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Surfboard making and environmental sustainability: New materials and regulations, subcultural norms and economic constraints

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Abstract
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Surfboard making and environmental sustainability

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Abstract: This chapter discusses environmental sustainability issues in surfboard-making, and dilemmas that arise as a consequence of the industry's combination of structural economic features and subcultural origins. We draw on qualitative, longitudinal research within 36 surfboard-making workshops in Australia, Hawai'i and California to document issues such as dependence on petroleum products, harmful chemicals and poor waste management practices. Such issues have their origins in the industry's highly informal, subcultural 'scenes', from which surfboard manufacturing emerged in an incremental fashion with minimal regard for environmental impact, and with haphazard regulation. We also discuss cases where new materials have been developed, and workshops have sought to 'do the right thing', installing new production and waste management technologies. Diffusion of such sustainability innovations is hampered by norms among surfers, who prefer the performance aspects of traditional materials, by economic constraints on small surfboard workshops, and variations in national scale regulation that shift the problem from one jurisdiction to another. Those workshops in more regulated jurisdictions, who have invested in best-practice equipment and processes, have been caught out by resulting problems of necessary increased production in order to cover high capital costs. The industry's strong local ties and use of hand-made production techniques provide a rich cultural heritage to the industry, but also effectively cap workshop size and capacity. Capital investments necessary to produce surfboards with smaller environmental footprints put such small workshops at risk of not being able to make or sell enough boards to survive. The result is a paradox between surfboard making's 'soulful' side and increasing recognition that lack of regulation is harmful to the very environment that surfing culture cherishes.

Introduction

Surfers are well aware of oceanic sustainability issues such as water quality and pollution, impacts of tourism, and local conflicts over coastal development. But there are also sustainability problems associated with the very equipment needed to participate in a surfing life. Surfboards are manufactured items that entail a host of upstream labour and environmental issues. This chapter accordingly discusses environmental sustainability issues in the surfboard-making industry, and dilemmas that arise as a consequence of uneven regulation, and the industry's combination of structural economic features and subcultural origins. We draw on qualitative, longitudinal research where we have visited and interviewed people in 36 surfboard-making workshops in Australia, Hawai'i and California over half a decade (see Warren and Gibson 2014). In this chapter we document sustainability issues such as dependence on petroleum products and harmful chemicals, differences in environmental regulation and poor waste management practices – issues related to making surfboards with which many surfers may not be so familiar.

Such issues are linked to the production processes involved in surfboard-making, which we describe in the first section of the chapter. The qualities of the finished product – especially its disposability and (lack of) durability also influence overall environmental impact. In earlier eras of wood construction, exemplified in pre-colonial Hawai'i – where board-making was governed by customary practices and part of a revered craft in fine timberwork – surfboards were expected to last. That sentiment underpins the current revival in timber board-making among collectors and connoisseurs. Nowadays, thought, most regular recreational surfers can go through two or three polyurethane (PU) foam surfboards every year.

In this regard, surfboards appear to be increasingly like most other mass-consumerist commodities – throwaway items with very limited functional life. Since the 1980s, as surfing became big business, surfboard-making companies with local origins have turned into corporate entities. Surfboards are the figurative heart of a wider, global surf-manufacture industry with immense power to fuel consumerism. Tentacles have spread into related retail industries and manufacture of wetsuits, apparel, shoes, sunglasses, watches and hats. Each of these consumer items – which are in turn caught up in high-throughput fashion cycles of manufacture-retail-purchase-use-dispose-replace – entails its own set of upstream sustainability issues in different countries that are rarely transparent to the consumer. As a preface to this chapter, it is therefore important at one level therefore to consider surfboards within a wider network of surf apparel and equipment manufacture with a complex host of environmental and labour issues, spread across many countries.

Sustainability issues for surfboard-making are nevertheless also refracted by a combination of factors that pertain to the local contexts of production. Characteristics of how the industry emerged in specific places and times has led to environmental, labour and health issues within individual workshops. Later in the chapter, we describe how sustainability issues are exacerbated by the industry's highly informal, subcultural 'scenes', from which surfboard manufacturing emerged in an incremental, haphazard fashion with minimal regard for environmental impact and regulation. That regulation in turn varies across countries and states – so that well-meaning environmental protection instituted in one location can have the adverse effect of shifting the problem elsewhere.

