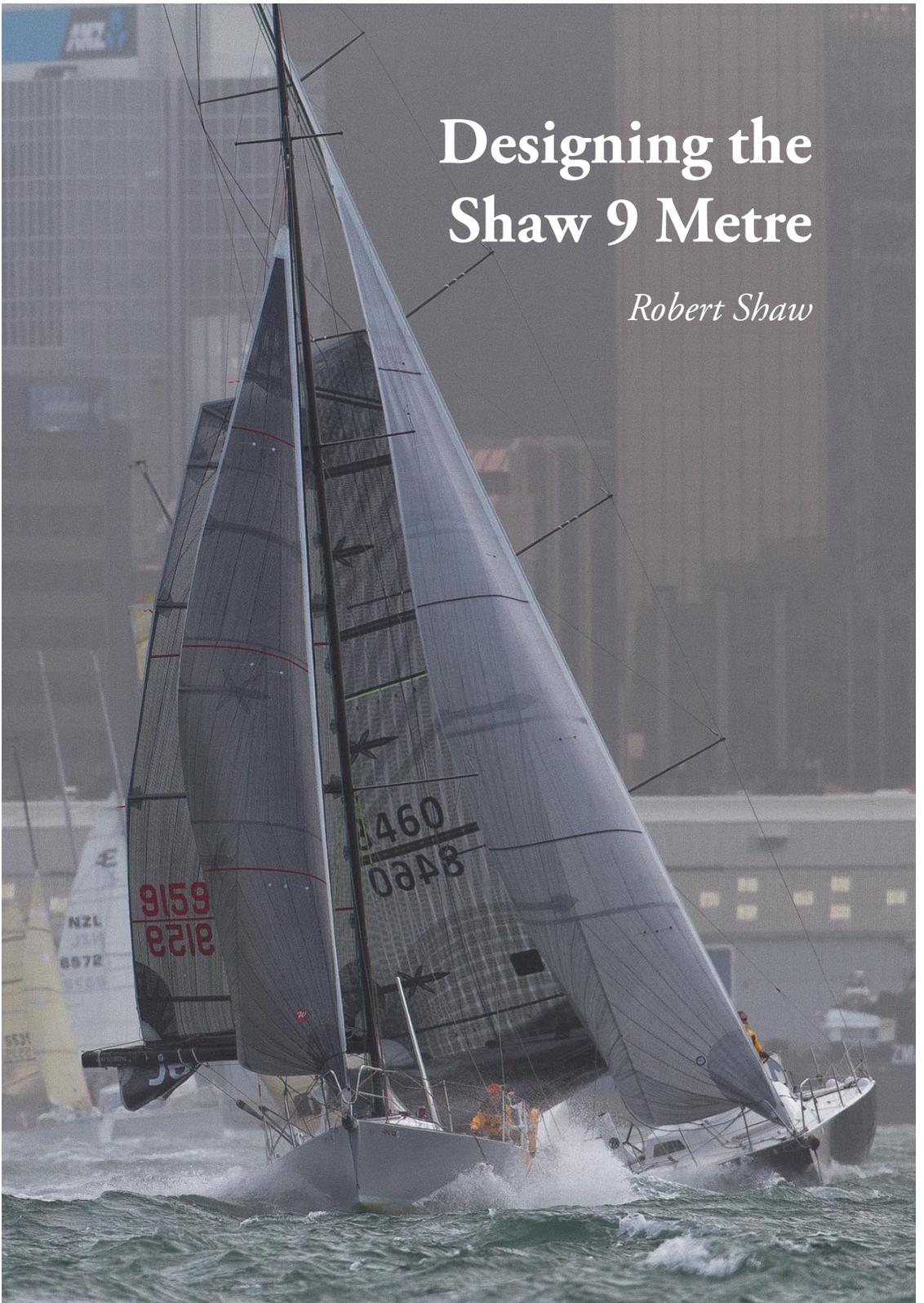


# Designing the Shaw 9 Metre

*Robert Shaw*





# Designing the Shaw 9 Metre

How does the process of design inform the development of a 9 metre racing yacht?

*Robert Shaw*

A thesis submitted in partial fulfilment of the requirements  
for the degree of Master of Design, Unitec 2011



*What attracts the eye seems to please the water*  
— *Olin Stephens, 1908–2008, yacht designer*



## Acknowledgements

Designing and building the Shaw 9 metre, and writing this exegesis, has been a long and time-consuming process. Many thanks to my wife Sarah Ell and my supervisor Dr Cris de Groot for their patience and support during this period.

Thanks also to my sister, Dr Susan Shaw, for her input into this exegesis, and to my parents, Graeme and Betty Shaw, for introducing me to the world of sailing and encouraging my interest in yacht racing and design over the years.

Finally, thanks to the crew of *Karma Police* for helping me campaign the boat to its full potential.



## **Contents**

Acknowledgements	7
List of figures	11
Abstract	13
Introduction	15
1: Views of yacht design	19
Conventional wisdom	19
Literature review	21
2: Project outline	29
Research method	29
Project outline	33
3: The design journey	37
Specific design drivers	39
Concept development	41
4: Specific design aspects	45
Aesthetics	46
Hull and deck design	49

Interior	56
Construction methods	64
5: Evaluation	85
Accessibility	86
Performance	86
Handling characteristics/feel	88
Independent evaluation/press coverage	90
6: Conclusion	95
Research reflection	99
Further research	100
Appendix I: Race results	101
Appendix II: Press coverage	102
Appendix III: Nomenclature	118
Bibliography	119

## List of figures

1. <i>Karma Police</i> sails on Auckland Harbour, May 2009.	17
2. The yacht design spiral. (Larsson and Eliasson)	25
3. The action research spiral. (Zuber-Skerritt)	31
4. Design spiral for the development of the Shaw 9 metre.	32
5. Tangible and intangible aspects of the yacht's design.	35
6. The six degrees of freedom, as they relate to yacht design.	40
7. Preliminary concept drawing of the Shaw 9 metre.	43
8a and b. The Shaw 9 metre (overall aesthetic).	47
9. Draft lines plan for the Shaw 9 metre, with moderate dimensions.	53
10. Second draft lines plan, with a higher volume.	55
11. Interior, looking forward to the front hatch and crash bulkhead.	57
12. Interior, looking aft past the keel box and mast step.	57
13. CAD representation of the final hull lines.	59
14. Deck plan.	61
15. Underside of the cockpit.	63
16. Construction of the main companionway.	63
17. Construction drawing for the Shaw 9 metre.	64
18. Construction of the hull 1.	65
19. Construction of the hull 2.	65

20a and b. Construction of the hull 3.	67
21. Deck construction 1.	69
22. Deck construction 2.	69
23. Structural steel keel spar being fitted with foam fairing.	71
24. CNC-machined female rudder moulds.	71
25. Transverse hull plan showing keel and line of the daggerboards.	73
26. Deck plan showing the position of the daggerboards.	73
27. Upwind sail plan (full sail).	75
28. Sail plan with the addition of downwind sails.	77
29. Full sail plan, taking into account number two jib and one and two reefs in the mainsail.	79
30. <i>Karma Police</i> under masthead gennaker.	81
31. Overall costing for construction of a Shaw 9 metre.	87
32. 'David vs. Goliath.'	89
33. <i>Karma Police</i> shortly after the start of the 2009 Coastal Classic.	91
34. <i>Karma Police</i> before the start of the third 2010 SSANZ Simrad series race.	91
35: Shaw 9 metre <i>Karma Police</i> in short-handed configuration.	93
36: Shaw 9 metre <i>Karma Police</i> (9159) powers out of Wellington Harbour ahead of Ross 45 <i>M1</i> (8460).	97
37: Technology transfer.	98

## **Abstract**

This aim of this project was to explore how the process of yacht design informed the development of a 9 metre racing yacht with a canting keel. It explores the interrelationship of art and science in the process of developing the fastest yacht of its size and type in the world, with particular reference to accessibility in terms of cost, quantifiable performance and the user experience (handling characteristics and ‘feel’).

The theoretical framework is based on the action research model described by Zuber-Skerrit (2001). This was in keeping with the concept of yacht design utilising a design spiral, in which each aspect of the design is explored and refined in turn, before a further iteration is developed, explored and further refined. The lack of a complete, recognised methodology for designing racing yachts has resulted in an environment which does not foster innovation, relying instead on engineering techniques which impose limitations on the design process. Designers are also limited to some extent by tradition — following what has gone before — as well as being hampered by class and rating rules. This project explored and defined a new methodological framework, blending the empirical knowledge obtained through scientific

techniques with experiential wisdom and artistic input.

This project involved the design development, construction and on-water testing of a 9 metre canting-keel race yacht, its appendages, rig and sails. The design was developed from first concept to a fully realised vessel, enabling thorough experiential investigation to ascertain its success.

The designed output from this project was a 9 metre yacht with a reasonable design and construction cost which has consistently outperformed larger and more expensive boats. It signals that in a field increasingly dominated by mathematical models and computer-based predictions, there remains a powerful role for experiential wisdom and artistic input in creating high-performance yachts.

## Introduction

The process of yacht design is by nature complex. When engaged with the notion of competitive performance, it requires a particularly creative and sophisticated understanding of many elements of design, including the artistic and intuitive aspects of the process as well as the science of engineering and aero-hydrodynamics, and the theory and practice of high-performance sailing.

Yacht design is a distinct discipline of naval architecture, different from the analytical disciplines such as hydrostatics, hydrodynamics, aerodynamics, structures and weight analysis. The yacht designer must be well versed in the analytical disciplines, but above all he will spend much of his time doing something called “design”, creating a geometric description of a craft to be built. (Miller & Kirkman, 1990, p. 187)

This project communicates the entire design process from conception

through the development, construction and evaluation of an innovative 9 metre racing yacht designed to meet specific needs. The unique design of this particular yacht constitutes a new body of work within the broader theoretical contexts of both design and yacht development. These in turn exist within the theoretical fields of naval architecture, yacht design and marine engineering. The development and evaluation of the Shaw 9 metre was informed and appraised in accordance with literature, and current knowledge and debates in the above fields. Through designing and building the boat, a reframing of established yacht-design conventions and processes occurred.

The iterative process of designing, testing, evaluation and refining that took place during the design journey drew on a wide range of expertise and current knowledge while also asking new questions. Many practices currently utilised by yacht designers are based on convention. Considering the design and development process through a research lens provides critique of some of these conventions and offers new approaches. This work provides a critical look at the process and contributes to debates about extending the frontiers of design and performance.

This work begins with a summary of relevant current literature and conventions in relation to yacht design. The bulk of this exegesis is structured into the third and fourth chapters. Having considered a number of options for presenting the process of critiquing conventional design, the design journey, then constructing, trialling and evaluating the yacht, based on an action research model, an integrated approach to the presentation of the information was chosen. This information is presented in relation to a number of specific design aspects. The final two chapters address evaluation, with a focus on published feedback from the yachting industry, and a conclusion which reflects on the journey in relation to the research process.



1. The Shaw 9 metre Karma Police sails on Auckland Harbour, May 2009.



# 1:

## Views of yacht design

### *Conventional wisdom*

The multifaceted nature of yacht design, informed as it is by theory and practice from various and diverse fields of knowledge, is both challenging and rewarding. However, the range of complex influences and issues required to be worked through to resolve the process into a coherent, successful design has not been well researched and documented. This is partly because, as Killing and Hunter (1998, p. 27) state, “Sailboats surely are unique among objects created by humankind in that they are perceived and even created in one configuration but employed in another” — that is, they are designed in a upright, static configuration yet utilised in a wide range of conditions and a dynamic environment. Skene (1935, p. 3) notes:

The antagonistic natures of speed, seaworthiness, large cabin accommodations and beauty, with the varying and uncertain effect of waves, change of heel and trim, cut of sails, etc., takes the problem . . . out of the category

of strictly engineering problems such as those of the aeroplane, locomotive or steamship, in which results can be predicted with great exactness by mathematics based on laboratory work.

The designing of yachts has evolved over many centuries and is now acknowledged as an iterative process. In the past 50 years the methods of design and development have become heavily influenced by the engineering discipline, which can stifle the influences of art and creativity in the process.

In the past, yacht designers concentrated on evolving traditional, proven hull, deck and appendage shapes. Historically, yacht designers used a combination of design and building experience, intuition and their “eye” — i.e. what they thought looked good to them — to develop new designs, drawing subconsciously on a range of types of knowledge. Phillips-Birt (1976, p. 15) describes “the ideal [yacht] designer” as “a magnificent creature who is at once a hydro-dynamist, an aero-dynamist, an engineer, a practical boatbuilder, an experienced seaman under sail, and an artist.”

However, with the development of mathematical or computer-based models, including velocity prediction programmes (VPPs) which generate polars (performance predictions), many modern designers have begun to rely more on “science” than “art” to define the parameters of their designs. Yet it is noted by Scarponi, Shenoï, Turnock and Conti (2006, p. 2) that “To bear the costs of a close modelling of a sailing yacht, with the purpose of getting accurate VPP predictions, is still far from being an easy task. . . . A numerical approach in terms of Computational Fluid Dynamics can also be regarded as a valuable source of information, but . . . numerical methods can provide just partial responses to designers”.

The lack of a complete, recognised methodology for the design of

racing yachts has resulted in an environment which does not foster innovation, relying instead on engineering techniques, which impose limitations on the design process. Designers are also limited to some extent by tradition — following what has gone before — as well as being hampered by class and rating rules such as IOR (International Offshore Rule), IMS (International Measurement System) and more latterly IRC (the current Royal Ocean Racing Club international measurement and rating rule), and by safety requirements. These factors combined have meant advancements in yacht design have been somewhat slow and restricted.

It is my contention that while science can play a significant role in design development, successful yacht design must continue to blend this empirical knowledge with experiential wisdom and artistic input, bringing intuitive processes to the endeavour. As Skene (1937, p. 3) states, “It must not be inferred that science is not an important aid in designing any kind of a yacht, but with it must be blended natural genius, imagination and much practical experience in handling and building boats”.

### *Literature review*

The vast majority of recent publications relating to yacht design come to it from an engineering perspective, based on academic research rather than practical experience and embodied, full-scale productions. Problem-framing and solution-finding methods tend to be science based. Current yacht design literature is lacking in works by practising yacht designers, describing actual design methods and processes, perhaps because of concerns about commercial sensitivity and the accompanying desire to keep specific processes “secret” in a competitive environment. Another aspect restricting the availability of detailed explanations of design theory is the inability of many designers to articulate their tacit

knowledge in an explicit form; Schön (1988, p. 181) notes, “Designers are usually unable to say what they know, to put their special skills and understandings into words. On the rare occasions when they do so, their descriptions tend to be partial and mistaken: myths rather than accurate accounts of practice.”

Some literature has explored the influence of art in yacht design — that is, the use of more intuitive processes and the concept of the “designer’s eye” for what looks right — but little research exists which explores the interrelation of art and science in this field.

The literature I have identified for this project covers the spectrum of yacht design disciplines from science and engineering to art. Within these fields I have specifically looked to literature which has a strong link to design method. The process of design is strongly identified throughout these texts in the contexts of either engineering design, design method or the aero-hydrodynamics of yacht design.

## Science

As mentioned above, much current literature concentrates on the engineering and mathematical aspects of yacht design (that is, science). With the development of computer-aided drafting techniques and modelling software which predicts the performance of hull and appendage shapes, research has concentrated on the fields of fluid dynamics and aero-hydrodynamics, including wind-tunnel and tank testing.

Most of the authors of recent books on design have been engineers and academics rather than practising designers. Particular examples include works with an emphasis on aero-hydrodynamics (Marchaj, 1988), and espoused principles of yacht design (Larsson & Eliasson, 1994).

While Marchaj is a sailor, his work is presented from an engineering

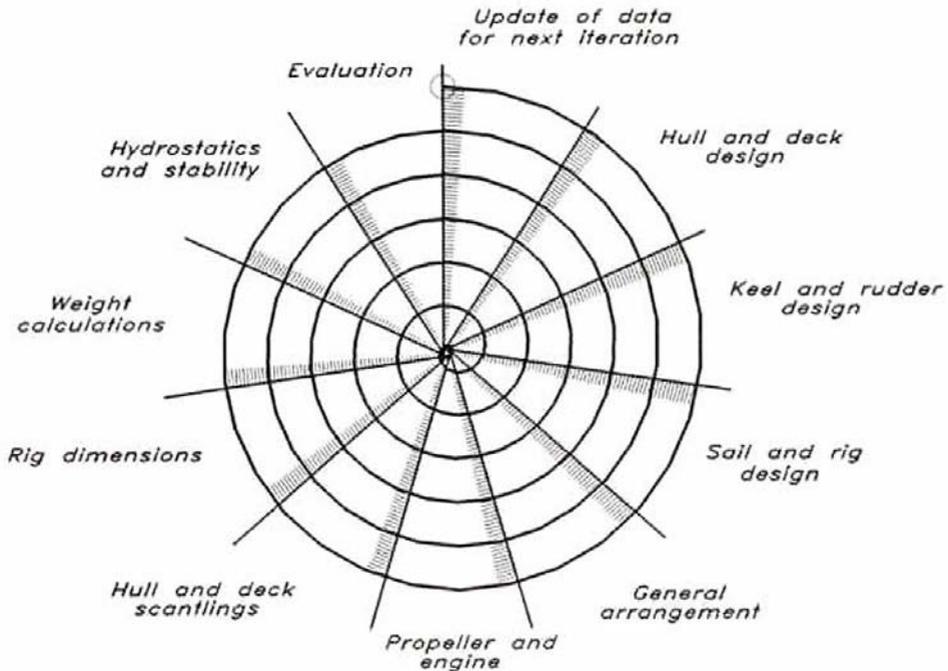
perspective, and provides a precise and detailed scientific analysis focusing on the science of yacht performance. It includes discussion of the fundamental factors governing yacht performance and sailing characteristics, including the findings from wind-tunnel and tank testing of various concepts and designs. It focuses on the physics of the aero-hydrodynamic interaction of flowing air and water with sails, hulls and appendages.

Larsson and Eliasson also come from an academic background, although again Larson is an experienced sailor. Their work is highly scientifically focused, reviewing design process and methodology from an engineering and mathematical analysis perspective. It explores the geometry of yachts and the effect of engineering considerations, classification societies and international standards on yachts and their performance. It also includes analysis and discussion on computational fluid dynamics (CFD) and the effect of these technologies on the design of yacht hulls, appendages and sail plans.

Larsson and Eliasson (1994, p. 5) note that, “Yacht design is an iterative, ‘trial and error’ procedure” involving a design spiral, “where the designer runs through all the design steps and then returns to the starting point, whereupon a new ‘turn’ begins” (see diagram page 24).

Other works to approach the design process from an engineering viewpoint discuss the physics of sailing and its impact on yacht design (e.g. Garrett, 1996). Although Garrett aims his work at practising sailors, he writes from the point of view of a physicist and emphasises the scientific nature of yacht performance. It is a clinical review of the design process, focusing on science-based solutions to many design dilemmas.

Most academic papers recently published and presented at design conferences and symposia are also engineering based. Examples of these include papers on scientific methods in yacht design (Larsson, 1990) and using computer programs to predict performance (Roux,



2. The yacht design spiral (Larsson and Elissaon, 1994, p. 5).

Huberson, Hauville, Boin, Guilbaud & Ba, 2002). In a similar vein are papers and presentations about mathematical programming in relation to rig design (Wallace, Philpott, O’Sullivan & Ferris, 2006) and the use of velocity prediction programs (Scarponi et al., 2006).

## User experience

As noted above, several science-based publications also touch on the user experience, in that they are either written by or for sailors. Bethwaite (1993) is a good example of a book that discusses high performance yachts from the perspective of a sailor while referencing scientific information. It is a wide-ranging discussion on the design and operation of racing yachts written by a former aeronautical engineer

who became involved in high-performance skiff racing and design. It includes the outcomes of a broad range of research projects undertaken to better understand and refine the science of sailing, among them a unique and detailed discussion on the environmental effects of wind and water on design, as well as investigating various sailing techniques including kinetics and dynamics and how these can be employed to enhance performance.

Killing and Hunter also (1998) present an explanation of the principles and practice of yacht design as they apply to a user audience of racing sailors, drawing on their respective backgrounds in yacht design and competitive yacht racing. This publication is accessible to sailors as the information provided by the authors blends detailed analysis with real-life experience. Killing and Hunter place strong emphasis on user requirements and techniques for the optimisation of a given design, and this work is a good source of information on current thinking in the development of high-end race yachts such as International America's Cup Class yachts.

## The blending of art and science

As stated above, the majority of recent literature concentrates on the scientific and engineering aspects of yacht design. However, several relevant works draw heavily on the artistic and aesthetic aspects of design, combined with scientific and engineering-based knowledge, and refer to the blending of art and science in this process. For example, while Killing and Hunter (1998) deal mainly with scientific principles of yacht design, the authors note,

You can use science to explain why a design feature is wrong, or less than ideal, but you must also realize that, while modern yacht design employs science, this does not

necessarily make it absolutely scientific, and it is all the richer for this. Rare, if not non-existent, are craft that spring fully formed from a stream of calculations. (p. 13)

An acknowledged classic in this field is Skene (1935). While informed by the engineering knowledge of its time, Skene's work strongly acknowledges the influence of experiential knowledge and an intuitive sense in the design process:

It is not enough to be fond of boats and full of inspiration . . . ; it is not enough to have had years of experience at sea and in the boat shop . . . ; it is not enough to know all about resistance, displacement, stability, etc. — for the purely scientific designer may blunder on many practical considerations . . . Every boat is an experiment, but . . . the designer has a great advantage in stepping with confidence, born of experience, from one design to another with intelligent improvement in each succeeding boat. (pp. 3–4)

Phillips-Birt (1976) also explores the interaction of art and science in yacht design, with more attention paid to the aesthetics of yacht design than in any other text. This work discusses the relevance of proportions and the influence of traditions on the design, build and sailing of modern yachts.

