all sails is approximately 7.5 tons.

40–45 knots

At 40 knots we consider sending the topgallant yards to the deck. This reduces windage aloft and helps to lower the ship's centre of gravity. Being light, they are vulnerable and if the conditions worsen they are a dangerous place to be if a sail should break loose from its gaskets (lashings). Crewmen would have to climb 100 feet aloft to wrestle the sail back under control – an exhausting job. The main tops'l is close reefed and the anchors are secured with extra lashings. The rigging starts to howl, spray is fairly constant and the ship is starting to gather impressive speed – anywhere from nine to 11 knots. She carries about four spokes of weather helm and when the swell lifts her stern she wants to gripe further. Total sail area is down to 4,060 square feet; at 40 knots there is approximately 9.3 tons of pressure from all sails.

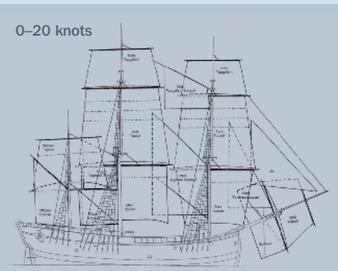
45–50 knots

At 45 knots, the main course has the sheet eased to spill some wind, or a reef is put in instead. The lee clew is far enough aft on this sail when braced up that it will try to force the ship's head up into the wind. If the wind is on the quarter or further astern, this sail would have been handed and furled earlier, letting air through to the sails further forward and placing the centre of effort well forward. The main stays'l, tiny mizzen stays'l and fore topmast stays'ls are the only fore and aft sails still set. The braces controlling the tops'l yards feel like iron bars due to the strain from the wind in the sails. If the blow is expected to last, we may 'house' the fore and main topgallant masts. This takes skill for the crew to do in rough weather. The masts are lowered vertically and lashed to the topmasts, and their standing rigging is shortened by tying sheep-shanks. Alternatively, the masts can be sent right down to the deck and secured on the gallows. Life lines are run out on deck for the safety of the crew. The seas build to about six metres and anything that has not been securely lashed starts to work its way free. Seen from the waist, the seas loom above the horizon as the ship descends into the troughs. Some seas collapse under their own weight and slop onto the deck. Sail area is 3,960 square feet. With the wind at 45 knots, the pressure from all sails is approximately 12 tons.

50–55 knots

With the wind reaching 50 knots the tops'ls need to come in and a reef is put in the mainsail. It takes all hands to handle the lines, go aloft and tame the angry, flogging canvas! If you haven't recently cut your fingernails, you may soon lose them. The crests of the waves are being blown off into long white streaks across the sea. The air is starting to fill with spray and stings your face like a sand blaster. It's an effort just standing up against the wind. Think of the force on your hand held out of a car window on the freeway. Now imagine that

0–20 knots

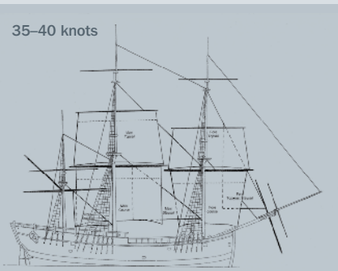


20–25 knots

25–30 knots

30–35 knots

35–40 knots



Illustrations by Anthony Longhurst.

Endeavour in the Indian Ocean in 1996, studding sails set to weather off the fore yards.

Endeavour in a strong gale in the Cook Strait, New Zealand, 2000. Photographer Anthony Longhurst

over your entire body as you climb to the tops'l yards 60 feet above the deck as the ship rolls to 30 degrees or more. The deadlights on the great cabin windows are now dogged tight, so is the forward hatch and we have to use the after hatchway to get on deck or go below. The total sail area set is 2,407 square feet. At 50 knots of wind, the pressure in the sails is approximately 9 tons.

55–60 knots

At 55 knots, it is time to hand and furl the main course. This is a large sail of almost 1,000 square feet and has to be treated with respect. The tacks (lines that lead the windward clew forward) have a diameter of 44 mm and at times require the entire ship's company to handle. We need about 20 people to lay out on the yard to furl, always starting at the weather yardarm to help spill the wind from it. If you were to start on the leeward side, the sail would act like a funnel and would be impossible to control. The gaff-rigged mizzen course would now be reset along with the main stays'l. The fore topmast stays'l would be handed and furled, and a reef placed in the fore course. If this weather lasts for days, the seas build to over ten metres; it often feels as though they are going to crash on top of you. In these conditions you really begin to appreciate the ship's design. With her high topsides and buoyant bow, she lifts and lets the seas pass under her. Rarely does a big sea break onto the decks. More modern ships in these conditions often find their decks awash. The sail area set at this time is 1,473 square feet. With the wind at 55 knots, the pressure from the sails is approximately 6.6 tons.

60–65 knots

Most people want to go home about now! At 60 knots you have the choice to 'lie to' (heave to) or to scud (run before the wind) if there is the sea room to do so. To scud we have to hand the mizzen course and stays'l, ease the main stays'l sheet and square the foresail. The foresail sheets would be eased in order to get the centre of effort way out ahead of the ship and to lift the bow. By doing this you reduce the chance of broaching (turning side on to the swell) as the ship surfs the waves. Steerage is lost as a vessel surfs and the helmsmen have to be on their game to catch any deviation in the ship's course immediately. Heavy lines can be trailed astern in order to create drag on the stern, reducing the chance of rounding up if a wave was to catch her – although this can increase the chance of being pooped (having a wave board over the stern). Over time these large following seas can reach 15 metres in height. The air is completely full of spray, as the wind strips the crests off the waves and hurls them along the sea surface and into the air, turning the seas completely white. The noise is like standing in a tunnel with a freight train roaring past. It's almost impossible to hear a person standing next to you yelling at the top of their lungs! The sail area is down to 1,027 square feet. At 60 knots of wind there is approximately 5.5 tons of pressure in the sails.

