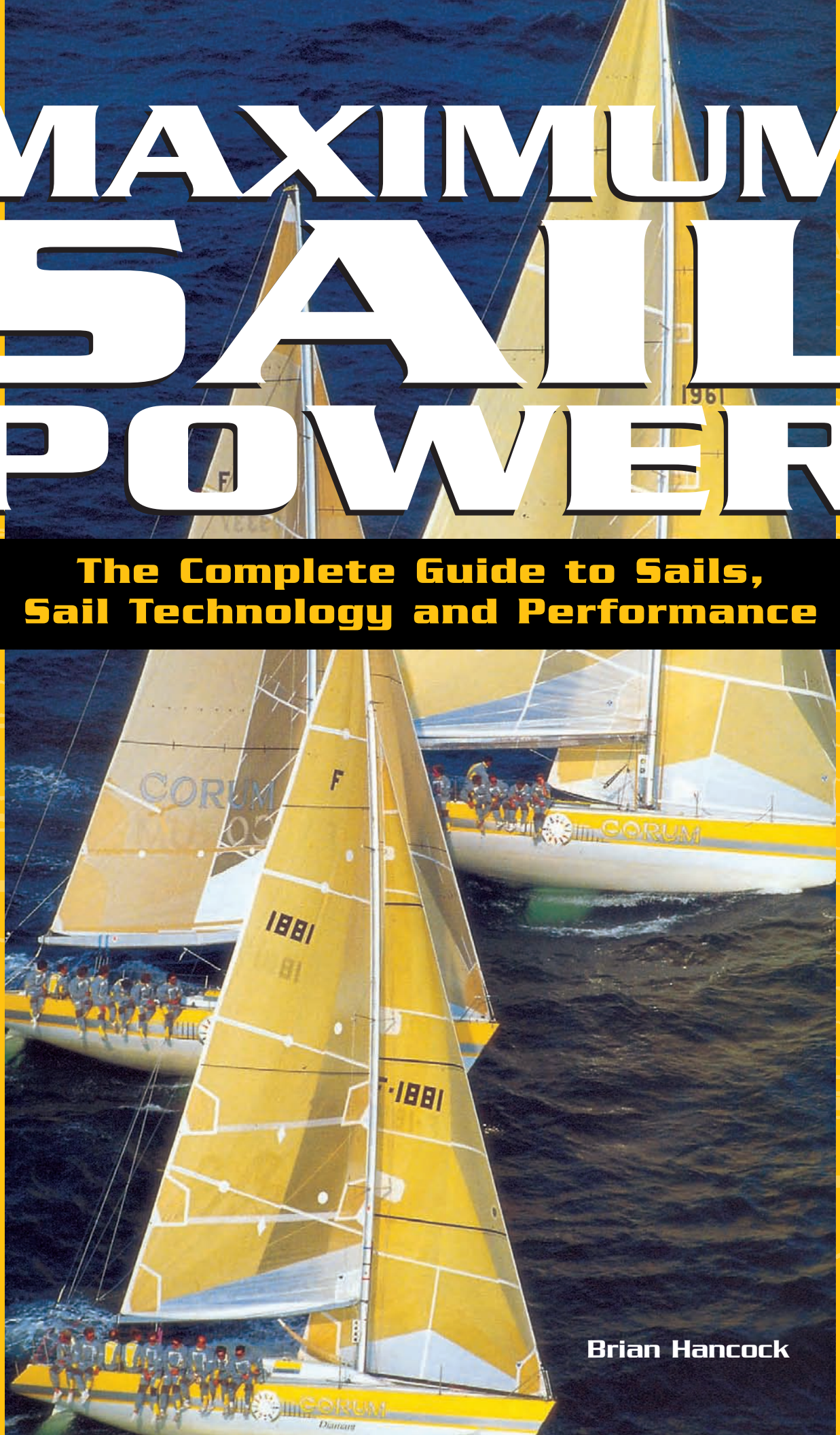
MAXIMUM SAIL POWER

The Complete Guide to Sails, Sail Technology and Performance



Brian Hancock

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Brian Hancock is an expert in sails, sailmaking, and offshore ocean racing, having made a career as a professional sailor for almost three decades. He apprenticed at Elvstrom Sails in South Africa before leaving the country to sail around the world. In 1981/82 he sailed as a watch captain aboard the American yacht, *Alaska Eagle* in the 27,000 Whitbread Round the World race. Four years later he returned for a second Whitbread, this time aboard the British yacht, *Drum*. In 1989 he sailed as Sailing Master aboard the Soviet Union's first, and by happenstance last, Whitbread entry, *Fazisi*. With more than 200,000 miles of offshore sailing to his credit Brian is uniquely qualified to write about sails and the business of making sails.