Also drawing on the artistic and aesthetic aspects of yacht design is Endean (1992), which presents examples from four decades of successful New Zealand yacht design. This review includes details normally not made public by designers, including displacements and hull-lines plans. It is an invaluable insight into how local designers have sought to solve the design problems to produce a range of different

boats, the performance of which has since been well documented. It also discusses the artistic and aesthetic aspects of these designs.

A further important work in this area refers to yacht design as a fine art. Miller & Kirkman (1990) updates an earlier presentation to the Society of Naval Architects and Marine Engineers to include discussion of new scientific methodologies and technologies in yacht design, but reemphasises the importance of artistic, intuitive and experiential input into design. As they note,

Yacht design has been propelled into the world of science and high technology as well as that of the art of traditional design . . . While the importance of the art remains undiminished in good design, its nature has shifted to embrace the application of hydrodynamic and aerodynamic sciences. (p. 187)

However, they emphasise that,

Yacht design is *not* hydrodynamics, weights or structures; it embraces these, but exceeds them in scope. . . . [The yacht designer] may well employ experts in various disciplines to assist him, but he must never lose control over the process. (p. 187)



## 2:

### **Project outline**

#### *Research method*

The primary focus of this project was to investigate how the research process informed the design of this particular 9 metre racing yacht. The process of yacht design is complex and draws on a range of knowledge and expertise. The blending of art and science is apparent within the design endeavour but, along with the amalgamation of theory and practice, is not always articulated well by yacht designers.

The research method chosen for this project needed to acknowledge these complex dynamics within this practical and iterative process, which led to the choice of action research as a method. The iterative nature of the design process lends itself to action research, as this method accommodates the cyclical process of identifying problems, analysing them and taking action to address issues before evaluating the results and moving into another cycle (Swann, 2002). Each iteration of the process adds to the theory.

The history of action research can be traced to the 1940s; however, many iterations of it have emerged since then. Elden and Chisholm

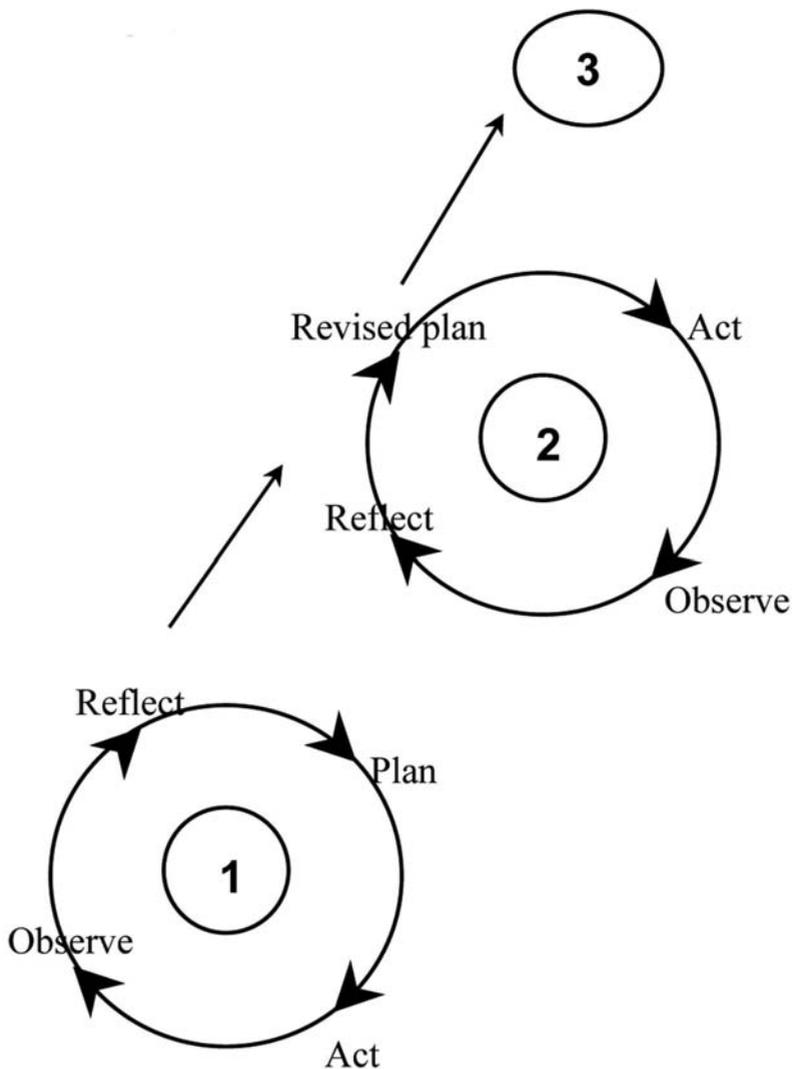
(1993) state that there should be five characteristics present: acknowledging that the researcher is engaged (and therefore may have some bias); focusing on solving real-world problems; the systematic collection of information; the researcher participating in the research problem and process; and the sharing and dissemination of knowledge.

As skills normally associated with trades have become more widely articulated, professionalism has extended to yacht designers. As part of this process the notion of reflection (Doloughan, 2002) has become valued to describe the way in which designers think about and refine their works. Professionalism brought with it the need to justify and defend decisions and this logically led to an emphasis on gathering information and testing practice.

There are a number of challenges to action research as a method, including its incompatibility with some concepts of positivist science (Susman & Evered, 1978; McKay & Marshall, 2001). By its very nature action research values intimate engagement of the researcher in the process and the iterative process, so it is therefore counterproductive to analyse it with reference to a paradigm built on the foundations of neutrality and objectivity. A further point made by detractors is that there is no tidy definition of action research (Altrichter, Kemmis, McTaggart & Zuber-Skerritt, 2001). While this is a valid comment the reality of the design process itself is that it is intricate and complicated, which therefore makes action research more rather than less attractive as a research method in this instance. Despite these challenges to action research it remains a sound way of illuminating the design process primarily because of the value placed on linking theory and practice (Avison, Lau, Myers & Nielsen, 1999).

Along with the various definitions and explanations of action research there are also many diagrammatical interpretations of the process. For the purposes of this project the elements of planning, acting, observing and reflecting illustrated by Zuber-Skerritt (2001) have been used

to explain the project. This illustration of the action research cycles interrelates well with the notion of yacht design as a complex, spiral process (as articulated by Larsson & Eliasson, 1994, p. 5 — see page 24 of this exegesis).

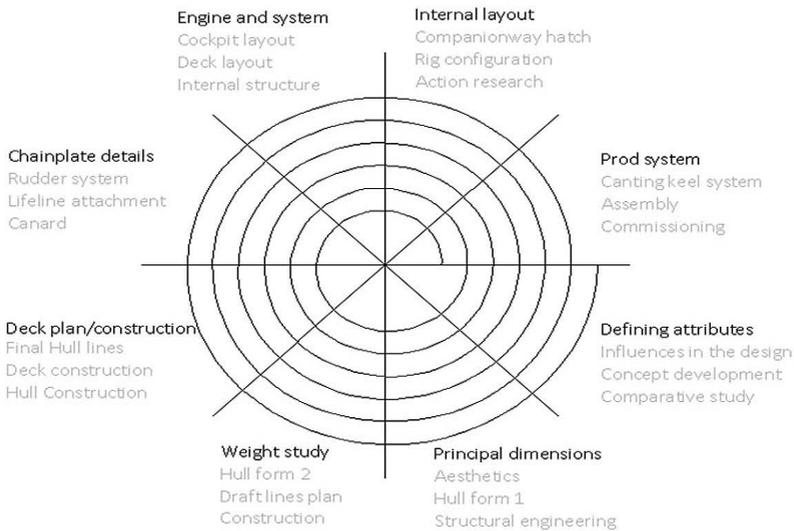


3. The action research spiral. (Zuber-Skerritt, 2001, p. 20)

Chapter three of this work is presented under specific headings which relate to particular design aspects. The information relating to each of these aspects has been considered and is presented with reference to the elements identified by Zuber-Skerritt (2001).

The Planning phase for each aspect included identifying current challenges and the foundations of them, including conventional wisdom and limitations on construction and knowledge. The Acting phase is evident in relation to each of the design aspects as a process was put in place to respond to the identified challenge. Observation is apparent in the information that was gathered during the development for each of the aspects — a key step, as the systematic gathering of information is what distinguishes this journey from alternative processes of designing a yacht and contributes research knowledge to the field. Reflection on the action is then used to inform the next iteration of the process.

Ultimately the completed product could be considered as a new theory of how to design a high-performance yacht.



4. My design spiral for the development of the Shaw 9 metre. Each aspect was investigated in turn, then a new iteration commenced.

## *Project outline*

The overall aim of the project was to develop an innovative 9 metre racing yacht which defines and fills a previously undeveloped niche in the performance yacht market, and is the fastest yacht of its size and type in the world. Parallel to this is the aim of documenting and communicating the complexity of the yacht design process using an action research method, and evaluating the success of the project against the three key considerations of:

- Accessibility (in terms of cost and ease of construction, and transportability of the finished boat)
- Performance (including quantifiable elements such as speed)
- Handling characteristics/feel (user experience).

I aimed to further develop my abilities as a designer through researching and applying the action research method to this practical design project. Building on the success of previous yacht design projects, I sought a new project that would help extend and further develop my skills and experience.

One of the early challenges was to find a way to fit the vastness of a complete yacht design and build project into the framework of the master's programme without losing focus on specific aspects which I was keen to explore in more detail. This project focuses on the iterative design development process, from the initial concept design through to final design and construction, covering the consideration of aesthetics, hull and deck form, keel and appendages, and rig and sail dynamics. Each of these factors was assessed in terms of their impact on the key considerations listed above: accessibility, performance, and handling.

The objective was to bring creativity to the fore in the design and development process and complement this with specific engineering expertise where it could enhance the yacht's development. This is a refreshing look at the development process as applied to yacht design

but one which I believe has significant benefits over the engineering-driven processes which have become predominant in recent published material.

This caused a shift in the focus of the project from the science-based, tangible drivers such as compliance to regulations and physical characteristics to less tangible concepts such as user experience and feel (see figure 6, opposite). Framing the yacht design problem and objectives in this alternative context changed the order of priority by putting the human experience first and requiring the engineering requirements to follow and adapt to or inform these, rather than drive them.

TANGIBLE	INTANGIBLE
Project objectives	Deceleration into waves
Development method	User experience
Componentry	Performance
Hydrostatics	Fluid dynamics
Physical characteristics	Feel

5. Tangible and intangible aspects of the yacht's design considered during the design investigation. This chart shows how aspects of both art and science were utilised in the process.



### **3:**

## **The design journey**

The development of the Shaw 9 metre yacht provided a platform for the exploration of the interrelation of art and science in the practice of yacht design. The complexity of a yacht design project, combined with a limitation on time and analytical resources, meant adopting a design method which draws on both intuitive and scientific methods to achieve effective and creative solutions.

While refining the concept I also conducted a study of existing boats of a similar size and type and identified their principal dimensions. I then considered their performance and known sailing characteristics, ascertaining which combinations had worked well in the past. Through this process I gathered a plethora of data relating to the physical characteristics of a wide range of boats.

As there is no way to accurately validate the actual performance of these boats, I expanded on the technical data available with my own experience and observations. Judgement of the handling characteristics of these boats is highly subjective, so ultimately the information gathered could only be used as a guide, and carefully considered in context.

Also, there were no other examples of boats with similar proportions

to my design which had a canting keel, so I had to extrapolate what effect this variation would have on the yacht's performance.

The process of designing the Shaw 9 metre was complex. It was necessary to explore conventional wisdom, draw on a wide range of professional knowledge and experience, and engage with colleagues and other experts, while constantly reflecting on the aim and the need to address problems innovatively.

It was important to develop my own approach to the design process, within the established framework of the action research spiral: Skene (1935) notes,

Originality based on one's own study and experimental work is really the keynote of success. He who does things in a certain way because others are doing it and have always done it that way contributes little to the advancement of the art. (p. 4)

In developing the overall concept design and then refining each specific design aspect, this process involved engaging with the action research model described above: planning a design action, acting on that, observing the effects of that plan on the design, and reflecting on how each aspect could be altered and improved in a further iterative spiral.

This resulted in a design journey which took the form of a long, detailed and evolving spiral. A number of key elements in the design have been identified and the design process, production and results are presented to give insight into the journey.

This and the following chapter outline the process of creating the new design. They articulate the theoretical concepts that were engaged and the context of this engagement. The intellectual process of analysing, critiquing and problem solving are outlined. Ongoing critique of the work itself through the successive design iterations is also presented.

## *Specific design drivers*

Several key characteristics of the design were explored through an inter-relationship of art and science during this project. One of these was accessibility: creating a yacht which would appeal to a wide market sector by offering high performance and ease of sailing at an affordable cost. The design had to ensure the boat's construction was affordable, so it could feasibly be built either as a one-off project or a production boat, rather than remaining a theoretical design only.

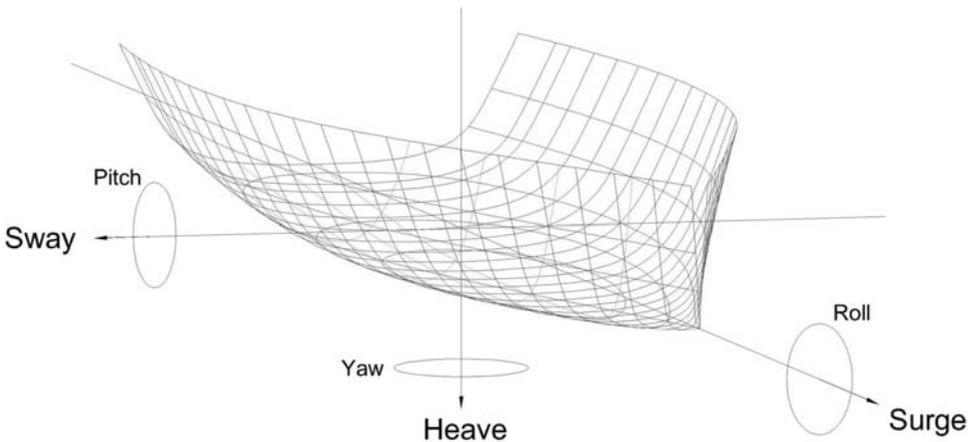
Also in terms of accessibility, the yacht needed to be easy to transport. In the past, many yachts have either been physically sailed to their delivery destinations or deck-shipped at great expense. However, a growing global market and larger numbers of international circuit regattas have led to an increasing trend towards yachts that are transportable by shipping container (e.g. the Russell Coutts 44 class yacht). One of the important design drivers in this project was addressing transportability by analysing methods of transport, and refining the boat's physical dimensions and ease of rigging and unrigging to make it as portable as possible.

The second important aspect was the boat's performance. The overall aim of the design was to produce the fastest boat of its size and type in the world, with good all-round performance in a wide range of conditions. This is quantifiable in terms of observed performance and race results once the boat is launched. However, Skene (1935) states:

The problem of designing a sailing yacht with speed as a foremost consideration is a most complex one. External conditions to which a yacht is subject, such as force and direction of wind, condition of sea, etc., are constantly changing so that the attainment of a given speed may not be sought, but rather such a form as shall be easily driven

at all speeds within appropriate limits . . . A harmonious adjustment between power and resistance should be sought. (pp. 10–11)

The third aspect is less tangible: the yacht's handling characteristics and the experience it provides the user in terms of its "feel" and ease of use when being sailed. This cannot be quantified and scientifically described but can be observed once that yacht has been launched. This aspect is therefore informed by science and engineering but in terms of analysis falls more in the realm of "art". A yacht cannot merely be fast in terms of straight-line speed; if it is difficult for the crew to extract this performance or the boat is uncomfortable and inconvenient to sail well then the design cannot be considered successful or to have fulfilled its purpose.



6. The six degrees of freedom, as they relate to yacht design. Yachts are designed to be utilised in a dynamic medium, and thus as subject to three-dimensional motion. The motions to be considered are back and forth (surge), left and right (sway), up and down (heave), and rotation around these axes (pitch, yaw and roll).

## *Concept development*

The development of the concept first centred around the overall size of the boat. The main drivers here were cost and achievability issues, including time to design and build and the cost of design and construction. I settled on an overall length (LOA) of 9 metres for several reasons:

- affordability compared to, say, a 12 metre or larger yacht
- affordability of campaigning, marina storage and ongoing maintenance
- established sailing divisions/records for yachts 30 feet/9 metres and under
- ability for the boat to be transported in a 40 foot (12 metre) shipping container
- suitable size for sailing with a crew of no more than six, and as few as two
- large enough to safely compete in longer-distance and offshore events.

The second defining attribute was the boat's maximum beam. I wanted the boat to have a generous beam to gain the righting moment required to be competitive and to enable short-handed sailing without the need for a high ballast ratio and increased displacement. However, as transportability by container was a key goal, this applied a restriction on the beam. I resolved that it would need to have the maximum beam possible which would still enable containerisation.

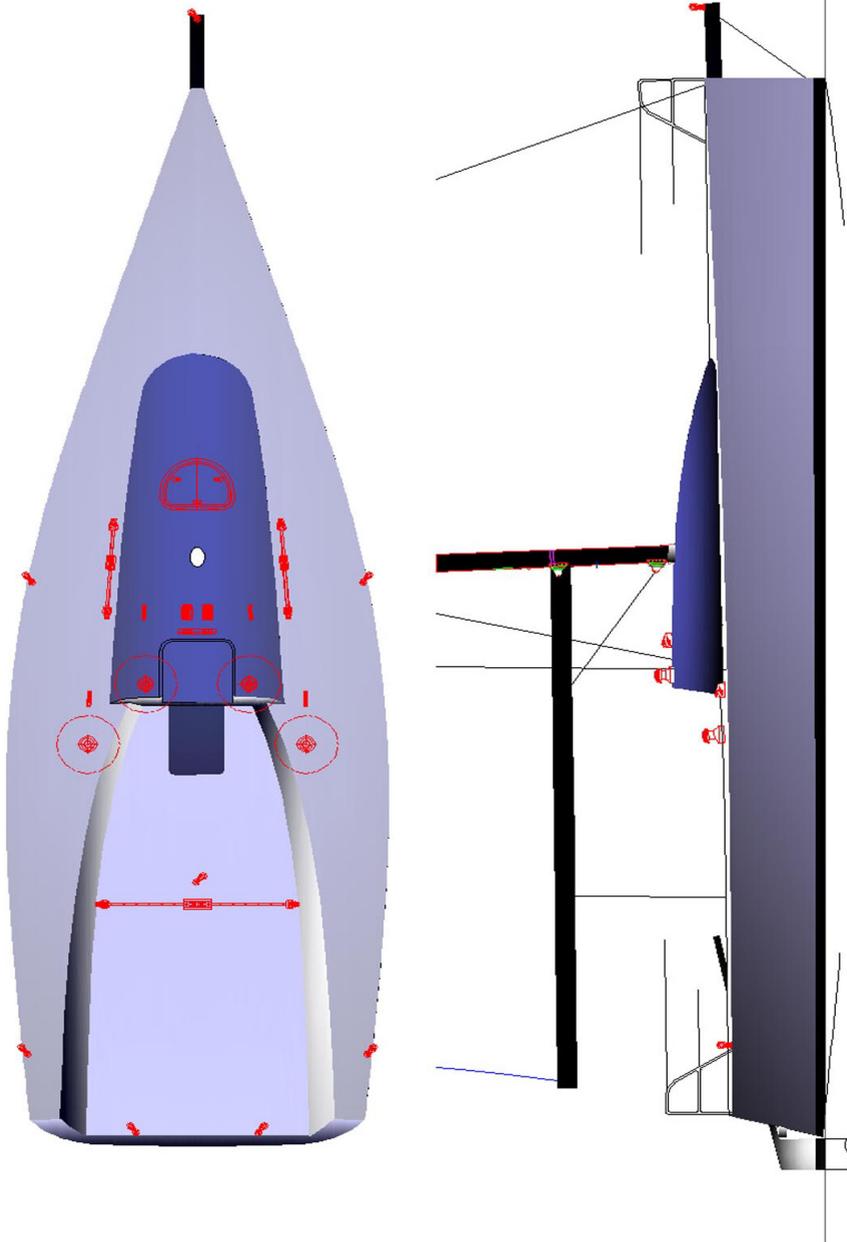
To ascertain this, I drew up a representation of the inside dimension of a container door in CAD and used this to experiment with various cross-sections through a draft yacht model. I found I could attain a maximum beam of 3 metres and fit the boat into the container by rotating the hull to approximately 50 degrees from horizontal.

After identifying these defining attributes of the boat, I began to build a visual image of what form the boat would take. This led to a phase of problem shaping, identifying all the issues related to the development of a robust concept to meet the key criteria of accessibility, speed/performance and handling. The process-based challenge was to develop a complete concept with the flexibility for refinement through each iteration of the design spiral while maintaining a consistent vision of the outcome.

To achieve this I developed a set of fixed parameters which were essentially non-negotiable: the overall length of 9 metres, the ability for the boat to be transported by container (which defined a maximum beam of 3 metres), and the ability for it to be sailed by a crew of two to six people. These factors were identified as defining elements of the concept design.

I also identified other elements as negotiable, to be developed through each iteration of the design, such as righting moment, displacement, construction materials, sail area (up- and downwind) and configuration, keel mechanism, other appendages and the deck plan. This enabled the ongoing development of the design and refinement of the concept once the project was underway, and provided a fertile environment for flexibility in ongoing concurrent design, as the development of these aspects was not limited to the initial design process.