Despite such problems, there are exemplary cases where innovators have sought to 'do the right thing', experimenting with new materials. We describe some of these advances. Elsewhere, surfboard workshops have installed new production and waste management technologies, only to be caught out by resulting problems of necessary increased production in order to cover high capital costs. The industry's strong local ties and use of hand-made production techniques provide a rich cultural heritage to the industry, but also effectively cap workshop size and capacity. Capital investments necessary to produce surfboards with smaller environmental footprints put such small workshops at risk of not being able to make or sell enough boards to survive. The result is a paradox between, on the one hand, surfboard making's 'soulful' side and increasing recognition of environmental impact, and on the other, a small-scale cottage production model that eschews regulation, and continues to use of high–impact petroleum based products that are harmful to the very environment that surfing culture cherishes.

This paradox erupted on "Blank Monday" – 5 December 2005 – when the world's largest supplier of raw materials for the surfboard industry, Clark Foam (with a turnover in excess of US$25 million p.a.), ceased making pre-fabricated 'blanks' (from which surfboards are shaped) and began destroying long cherished moulds and irreplaceable equipment (Finnegan 2006). In a fax sent to his customers, company founder Gordon 'Grubby' Clark explained his reasons for closing:

> …Effective immediately Clark Foam is ceasing production and sales of surfboard blanks…The short version of my explanation is that the state of California and especially Orange County where Clark Foam is located have made it very clear they no longer want manufacturers like Clark Foam in their area. The way the government goes after places like Clark Foam is by an accumulation of laws, regulations, and subjective decisions they are allowed to use to express their intent. Essentially they remove your security, increase your risk or liability, and increase your costs. (Quoted in Warren and Gibson 2014: 107).

A specific contention was with the environmental and workplace safety consequences of making foam blanks using a variety of harmful chemicals. Tightening Californian environmental and safety restrictions had been placed on use of a toxic chemical used in polyurethane production called Toluene Di Isocyanine (TDI) in the blank casting process. Knowledge of the toxicity and environmental impact of such chemicals had lurked in the industry for decades, but little had ever been done to improve materials and production processes. Blank Monday brought the issue to the surface, and revealed to the surfing community the ugly kinds of environmental and economic issues upstream in the surfboard industry.

We discuss a range of such issues here, and survey attempts after Blank Monday to improve environmental sustainability performance in the industry. Much experimentation has transpired, but many unsustainable practices continue, amidst economic constraints and 'traditional' ways of doing things within surfing subculture.

Before we proceed, it is worth clarifying the approach taken here to our interpretation of sustainability issues: we primarily focus on *environmental* aspects of sustainability – conceptualized in the accepted manner as wise use of earthly resources while minimising long-term ecological detriment, such that future generations can continue to enjoy those same resources. Such a focus foregrounds issues that impact upon ecological quality and human and environmental health. But we also recognize that sustainability is more accurately a complex mix of environmental pressures entwined with economic, social, political and cultural dimensions. Together these dimensions are important in explaining the environmental consequences of surfboard-making, and the possibilities (and limits) to improving sustainability performance.

For this reason, interwoven in the discussion below regarding environmental impacts are discussions of related factors such as the structure of the surfboard industry, regulation, changing technology and production methods, and the inheritance of subcultural attitudes and arrangements between makers and customers. What transpires from this interweaving of factors is that there are many paradoxes and trade-offs in surfboard-making that make it difficult to prescribe simple pathways forward. Gains made in some areas are offset by losses in others; steps that might solve one problem create new ones (cf. Head et al 2013). Nevertheless we hope that by drawing together discussion of these issues and paradoxes, readers – and especially surfers themselves, who through their purchasing decisions encourage positive change in the industry – will be a degree more familiar with the key issues.

How – and where – are surfboards made?

There are two simple labour specializations in the contemporary surfboard production system, reflecting the industry's origins as a do-it-yourself backyard industry, and before that, the basic division of labour in traditional Hawaiian method. These two specializations are *shaping* and *sealing*. The *shaper* is responsible for designing and sculpting out the surfboard's profile or 'shape'. Whereas once cuts of timber were the dominant material worked upon, surfboards are now mostly made from PU foam, adapting generic blocks of material called blanks. Following almost identical methods pioneered by Hobie Alter and Grubby Clark in the late 1950s, liquefied PU is poured into concrete casts where it cures and forms a solid mass that is the blank. Moulds are set in variety of lengths and widths.