Brian also owned his own boat, *Great Circle*, an Open 50 carbon-fiber, water-ballasted sailboat designed and built for single-handed sailing and Brian did a number of solo offshore passages. Some of his experiences are recounted in his book, *The Risk in Being Alive*, published by Nomad Press. These days he works on special sailing projects and writes for magazines around the world while raising a family in Marblehead, Massachusetts.

Dedication

For my father who taught me to sail, and for all my crewmates who have shared a watch with me

Acknowledgments

This book has been a fairly reasonable undertaking and it would not have been possible without the help and encouragement of the editors at Nomad Press. Many thanks to Alex Kahan for agreeing that this was a worthwhile project and encouraging me to go ahead with it. Thanks to Susan Hale and Lauri Berkenkamp at Nomad who patiently prodded me to make sure that the book got completed when more amusing exploits like sailing and skydiving had me distracted.
And Jeff McAllister who did a terrific job laying out the book in an immensely readable fashion.
Also thanks to the "nagger," Adam Cort, whose diligence as an editor made this a far better book than I could ever have hoped to write on my own.

Mostly, however, I would like to thank my crewmates who sailed with me over the years and whose knowledge and expertise are contained in these pages, especially those who thought enough of what I had written to give the book their resounding endorsement.
It's gratifying to be acknowledged by your peers.

Brian Hancock
Marblehead, Massachusetts, 22 August 2003

George Day
Publisher & Editor,
Blue Water Sailing

"*Maximum Sail Power* is the best book on sails and sail trim to come along in a generation. Brian Hancock knows his subject and has the sailmaking experience and sea miles to know what really works and what does not out there on the open sea. If you are in the market for sails or want to become a better sailor, *Maximum Sail Power* will steer you straight and true."

Herb McCormick
Author, NY Times *sailing writer, editor of* Cruising World Magazine

"Brian Hancock is the rarest of seagoing creatures, a consummate sailor with countless miles in all conditions under his keel, and a gifted writer who can both spin a yarn and transpose complex technical material into clear, understandable prose. His *Maximum Sail Power*, a definitive treatise on the art and science of harnessing the breeze, joins a select handful of classic sailing books that deserve a space on the shelf of any well-found sailing vessel."

Bernard Stamm
Winner 2002/03 Around Alone (Class 1)

"Sails are not only the engine of the boat, but they are very important to the overall performance of the boat. Therefore it's critical that you understand how they are made, and how to get the best performance from them. Brian's book covers it all including how to trim and handle sails, and more importantly how to understand the subtleties of the wind and how it relates to sails. I know you will learn a lot from reading this great book."

Brad Van Liew
Winner 2002/03 Around Alone (Class 2)

"While Brian was writing this book he was also working closely with our team on *Tommy Hilfiger Freedom America* to develop the sail program and make a suit of sails that would not only win the race for us, but make it around the world in one piece. It's clear that he knows his stuff. The sails performed perfectly and I never once had to worry about the design and engineering. All that knowledge and experience is contained in this book and I urge you to read it."

Cam Lewis
Olympic medalist, skipper of Team Adventure

"Brian was integral and a key team member in the sail development for the megacat *Team Adventure* and through his bountiful knowledge and global experience we were able to circumnavigate the world without any sail problems. Now his exciting new book contains that knowledge and experience from his decades of sailing and sailmaking – all you have to do is pick up a copy and read it. It's clear that he knows his stuff not only for big catamarans but for more conventional race boats and cruising boats as well."

"Brian Hancock does a beautiful job blending the art and science of sail technology. For most sailors, the theory of sails is a mystery. Brian makes it understandable for the club sailor, cruiser, and the racing expert. *Maximum Sail Power* makes the process of using sails and understanding their theory easy."

Gary Jobson
America's Cup winner, ESPN commentator

"The mystery of how to obtain the best performance from your sails has been exposed. This book will be of inestimable value to the learner and experienced sailor alike. Sail trimming has always been considered an art. Brian Hancock has shown how it is a science."

Sir Robin Knox-Johnston
First sailor ever to solo circumnavigate the globe non-stop

"Sails are the engine of any boat and understanding the principles of sail set-up and maintenance is crucial to good sailing. Brian's book covers what you need to know about the subject. He has written a concise book in language we can all understand – you can tell Brian has a passion for the sport and masses of experience to share in both sailing and sailmaking."