The risk of being overly reliant on this method of development was that it could tempt poor planning, resulting in having to adopt inferior solutions as opportunities could be lost to fuse various design elements. To ensure this process was successful I developed a clear concept and vision for the boat, accompanied by detailed plans of each iteration with areas for development and possible options for their final form clearly identified. Specific design aspects (as outlined in the following chapter) were then approached using the action research spiral model.



7. Preliminary concept drawing of the Shaw 9 metre.



## 4:

### **Specific design aspects**

The design of a yacht incorporates many elements which by nature are complex, interconnected and interdependent. Selected elements or components of the design of the Shaw 9 metre are outlined here. All of these, separately and corporately, informed the design process. They are presented here to illustrate the level and processes of analysis and development that took place during this design journey.

The specific elements discussed here, in relation to the action research model and the key considerations of accessibility, speed and handling, are:

- Aesthetics
- Hull and deck design, including weight and balance
- Construction methods
- Keel and appendage design
- Rig and sails.

## *Aesthetics*

It is recognised by Miller and Kirkman (1990, p. 187) that “In performing ‘design’ the designer creates a primary geometric description of a craft which fulfils a need, observes the niceties of the various technical areas mentioned, and also pleases aesthetic sensitivities”. Further, Skene (1935, p. 10) comments on the concept of “harmony”, and the blending of the various features of the yacht into “a harmonious whole”. He notes, “It is impossible to lay down any test for harmony. Familiarity with this principle must come through practice and observation.”

Another design challenge was to make the yacht aesthetically pleasing while fulfilling its practical purpose. Dijkstra (2001, p. 276) notes,

An artefact that perfectly meets the rules of good design will most likely satisfy the user in fulfilling the need (or needs) [for which it is produced]. The rules of good design are derived from the laws, patterns and theories that describe the behaviour of a particular physical reality. . . . Combined with the designer’s knowledge of aesthetic rules and harmonic proportions, the design gives the yacht its beauty.

I wanted to give the yacht a signature look, so that it would be unique and easily recognisable as my design. To determine the look I researched the changing trends in yacht aesthetics over the past 50 years and the influence that aesthetic demands have had on various aspects of yacht design.

Traditionally, yachts have had gracious, sweeping sheerlines that drop from bow to stern, with their lowest point at about two-thirds of the length aft from the bow. More recently designers have been using straight sheers and in some cases aggressive-looking reverse sheer. The benefits and negatives of each are subtle in the context of the effect on



8a and b. The Shaw 9 metre has a plumb stem, slightly angled stern and moderately sweeping sheer, to make the yacht look contemporary but not extreme.



performance, but have a major impact on the overall look.

I decided on a modern take on the more traditional sweeping sheer, to make the boat look contemporary without being radical or extreme. I straightened the sheer considerably in the mid section and reduced the upturn aft to give the boat a subtle but distinctively unique look compared to other boats of similar size and purpose. An added benefit of this type of sheer was that it enabled me to increase the midsection volume of the boat, as the straightened sheer allows increased freeboard at the hull's maximum beam.

I then followed an iterative process of design development using the action research spiral model, refining the proportions of the boat within the "box" I had defined of maximum length and maximum beam (see pages 40–42 of this exegesis).

Another area in which both aesthetics and performance considerations came together was in the design of the overhangs fore and aft. Overhangs are a feature influenced by fashion, rating rules, performance and the length of marina berths. For this boat the factors which influenced the size of the overhangs were largely performance-related. As the boat will race for divisional records in some races where divisions are set by the overall length (LOA) of the boat, a measurement which does not include bowsprits or transom-hung rudders, I designed the stem to be plumb, with a minimal transom overhang past the waterline length (LWL). As the concept of the boat is powerful, with a large sail area and a low displacement–length ratio, the stern overhang can be minimal. A heavier boat or one with less sail area would better suit a longer aft overhang, so that the wetted surface would be reduced in light weather and then increase when the boat was underway. For this boat a short overhang which takes a small wetted surface penalty in the light makes for a more efficient boat once sailing at close to its hull speed. The plumb stem and slightly angled stern also make the boat's proportions look balanced.

## *Hull and deck design*

Within the parameters of maximum length and beam, section shape was primarily driven by the need to maximise form stability and produce a hull that maintains a high prismatic coefficient when heeled. Wetted surface area is a consideration in any yacht design but for this boat it was a secondary consideration to the more critical form resistance.

With the forward sections, my aim was to achieve a powerful shape that would provide good lift for reaching and running conditions, while not being so full that the boat would slam excessively when sailing upwind in a seaway. Based on my observations of other boats and previous design projects, I knew these attributes needed to be achieved while maintaining the chosen distribution of buoyancy.

These elements are intrinsically linked and variation to any of them could only be made with consideration of the effect the alteration would have on the other elements that define the hull form.

At this time I defined the elements that would determine the hull form. Given the desired characteristics I set the initial prismatic coefficient ( $C_p$ ) at .557 and the centre of buoyancy at 55% aft. Next, I set the distribution of buoyancy using a personalised spreadsheet, based on the wave form theory developed by Colin Archer (Skene, 1935, p. 41) and developed based on my personal experience and feedback from other designers who have successfully applied the same principle.

In determining the fore and aft rocker I tried to give the boat an easy entry with a soft transition through the mid-section. The run aft is critical to ensuring performance over a range of conditions and points of sail, so I tried to balance a straight run aft for maximum pressure recovery, which promotes planing, with a balanced transition from the mid- to aft sections. By balancing the need for a straight run aft with an even and balanced rocker and diagonals, the boat will sail bow out when fast reaching and running, which has a range of desirable effects including reduced wetted surface and increased control.

Right from my initial concept I had envisaged a boat with high form stability, as this has proven in my previous designs to be effective when combined with a relatively low ballast ratio, average crew weight and light displacement. From observations and experience I have identified that boats with moderate proportions perform the best over a wide range of sailing conditions. There is some evidence that boats with more extreme hull forms can achieve increased performance in some conditions but these gains can be offset by reduced performance in conditions to which they are less suited. It was a high priority for this boat to perform well over a range of wind and sea conditions, due to the changeable conditions experienced around the upper North Island, exaggerated by longer course, passage and overnight races.

Based on these parameters, I developed two candidate designs as computer models, which enabled me to make numerical comparisons between them. Of particular interest was the effect of increasing waterline beam on the boat's small-angle stability and wetted surface area. However, computer modelling is unable to express numerically the effect such changes would have on the sailing characteristics of the boat. While it may be clear that one model may, for example, have increased wetted surface or improved righting moment, computational analysis doesn't provide any feedback on how these differences will actually affect the sailing performance when their effect on the total package is considered, including the effect on balance. These limitations of computer modelling are noted by several authors, including Levadou, Prins, & Raven (1998), and Roux et al. (2002, n.p.), who state,

One of the major difficulties of such a computation [using CFD programs] is that the flow over any one of the components — sails and hull — operating in a real sailing boat is a very complex combination of many phenomena, some of which being clearly non-linear. Besides this, a

sailing boat is an integrated system in which sails and hull closely interact.

Larsson (1990, p. 359) also notes that “A weak point of most [computer] VPPs is the prediction of the performance in waves . . . Waves create effects in all degrees of freedom . . . therefore a complete model for the wave effects is out of reach at present.”

I then proceeded to hand-draw two draft lines plans for the hull, developing the basic computer sketches and bringing together the characteristics of hull form and weight that I had so far predetermined. This was a major step, as the initial overall lines plan is a major expression of the concept of the boat and has the single largest influence on the outcome of the design, both in performance and appearance.

Developing both of these initial plans as hand drawings as opposed to computer-generated models made for a much more tactile process. The hull lines are built up using a systematic approach, in which the shape, characteristics and effect on the design of each line are carefully considered before it is drawn, allowing a clear process to realising the solution to the design concept rather than following a set of computer-generated figures.

First I developed a plan for what I considered to be a boat of moderate dimensions that would fit within the parameters that had been defined for the boat and was consistent with all of the elements of hull form and aesthetics that I had determined. I drew a balanced boat that I considered to be a good all-rounder in terms of performance.

Next, I did a variation on this design which was a more powerful adaptation of the same concept. I kept all of the base parameters the same, including deck line, sheer line and displacement freeboard, but concentrated on giving the hull a higher volume and therefore higher form stability.

I pinned both of these lines plans on my office wall and studied

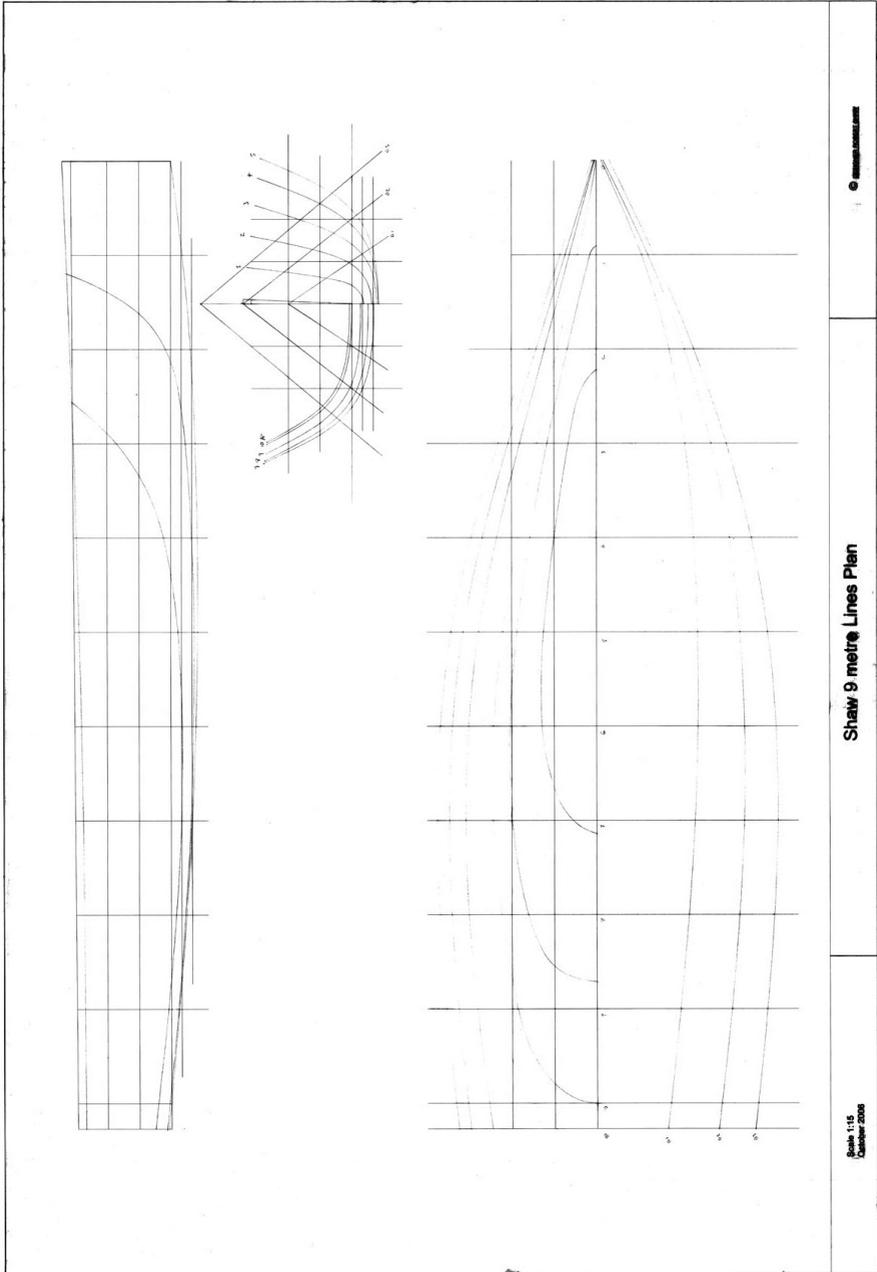
them, evaluating their merits and how each would vary in performance over a range of conditions and scenarios. Each day I would spend time on the process of observation and reflection, considering these two plans and what variations I could make to them and how I could improve the performance potential of the boat's design. During this time I continued to develop other aspects of the boat, including the sail plan, appendages, interior and the final design of the deck (see below).

Through this process I made minor refinements to the design based on improving its balance (see below) and how this would affect the yacht's performance in a wide range of sailing conditions. My research and careful consideration of the design led me to the more powerful of the two models.

## Weight and balance

As part of the design refinement process and action research spiral, I set up a spreadsheet to develop a detailed weight study for the boat. This went through several iterations as the boat's design and construction progressed. Every component was weighed as it was built and its longitudinal centre of gravity (LCG), transverse centres of gravity (TCG) and vertical centre of gravity (VCG) considered and updated on the spreadsheet to ensure the finished boat would end up floating correctly, and that any discrepancies from the original weight study could be accommodated where possible in the ongoing construction. Although it is possible to adjust the amount of ballast in the keel to compensate for minor discrepancies, it is essential to get the weight study as accurate as possible before the final design of the hull is committed to building, as increasing any weights would likely result in a drop in stability and have a negative impact on performance and handling characteristics.

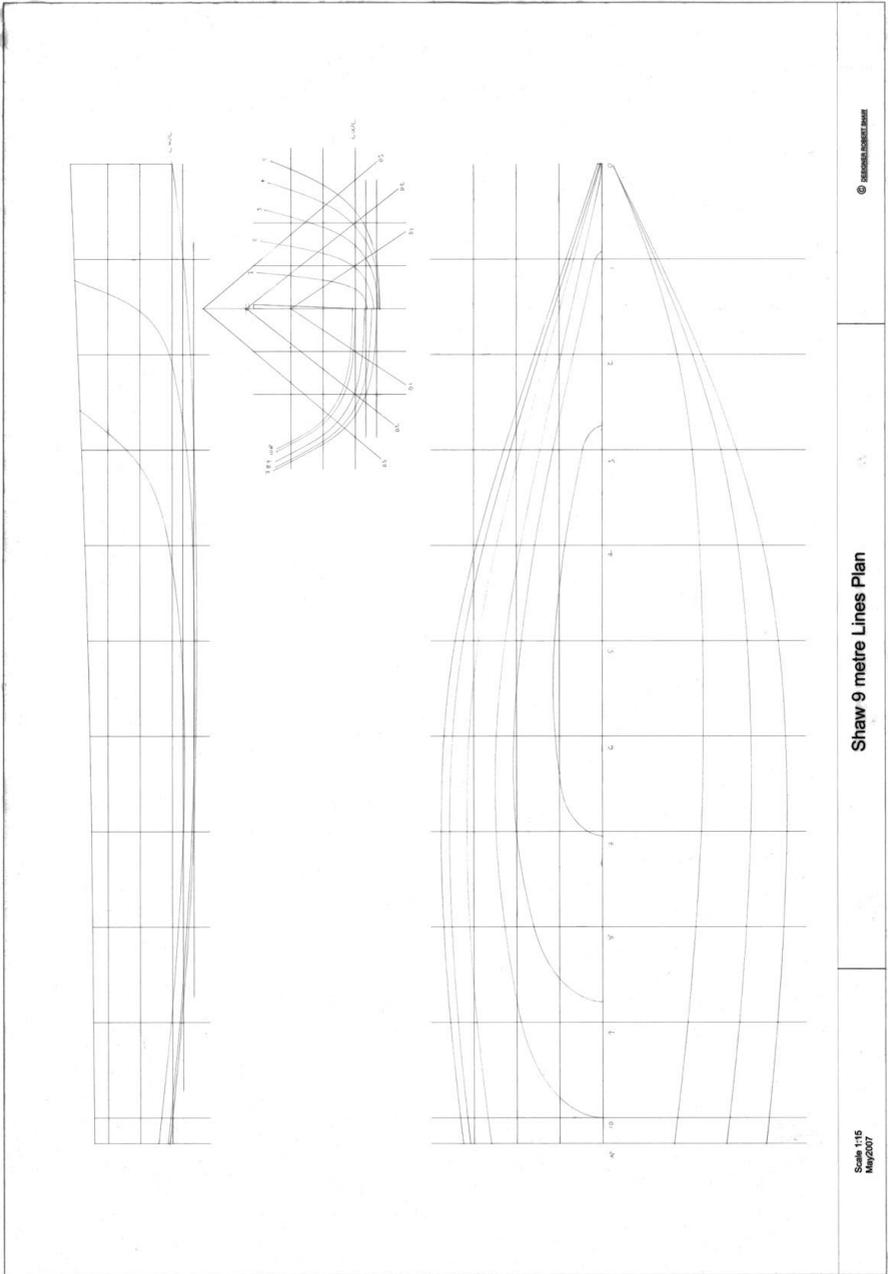
9. Draft lines plan for the Shaw 9 metre, with moderate dimensions.



Fore and aft balance had to be considered in relation to beam, ballast, crew placement, righting moment, displacement-length ratio and the conditions for which the boat is to be optimised. This is ultimately determined by evaluating the fore and aft symmetry of the hull, expressed by the diagonals, while considering these other factors in the context of the boat's concept.

Waterline angle of entry is a critical component contributing to resistance. Every effort was taken to minimise this angle while maintaining the fore and aft balance of the boat. A slight hollow is acceptable in the first 5% of the waterline length but any more than this can have negative effects on resistance and handling characteristics. The result of my design research was a waterline entry which has a slight hollow in the first 200mm, fairing into a straight line aft to station 3.5, then into a curve which runs through the mid-section of the hull.

10. Second draft lines plan, of a more powerful boat with a higher volume.



© BARNES & BARNES

Shaw 9 metre Lines Plan

Scale 1:15  
May 2007

## *Interior*

In terms of the boat's interior, concessions to comfort are at a minimum to reduce both weight and cost.

The structural layout consists of two fore and aft girders offset from the centreline running almost the full length of the boat. These girders serve many purposes, including providing fore and aft stiffness and support under the cockpit sole, containing water by creating a keel box, and creating a bunk front to which bunk can be added if required.

There is one full bulkhead forward which supports the prod assembly and doubles as a crash bulkhead in case the forward section is damaged in a collision. One other bulkhead is located under the mainsheet traveller to support the deck and ensure that this area remains completely rigid, as any movement would interfere with the operation of the traveller car system. This bulkhead also helps to manage the twisting load exerted on the boat by the crew sitting on the side, countering the side force of the mast and rigging, and also the mainsheet traveller loads.

There are two ring frames forward between the keel floors and the forward bulkhead, to reduce the panel size of the hull for increased strength in this high slamming-load area. The keel is supported by two keel floors which run athwartships across the boat. The floors are the strongest part of the boat, as the point load exerted on them by the keel pivot and purchase system is very high.

The floors run from gunwale to gunwale across the boat to help dissipate these loads evenly into the structure. An additional floor is located just forward of the forward keel floor and this, combined with the keel floor, make the mast step.

Immediately behind the aft keel floor is the chainplate attachment for the V1 and D1 rigging. Spanning the region from aft of the chainplates to forward of the mast step is an additional laminate on the inside skin to help dissipate the loads around this area.



11. (Above) Interior, looking forward to the front hatch and crash bulkhead.

12. (Below) Interior, looking aft past the keel box and mast step to the main hatch.



Locating all of these high-load components, including the crew weight, in close proximity makes the structure highly efficient. Further, having these components located close to the centre of the boat reduces the pitching moment of the boat, improving the sailing dynamics, particularly when sailing upwind in waves.

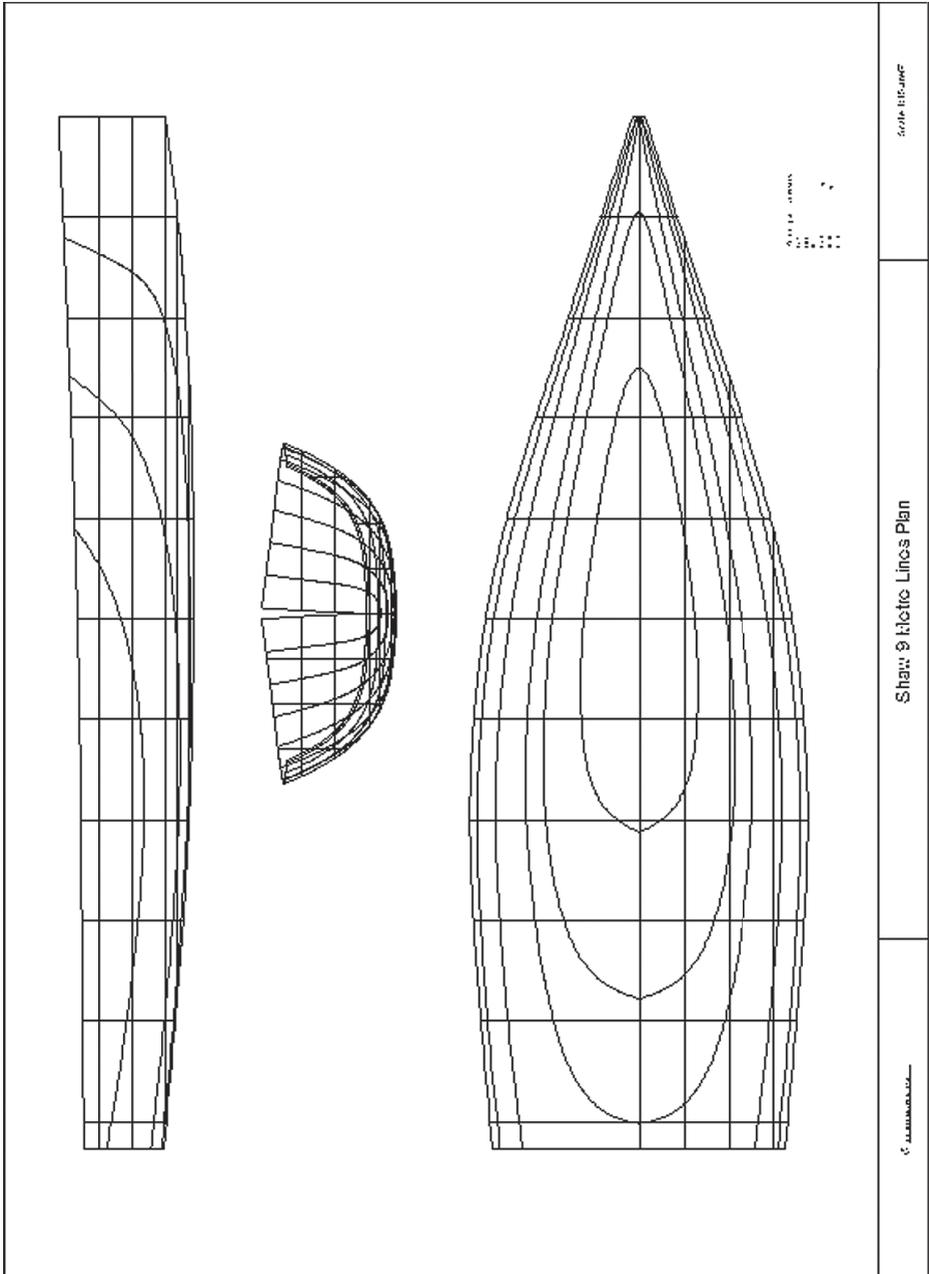
## Final hull design

I chose not to complete the analysis of the draft hull lines and reach the final model until the construction of the deck was complete and the weight study updated and finalised (see pages 50–53). For this process, I transferred my hand-drawn lines plans to the computer and proceeded using a CAD (computer-aided drafting) model, supplementing the CAD image by plotting out many scale drawings for ease of viewing.