65+ knots

If the wind was to increase further, the foresail would have to be handed and the ship turned to lie to. This can be dangerous as you need to turn the ship temporarily broadside (side-on) to the swell. The right moment must be chosen carefully! To lie to, the foresail must be furled and the mizzen course set. The vessel will then ride about four points (45°) to the wind, meeting the seas with her buoyant bow that lifts and rides over them. The wind on her high stern helps to keep the ship's head to wind. This is where Cook said 'No sea can hurt her laying (hove) to under a mizzen balanced'. While lying to with the mizzen course and main stays'l set, the vessel slowly forges ahead and does not fall too greatly to leeward. It can sit like this until the conditions abate. The ride is not particularly comfortable as the ship pitches and at times rolls heavily; everything would be wet and everyone exhausted. The rigging still has to be carefully attended for wear and tear and all sails need extra gaskets so the wind cannot tear them open. We are down to 711 square feet of sail with approximately 3.8 tons of pressure from 60 knots of wind.

I have referred often in these pages to weather helm. This natural tendency to steer up into the wind can be used to advantage. It can be reduced by the set of the sails or it can be exaggerated to assist in getting the ship to tack, speeding the natural process of rounding up to get the bow through the wind and settled onto the other tack.

When it is blowing quite fresh, it is more advisable to 'wear' (gibe) the ship onto the other tack, if sea room allows, rather than tacking through the wind. This is because the rigging best supports the masts from pressures from athwartships (the side) or from aft (behind). While stays that lead forward help steady the masts, they are not as strong as the numerous shrouds and backstays that do the majority of the supporting. If a stay was to break while the wind was blowing from ahead, the rig could be lost.

Endeavour is capable of sailing to windward, but not like a modern yacht. She can sail with the wind about 60 degrees apparent from the bow. Since she loses about 20 degrees of leeway with an experienced hand on the helm and all sails properly trimmed, she can make good about 10 degrees to windward. If we try to point the vessel any higher, the lift created by the sails is lost and leeway increases, so the ship falls away from the wind. With a sea running she will hold her ground if properly sailed and steered, but any unfavourable current will work against her. To work the ship away from a lee shore can be very difficult – as countless sailing-ship wrecks attest.

Endeavour, however, is a very comfortable sailer. She is built strongly and her rig, if well managed and maintained, will survive any weather. But it can be easily damaged if handled incorrectly, putting those on board at risk.

Part of the reason behind building a replica vessel is to learn about the problems faced by those who went to sea on the originals. This is where we gain an understanding of the evolution of the sailing vessel to the present day, and develop appreciation for the societies and the people who built and sailed these impressive ships. ■

Author **Anthony Longhurst** is a leading hand, shipwright and rigger with the HM Bark *Endeavour* replica team. His involvement with tall ships began in 1986 at age 13 and he sailed with *Endeavour* as a watch leader, shipwright, sailmaker and boatswain from 1995 until 2000. During the replica's first world voyage he logged over 60,000 nautical miles, which took him to New Zealand, South Africa, England, the Caribbean, east and west coasts of the USA and Hawaii. Anthony rejoined *Endeavour* in 2005 when she came under ANMM management.

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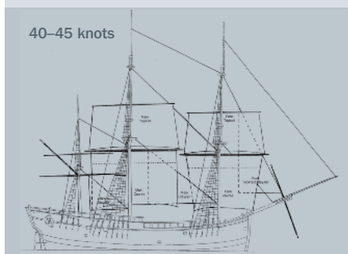
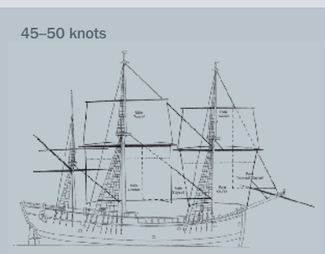
40–45 knots



45–50 knots



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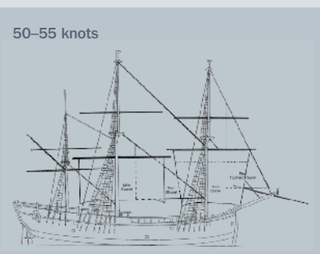
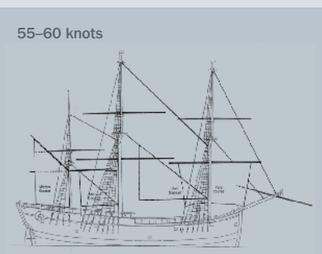
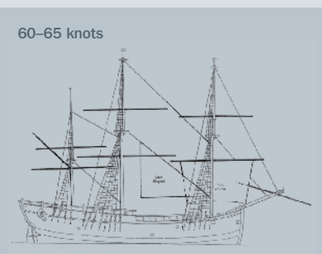


55–60 knots



60–65 knots



65+ knots