Ellen MacArthur OBE
2nd place, 2000/01 Vendée Globe, UK Yachtsman of the Year

"Brian's involvement with the sails on all my sailing projects from the early Whitbread races to my latest expedition sailing vessel *Pelagic Australis* has been integral to the success of each project. This is a storehouse of information that will be useful to the novice boat owner or the experienced cruiser/racer alike in order to demystify the "art" of sails, sail making and repair."

Skip Novak
Four-time Whitbread Round the World Race veteran, co-skipper of Innovation Explorer *in The Race*

"*Maximum Sail Power* is a well-written book by a well-known sailor. It is a comprehensive guide to how sails are made and work for all levels of sailors. Brian's experience shines through in all aspects of his writing. This book is a must-read for all sailors."

Tom Whidden
President, North Sails

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Photo by Roy Riley, Marinepics

Bobst Group Armor lux *sailed by Bernard Stamm breaks through a wave shortly after crossing the finish line in Tauranga, New Zealand. Stamm went on to win Class 1 of the 2002/03 Around Alone race.*

HOW TO GET THE MOST FROM THIS BOOK

Sails and sailmaking is a fascinating and increasingly complex subject. It's a combination of art, science, history, and mystery. Many sailors enjoy these complexities and spend days, sometimes weeks, even years studying the subject and using it to their advantage either on the race course, on a bluewater passage, or while out for a weekend cruise. Others find that it has become too complicated, too unwieldy, and far too difficult to understand. They feel overwhelmed by the enormity of the subject and view it as a large, kindly uncle whom they would like to know better, but whose presence is so imposing they don't make even the first attempt at getting acquainted. This book is designed to be your bridge between that unfamiliar world and your desire to know more about this important aspect of something you love. I feel strongly that an understanding of sails and the way they work is a part of basic seamanship and therefore important to all sailors.

While the weight of this book and depth of the topic might make you less inclined than ever to come to grips with the subject, the book is designed to lead you step-by-step through the process, making the journey as simple as possible. It's not necessary to read every word in each chapter. In fact, much of what is written might already be familiar to you, in which case you can skim those areas. It's also not absolutely necessary to read each chapter in order. You might find a particular part of the book that interests you, and if so I suggest you start the book at that point.

On the other hand, the book was written and laid out with a definite plan in mind, and if you start at page one and work your way through to the end a lot of what once seemed difficult to understand or too technical to grasp should become clear. It is possible to become a good sail trimmer without understanding the theory behind lift and drag, but you will definitely be a better trimmer if you understand how a boat sails and all the other nuances of sail design and handling. At the very least it will make you popular back at the yacht club. Who else bellying up to the bar will know about circulation, boundary layers, and lift, to say nothing of finite element analysis and how to carry out the perfect float drop at the leeward mark?

***Maximum Sail Power* is divided into a number of sections plus an appendix:**

Chapter 1 is a hypothetical visit to a sailmaker. This chapter goes hand-in-hand with Chapter 14, which includes a series of questions that you might want to ask your sailmaker once you have a greater understanding of the subject.

Chapters 2–7 are the real meat of the book. They describe the process of creating a sail, starting with the raw materials and working through each step until the finished product is ready for use. The chapters cover everything from the basic properties of different kinds of fibers and the construction and engineering of fabric to the design and construction of different kinds of sails, including the latest molded sails.

Chapters 8–10 look at three important areas: downwind sails, storm sails, and sail inventories in general.

Chapters 11–12 are a comprehensive look at sail trim and sail handling.

Chapter 13 looks at sail repair.

Chapter 14, as already mentioned, is a question-and-answer section with all the questions you might possibly want to ask your sailmaker.

Chapter 15 examines the theory behind how boats sail, including an in-depth look at the aerodynamic and hydrodynamic theory behind how foils work and how a sailboat can sail close to the wind.