With the design transferred into a CAD program, I was able to move from the art-based approach of the early concept design to a more scientific one, analysing the design's key characteristics such as stability and balance from an engineering standpoint, and refining details. I used this methodology because I wanted to be confident in the concept design before working on the detailing; I believe if the basic (art-based) concept is flawed, science cannot be deployed to “fix” it.

Having gone through a thorough process of determining both the desired numerical attributes for the final draft and its form characteristics, the development of this final model was a straightforward process. This enabled me to concentrate on achieving a perfectly fair and accurate model, blending together the optimum numerical and form characteristics identified through the iterative design process.

The experience of creating this model was quite a contrast to the previous stages of design development. Whereas in earlier iterations I frequently experienced a sense of surprise or intrigue as the model was developed, this time it was more of a feeling of familiarity, as the model was the development result of maturing objectives. This indicated the



Scale 1:1000

Shaw 9 Metre Lines Plan

© 2000-2001

13. CAD representation of the final hull lines.

success of the action research spiral model, as observation and reflection at each stage of the design development enabled a clear, well-considered and logical design to emerge.

## Deck design

Having drawn several iterations of draft plans for the hull, I had defined the sheer line, deck line, stem and transom profile. These would not be able to change once the deck was built.

As the deck is the second largest structure next to the hull, it gives a good gauge of the weight per square metre of the chosen construction method. Building the deck first allowed me the opportunity to update the weight study for the final hull lines drawing before committing to the hull shape.

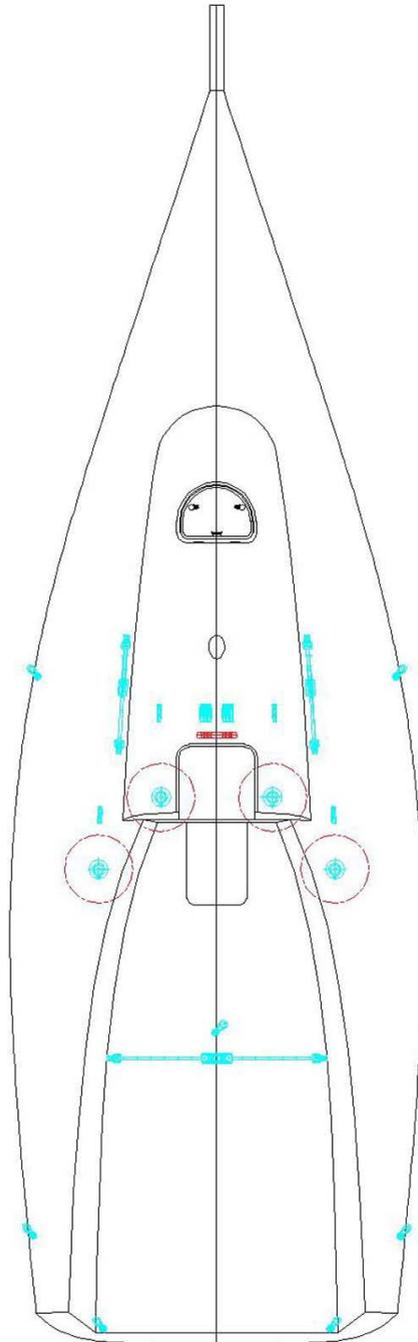
The design of the deck was a compromise between meeting Yachting New Zealand's Category 3 safety requirements, which provide a formula for maximum cockpit volume, and the ergonomic needs of the crew both while on deck and in the cabin space. The placement of the yacht's engine also impacted on the deck and cockpit layout.

I balanced the need to have a maximum-length cockpit for ease of working and keeping the crew well spaced during manoeuvres with allowing sufficient space between the aft cabin bulkhead and the keel box, to enable easy access down the companionway to the yacht's interior. I allowed a minimum of 500mm so that there was sufficient space for the crew to pack sails, navigate or cook without their movements being restricted by the keel system.

### *Case study: companionway hatch*

Considering a range of options for the main companionway hatch, the objectives were to have a simple access point that was easy to get in and out of but that could be sealed watertight. It needed to provide

14. Deck plan, showing position of winches, tracks, clutches and traveller.

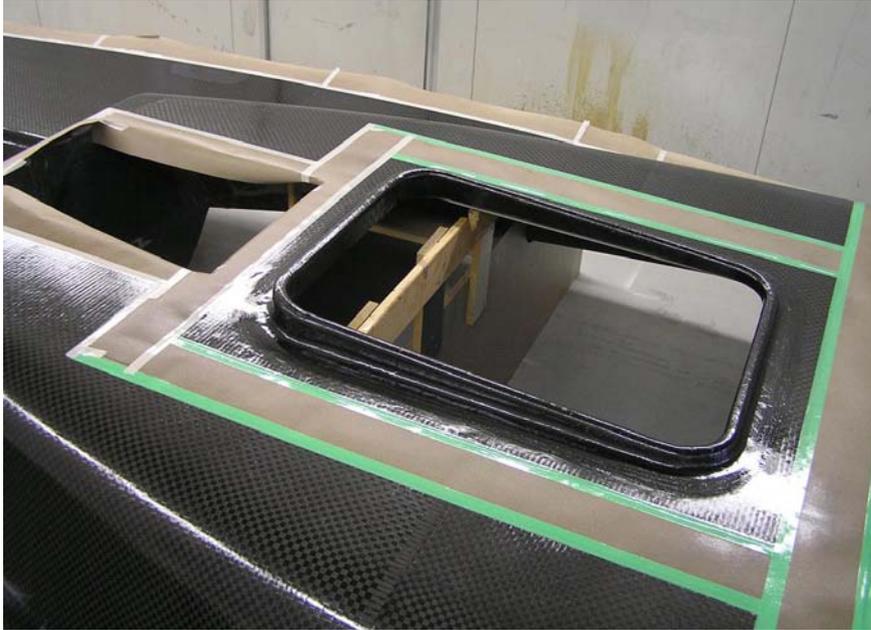


all-weather access to the cabin, be lockable from inside or outside, and prevent water ingress in case of the cockpit flooding or the boat being knocked down. This last factor had a large bearing on the maximum possible size of the hatch, which also needed to be big enough to enable the crew to get the sails in and out of the cabin in all conditions while underway. It also needed to look good, be easy to operate and be as light as possible.

I considered an envelope-style sliding hatch closing with a washboard arrangement. I drew some concept sketches, then developed a final design and working drawings, which indicated that such an option would be complex and take a large amount of time to build. I then considered some variations on this type of system, including twin hatches, but this option was quickly ruled out due to the narrow cabintop, largely defined by the 9 degree sheeting angle. I also investigated having the hatch top split down the centre and hinged each side, but I decided this was impractical in a racing environment, where loose sheets could get caught on the hatch tops and the halves blown around by the wind. Having the hatch open on gas struts would also be impractical, excessively heavy and expensive.

The other option I investigated utilised a regular Lewmar deck hatch. However, I felt that the aesthetics would be compromised, the geometry of the hatch was poor and it would create workspace issues. It would also result in a weight penalty, and if such a hatch was even slightly open to allow sheets to run through, it would lose its watertightness.

Finally I settled on a drop-leaf washboard and a removable hatch lid, held in place with slide bolts, for simplicity and weight reduction.



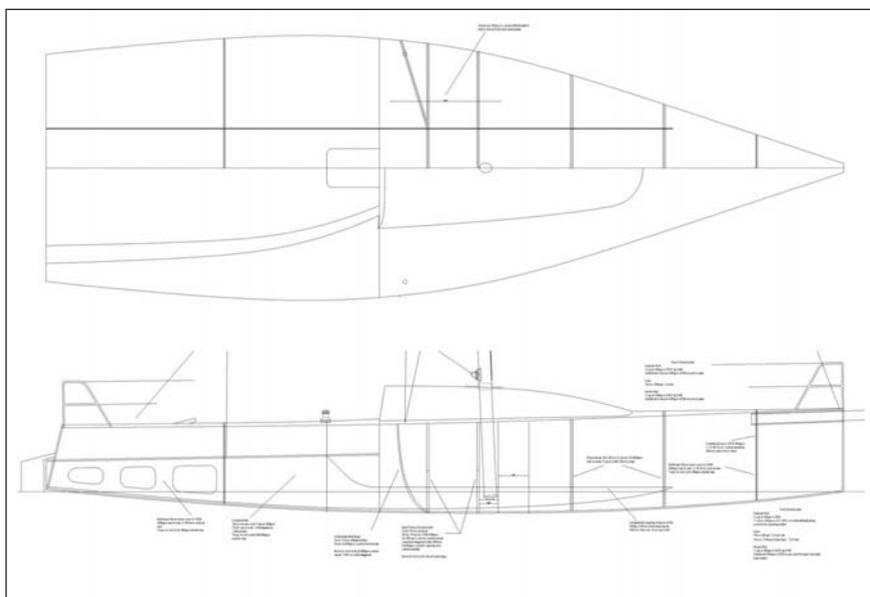
15. (Above) Underside of the cockpit, including cockpit hatch and outboard well.  
16. (Below) Construction of the main companionway.



## *Construction methods*

The cost of producing a full hull and deck plug over which to build the boat over would be approximately \$30,000, while the cost of building temporary frames was around just \$1000. Therefore, building a full plug would result in a big increase in cost for only a small improvement in strength and finish and reduced weight. Having reviewed the options for construction I settled on building the boat of carbon fibre and foam composite over frames, which was the best compromise to achieve a light, strong and stiff boat at a reasonable cost.

The engineering characteristics of the hull structure were based on the American Bureau of Shipping (ABS) guide for the structures of small craft under 24 metres. This standard is cited by ISAF (International Sailing Federation) and many clubs and race organisers as a minimum standard for boats to compete in long-distance races. (Note: this standard has since been superseded by new ISO standards.)



17. Construction drawing for the Shaw 9 metre.



18. (Above) Construction of the hull 1: inside laminate over foam core, with fore and aft girders in place. The core was planked over female frames.

19. (Below) Construction of the hull 2: all structural components in place and clear-coat applied over laminate, ready for the deck to be fitted.



The engineering of the various components and structures was a collaborative process. Initially I relied on my own experience, knowledge and ability to determine structures and then, as the project progressed, I sought the input of specialists such as structural engineering consultants to further refine these. I also worked with consultants on the high-load areas of the chainplates, keel attachment and keel fin assembly.

The frames were CNC-cut to the inside shape of the deck and outside shape of the hull and set up on the floor so the boat could be built upright. The frames were notched to take stringers to give added accuracy and ensure the fairness of the structure. Foam core was then fitted over the frames, with some high-density foam in high-load areas such as under winches.

The hull was built right way up in two halves, split down the centreline. Using this technique gave good access to the entire hull surface, eliminating the need to build a scaffolding to span across the hull for access. The core was fitted to the inside of the temporary frames by planking across the boat, reducing the deflection in the planks as they were placed around the compound shape of the hull. The foam was machined into narrower planks towards the forward sections of the boat, where the shape of the hull is more pronounced. Some of the foam planks required heating to around 80°C to soften them and enable them to bend around the tightest sections.

Once the entire foam core was in place, any minor fairing of the surface was completed before applying the inside laminate. The laminate was wet out with a resin impregnator to the correct resin/fibre ratio to ensure the desired strength–weight properties.

The two halves of the hull were then joined together and the interior structure fitted, before the deck was attached and the hull and decks turned over. The exterior of the core was faired and the necessary rebates machined into it where the outside laminate would lap, around areas of reinforcement such as chainplates. The outside skin was then laminated.



20a and b. Construction of the hull 3: application of exterior hull laminate.



## Deck construction

The deck was built by setting up the temporary frames upright in the workshop. Building the deck facing upright (as opposed to upside down) gave me the opportunity to assess the look and functionality of the layout and make any changes as the job progressed. Although I had modelled the shape and proportions of the deck structure in CAD, it was still hard to accurately predict what the finished product would look like.

Building in this way is essentially the same as building a full-size mock-up, as it is possible to sit and stand on the deck structure, rehearse various scenarios and consider the functionality of the layout. I took advantage of this flexibility to make several changes to the deck layout and to reduce the height of the cabintop before progressing with the build. This improved visibility forward from the helm and lowered the cabintop winches to a more workable height.

After laying up the outside skin, the deck was reinforced with temporary reinforcement, ready to be turned over. A new set of temporary frames were cut to support the deck while it was inverted. Once set up upside down, the deck was faired inside and the inside laminate applied.



21. (Above) Deck construction 1: Foam core fitted to temporary frames prior to lamination.

22. (Below) Deck construction 2: Laminated deck inverted, showing hatch openings.



## Keel and appendages

Development of the appendage package started with the design concept and developed as the overall design evolved into a more robust design solution. The initial design brief stipulated a canting keel, enabling the design to achieve a low displacement–length ratio while still having a generous righting moment. This would give good all-round performance when sailing both fully crewed and short-handed. I had an expectation that the keel could be canted with a manual system given the size of the boat and the associated loads.

The canting keel is a pivotal component, Having considered various ballast ratios in terms of performance and the requirements for meeting Category 1 safety requirements for stability, I settled on a total bulb weight of 550kg. I set the total draft at 2.5m, as this would enable the boat to sail in harbours around the North Island without too great a risk of hitting the bottom and also allow the boat to be accommodated in the marina at Westhaven. This 2.5m draft also means the boat can be pulled out onto a floating dock for its bottom to be cleaned regularly.

I began a process of investigating the suitability of using a carbon fin for the keel strut, including consulting with engineers. Carbon was my first choice for the fin, largely due to the ease of construction, the reduced weight of the structure and the fact that carbon wouldn't corrode in the saltwater environment. Early feedback was positive and the method looked to have a lot of merit.

However, when it came time to finalise the engineering of the fin I found all the engineers I had consulted with either became concerned about liability issues associated with using a carbon fin or referred to aspects of engineering a carbon fin as a “black art”, alluding to its inability to be adequately quantified. This soon led to me abandoning the idea of using carbon in the fin as I could not quantify the risk that the fin might fail or have inherent problems that would affect its operation, or compromise the safety of the boat and crew.



23. (Above) Structural steel keel spar being fitted with foam fairing.  
24. (Below) CNC-machined female rudder moulds.

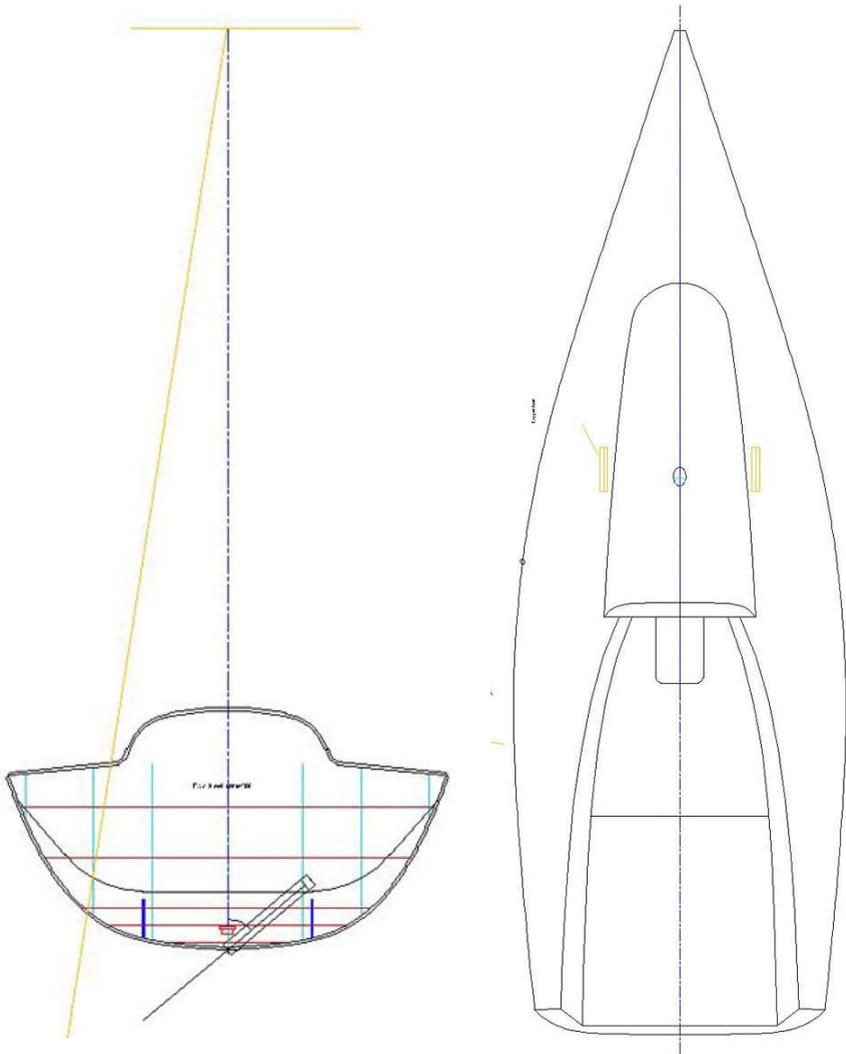


This introduced a new issue, in that changing the keel's construction from carbon fibre to high-tensile steel would have an impact on the weight study, which was now set and the hull design complete. Changing the construction material meant a weight increase of approximately 120% in the fin alone. Fortunately I had allowed for some contingency in the weight study which absorbed most of this increase. Also, due to the increased fin weight, I was able to reduce the weight of the bulb a little to compensate without a reduction in righting moment.

As the canting ballast fin's sole purpose is to support the ballast, not to also produce the hydrodynamic side force to counter the aerodynamic side force of the sails as in a conventional yacht with a fixed keel, it was possible to develop a section shape which was optimised solely to reduce drag.

Ballast bulbs range a lot in shape and form, the main influences on the latter being handicap rules and the speed at which the boat has been optimised to sail. The main objective for the bulb on this boat was for low drag across a broad speed range, accepting some penalty in increased wetted surface area to achieve a shape that would have good performance at higher speeds as the boat has a large sail area to help overcome the increased wetted surface. Having the bulb completely round in section gave the advantage of minimising surface area for its volume and was the easiest shape to maintain in good condition.

To generate sideways resistance in the absence of a fixed keel, I specified a pair of asymmetric daggerboards, to be positioned through the hull to either side of the mast. These are raised and lowered as required using a manual purchase system.



25. (Left) Transverse hull plan showing keel fully canted and line of the daggerboards through the hull.
26. (Right) Deck plan showing the position of the daggerboards to either side of the mast.

## Rig and sails

There are numerous examples of boats which achieve good performance in a defined set of conditions or when sailing within a narrowly prescribed range of apparent wind angles, such as the Open 60 and Volvo 70 class yachts currently used in major offshore races (Ward, 2009, p. 40). The objective with this design was to achieve excellent all-round performance with minimal compromise so as to avoid any potential weakness or Achilles' heel.