The other main materials used instead of PU foam in blank construction include expanded polystyrene (EPS) and extruded polystyrene (XPS). EPS and XPS boards last much longer than PU boards – an immediate advantage on the sustainability front. XPS is in turn much more dense than EPS, giving a tighter foam beading and a much better strength to weight ratio, but is more difficult to work, and to fix, when dinged.

Shaping workshops then order PU or EPS/XPS blanks to suit their needs from supply companies. In the United States Clark Foam was by far the dominant supplier until

Blank Monday. In Australia, companies such as Burford Reinforced Plastics, South Coast Foam and Bennett Surfboards (manufacturing blanks as Dion Chemicals) are the dominant players. In southwest England, where the sport has expanded rapidly in recent years (supporting a burgeoning shaper scene) blanks are imported from the United States and Asia (see below).

Blanks are then either hand-shaped, or shaped by automated machines. Where blanks are hand-shaped, after selecting an appropriate mould the shaper traces the outline of the surfboard onto the blank (the 'plan shape'). Next a handsaw or electric jigsaw is used to cut out the plan shape from the blank. After this the shaper begins planing rougher sections of foam, working to achieve a smooth and even finish along the rails, while reducing thickness through the blank to suit the design they have created. After planing the surfboard's length, thickness and width to the desired dimensions, the shaper uses surface form tools (surform) to fine-tune each design. Features such as tail concaves and nose shapes are delicately crafted with the surform.

Where blanks are automatically shaped, computer algorithms based on hundreds of precise measurements from existing physical boards drive machines that cut shapes with a very high degree of accuracy. Frequently these mimic or even directly copy ideal prototype designs or 'magic' shapes that were previously crafted by hand shapers on existing boards. Next, with both hand-shaped and machine-shaped boards, sandpaper of different grit size helps further refine the design. In larger workshops finer sanding work is often devolved to a specialized sander, employed to ensure efficient production when factories need to move through large numbers of orders. In smaller workshops a single shaper does all the sanding work.

After the surfboard's shape is finished it moves to glassing. The *glasser* (also called a *laminator*) seals the surfboard to ensure the foam shape is waterproof and rigid. Glassers layer surfboards in fiberglass cloth, spreading liquefied resin over the top and bottom surfaces of the board to give a smooth and shiny finish. While shapers regularly receive most of the fame and attention for their work as designers and artists in the production process, glassers play an essential role in surfboard manufacturing. Mistakes here ruin the board.

The glasser's job begins with layering – called 'lapping' – the finished shape with lengths of fiberglass cloth. Next the glasser spreads a liquefied resin to begin the process of sealing the board. Workshops use two types of resin – polyester and epoxy. Epoxy resins are stronger and more adhesive to the fiberglass sheeting compared with polyester resins. But epoxy is only suited for use with EPS/XPS blanks because the resin adversely reacts with traditional PU foam, causing discoloration. Epoxy resin is also more difficult to spread over the blank and more expensive than traditional polyester resins – on average 2.5 times the price per pound. As a result EPS/XPS blanks and epoxy resins are used much less frequently than PU foam and polyester resin.

After lapping the glasser completes the fill coat, also known as a 'hot' coat. Here the resin is not actually heated but used to saturate the fiberglass cloth and fill gaps in the weave. The process is carried out on both sides of the board. Once the fill coat cures the board is again intensively sanded with different grit sizes, which helps smooth out rough bumps and imperfections. The board is then cleaned with an acetone and polished to achieve a dull finish. Like shaping, the sanding and polishing work after the resin has cured is often devolved to an apprentice glasser, specialized sander or polisher. Once the glassing is finished the desired result is an evenly covered and sealed surfboard, which is waterproof and able to withstand significant beatings from breaking waves and surfing bodies.

The typical surfboard workshop is a collection of separate spaces, divided and organized to allow the completion of different work tasks: shaping, glassing, drying, sanding and art designs are all usually completed in their own separate rooms. Glassing rooms must be well ventilated, with good lighting. In California and Australia, workshops are required to store materials (resins, hardeners, paints, solvents, and acetone) in a secured room, in accordance with local environmental and workplace safety regulations.