Again, you may choose to read only one or more sections of the book, although I urge you to make an effort to read them all, including the last chapter on sailing theory. I also encourage you to attempt to come to grips with some of the more complicated sail-handling maneuvers covered near the end of the book since the more you know about handling your sails the better sailor you will be. I have tried throughout the book to keep an even balance between racing and cruising. Rather than separate the two groups and address their specific needs independently, I thought it was important to keep them together, since cruising sailors can always

Photo by Mark Pepper, Marinepics

French sailor Thierry Dubois storms across the finish line aboard Solidaires *in Salvador, Brazil, at the end of Leg 4 of the 2002/03 Around Alone race.*

Bernard Stamm turned in an impressive performance aboard Bobst Group Armor lux *in the 2002/03 Around Alone.*

learn something from the racers and vice versa. If in parts of the book it appears that I am heading off on a subject that is not interesting to you as a cruising sailor, humor me and stick with it. You may learn something that can be applied to your cruising. Same too for racers. The experience of cruising sailors has contributed greatly to the sailmaking industry and as a racing sailor you might just learn something about durability and fabric engineering that can help you out on the racecourse. In its entirety, the subject of sails and sailmaking is fascinating. I hope that this book will give you a greater understanding of the topic and that you will derive more enjoyment out of your sails, and by extension, your sailing.

INTRODUCTION

In the fading light of a South African summer evening we took off from a small airfield and flew along the coast watching the bays and harbors unfold as we skimmed the treetops. A strong wind was blowing, lacing the ocean with white streaks of spindrift and buffeting our small helicopter. Table Mountain cast long shadows as the sun dipped slowly over the western horizon. Where the water was shaded, the whitecaps stood stark against the dark sea, but toward the horizon they sparkled like small diamonds, reflecting the last light of day. As the cape peninsula tapered to its scenic point I could just make out the boat a mile off the beach crashing through steep waves. Spray was flying from both hulls as the 110-foot megacatamaran *Team Adventure* sliced through the water at 30 knots. She was heading for the Southern Ocean and beyond, to Cape Horn, the Atlantic Ocean, and finally back to France and the end of her voyage. We hovered a few feet above the top of the mast looking down at the sheets of water rising from each bow and pitied the crew hunkered on deck holding on for the ride of their lives. From my vantage in the chopper I could see both the clean twist of her mainsail and its smooth overall shape. Surprisingly, the thought that passed through my mind was, "trickle down does work."

I was partly responsible for the sail development program for *Team Adventure* as she prepared for The Race, a nonstop circumnavigation of the world. It was a loaded responsibility since the success of the effort, indeed the safety of the crew, depended upon some of the decisions made before the start of the race. My realm was fabric: the myriad clusters of fibers, film, adhesive, and thread that collectively would harness the wind and propel the boat around the planet. Since the race was nonstop and the sails so enormous and unwieldy, there would be no way to repair any of them if they ripped or came apart. The mainsail that was bent on the boom at the start would have to remain in use until the finish some 27,000 miles later. Working with a number of sailmakers we tested all the usual suspects, including Kevlar, Spectra, Vectran, and carbon, each both alone and in various combinations. We also looked at some of the newer sail engineering techniques like North's 3DL process, UK's Tape Drive, and Doyle's D4. In the end we settled on a revolutionary fabric called Cuben Fiber, which tested off the charts when compared to the others to the point where the numbers looked almost too good to be true. In fact, in some areas they were, but overall the fabric showed so much promise that most of *Team Adventure's* sails were eventually made from Cuben Fiber. Of course, there was an element of risk involved. Cuben Fiber had never been used for a voyage of this nature before, a fact that alone should have disqualified it from consideration. But we compensated for this drawback by over-engineering the sails. And when the boat took off from Marseilles on the last day of 2000, everyone involved in the sail development process was satisfied that the sails would not only go the distance, but also provide the crew of *Team Adventure* with an edge over its competition.

" . . . we tested all the usual suspects, including Kevlar, Spectra, Vectran, and carbon, each both alone and in various combinations."

As fate would have it, it was an engineering problem associated with equally exotic fibers used for the construction of the hull, not the sails, that forced the boat

Considered the world's fastest sailboat, Team Adventure *is 110 feet of pure power capable of sailing at 40 knots.*

to make an unscheduled stop in South Africa. When I flew to Cape Town to coordinate the repair of the boat, I saw that even after a little over 10,000 miles of use the sails still looked like new. Aside from some opaque crinkles in the laminate from being stuffed into a bag, the "risky" fabric we had chosen seemed to be performing beyond expectations. As I checked the sails and talked to the crew, I realized that the design parameters outlined for these sails would be the same for just about any inventory of sails that might be used for an offshore passage – light sails that hold their shape and have sufficient durability to circumnavigate the world without stopping – and that I might very well be looking at the future of cruising

sails. This feeling was further reinforced that evening as I watched *Team Adventure* plunge from wave crest to trough. I felt sure that one day in the very near future we would be seeing Cuben Fiber sails on some of the larger cruising yachts, perhaps even on smaller ones as the fabric became more accepted. The technology developed and tested at the "lunatic" fringe would one day "trickle down," to use a phrase that President Reagan made famous, to the average cruising sailor.