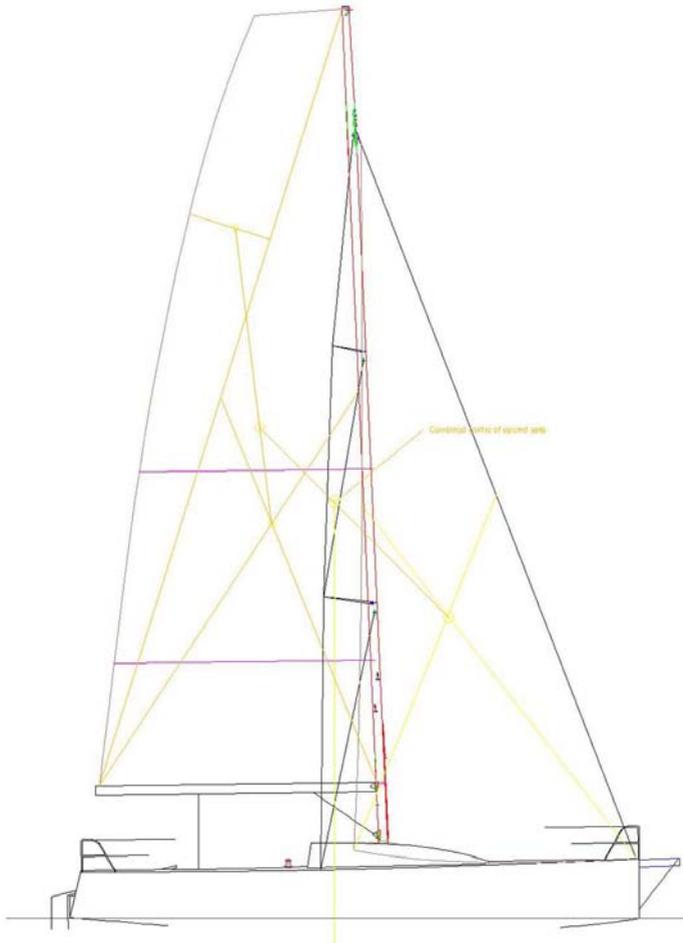
My experience in smaller designs had proven the performance gains that can be realised through good balance of the sail plan and the interaction of the sail plan, hull form and appendages. Versatility is key to achieving this and ensuring good performance over a range of conditions and apparent wind angles.

Hull form is the greatest component of the yacht's overall balance, but the sail plan plays a major part. As Larsson and Eliasson (1994, p. 155) note, "One of the most difficult problems in the design of a sailing yacht is to find the best longitudinal position of the sail plan relative to the underwater body." A yacht's balance is also difficult to ascertain using scientific formulae and computer-based models; Larsson and Eliasson (p. 155) also state that "An entirely theoretical solution to the problem has never been presented."

### *Spreaders*

The configuration of the rig needed to allow good control and ease of adjustment while also being stable and reliable. The boat needed to be capable of being sailed short-handed, and a big part of achieving that is to have a rig set-up that is easy to handle.

This factor led to an action research investigation into the incorporation of raked spreaders in the rig design to give the mast good support both athwartships and fore and aft. After experimenting with



27. Upwind sail plan (full sail), showing the combined geometric centres of the plan.

the effect of spreader rake on some numerical models it was found that a spreader rake of 27 degrees was a good compromise, providing good support both laterally and fore and aft.

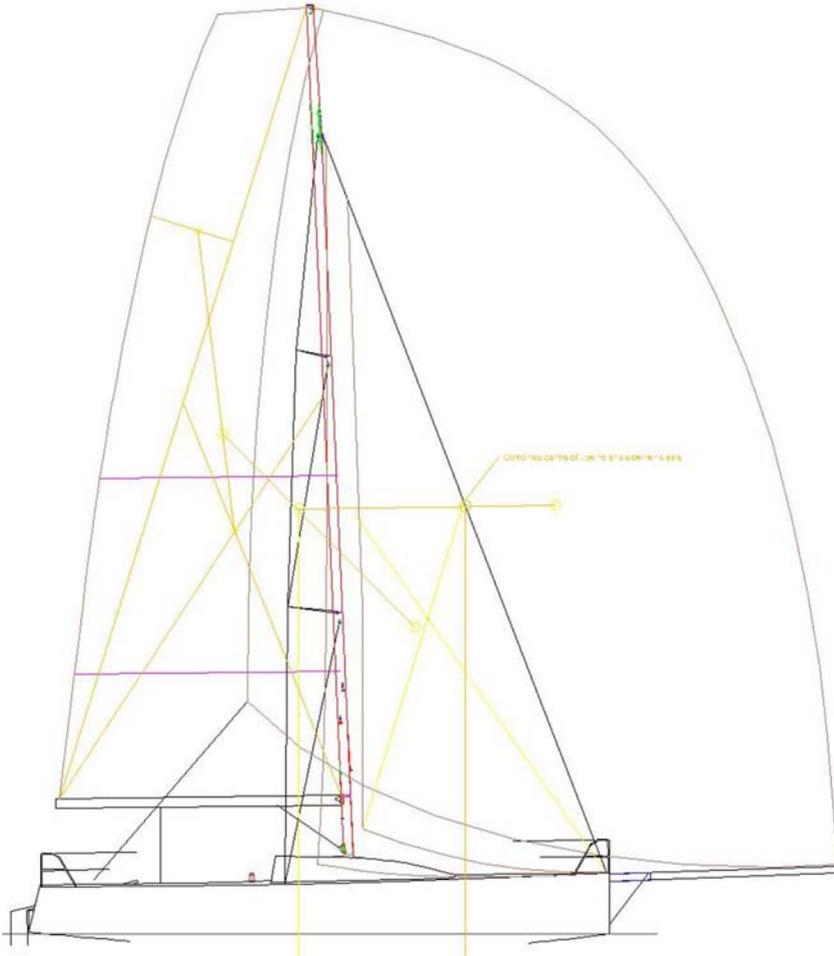
## Backstays

Although the spreader rake is adequate to support the mast in most conditions, two exceptions to this were identified. Firstly, when running downwind under masthead gennaker in apparent wind above 15 knots there is potential for the rig to be overloaded. Sea state also has a big effect on this, as when the boat runs into the back of a wave and decelerates, a considerable load increase is transmitted through the rig. As wind speed and wave interference increase, the loads generated increase also. As noted by Larsson (1990, p. 359), this is something which can't accurately be calculated or modelled beyond a "seat of the pants" prediction. As the boat is intended to excel in such conditions, it was important that the rig be set up to take these worst load cases into account, so the crew wouldn't be forced into reducing sail area and therefore performance at these times.

The other situation identified where the rig performance needed to be enhanced to achieve optimal results is sailing upwind once the boat has reached full power. In this situation the rig can greatly benefit from the addition of a backstay, either fixed or running, that can be used to both de-power the mainsail and increase the forestay tension, reducing some of the sag in the forestay.

A single topmast backstay arrangement is often used to achieve this on boats of this size, but was not practical on this design due to the desired mainsail profile, with the head of the main extending far beyond the line of a conventional backstay. For this reason I decided on a pair of running backstays.

However, traditional running backstays (runners) require a pair of



28. Sail plan with the addition of downwind sails (masthead gennaker on extended prod).

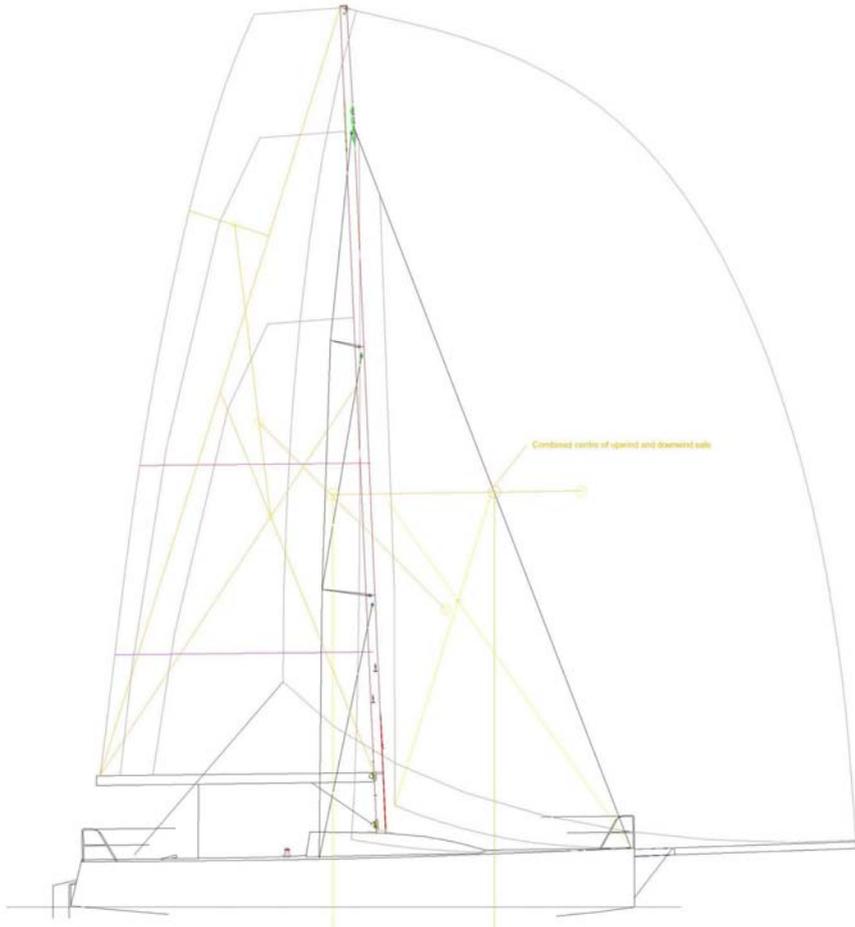
dedicated winches to handle the line loads and allow accurate trimming. The downsides of adding an additional pair of winches are increased cost and weight, loss of deck space and the complexity of loading and unloading the runner tails on the winches during manoeuvres such as tacking and gybing. This loading and unloading is not such a problem when sailing the boat fully crewed, but presents a very real issue when sailing short-handed, when the skipper has to steer the boat, trim the main, clear the sheets and trim the runners simultaneously during manoeuvres.

This initiated a further design spiral to produce a new solution to the traditional winch-based method of trimming the runners, which resulted in the development of a rope purchase system utilising a pair of clutches, with coarse and fine-tune elements built into it. This enabled quick release and the ability to quickly reset the runners by pulling a single line that would automatically lock and set in the rope clutch. This would ensure the safety of the rig when gybing the boat in high winds. With the addition of a fine-tune cascade purchase system, the higher loads necessary to increase forestay tension for improved upwind sailing could also be achieved.

### *Sail plan*

In the context of this design, a range of sail plan options were extrapolated and evaluated based on past experience and researching existing boats. As this boat didn't need to meet any specific handicapping or measurement rules, a much broader scope of options could be explored in the sail plan.

To determine total sail area it was necessary to consider the conditions in which the boat would be sailed, and identify what amount of sail area would give the boat optimum performance over the widest range of conditions. The weight of the sail plan also needed to be considered,



29. Full sail plan, taking into account number two jib and one and two reefs in the mainsail, showing their effects on the geometric centre of effort.

as increases in weight aloft are highly detrimental to righting moment. Ease of sail handling needed to be considered too, and excess drag from too much sail area or an oversized rig had to be avoided.

Through observing and reflecting on different sail-plan options I identified that a worthwhile increase in upwind sail area could be achieved without excessive increase to the height and weight of the rig by increasing the J measurement (the distance between the forestay and the mast) beyond what would normally be found on a boat of this size. This increased the area of the foretriangle and located the increased sail area low down on the sail plan, minimising the capsize moment generated. This also made the sail plan more versatile and is a more efficient means of increasing upwind sail area than the alternatives of increasing the mainsail area through increasing the E (foot of the main), P (luff) or roach measurements. The observed downsides of increasing the E measurement are increased weight in the boom, the potential for the boom to hit the water when the boat is hard reaching, and the imbalance effect the mainsail has on the boat when sailing at apparent wind angles of between 35 and 75 degrees.

Having concluded that increasing the J measurement would provide some positive benefits, the next design spiral was motivated by determining the best way to achieve this. My experience on boats where the J measurement had been increased by moving the forestay forward on the stem or onto a sprit was that this upset the balance of the boat, particularly in two-sail reaching conditions where the hull sections lacked the power necessary to convert the drive generated by the jib into forward momentum. This often results in the rudder loading up as the bow sections of the hull are depressed under the drive from the jib. This leads to a boat that is difficult to control and very wet on deck.

The alternative solution is to move the rig aft in the boat so that

30. *Karma Police* under masthead gennaker, flown off the extended prod.



the mast is stepped onto the forward keel floor. This is a solution that I haven't seen employed on any other boats in New Zealand but has the added advantage of simplifying and consolidating the structure in the boat as well as centralising the rig weight in the boat. Having the weight of the rig located further aft is very desirable in hard downwind running conditions, as it helps maintain control and means larger sails can be carried into higher wind ranges. It also helps reduce the pitching moment of the boat, which in turn improves potential upwind performance when sailing in any kind of seaway. Consequently I decided to locate the mast step in this further aft position, incorporating the forward keel floor.

One other option for increasing sail area without increasing the size and weight of the rig was to increase the roach of the mainsail. This is most efficiently achieved by increasing the size of the head of the sail from the traditional pin-head profile to the more modern square top. I opted for a square top of proportions that would provide an efficient drag profile and which could be accurately controlled for shape. To further increase the size of the head of the mainsail would make the sail hard to manage, raise the centre of effort and capsize moment and increase the drag profile of the sail.

To achieve optimal performance reaching and running, I decided the boat would need to be equipped with asymmetric downwind sails set off a retractable prod. This decision was based on my experience and observation of other boats, including my own previous sportsboat designs.

Various prod options were considered, including the length of the prod and the potential to be able to rotate it to windward, as has been favoured by some designers. Rotating prods introduce structural and watertight integrity issues which I consider difficult to address sufficiently to ensure safety and reliability. Having a non-rotating prod can be offset by a combination of increasing the length of the prod and

designing the gennaker so that it has large shoulders which can project to windward of the mainsail when running downwind.

Further to this, from analysis of the effect of apparent-wind sailing on light displacement boats, I identified that having the ability to project the sail to windward using a rotating prod is of importance only in light airs sailing. Once the wind speed has increased to the point where the boat is able to build its own apparent wind, then that apparent wind is always forward of approximately 120 degrees. The result of this is that the gennaker is always set in clear air which is undisturbed by the mainsail.

The factors affecting prod length were structural engineering considerations, weight, gennaker projection, balance and the ease of gybing the gennaker. Considering all of these factors led to a final compromise length of 3.6 metres from the stem. This was long enough to have a positive effect on all the criteria above while avoiding taking a large weight penalty accrued through trying to manage the loads of a longer prod.

The addition of a fixed 600mm sprit with bobstay to carry a tight-luffed code zero sail also contributed to the support of the prod and made it practical to push the prod out to 3.6 metres. The inclusion of the fixed sprit for a code zero was a defining element of the sail plan. This enables the crew to extract the full potential of the design without having any weaknesses, as well as providing increased versatility when sailing in a range of conditions or short-handed.



## 5: Evaluation

Construction of the Shaw 9m *Karma Police* was completed and the boat launched in May 2009. A sister ship, *Deep Throttle*, was launched in February 2009. On-the-water testing, trialling and racing of these two boats was then carried out to assess the performance of the design and investigate how the action spiral process resulted in its success.

As stated earlier, the process of designing the Shaw 9m combined aspects of “art”, or using intuition and the “designer’s eye” to generate ideas and concepts, with the “science” of using computer evaluation tools and engineering disciplines to develop and refine the design. The three key considerations in the design of the yacht were:

- Accessibility (in terms of cost and ease of construction, and transportability)
- Performance (including quantifiable elements such as speed)
- Handling characteristics/feel (user experience and ease of sailing and crewing).

As well as my self-evaluation of the concept, since its launch the boat has been reviewed by independent authors and featured in a number

of published articles and website reviews. It has also generated a strong race record, both short-handed and fully crewed.

### *Accessibility*

A key driver was for the boat to be accessible, keeping the cost of construction and running to a reasonable level while still producing a yacht which would offer high performance and ease of sailing. This was done through the considered design of hull, deck and rig, in terms of specification of construction materials, rigging and deck gear.

The design resulted in the production of a 9 metre boat for around \$285,000, comparable to other boats of this size, and considerably less expensive than other boats offering a similar performance, which are larger. Using the action research spiral to investigate and refine aspects of the construction process as outlined earlier made a major contribution to keeping the boat affordable. This in turn made the boat appealing to a wider market sector.

Also as noted earlier, through the design process I ensured that the boat could be transported in a container. This has resulted in considerable interest from overseas, especially Australia and the United States, in constructing new hulls from the design plans in New Zealand and transporting them by sea.

### *Performance*

The main aim in terms of performance was to produce the fastest boat of its size and type in the world, with good speed in a range of conditions and all points of sail. Since its launch, the Shaw 9 metre has won a number of races and regattas and has proved to be an excellent

31. Overall costing for construction of a Shaw 9 metre, showing breakdown of various aspects and components (at 12.5% GST).

Item	Details	Material/ component cost	Materials/ components no GST	Hours @ \$52/hr	Total no GST
Hull structure	Hull area 30m2	\$ 9,000	\$ 8,000	270	\$ 21,500
Deck structure	Deck area 23m2	\$ 6,200	\$ 5,511	260	\$ 18,511
Internal structure	Bulkheads,girders, keel floors	\$ 11,700	\$ 10,400	600	\$ 40,400
Transom/hatch details		\$ 1,000	\$ 889	100	\$ 5,889
Construction details	Chainplates/forestay/gudgeons	\$ 1,100	\$ 978	150	\$ 8,478
Attachments	Fastenings etc	\$ 600	\$ 533	100	\$ 5,533
Assemble components		\$ 200	\$ 178	120	\$ 6,178
Appendages	Rudder and canard/case	\$ 2,800	\$ 2,489	110	\$ 7,989
Canting keel	Steel work/bearings, all components	\$ 8,000	\$ 7,111		\$ 7,111
Keel fairing and finishing	Foam/glass epoxy	\$ 300	\$ 267	110	\$ 5,767
Bulb	Lead and casting	\$ 2,850	\$ 2,533	30	\$ 4,033
Rig	Complete with standing rigging/mast base	\$ 31,000	\$ 27,556		\$ 27,556
Boom	Inc exit boxes, vang attachment	\$ 3,500	\$ 3,111		\$ 3,111
Running rigging	Halyards/sheets	\$ 2,400	\$ 2,133		\$ 2,133
Prod and sleeve	C-Tech	\$ 3,600	\$ 3,200		\$ 3,200
Sails	Main, 1-2-3 -storm jib mast head and fract AP	\$ 24,500	\$ 21,778		\$ 21,778
Stations push/pullpit	Stainless	\$ 5,500	\$ 4,889	40	\$ 6,889
Deck package	Lewmar winches/hardware	\$ 13,900	\$ 12,356		\$ 12,356
Electronics	Nexus	\$ 3,500	\$ 3,111		\$ 3,111
Engine and instillation	Yamaha 15	\$ 3,750	\$ 3,333	70	\$ 6,833
All fairing and painting		\$ 3,000	\$ 2,667	250	\$ 15,167
Instruments bracket and dash		\$ 250	\$ 222	40	\$ 2,222
Attach deck package		\$ -	\$ -	110	\$ 5,500
Step keel and rig/commissioning		\$ -	\$ -	40	\$ 2,000
<b>Total</b>		<b>\$138,650</b>	<b>\$123,244</b>	<b>2400</b>	<b>\$243,244</b>

GST incl = \$273,650

performer. Key performances have been in the 2009 and 2010 Coastal Classic races from Auckland to Russell, 2010 Bay of Islands Sailing Week, 2009–10 Nexus Gold Cup inshore series, and the 2009 and 2010 SSANZ B&G Simrad Triple short-handed series (see Appendix 1, pages 99–100).

The yacht's fully-crewed performance is such that its PHRF (performance handicap rating factor) handicap has been revised upwards four times since its launching, from .880 to .935, indicating that the boat's actual performance consistently exceeds the performance expected from a boat of its size and type. Also, the vast majority of boats of this size are classified race in division 2 or B for boats 10.6 metres or smaller. However, the Shaw 9 metre races in division A or 1 against boats 12 metres and over. In this division it consistently beats the 12 metre entries on the water and has several times taken line honours in this division against boats 15 metres and longer, including the 16 metre Transpac 52 *Georgia*, designed by America's Cup designers Botin and Carkeek.

The yacht has also been successfully raced two-handed, finishing the 2010 SSANZ Simrad winter two-handed series with the shortest elapsed time in longhaul division A.

Speeds of 7.5 knots and an apparent wind angle of 28 degrees are typical when sailing upwind, with top speeds of 24 knots recorded by GPS when reaching in 30 knots true wind and flat water.

### *Handling characteristics/feel*

The Shaw 9 metre has proved to be well-behaved and easy to handle in a wide range of conditions, with no noticeable vices or areas of reduced performance. The yacht has been sailed extensively over short harbour

32. David vs. Goliath: *Karma Police* leads the 16 metre Botin and Carkeek Transpac 52 *Georgia* downwind in a winter series race on Auckland Harbour.



courses, including windward-leeward courses, as well as longer distances in races of up to 120 miles. It has proved easy to handle by a crew of five or six, and by just two sailors in short-handed events. As well as being sailed by experienced crew, the boat has also been successfully campaigned by less experienced sailors, including a mixed crew of male and female sailors, with a female helmsperson.

Over time some aspects of the deck gear and setup have been refined, including upgrading the sheaves on the purchase system for the canting keel, and the addition of further sails to the wardrobe to enhance performance on particular points of sail, including a code zero and A5 reaching sails. Significantly, however, all other aspects of the yacht have remained as originally designed.

### *Independent evaluation/press coverage*

The Shaw 9 metre has received extensive local and international press coverage, including in the Royal Ocean Racing Club's *Seahorse* magazine (UK), the Sailing Anarchy webpage (USA, the world's most viewed sailing website, with more than 30,000 registered members and receiving over one million unique views each month), and in *Boating New Zealand* (see Appendix 2, pages 101–105).

Writing about the Shaw 9 metre *Karma Police* in *Seahorse* (2009, Ivor Wilkins states:

The lines are sweet, with a hint of sheer, gently flaring topsides, and a nicely balanced profile. . . . Make no mistake, the speed-producing elements are all there: carbon-foam composite construction, a powerful sail-plan, high ballast ratio, long waterline, light displacement. But they are packaged discreetly in a smooth design that exudes quiet confidence. (p. 15)



33. (Above) *Karma Police* shortly after the start of the 2009 Coastal Classic, reaching up the Rangitoto Channel under masthead gennaker.

34. (Below) *Karma Police* in short-handed configuration, at the Wellington restart of the 2011 SSANZ Round the North Island two-handed race.



Wilkins also reviewed the performance of *Karma Police* and *Deep Throttle* in the 2009 Coastal Classic in the Royal New Zealand Yacht Squadron's *Breeze* magazine, under the heading 'Dinner early as Crichton's supermaxi steals the show . . . but the small yachts take the glory', noting:

The trio of 9m sport boats [*Karma Police*, *Deep Throttle* and Elliott 9.1m *Overload*] crossed the finish line with elapsed times that put them in the top 10 in the fleet . . . All three of them smashed the record for the fastest monohull under 9.14m . . . In fact, they were also faster than the record for the next size category, 9.14–10.66m. . . . Given that these little flyweight combatants would cost about the same or less than a maxi [yacht] mainsail, they punched way above their weight on a bang for the buck basis. (2009, p. 32)

Following the 2010 Coastal Classic, Wilkins again featured the Shaw 9 metre in *Breeze*, writing:

The two 9.1m [sic] Shaw boats . . . gave notice last year that they were going to be a nuisance to much larger boats in reaching conditions. . . . This year the three Shaw boats [*Karma Police*, *Deep Throttle* and the Shaw 10 metre *Orbit*] went even better, with their 5th, 6th and 7th places on line and all three podium places on handicap . . . extraordinary results considering the size and pedigree of the Division One fleet. (2010, p. 28)

Wilkins also noted, 'It is believed to be the first time one designer has scored a Division One trifecta in this race.' (2010, p. 32)



35: Shaw 9 metre *Karma Police* (centre front, red gennaker) jumps out of the start of the 2010 Coastal Classic. The yacht finished 7th on line, ahead of many larger yachts. (Photo: Ivor Wilkins)

The Shaw 9 metre was featured in the December 2009 edition of *Boating New Zealand*, with reviewer Rebecca Hayter stating “The boat converts any puff of wind into acceleration worthy of a mention on *Top Gear*” (2009, p. 52).

*Deep Throttle* and *Karma Police* were named number two and three in the racing yacht category of *Boating New Zealand*'s “Boats of 2009”:

Our judges liked the technical innovations Shaw incorporated into *Deep Throttle*, and her recent racing successes point to how well she fulfils her design brief. (2009, p. 41)

Karma Police was also described as:

blindingly fast and amazingly responsive . . . She further impressed our reviewer with her exceptional upwind performance and our judges liked the boat's purity of function and her high-tech construction. (2009, p. 41)

## 6: Conclusion

The satisfaction of any one requirement necessitates something antagonistic to some other requirement equally clamorous for satisfaction. Your vessel, to be perfect, must be light, of small displacement, and with the centre of gravity brought very low; she must also have large displacement, and the ballast must not be too low, in order that she may be easy in a seaway; she must be broad, narrow, long, short, deep, shallow, tender, stiff. She must be self-contradictory in every part. A sailing yacht is a bundle of compromises, and the cleverest constructor is he who, out of a mass of hostile parts, succeeds in creating the most harmonious whole. It is not strange that designers pass sleepless nights, and that anything like finality and perfection of type is impossible to conceive. No wonder that yacht designing is a pursuit of absorbing interest.

— *Lord Dunraven, America's Cup challenger 1893 & 1895*

The development of the Shaw 9 metre provided a platform for the exploration of the inter-relationship of art and science in the practice of yacht design. Having considered the existing research and conventional wisdom that inform current design practice in this field, the complex journey of designing this new yacht took place, utilising an action research model to establish a design concept and explore and refine aspects of it according to the three key considerations of accessibility, performance and handling characteristics. The design journey underscored the need to observe and reflect, to consider conventional wisdom and explore ways of expanding it, drawing on a balance of science (mathematical- and computer-driven processes) and art (intuition, past experience and the “designer’s eye”).

The action research method and use of a design spiral methodology proved highly successful in the development of the Shaw 9 metre. Focusing on the key considerations mentioned above, each aspect of the design, including the overall look (aesthetics), construction methods, hull and deck design, keel and appendages, and rig and sail design, was examined and developed using the process of planning, acting, observing and reflecting, leading on to the next iteration of each aspect and its development.

The resulting design is an aesthetically pleasing, modern-looking yacht which is cost-effective to build and campaign, and able to be transported by container, thus fulfilling the criterion of accessibility. Since its launching, the yacht has been sailed successfully in a wide range of conditions and configurations (e.g. two-handed and fully crewed, in short- and longer-course races), fulfilling the criterion of all-round performance, with no weak areas or points of sail, and demonstrating the value of the appendage and rig and sail designs. On-the-water experience has also proved that yacht’s positive handling characteristics, showing it to be an easy and comfortable boat to sail, with no discernable vices — the result of the careful consideration of

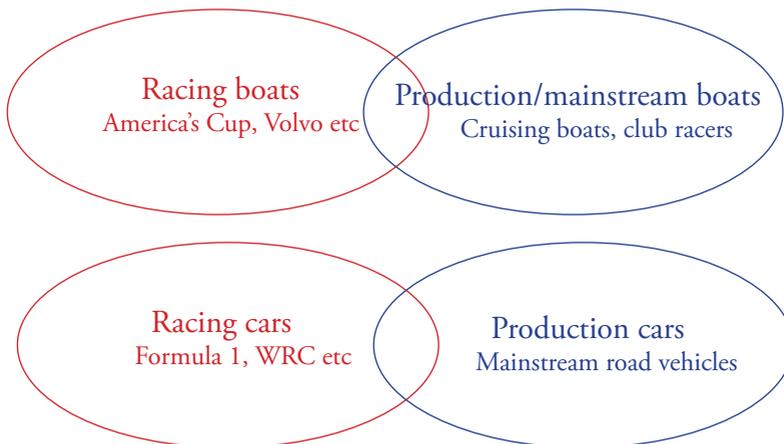


36: Shaw 9 metre *Karma Police* (9159) powers out of Wellington Harbour ahead of Ross 45 *MI* (8460) in the 2011 SSANZ Round the North Island two-handed race.

the design of the hull shape and deck layout.

The signature look of the yacht was developed through a combination of intuitive thought and hand-drawing, based on my experience of previous yacht designs and what I felt “looked right”, and computer modelling and theoretical design processes and tools. The major design challenge here was to develop a yacht which not only looked fast but went fast, and vice versa.

During the design and build process, construction techniques were evaluated, tested and refined, resulting in a construction system which kept material and time costs to a reasonable level whilst producing a lightweight and therefore easily driven boat. The challenge here was to draw on up-to-date technologies and materials developed for such grand prix events as the America’s Cup and Volvo round-the-world race and utilise them in a way which would be cost-effective for the non-professional owner. Specifying the materials and laminate, including selecting areas of particular load-bearing, required a more science- than art-based approach and drew on the engineering discipline.



37: Technology transfer: technology utilised in grand prix boats such as America’s Cup or Volvo 70 yachts crosses over to ‘civilian’ racing boats in the same way Formula 1 technology over time influences production car design.

Engineering and more scientific investigation also came into play in the design of the yacht's sails and rigging and appendage package. However, again the art of yacht design came into the process, as the true balance of a theoretical design cannot be ascertained solely by mathematical techniques. The challenge here was to evaluate available science-based knowledge of loads and stresses and combine it with my intuitive sense of what was appropriate, based on past experience, to specify the rig configuration and sail plan.

### *Research reflection*

Yacht designers have always had a strong interest in the physics of sailing, and during the twentieth and twenty-first centuries have borrowed much from the associated fields of engineering and aerodynamic research. As the knowledge base of these fields advanced, the natural tendency for designers was to try to apply this new knowledge to the field of yacht design as much as possible. Then a new problem developed. The designer now increasingly had access to a rapidly expanding body of knowledge, but still the same limited time and financial resources available to determine the best use of the available science. Also, as Philpott and Mason (2002, n.p.) note, "there has been some reluctance by yacht designers in adopting the methods of mathematical programming. In this respect, the seasoned eye of the designer is often thought to be a better judge of the difficult tradeoffs to be made than any optimization software." The yacht designer's traditional tools of judgment, intuition and experience have thus taken on a new focus and remain essential tools in this development process.

On reflection, the action research model was ideally suited to the development of the Shaw 9 metre. The concept of an iterative process or design spiral is particularly appropriate for yacht design, through which different aspects of the design can be explored, evaluated and refined to result in the desired final package. Through this process decisions could

be made to what degree the combination of art and science integral to the yacht's design would be deployed when considering each factor.

It is my contention that successful yacht design must continue to rely on this combination of art and science, bringing together aspects of intuitive processes and mathematical and engineering disciplines. As Perry (2008, n.p.) states, "It's a pretty Zenny thing in the end . . . you have to rely upon intuition based upon experience. If it were a simple matter of math then every boat would look pretty much the same."

### *Further research*

Following the exploration and critique of the various development methods used in yacht design today, and this design project, I believe there is scope to develop a new methodological framework for the evaluation and refinement of future yacht designs. Complementing the trend towards scientific and computer-driven processes in racing yacht design, I would like to reinforce the value of the art of yacht design in future design investigations. The valuable, technologically advanced, scientific tools available to yacht designers today can still be complemented by the judicious use of the "designer's eye", intuition and experience-based knowledge to produce highly successful designs.

## Appendix I

### Race results

Shaw 9 metre *Karma Police* and its sister ship *Deep Throttle* have been widely campaigned since their launching in early 2009, across a range of race types (e.g. windward-leeward, harbour, coastal) and fully crewed and short-handed. Following is a list of key race and regatta performances:

*2011 SSANZ Round the North Island two-handed race*

*Karma Police* line 1st division 2, overall line and PHRF handicap 2nd

*2011 Bay of Islands Race Week (short and medium course)*

*Karma Police* line 2nd

*2010 Coastal Classic*

*Deep Throttle* line 5th, PHRF handicap 1st division 1

*Karma Police* line 7th, PHRF handicap 3rd division 1

*2010 Bay of Islands Race Week (short and medium course)*

*Karma Police* line 1st, PHRF handicap 1st division B

*Deep Throttle* line 4th, PHRF handicap 2nd division B

*2009 Coastal Classic* (Auckland to Russell, 120 miles)

*Deep Throttle* line 9th, PHRF handicap 2nd division 1

*Karma Police* line 10th, PHRF handicap 3rd division 1

*2009 Roy McDell Memorial, Gold Cup* (72 nautical miles)

*Karma Police* line 3rd, PHRF handicap 1st

*2009 Bean Rock Memorial, Gold Cup* (50 nautical miles)

*Karma Police* line 3rd, PHRF handicap 1st

*2009 SSANZ Be&G Simrad Barrier Triple series* (two-handed)

Barrier 50 (50 miles)

*Karma Police* line 2nd, PHRF handicap 2nd longhaul division 1

Barrier 60 (60 miles)

*Karma Police* line 3rd, PHRF handicap 2nd longhaul division 1

*2009 SSANZ Be&G Simrad Barrier Triple series* (two-handed)

Barrier 50 (50 miles)

*Karma Police* line 2nd, PHRF handicap 2nd longhaul division 1

Barrier 100 (50 miles)

*Karma Police* line 3rd, PHRF handicap 4th longhaul division 1

Overall series

*Karma Police* line 1st overall longhaul division 1

## **Appendix II**

### **Press coverage**

The articles about the Shaw 9 metre appended following have appeared in a range of publications in New Zealand and overseas:

*Seahorse*, 358 (December 2009) pages 100–101

*Boating New Zealand* (November 2009) pages 102–108

*Boating New Zealand* (December 2009) page 109

*Boating New Zealand* (July 2009) pages 110–111

*Breeze* (July 2009) pages 112–113

'Foncia is still competitive, and in this race we could test her properly across a full range of conditions.'

'But more important is that we saw areas where we could really improve her performance, especially downwind in light weather, which was not so much a focus when we were preparing for the Vendée Globe...' (In which Michel completed the course nearly a week faster than any of his rivals).

'On balance, however, we have confirmation that *Foncia* is still a good boat,' Michel added. The rest of the Imoca 60 class will have raised a glass to that news, no doubt.

Patrice Carpentier



## NEW ZEALAND

It is a measure of how far sportboats have ingratiated themselves into the mainstream that a 9m yacht with a 3.6m prod, twin asymmetric daggerboards, plus a pencil-slender 2m canting-keel strut and bulb can be described as 'moderate'.

Yet that is exactly the impression given by *Karma Police*, the latest creation from up-and-coming young New Zealand designer Rob Shaw. The lines are sweet, with a hint of sheer, gently flaring topsides, and a nicely balanced profile. Often these boats are more aggressive looking. Hard chines, extreme beam, sharp edges – with killer names to match, more often than not drawn from the darker corners of the punk genre.

Gazing upon Shaw's creation, even grey-haired baby boomer types can feel the pulse quicken and see real possibilities for taking on the X and Y generations and showing them a thing or two. Make no mistake, the elements are all there: carbon-foam composite construction, a powerful sailplan, high ballast ratio, long waterline, light displacement. But they are packaged discreetly in a smooth design that exudes quiet confidence.

'There is nothing too extreme about this design,' Shaw agrees. 'I am a fan of moderate boats. Extreme yachts work well in certain conditions, but for a boat to work well in a wide range a more moderate approach is nicer to sail and gives a more consistent performance.'

'One of the things I was trying to achieve with this design was not to have something that is cranky and hard to sail. It is easy to design something with massive potential but where it is difficult to extract that potential. Boats like that definitely have their place, but I was going for something where you could achieve a high percentage of the potential most of the time.'

'This boat is also intended for longer passage racing, including overnights, where less extreme features would produce a more comfortable ride – and therefore reduce crew fatigue.'

But lest we become lulled into placing this yacht in some middle-of-the-road marine suburbia, it is not all soft curves and kid gloves. A distinct note of aggression is evident in the hard bow knuckle, which maximises waterline length to the last fraction of a millimetre. 'I could have rounded it a bit more,' said Shaw, 'but aesthetically it is better than having some indecisive fudge.'

Launched in the winter and with a work-up programme interrupted by an unfortunate accident, *Karma Police* has yet to show its full potential. But Shaw is more than pleased with what it has achieved to date.

'The boat is planned for racing fully crewed with four or five people, but is also intended for short-handed racing. In two out of three two-handed offshore winter races *Karma Police* was the smallest boat in the A Division (determined on PHRF handicap). Yet we finished the first race (50 miles) second on line and handicap to *Wired*, the 16m Bakewell-White canting-keeler. In the second race (60 miles) we were third behind *Wired* and an Open 50, second on corrected time.'

'We were really pleased with that, considering that we were still working out how to get the best performance. In both races we had a bit of everything in terms of conditions, including 35kt squalls. In the second race we did most of the course with a reef in the main, so there was a pretty good breeze.'

'The 50-footers got away from us upwind, but we were very even with the 40-footers upwind and as soon as we started reaching or running, we were over the horizon. It is impressive how

these canting-keel yachts go upwind. You know they are going to fly downwind, but to match it upwind in offshore conditions against 40-footers was very interesting.'

Clearly the twin deep-draft daggerboards set alongside the mast are doing an admirable job. A single midships canard was considered for ease of use, but Shaw wanted the lift benefit from asymmetric foils. 'We know we take a bit of a weight penalty, plus the increased cost, but the performance gain is definitely worth the sacrifice.'

'I was a little concerned about how complicated the twin daggerboards might be from a crew management point of view, but we have had no problem with them whatsoever, no binding or anything like that. I have been pleasantly surprised at how easy they are to handle.'

The development of this boat comes as part of a progression that has seen Shaw's designs ride the sportboat wave from its early revolutionary beginnings to mainstream acceptance. Growing up in the Bay of Islands, his sailing career followed the traditional New Zealand pattern, starting with P-Class dinghies before later advancing into small keelboats.

He completed a boatbuilding apprenticeship with Max Carter, where he had his first introduction to yacht design. 'I worked on projects that Max designed and built. Max also had a close relationship with Laurie Davidson. Max encouraged his apprentices to get involved in the design aspects as well, so we had the benefit of his experience and also had Laurie Davidson as a kind of arms-length mentor. I drew a lot of influence from him and his approach to things.' Indeed, it is not hard to detect a Davidson-esque look in the aesthetics of *Karma Police*.

A switch to Cookson Boats opened opportunities to work in the shore team with Team New Zealand at the 1992 America's Cup in San Diego, after which Shaw took up an opportunity to lecture in boatbuilding at Auckland-based Unitec. Apart from designing and building yachts he has spent a lot of time sailing, including on large multihulls, which have had a significant bearing on some of his ideas.

His design portfolio has grown to five designs with some 15 boats built to date, including two of his latest 9m yachts. The portfolio began with a 6.5m sportboat, which proved very successful. The first eight were cedar and glass construction, but a production run in foam and glass with carbon rigs is about to get underway out of Tauranga, east of Auckland. 'There is strong interest from Australia, the US, Asia and Finland. When I first did these boats there wasn't much of a sportboat movement like there is now,' said Shaw. 'There was quite a risk of these boats being an orphan. Then we had an influx of Magic 25s in New Zealand and a sportboat circuit of five regattas was established. We had a good time competing on that circuit.'

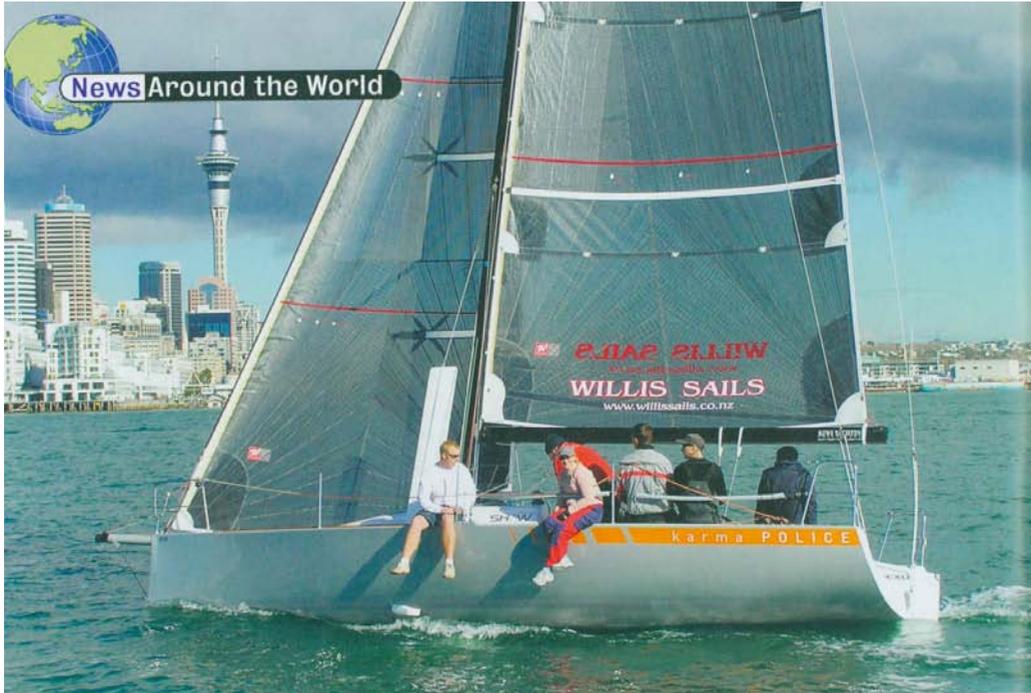
Shaw found himself typecast as sportboat designer and drew a number of developments on the original prototype, a 7m extreme yacht with hiking racks and an oversized rig, followed by a 7.5m built in Nomex and carbon for boatbuilder Craig Partridge. 'This is a slightly more user-friendly design, for a bunch of guys in their 50s to compete with the young guys! They are still out there doing it and loving it.' A 10.6m cruiser-racer with canting keel and an interior was also built for a Bay of Islands client as a fast passage maker.

And then, most recently, Shaw's own 9m and a sistership that is also competing up in the Bay of Islands. This sistership, called *Deep Throttle*, is campaigned by two-time Volvo Race veteran Justin Ferris, with Tony Dalbeth and Richard Tingey. A frequent addition to the crew is Mike Quilter, a name that needs no introduction in the grand prix world of round-the-world and America's Cup racing.

'These boats are really intended for coastal racing,' Shaw said of the *Karma Police* design. 'We will do all the coastal races in New Zealand and also plan to do the two-handed Round North Island Race. With a moderate beam and an easy system for removing the keel, these yachts can also fit into a 40ft container for shipping to regattas like Hamilton Island Race Week in Australia, or across to the United States.'

Although the racing intent is clear in the absence of any interior, minimal facilities can be installed for weekendening or longer races. These comprise cloth quarter berths, a removable forward double

SEAHORSE 15



Rob Shaw's 9m *Karma Police* proving gentle on the water molecules during early trials. A sistership is raced locally by Volvo veteran Justin Ferris. Shaw's larger 35-footer *Rehab*, launched in 2008, is also turning heads in New Zealand, proving a potent performer with deep canting keel plus a single forward canard. These boats follow a string of clean and fast sportboats from the same design office

berth and a detachable galley unit. Auxiliary power comes from an outboard engine located in a cockpit well.

The triple-spreader carbon mast supports a sailplan comprising a 42m<sup>2</sup> square-top mainsail, a 22m<sup>2</sup> jib and a monster 120m<sup>2</sup> masthead gennaker on the retractable prod. The prod extends 3.6m from the stem, through a 600mm tube supported by a bobstay. A Code Zero can be flown from the tube. Although the spreaders are swept at 27°, providing plenty of support for the mast, *Karma Police* does include running backstays for 'extra insurance' in offshore conditions. The keel cants to 50° either side of the centreline on a rope purchase system led through to port and starboard cockpit winches.