It's this trickle-down process that has served to intrigue and confuse many sailors out there looking for sails for their own boats. Years back the choices were simple: Dacron for mainsails and headsails, and nylon for spinnakers, all of them constructed in pretty much the same fashion. Because of the way Dacron was woven into sailcloth, the sails were built in a cross-cut style with long panels of horizontal sailcloth running from the luff to the leech. The same was true for the early spinnakers. That, however, was a simpler time in more ways than just the sailmaking process. These days it's a complicated world made more so by the increasingly competitive nature of the sailmaking business. One sailmaker will be adamant in his recommendations, while another will be just as definite about something completely different, both making recommendations for the same application. The reality is that both may be right. There are many ways to make an equally good sail and even that old standby Dacron has a role to play in the modern sailing world. In fact more than 70 percent of all new sails currently being manufactured are built from Dacron. The hard part for the individual sailor is deciding which way is right for him. What is it exactly that he or she needs in the way of sails? How do they fit within a given budget, and equally important, how do they fit within proposed sailing plans? These are individual choices unique to each sailor, but this book will go a long way toward helping you, the reader, understand what will best suit your needs once you have decided what they are. You will come to understand how different fibers and fabrics might work on your boat, and how to best invest your hard-earned money. It's a complex subject that is fascinating to

Close racing at Block Island Race Week.

some and frustrating to others. It's my job to lead you through the process, at times getting you wet when we take leave of the technical work and go sailing, but along the way we will unravel the complexities of this complicated, yet uniquely interesting, subject. My hope is that some of the passion and practical experience I have gained from years of sitting on the side of a boat gazing up at the sails will rub off on you. Most of all I hope that you will be better informed and able to make the appropriate decisions the next time you are shopping for sails for your boat.

This book starts with a hypothetical visit to a sailmaker. Use it as a guide for your own sailmaking experience. These days sail-buying choices are so vast it's impossible for me to dictate precisely what you should or should not do when it comes to choosing a sailmaker. In the end it's an individual decision. But, if you do your homework and take the time to understand the subject, you can get just as good sails from your local mom-and-pop sailmaker down the street as you can from a globe-trotting sailmaker working for one of the big franchises. Shop around, compare prices and details, and remember one important thing: There are many different ways to make the same sail and all of them may result in an excellent product.

Chapter 1

A TRIP TO THE SAILMAKER

A Hypothetical Look at Buying Sails

It was not so many years ago that buying a new sail for your boat meant a pleasant trip down to your local sailmaker. You made a call (e-mail was not yet invented), set up an appointment, and then spent a few wonderful hours looking at bolts of cloth, talking boats, and settling on a price. If you were a good customer a handshake would seal the deal, the sail would be made, and a few weeks later it was delivered to your boat an invoice would arrive by mail. Your sailmaker knew you by name – both yours and your boat's – just as your family doctor knew your medical history. More often than not the sailmaker would bend the sail on personally, take the boat out for a sail to check the fit and cut of your new purchase, and generally treat you like, well, a customer.

Those days, however, are long gone. We live in a much more technically advanced world where even important purchases like a new sail are done via e-mail, phone, the Web, or some other "convenient" means. Old-fashioned service is gone, unless of course you are spending upward of fifty thousand dollars, and that's not necessarily a bad thing, since then, as now, that service didn't come cheap. True, you want the sail to fit right, look good, and perform well, but you also want all these things at a reasonable price. For a sailmaker, spending the afternoon out sailing with a customer, while a pleasant experience for both parties, is costly, and that cost inevitably has to be added on to the price of the sail. These days, with modern fabrics, computer technology, and vast databanks of empirical information, the chances of a sail not fitting perfectly and looking good the first time out are becoming increasingly remote. In fact, the truth is that today you really don't need to know your sailmaker personally, nor do you need a personal visit and sail check to ensure that everything came out as designed. The world has changed, and so has the sailmaking industry. In some cases you are now able to simply "add one to your shopping cart" with the click of your mouse, and have the sail show up via FedEx a few weeks later.

"For a sailmaker, spending the afternoon out sailing with a customer, while a pleasant experience for both parties, is costly, and that cost inevitably has to be added on to the price of the sail."