In all, then, *Karma Police* is something of a deceiver. It does not have all the hard-edge brashness of a fully tricked street racer, with go-fast stripes, bling wheels and throbbing exhaust. It is more refined and less obvious, a bit more mature perhaps, like a pedigreed European GT. More gentleman-racer than boy-racer perhaps, but when the lights turn green, there is more than enough horsepower to leave rubber on the road.

Ivor Wilkins

## AUSTRALIA

It's said that with many people the older they get the more famous they become in their own mind. It's a thought that's certainly been revisited in Australia in recent weeks – all because Dutchman Peter van Oossanen, for the second time, has claimed he, not Ben Lexcen, designed the revolutionary upside-down winged keel for 1983 America's Cup winner *Australia II*.

Many Australians close to the coalface in this debate have chosen to ignore the Dutchman's assertions – primarily because by ignoring them they give his claims the credence they feel they deserve: zero. Others have come out fighting yet again, for two reasons: in the hope they can assist van Oossanen's memory lapse and put things straight, and also to defend the honour of a man deceased. Lexcen died in May 1988, aged just 52.

Van Oossanen's latest claim came in an interview with Dan

Spurr, which was published in *Professional Boatbuilder* magazine. It has subsequently been debunked far and wide, especially by senior *Australia II* crewman John Longley and many of Lexcen's close friends.

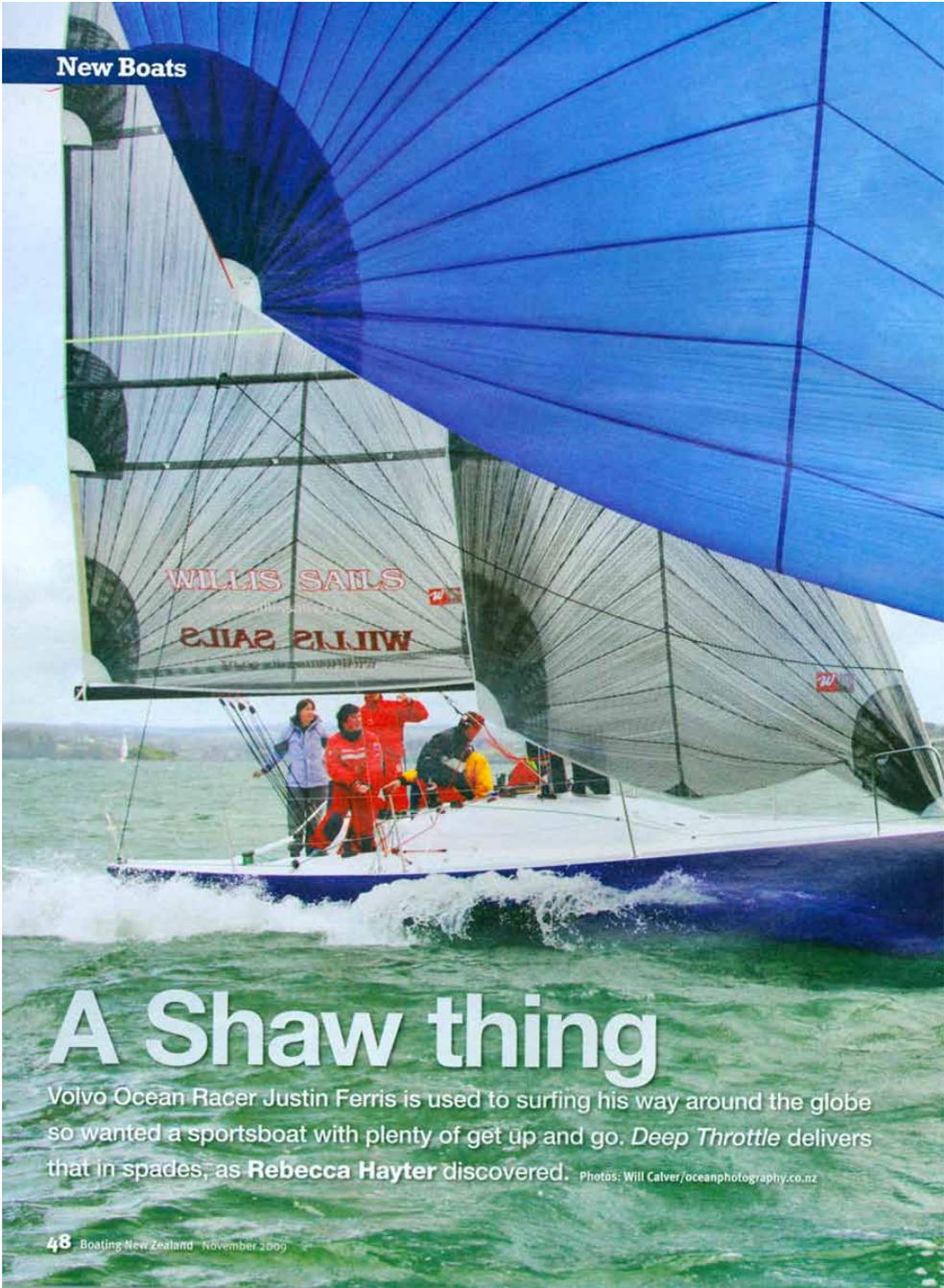
In brief (for those too young to remember...), van Oossanen was a technician/designer at what was in the early 1980s the Netherlands Ship Model Basin (now known as MARIN). This was the organisation that the New York Yacht Club, as holders of the America's Cup, agreed Alan Bond's *Australia II* syndicate could use for design development and tank testing under Lexcen's guidance.

In 1983, when it was becoming apparent that the NYCC's defender – Dennis Conner's *Liberty* – was going to have a serious fight on its hands with *Australia II*, some members of the NYCC went to great lengths to try to disqualify *Australia II*. Using fair means and foul they tried to prove that van Oossanen, not Lexcen, was responsible for the design – and America's Cup rules demanded that the designer of the challenger had to be a national of the challenging nation. But no matter how hard they tried the Americans could not find any evidence to show that Lexcen, as the principal designer and leader of the team, had not been the driving force and influence behind *Australia II*'s radical configuration.

Also, it must be realised that if van Oossanen had wanted to blow *Australia II* out of the water by claiming the design was his, he had plenty of time to do so during the lead-up to, and immediately after the Cup match, which *Australia II* won 4-3 in enthralling circumstances.

The fact is that Lexcen – self-educated and unquestionably a non-conformist genius – was enamoured with the flow of water around hulls and their appendages from early in his life when he first became interested in the design and building of sailboats. Later, when he ran close to being banned by the 18ft skiff movement – because he was considered to be too radical with his championship-winning designs – he was already experimenting with winglets, end-plates and foils in a desperate bid to reduce drag and improve performance. And in the next Lexcen era there was never anything conventional about his offshore racing designs: you

IVOR WILKINS



New Boats

# A Shaw thing

Volvo Ocean Racer Justin Ferris is used to surfing his way around the globe so wanted a sportsboat with plenty of get up and go. *Deep Throttle* delivers that in spades, as **Rebecca Hayter** discovered. Photos: Will Calver/oceanphotography.co.nz

48 Boating New Zealand November 2009

Boat Review: **Shaw 9m canting keeler**

WIN A NEW **SIMPLAD** ESEE BY NAVIGATION PACKAGE WORTH **\$7700!**

...of the world's best sailing holidays...magazine

# BOATING

NEW ZEALAND



**24** pages of projects, seamanship & handy DIY hints

**Happy 50th**  
Our salute to the iconic **Stewart 34**

**Cast off**  
We cruise the Marlborough Sounds  
New Zealand, Gullies... and much more

ALSO REVIEWED: Edson's Handy 88 • Markins 810 • Bunking Cat • Shaw 20m Canting Keeler



When Justin Ferris isn't romping around the world in Volvo Ocean 70 yachts – *Pirates of the Caribbean* and *Puma* – he's raking up the local competition in Kerikeri.

Until recently he crewed on Richard Tingey's Beneteau First 40, *Northern Rebel*, but to avoid the on-and-off-loading of cruising gear, Ferris, Tingey and local boatbuilder Tony Dalbeth decided to get a small, fast race boat.

With Ferris' Volvo Ocean 70 experience, that turned out to be a 9-metre (30-foot) canting keeler, built by Dalbeth, and designed by Rob Shaw. The indigo-coloured speedster is *Deep Throttle*, named for the throaty roar of a high-powered motorbike, and sistership to Shaw's Auckland-based *Karma Police*.

With a weight-conscious construction in Nomex carbon fibre, with foam in the slamming areas, generous foretriangle,

five agile crew, and canting ballast, *Deep Throttle* is beating up the bigger boats on the track – and playing with the sporty Bay of Islands fleet of *Animal Biscuits*, *Orange Peeler*, and the *Ross 40*, *Revs*.

Shaw designed the boat to be sailed either fully-crewed with five agile crew, or short-handed. Shaw, and crew Blair Gerrard, sailed *Karma Police* to second on PHRF in the first two Shorthanded Sailing Association of NZ winter races. In conditions up to 35 knots they finished clear ahead of the 40-footers on line in both outings. Fully crewed, the 30-footer was third on line, behind the over-50s *Wired* and *Starlight Express*, in the 72-mile Roy McDell Memorial around the Hauraki Gulf, including a blast reach in up to 25 knots under fractional gennaker.

"I wanted to challenge traditional keelboat design thinking, and draw on other aspects of sailing, including my experience of sportsboats and multihulls, to design a fast, exciting boat that was still

"The best job is driving. The helm never loads up. It's so responsive – you get a puff, give it a bit of a shake, and the whole thing takes off."

easy to handle," Shaw says. "It's more of a coastal racer than for around the cans – events like the Gold Cup are perfect for us, as she can really stretch her legs. Five crew is comfortable, but short-handed, the canting keel means we don't miss the weight on the rail so much."

*Karma Police* may even do the Two Handed Round North Island Race. The Shaw 30 also fits into a container for easy shipping to overseas regattas.

Having briefly covered *Karma Police* in *Boating's* July issue, I was looking forward to a sail on *Deep Throttle* in Kerikeri. The cockpit is long and low, and concentrates the deck gear – and therefore the crew weight – well forward. During tacks and

gybes this area resembles a circuit trainer at the gym.

"Things get pretty busy in the for'ard cockpit," Shaw says.

The working sail area of 66m<sup>2</sup>, and downwind sail area of 162m<sup>2</sup>, is not extreme but the boat only weighs 1800kg, including five crew and safety gear, so it's a generous power-to-weight ratio. Ballast is 550kg, so the positioning of crew is crucial to stability and trim. It's easier to yell "weight in, weight out," in the puffy stuff than to winch up the canting keel, so the crew are kept active.

There are two main differences between the boats. *Karma Police* has twin daggerboards, built in foam and carbon,



Prod extended, top and middle, and retracted



*Deep Throttle* has a single gybing canard, which is lighter, and easier to manage in the relentless tacking up Kerikeri Channel, and when sailing short-handed.

Upwind, *Karma Police's* outer, asymmetric board gives her better lift. Her retractable, non-rotating prod is fitted centrally, which proved costly in a recent collision which pushed the prod back into the mast; *Deep Throttle's* prod is offset, to accommodate the central canard.

The other difference is in the canting arrangement. *Deep Throttle's* keel winches are further aft, beside the main trimmer, where they are also accessible to the helmsman.

### Open 70 innovation

Ferris has borrowed a jib sheeting system from Volvo Ocean 70s. A bridle system is rigged athwartships, running from a padeye inboard beside the cabin and a padeye out on the rail, controlled with a purchase system back in the cockpit.



Justin Ferris



This makes for easy switching between inboard and outboard sheeting, and allows the trimmer the option of moving the jib lead up and down, as well as in and out, with only two control lines.

We had about 20 knots of breeze, with tantalising puffs that had us hoping for more. Ferris took the helm; Tingey was on mainsheet, traveller, twin backstays and keel duties; Dalbeth was in the pit, looking after halyards, canard, prod, tackline, jib

Better boating starts here

**SMART MARINE**  
BOATING & FISHING

RECORDS OF SALES OF MEMBER AND NON-MEMBER BOATS JOIN ONLINE OR INSTORE TODAY

AA Rewards

**PRICE SLASH**  
FISHELITE 640C  
The best priced quality colour fishfinder/chartplotter combo on the market!! Easy-to-read & use sunlight viewable 6" colour screen.  
Smart VIP Price! **\$1200** (no vip card \$1300)

**FREE NZ CHART**  
Smart VIP Price! **\$160** (no vip card \$180)

**COBRA HH25 HANDHELD VHF**  
Includes 12vlt recharge adaptor and reed batteries  
Smart VIP Price! **\$160** (no vip card \$180)

**PREMIUM ICE BINS**  
50LITRE STORAGE 100000  
• Keep ice for days  
• Range of sizes from 27 to 180L  
• Colours vary  
**MASSIVE 25% OFF!**

**HAVE YOU GOT YOUR NEW 406 EPIRB?**  
GAIL MT400E  
Smart VIP Price! **\$540** (no vip card \$600)  
GAIL MT400E  
Smart VIP Price! **\$799.00** (no vip card \$850)

**BULK BUY!!**  
An inflatable lifejacket that's SUPER AFFORDABLE!  
QUICKSILVER INFLATABLE LIFE JACKET  
60 x 21cm  
Smart VIP Price! **\$129** (no vip card \$149)  
Smart VIP Price! **\$240** (no vip card \$260)

**ANCHOR PACK SALE**  
• 50 and 100 metre nylon anchor packs  
• From 8 - 16mm  
• Spliced with thimble  
**HUGE 25% OFF!**

**SUMMER SIZZLERS**  
Kwi Sizzler BBQ  
Smart VIP Price! **\$299** (no vip card \$329)  
WITH WINDOW  
Smart VIP Price! **\$349!** (no vip card \$379)

**WICKED WATER TOYS**  
SUNO TUBE **\$270**  
LOOSE UNIT-LAKE SNAKE - 3 PERSON **\$270**  
SPINNING GYRO TUBE **\$229**  
WAKE RYDER **\$600**  
NZ'S BIGGEST RANGE OF WATER TOYS FROM \$89.99 - SEE INSTORE OR ONLINE NOW!

**ROCNA**  
"The best by test!"  
The ultimate solution to your anchoring needs!  
• Sizes to suit from 6m to 20m boats  
From **\$259**

**FREE "SHAKE" TORCH**  
Batteries not required  
Worth \$19.99  
Send around \$59 - & other products this ad in store or type in comments "free shake torch" when placing a web order!  
Limited to 1 per customer, must be existing or new SMART VIP member - (not as below)

**LJWNR PRO SERIES ANCHOR WINCHES**  
• Strong 100% 316 stainless steel housing  
• Powerful motor providing fast line speed  
• Conventional VDF slotted deck installation  
• MASSIVE 5 YEAR WARRANTY  
PRO 100 **\$1399**  
PRO 1000 **\$1699**  
SLEETS BOATS UP TO 20

MAIL ORDERS FREEPHONE: 0800 80 50 40  
123 Beaumont St. Westhaven, Auckland  
P • 09 358 2850 F • 09 358 1742  
E • info@smartmarine.co.nz  
Specials available until 30th November or stocks run out

BUY ONLINE  
at NZ's largest boating & fishing website!

**WWW.SMARTMARINE.CO.NZ**

# ENDURANT BATTERIES



POWER THAT GOES THE DISTANCE!

## New Zealand's most extensive Marine Range

- Low Maintenance
- Maintenance Free
- Marine Engine Start
- Deep Cycle
- House Bank

Flooded, Gel & AGM  
24 Month Warranty



Quality, Performance & Reliability Guaranteed

Hella Endurant Batteries are available from  
Leading Auto Electrical & Specialist Marine Outlets



sheets, and spinnaker trim. The foredeck has little space for handling the gennaker and code zero, but luckily boats such as this come ex-factory with a couple of keen, young lads who have glue on their feet, the agility of seals, and the more you soak them, the bigger they grin. On this day, the bow crew were Sam Baird and Dalbeth's son, Ned.

The 6hp outboard took us out of the marina and into the main channel. With the outboard stowed, the mainsail and jib hoisted, and the keel winched up to windward, we were easily making eight to nine knots. The boat converts any puff of wind into acceleration worthy of a mention on *Top Gear* and, although she's tender, Ferris says she carries her momentum through any chop.

*Deep Throttle* is a talker. In the light stuff she hums, as foils and rigging get in tune; in stronger breezes, the hum softens, but she whooshes as her hull slices the sea.

Timing in crew work is everything when sailing canting keelers – not only for speed and ability around the track, but also to avoid being dead in the water at an embarrassing angle of heel. Just before tacking, the mainsheet trimmer releases the keel from its windward position so that it falls to leeward.

"Before Justin came home [from overseas] I used to just blow it," Dalbeth says. "But you can get a whole lot of slack in the line, and that creates more friction. So it's best to ease it, and keep control."

The helmsman waits until, as Ferris puts it, the boat has fallen onto the keel, before going into the tack. If the helmsman

and trimmer get their coordination right, a few turns on the winch will bring the keel up to windward. I had my turns winching up the keel to see how much effort is required – on both occasions, they felt sorry for me and finished it off.

### Helming hints

When helming a canting keeler for the first time, it's good to have some coaching from the regular helmsman. I was trying to poke it up for every lift, but Ferris says it is more important to keep the boat at an optimum angle of heel, around 16 degrees; get that right and the lifts seem to take care of themselves.

Otherwise, it is possible to heel the boat over so far that the keel and rudder stall, and the boat spins into a turn. During one race early on, *Deep Throttle* unintentionally executed a 360-spin at the top mark. And while I can't claim a full circle, I did manage to demonstrate the concept.

Shaw says a key part of the design was to achieve the right balance, so the boat would be nice to helm upwind, as well as feeling light and controllable downwind. *Deep Throttle* has raced in up to 40 knots. They had just one reef in the mainsail downwind, but needed two for the upwind work.

"It's a most unusual feel to the helm upwind in a seaway," Dalbeth says, "because the keel weight is out to one side."

The reaching leg of the race was in about 25-30 knots – a soaking blast at around 14-15 knots, peaking at 18. They hoisted the fractional chute, sitting on 19 knots.



"Reaching is where they are designed to go really fast," Ferris says. "The boat was really easy to handle. We did half a dozen gybes, just throwing it through. The boat was so well behaved. It never really comes off the plane through the gybe, so nothing loads up."

The fractional and masthead genakers are flown off the end of the 3.6m carbon-fibre prod. The code zero is flown from the fixed bowsprit, which has a bobsay to maintain good luff tension, so it is easy to change gears. When gybing, the crew centre the keel first, then the helmsman takes the boat through the gybe, and heats it up as the trimmer winds up the keel. The canard is lifted for downwind and reaching work.

"The best job is driving," Ferris says. "The helm never loads up. It's so responsive – you get a puff, give it a bit of a shake, and the whole thing takes off."

To fulfil offshore racing rules, the cabin has room for a stove, an off-watch crew member, and spare sails.

But the steel canting keel dominates, controlled by a rack of pulleys on spacers,

which resembles an oil heater. The 6:1 purchase control lines cross over below decks so that they emerge to windward. The wetbox for the keel is sealed with a boot made in the same fabric used for inflatable dinghies.

### Boating's verdict

When I asked the guys what they like about *Deep Throttle*, terms such as "amazing acceleration", "fun", "punches above its weight" and "no vices" flew thick and fast – most of which I agree with.

Back at the dock, I commented on the unusual shape of the rudder, the result of collaboration with Shaw and fluid dynamics guru Richard Roake. Ferris says there has been some speculation about it, but that it works well. After my, admittedly, brief time on the helm, I still think that the rudder needs a bit of tweaking, to handle those spins at the top mark.

On the other hand, when you sail on a boat like *Deep Throttle*, you're there for a challenge, not just a tootle down the highway. =



## MAGELLAN TRITON GPS

Water resistant and Rugged, your Magellan GPS is perfectly suited for power boating, sailing, freshwater and saltwater fishing, diving, kayaking, and all your marine adventures.



### Triton 2000/1500

- Large colour touch screen
- Rugged & waterproof (IPX-7)
- 2 Mega Pixel camera (12000)
- Voice recorder
- LED flashlight
- 3-axis electronic compass, built-in barometer (T2000)
- SD-card expandability enables you to take pictures and capture sounds, to record as you navigate, and add unlimited detailed maps



### Triton 500/400

- Advanced full-colour navigation
- 3-axis electronic compass and built-in barometer (T300)
- SD-card compatibility enables use of unlimited optional detailed maps
- Rugged and waterproof to take you anywhere



### Triton 300/200

- Large, full-colour display shows maps and data with crystal clear graphics
- Updatable detailed maps to maximize routing capability. (T300 only)
- Colour display (2.2" QVGA)
- Built-in maps and major points of interest
- Rugged and waterproof (IPX-7)

**ENL** Electronic Navigation Ltd

Proud distributors for 40 years

Electronic Navigation Ltd: 65 Gaunt Street Westhaven, Auckland. Ph 09 373 5595

Nelson Branch: 78 Wickerman Street. Ph 03 548 4987, Fax 09 548 2116

[www.enl.co.nz](http://www.enl.co.nz)

100015



<b>Deep Throttle</b>	
design	Rob Shaw
builder	Tony Dalbeth
loa	9.1m
lwl	8.8m
beam	3.0m
draft	2.5m
displacement	1800kg
<b>SAIL AREA</b>	
upwind	66m <sup>2</sup>
main	42m <sup>2</sup>
jib	22m <sup>2</sup>
gennaker	120m <sup>2</sup>

Boating  
New Zealand's  
**BOATS  
of 2009**

RACING YACHT

1<sup>st</sup>

**Elliott 9SS**  
*overload*

Just as in the real world of yacht racing, the contenders in the racing division of our Boats of '09 feature ran an extremely close race.

Our winner was the Elliott 9SS canting-keeler *Overload*, a yacht that thoroughly impressed our reviewer with her blinding

speed, although she was mindful of the skill required to sail such a thoroughbred.

"Under jib top *Overload* felt like a dinghy: sensitive to trim, quick to accelerate, and her stiff, carbon construction feels the bumps." Although only 30-feet long, *Overload* performs like

a much larger boat: "... into the wind... she suddenly changed gears, and felt like a much bigger boat," our reviewer reported.

Her owners consider *Overload* a dual-purpose boat, for harbour and coastal racing. They proved her coastal racing mettle in the recent HSBC Premier Coastal

Classic, at the same time endorsing our panel's faith in her. *Overload* came in eighth over the line in Division One, first on handicap – not bad for a 30-footer. Our second and third racing yacht choices took out second and third places on handicap in the same event.



2<sup>nd</sup>

Shaw 9m *deep throttle*

Canting keel race boat *Deep Throttle* narrowly pipped her near sister ship, the Shaw 9m *Karma Police*, into second place.

The judges liked *Deep Throttle*'s electrifying pace, and wonderful acceleration. Our reviewer admitted that

the boat is "... a challenge, not just a tootle down the highway."

Our judges liked the technical innovations Shaw incorporated into *Deep Throttle*, and her recent racing successes point to how well she fulfils her design brief.



3<sup>rd</sup>

Shaw 9m *karma police*

A few months older than *Deep Throttle*, but almost identical except for twin daggerboards, *Karma Police* was Rob Shaw's first 9m canting-keeler.

Like her sister, *Karma Police* is blindingly fast and amazingly responsive

says our reviewer, but she's also a challenge to drive well.

She further impressed our reviewer with her exceptional upwind performance and our judges liked the boat's purity of function and her high-tech construction.

December 2009 Boating New Zealand 41

New boat



## A Shaw thing

HAVING established his territory in sports boats such as *Manic*, *Animal Biscuits* and *Custard Truck*, Auckland designer Rob Shaw has moved up to pocket-size canting keelers. His debut consists of *Deep Throttle*, owned by Volvo Ocean Race sailor Justin Ferris in the Bay of Islands, and his own boat, *Karma Police*, which is sailing in Auckland.

"We've sort of done everything we can with sportsboats," Shaw says of his move to canting keels. "We wanted to do some longer races, like the Coastal Classic and two-handed racing."

Future racing may include the Two-Handed Round North Island Race next year.

*Karma Police* was built by Shaw with help from his boatbuilding students at Unitec. Her lightweight construction is carbon skins over a foam core, vacuumed over male moulds and post-cured. The retractable, non-rotating prod is carbon fibre. The foils were built inside CNC-cut female moulds for accuracy; the carbon fibre tiller and rudder weigh just 6kg. *Deep Throttle* has one daggerboard to provide lateral stability when the keel is

canting; the 30ft *Karma Police* has two. Shaw feels the twin daggerboards provide more lift, being asymmetric and slightly to leeward, but says there's little in it.

The mast is well aft from the bow, almost on top of the keel. This creates a generous foretriangle; with her square top mainsail, *Karma Police* has an upwind sail area of 66m<sup>2</sup>.

For downwind work, she flies fractional and masthead gennakers from the 3.6m prod. She can also fly a code zero from the end of the stem; a bobstay supplies the downward force and ensures good luff tension.

The rig is a triple-spreader configuration, with topmast runners for control and peace of mind when running under masthead gennaker. A coarse and fine-tune purchase system allows gybing without the runners being loaded onto a winch.

*Karma Police* will race fully crewed with six; the cockpit is designed to keep their weight well forward so it will get pretty busy in the space between the traveller and the cabin. Jammers either side of the cabintop handle just about

### Shaw 30ft canting keeler

loa	9.1m
lwl	8.8m
beam	3.0m
draft	2.5m
displacement	1800kg
sail area	
upwind	66m <sup>2</sup>
main	42m <sup>2</sup>
jib	22m <sup>2</sup>
gennaker	120m <sup>2</sup>





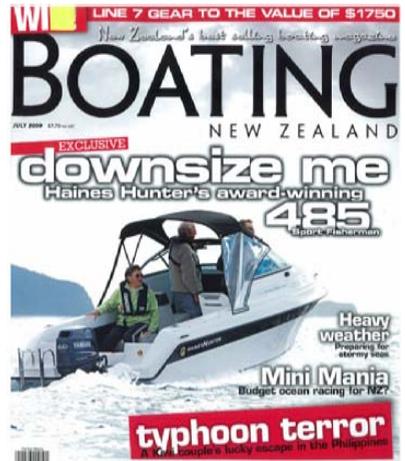
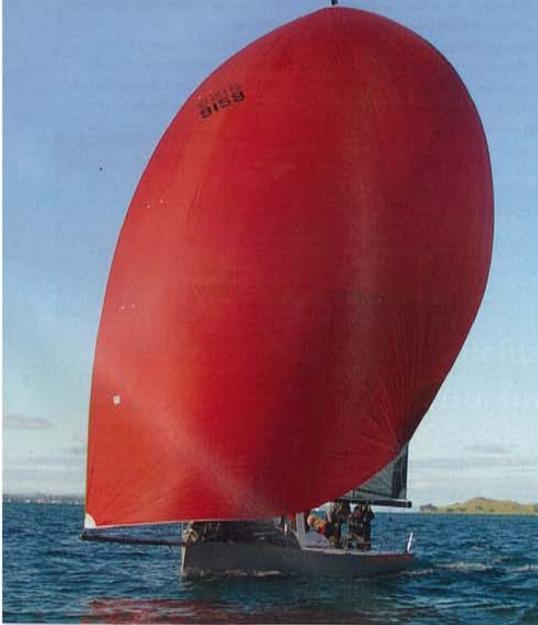
The crew of *Karma Police* are looking forward to a showdown with the Greg Elliott-designed *Overload* (above)

everything including halyards, tacklines, daggerboards and, most importantly, the canting keel. This operates on a 6:1 purchase, courtesy of an extremely impressive piece of steel fabrication, which dominates the cabin. The control lines for the keel are set up to cross over below decks, rather than creating an obstacle course above decks. The keel is wound from the windward side, which is easier to work and keeps crew weight on the high side.

Apart from the keel, the cabin is basically structure and a few electronics, including the Fusion stereo. Home comforts are nonexistent, although there

is space to fit pipe berths for long races either side, under the cockpit. The décor, however, is a high-tech gloss over carbon style and shows off the high standard of build.

*Karma Police* has done a few harbour races, and Shaw and his crew are looking forward to some tussles with the Greg Elliott-designed *Overload*. Shaw says he is impressed with his new boat's upwind performance, which he estimates to be in the mid-sevens with good height. Holst that big gennaker though, and *Karma Police* will be setting off the speed cameras. - *Rebecca Hoyer*





# Pocket Rocket is a smooth deceiver

By Ivor Wilkins

**The two identical 9.1m sportboats, Deep Throttle and Karma Police, that match raced all the way up to the Bay of Islands and finished the HSBC Coastal Classic Race just over a minute apart, 9<sup>th</sup> and 10<sup>th</sup> monohulls across the line and 2<sup>nd</sup> and 3<sup>rd</sup> respectively on handicap are the latest creations from young up and coming designer, Rob Shaw.**

It is a measure of how far sport boats

have ingratiated themselves into the mainstream that yachts with a 3.6m prod, twin asymmetric daggerboards, a pencil-slender 2m canting keel strut and bulb can be described as "moderate".

Yet, that is exactly the impression given by this design. The lines are sweet, with a hint of sheer, gently flaring topsides, and a nicely balanced profile. Often sport boats are more aggressive looking: Hard chines, extreme beam, sharp edges – with killer names to match, more often than not drawn from the darker corners of the punk

rock genre.

Gazing upon Shaw's creation, even grey-haired baby boomer types can feel the pulse quicken and see real possibilities for taking on the X and Y-generations and showing them a thing or two. Make no mistake, the speed producing elements are all there: carbon-foam composite construction, a powerful sail-plan, high ballast ratio, long waterline, light displacement. But, they are packaged discreetly in a smooth design that exudes quiet confidence.

"There is nothing too extreme about

this design," Shaw agrees. "I am a fan of moderate boats. Extreme yachts work well in certain conditions, but for a boat to work well in a wide range, a more moderate approach is nicer to sail and gives a more consistent performance.

"One of the things I was trying to achieve with this design was not to have something that is cranky and hard to sail. It is easy to design something with massive potential but where the potential is difficult to extract. Boats like that definitely have their place, but I was going for something where you could achieve a high percentage of the potential most of the time.

"This boat is also intended for longer passage racing, including overnighters, where less extreme features would produce a more comfortable ride – and therefore reduce crew fatigue."

But, lest we become lulled into placing this yacht in some middle of the road marine suburbia, it is not all soft curves and kid gloves. A distinct note of aggression is evident in the very hard bow knuckle, which maximizes waterline length to the last fraction of a millimeter. "I could have rounded it a bit more," said Shaw, "but aesthetically it is better than some indecisive big knuckle."

Before the Coastal Classic result, Shaw's Karma Police had already demonstrated an impressive turn of speed. "The boat is planned for racing fully crewed with four or five people, but is also intended for short-handed racing. In two out of three two-handed offshore winter races, Karma Police was the smallest boat in the A Division (determined on PHRF handicap). Yet we finished the first race (50 miles) 2<sup>nd</sup> on line and handicap to Wired, the 16m Bakewell-White canting keeler. In the second race (60 miles), we were 3<sup>rd</sup> on line behind Wired and an Open 50, 2<sup>nd</sup> on corrected time. We were really pleased with that, considering that we were still working out how to get the best performance.

"In both races we had a bit of everything in terms of conditions, including 35 knot squalls. In the second race, we did most of the course with a reef in the main, so there was a pretty good breeze.

"The 50-footers got away from us upwind, but we were very even with the

40-footers upwind and as soon as we started reaching or running, we were over the horizon. It is impressive how these canting keel yachts go upwind. You know they are going to fly downwind, but to match it upwind in offshore conditions against 40-footers was very interesting."

Clearly, the twin deep-draft daggerboards, set into the side decks alongside the mast, are doing an admirable job. A single midships canard was considered for ease of use, but Shaw wanted the maximum lift benefit from asymmetric foils. "We know we take a bit of a weight penalty, plus the increased cost, but the proven performance gain is definitely worth the sacrifice.

"I was a bit concerned about how complicated the twin daggerboards might be from a crew management point of view, but we have had no problem with them whatsoever, no binding or anything like that. I have been pleasantly surprised at how easy they are to handle."

The development of this boat comes as part of a progression that has seen Shaw's designs ride the sport-boat wave from its early revolutionary beginnings to mainstream acceptance. Growing up in the Bay of Islands, his sailing career followed the traditional New Zealand pattern, starting with P-Class dinghies and advancing into small keelboats.

He did a boatbuilding apprenticeship with Max Carter, where he had his first introduction to yacht design. "I worked on projects that Max designed and built. Max also had a close relationship with Laurie Davidson. Max encouraged his apprentices to get involved in the design aspects as well, so we had the benefit of his experience and also had Laurie Davidson as a kind of arms-length mentor. I drew a lot of influence from him and his approach to things." Indeed, it is not hard to detect a Davidson-esque look in the aesthetics of Karma Police.

A switch to Cookson Boats opened opportunities to work in the shore team with Team New Zealand at the 1992 America's Cup in San Diego and Shaw later took up an opportunity to be a lecturer in boatbuilding at the Auckland-based Unitec.

Apart from designing and building yachts, he has spent a lot of time sailing, including on large multihulls, which have had a significant bearing on some of his ideas.

"These boats are really intended for coastal racing," Shaw said of the Karma Police design. "We will do all the coastal races in New Zealand and also plan to do the two-handed Round North Island Race. With her moderate beam and an easy system for removing the keel, these yachts can also fit in a 40ft container for shipping to regattas like Hamilton Island Race Week in Australia, or across to the United States."

Although the racing intent is clear in the absence of any interior, minimal facilities can be installed for weekenders, short cruises, or longer races. This comprises cloth quarter berths, a removable forward double berth and a detachable galley unit. Auxiliary power comes from an outboard engine located in a cockpit well.

The triple-spreader carbon fibre mast supports a sailplan comprising a 42m<sup>2</sup> square-top mainsail, a 22m<sup>2</sup> jib and a monster 120m<sup>2</sup> masthead gennaker on the retractable prod. The prod extends to 3.6m from the stern, through a 600mm tube supported by a bobstay. A Code Zero can be flown from the tube. Although the spreaders are swept at 27°, providing plenty of support for the mast, Karma Police does include running backstays for "extra insurance" in offshore conditions. The keel cants to 50° either side of the centerline on a rope purchase system led through to port and starboard cockpit winches.

In all then, Karma Police is something of a deceiver. It does not have all the hard-edge brashness of a fully tricked street racer, with go-fast stripes, bling wheels and throbbing exhaust. It is more refined and less obvious, a bit more mature perhaps, like a pedigreed European GT. More gentleman-racer than boy-racer, perhaps, but when the lights turn green, there is more than enough horsepower to leave rubber on the road.

## Appendix III: Nomenclature

ABS	American Bureau of Shipping
CAD	computer-aided drafting
CFD	computational fluid dynamics
CNC	computer numerical control
C <sub>p</sub>	prismatic coefficient
IMS	International Measurement System
IOR	International Offshore Rule
IRC	Royal Ocean Racing Club international measurement and rating rule
ISAF	International Sailing Federation
LCG	longitudinal centre of gravity
LOA	length overall
LWL	load waterline length
PHRF	performance handicap rating factor
polar	computer-generated performance prediction
SSANZ	Short-handed Sailing Association of New Zealand
TCG	transverse centre of gravity
VCG	vertical centre of gravity
VPP	velocity prediction program

## Bibliography

- Altrichter, H., Kemmis, S., McTaggart, R. & Zuber-Skerritt, O. (2002). The concept of action research. *The Learning Organization*, 9 (3), 125–131.
- Avison, D., Lau, F., Myers, M., Nielsen, P. A. (1999). Action research. *Communications of the ACM*, 42 (1), 94–97.
- Bethwaite, F. (1993). *High performance sailing*. Blacklick, OH: McGraw Hill.
- Bevan-Smith, J. (1999). *The shape of speed*. Auckland: Reed Books.
- Boats of 2009. (2009). *Boating New Zealand*, December 2009, 38–55.
- Chapelle, H.I. (1971). *Yacht designing and planning for yachtsmen, students and amateurs* (revised ed.). New York, NY: W.W. Norton & Co.
- Claughton, A. & Oliver, C. (2004, November 15). *Design considerations for canting keel yachts*. Paper presented at the 18th International HISWA Symposium on Yacht Design and Yacht Construction, Amsterdam, 2004. Retrieved from <http://www.hiswasymposium.com/assets/files/pdf/2004/A.Claughton.pdf>
- Cross, N. (2001). Designerly ways of knowing: design discipline versus design science. *Design Issues*, 17 (3), 49–55.

- Dijkstra, S. (2001). The design space for solving instructional-design problems. *Instructional Science*, 29, 275–290.
- Doloughan, F. J. (2002). The language of reflective practice in art and design. *Design Issues*, 18 (2), 57–64.
- Elden, M. & Chisholm, R. F. (1993). Emerging varieties of action research: introduction to the special issue. *Human Relations*, 46 (2), 121–142.
- Endean, B. (1992). *Classic New Zealand yachts: four decades of successful yacht design 1950–90*. Wellington: GP Publications.
- Garrett, R. (1996). *The symmetry of sailing: the physics of sailing for yachtsmen*. Dobbs Ferry, NY: Sheridan House.
- Gerr, D. (2000). *Boat strength for builders, designers and owners*. Camden, ME: International Marine.
- Gordon, J.E. (1978). Structures, or why things don't fall down. Cambridge, MA: Da Capo Press.
- Hayter, R. (2009). A Shaw thing. *Boating New Zealand*, November 2009, 48–54.
- Hochkirch, K., & Fassardi, C. (2007, March 2). *Analysis of wave making resistance and optimization of canting keel bulbs*. Paper presented at the 18th Chesapeake Sailing Yacht Symposium, Annapolis, Maryland, March 2007.
- Hollom, D. (2010). A question of balance. *Seahorse*, 361, 40–43.
- Jeffrey, T. (2009). Old school. *Seahorse*, 353, 44–45.
- Killing, S., & Hunter, D. (1988) *Yacht design explained: a sailor's guide to the principles and practice of yacht design*. New York, NY: W.W. Norton & Company .
- Kinney, F. (1973). *Skene's Elements of Yacht Design* (8th ed.). New York, NY: G. P. Putnam's Sons.
- Larsson, L. (1990). Scientific methods in yacht design. *Annual Review of Fluid Mechanics*, 22, 329–85.
- Larsson, L., & Eliasson, R. E. (1994). *Principles of yacht design*.

- London, UK: Adlard Coles.
- Lenarz, R. (2003). The design process: the basics, part 1. Retrieved 14 March 2008, from <http://www.sailinganarchy.com/YD/2003/basics1.htm>
- Levadou, M. M. D., Prins, H. J., & Raven, H. C. (1998). *Application of advanced computational fluid dynamics in yacht design*. Paper presented at the 15th International HISWA Symposium on Yacht Design and Yacht Construction, Amsterdam, 1998. Retrieved from <http://www.hiswasymposium.com/assets/files/pdf/previous/15th%20-%201998/15th%20-5-%20Application%20of%20advanced%20computational%20fluid%20dynamic.pdf>
- López Pavón, C., Zamora Rodríguez, R., & Pérez Rojas, L. (2004). *Hydrodynamic study of a canting keel based appendage configuration*. Paper presented at MDY '04 International Symposium on Yacht Design and Production, Madrid, 2004.
- Marchaj, C.A. (1988) *Aero Hydrodynamics of Sailing* (2nd ed.). London, UK: Adlard Coles
- McKay, J. & Marshall, P. (2001). The dual imperatives of action research. *Information Technology and People*, 14 (1), 46–59.
- Milgram, J. (1998). Fluid mechanics for sailing vessel design. *Annual Review of Fluid Mechanics*, 30, 613–53.
- Miller, R. T., & Kirkman, K. L. (1990). Sailing Yacht Design — A New Appreciation of a Fine Art. *SNAME Transactions*, Vol. 98, 187–237.
- Perry, B. (2008). Chine on. Retrieved 16 October 2008 from [www.sailinganarchy.com](http://www.sailinganarchy.com)
- Phillips-Birt, D. (1976). *Sailing Yacht Design* (3rd ed.). London, UK: Adlard Coles.
- Philpott, A., & Mason, A. (2002). Advances in optimization in yacht performance analysis. Paper presented to the High Performance Yacht Design Conference, Auckland, 4–6 December 2002.

- Rogers, S., & Day, J. (2010). A softer approach. *Seahorse*, 361, 36–39.
- Roux, Y., Huberson, S., Hauville, F., Boin, J., Guilbaud, M., & Ba, M. (2004). *Yacht performance prediction: towards a numerical VPP*. Paper presented to the High Performance Yacht Design Conference, Auckland, 4–6 December 2002.
- Scarponi, M., Shenoi, R. A., Turnock, S. R., & Conti, P. (2006). Interactions between yacht-crew systems and racing scenarios combining behavioural models with VPPs. Paper presented to the 19th International HISWA Symposium on Yacht Design and Yacht Construction, Amsterdam, 13–14 November 2006.
- Schön, D. A. (1988) Designing: rules, types and worlds. *Design Studies*, 9 (3), 181–90.
- Skene, N. L. (1935). *Elements of Yacht Design*. New York, NY: Kennedy Bros.
- Susman, G. I., & Evered, R. D. (1978). An assessment of the scientific merits of action research. *Administrative Science Quarterly*, 23 (4), 582–603.
- Swann, C. (2002). Action research and the practice of design. *Design Issues*, 18 (1), 49–61.
- Tier, L., Owen, M., & Sadler, T. (2006). *Practical aspects of canting keel design, construction and analysis*. Paper presented to the 2nd High Performance Yacht Design Conference, Auckland, 14–16 February 2006.
- Wallace, J., Philpott, A., O’Sullivan, M., & Ferris, M. (2006). *Optimal rig design using mathematical programming*. Paper presented to the 2nd High Performance Yacht Design Conference, Auckland, 14–16 February 2006.
- Ward, B. (2009). Act two — part 1. *Seahorse*, 349, 40–45.
- Ward, B. (2009). Act two — part 2. *Seahorse*, 350, 42–45.
- Wilkins, I. (2009). Dinner early as Crichton’s supermaxi steals the show . . . but the small yachts take the glory. *Breeze*, 168, 28–32.

- Wilkins, I. (2009). New Zealand update. *Seahorse*, 358, 15–16.
- Wilkins, I. (2010). Little guns fire the big shots in Classic. *Breeze*, 174, 28–32.
- Wilkins, I. (2009). Laurie's latest: gold at the end of the rainbow. *Breeze*, 166, 28–32.
- Wilkins, I. (2009). Pocket Rocket is a smooth deceiver. *Breeze*, 168, 46–47.
- Zuber-Skerritt, O. (2001). Action learning and action research: paradigm, praxis and programs. In S. Samkaram, B. Dick, R. Passfield, & P. Swepson (eds). *Effective Change Management Using Action Research and Action Learning: Concepts, frameworks, processes and applications*. Southern Cross University Press: Lismore, Australia. 1–20.