Still, for all the high-tech, some aspects of sail buying remain the same, including the fact that the process starts by asking the right questions. This includes you asking the sailmaker questions, and the sailmaker asking you questions. You also need to ask yourself some hard questions like, "what kind of sailing will I be doing over the next couple of years," and "do I really need the latest molded sail from the most expensive fabric available when the experience level of my crew is questionable?" Remember, a sail is an expensive purchase and you need to be clear about what it is you are buying. If, for example, you are thinking about entering your boat in the Newport to Bermuda Race in two year's time, does it make sense to save a few dollars buying a new Dacron headsail because it's all you can afford when you know that an investment in fabric and engineering will pay long-term dividends? Perhaps instead of the Dacron sail

Some sail lofts, like the Doyle loft in Marblehead, Massachusetts, are in scenic locations making a trip to the sailmaker a very pleasant experience.

you could have your current sail recut, and in a year's time buy the laminated sail, which will still be fairly new when the race starts.

It is also important to articulate to your sailmaker what it is you expect from your sails. For instance, is out–and-out performance your goal, or are you willing to trade some performance for durability? Maybe sail handling is more important than sail shape. For a cruising sailor used to physically changing sails, the feel of the fabric might be more important than the cut of the jib, and a soft, tightly woven Dacron may be a better choice than a stiff, highly resinated one. Whatever the choice, the process starts by asking good questions. Sails are tailor-made items, and just like ordering a new suit, you should not decide on the first color you see. Do your homework and you will be more pleased with the results. And your sailmaker will be happy to know that he has satisfied a customer.

An educated customer is a sailmaker's best customer, which is where this book comes in. By the time you have finished the book you will have an understanding of what it takes to design and build modern racing and cruising sails. If you have an understanding of the different fibers, fabrics, and engineering details like the number of reefs you need or whether or not you want a cunningham in your headsail,

it will be a lot easier for your sailmaker to make you the sail you want. You should also talk to other sailors with similar boats, sailors with different boats, and a number of other sailmakers, since it's not only their job to sell you their product, but to make sure that you get what you want and not what they want you to have. Throughout this process remember this very important point: There are any number of ways to make the same sail, and in most cases they will all be good. There are, for example, various styles of fabric made by different fabric makers that will all do an equally good job, so don't get too concerned if two different sailmakers recommend two different types of cloth. Ask about the merits of each kind, but don't assume that one has to be "bad" and the other "good." By the same token, brand loyalty is good, and if you've had a good experience with a certain fabric maker then that's a good reason to ask for its product again. Sailmakers, fabric makers, and hardware makers appreciate loyalty, and the result will be a better sail for you.

Sailmakers need lots of important information from you if they are to do their job, so be sure that you are ready to provide it. They need to know, for example, if you plan to mostly race or cruise. They also need to know if you are daysailing or heading offshore, and in what region of the country you will be sailing. These days a lot of sail buying is done over the phone and a sailmaker located on Long Island Sound, where the summertime winds are light and variable, might not know that San Francisco has a blustery afternoon breeze that kicks up a short chop. This would be a valuable piece of information if you are a West Coast sailor and want your sail to be designed and engineered to suit the local conditions. A sail designed for use in choppy inshore waters will have a different shape than one used in long ocean swells offshore.

Once you have established the kind of sail you want, it's time to move on to the next very important step: information about your boat, i.e., its dimensions and the exact size of the sails needed to fit the rig. Rule Number One: Assume nothing, on both sides. It's not enough to tell the sailmaker that you have a Beneteau 345. There are six models of Beneteau 345 and they all have different rig dimensions. If you are not sure whether you have the tall or short rig, you must find out before the sailmaker even works up a quote. Be specific about which model you have and, equally important, know exactly what year the boat was manufactured. For example, a C&C 27 built in 1984 has a different boom length than a C&C 27 built in 1985. Also remember that some boat manufacturers offer different boom or hardware options, for example, either a conventional or a wishbone boom. You also need to tell your sailmaker if you know of any modifications done to the boat. Perhaps a former owner lengthened the boom or raised the lifelines; or maybe there is a whole new sporty rig on the boat. Small details like the height of your lifelines will have a bearing on your new sail. If it's a cruising headsail, the sail designer will want to be sure that the foot of the sail clears the lifelines so that it does not chafe. If it's a racing headsail the clew height will be placed so that it does not hang up on the lifelines each time you tack.

The same points apply to the rest of your rig. If you have a furling unit, make sure your sailmaker knows the make, model, and year of the unit. If the deck lay-