This 'traditional' set of arrangements (at least, since the 1950s) is also rapidly changing, especially for the shaping stage. Since the 1990s, modern computerized production methods now operate within the surfboard industry using different economies of scale to traditional manual approaches. Not only have computerized shaping and design replication been used to up-scale production to meet demand from larger numbers of novice surfers, but surfboard-making companies of different sizes have increasingly moved to manufacture boards in non-surfing regions where there are cheaper factors of production, and where environmental regulations are less stringent. The focus of these new spaces of surfboard production has been Asia, especially factories in China and Thailand, and smaller surfboard workshops in 'cheap' surf travel destinations including the Philippines and Indonesia. In such places computerized shaping technologies are being used to replicate standard designs en masse. In China, for example thousands of boards are exported weekly, most from Hong Kong, the Guangdong and Zhejiang provinces. The dominant market destinations for these boards are the United States, Australia, Brazil and Western Europe.

Diverse companies now manufacture (or subcontract the making of) surfboards, encompassing the traditional local workshops, surf corporations with countercultural origins such as Rip Curl, specialist factory producers newly present in the market (such as Global Surf Industries, Firewire and SurfTech, all based in Thailand), and diversified manufacturers such BenPat International and SHY Technology (both based in China) who make a range of other goods beyond surfboards including golf clubs and skateboards. Where surfboard-making has been offshored, CAD/CNC technologies are used to shape boards, with thousands of models manufactured from the same design. Glassing is carried out internally within the same factory, using a Fordist production line approach.

Larger, well-known independent surfboard labels seeking to expand their export market increasingly use foreign companies as contractors to produce their boards by computer. Global Surf Industries (producing 50,000 boards annually) and BenPat International (making an estimated 30,000 boards annually) shape, label and glass surfboards for other workshops before organizing shipping to final retailers. The lower labour and overhead costs of these factories allows them to charge comparatively less for their products while maintaining higher profit margins. In these ways surfboard manufacture is becoming more like other mass-consumer industries: high throughput, automated production, disposability. Costco for instance began stocking Chinese made surfboards in California and Hawaiʻi from 2008, selling them for US$200 to US$300. In most cases such prices are well below the basic production costs for competing local board-makers, and the boards themselves are low quality, lasting for a shorter period of time and having to be replaced more frequently.

Despite the shift to CNC automation, hand-shaping persists in many places, and the structure of the industry – geared around local shapers and small workshops – survives. Within striking distance of key beaches and prized breaks, groups of local surfers have sustained commercial demand for hand-made surfboards, even with cheaper imports available. The coastal and regional distinctiveness of surfing's underlying geography is an insurance policy of sorts. Local knowledge of breaks and wave types matters, as does attention to the individual weight, preferences and needs of surfers. Place seeps into the design and reputation of surfboards. Accordingly, environmental sustainability issues associated with surfboard-making operate concurrently at different levels associated with a diverging mix of manufacturing techniques, regulations and locations – both global and local.

Environmental issues and regulation

A host of environmental problems is associated with the above processes of making surfboards: use of non-renewal materials, carbon emissions, toxicity of petrochemicals, environmental pollution, waste disposal problems and health impacts from the production process itself.

Scant research has traced the contours of the carbon emissions associated with surfboard production. According to the most prominent study, carried out at the University of California Berkeley, the average surfboard creates 375 pounds of CO_2 emissions in the production process (Schultz 2009). Over its entire lifecycle, the carbon impact of a typical U.S. made, 5.5lbs shortboard is 600lbs of emitted CO_2. Regular recreational surfers can go through two or three surfboards a year – further multiplying the overall carbon impact of making, buying and using surfboards.

The material used in most surfboards – polyurethane – is a petroleum product, and it accounts for approximately a quarter of the carbon footprint of the finished product (Schultz 2009). Blanks are mostly cast from PU foams, with resins, catalyst and acetone used for sealing, cleaning and polishing. TDI has been used in surfboard blank manufacturing since the 1960s, but is now recognized as a serious lung irritant linked to chronic asthma. Resins meanwhile account for approximately 22 per cent of the carbon impact of a finished PU board, and 37 per cent of an EPS/epoxy board. Polyester resins are also infamous in the industry for their emission of volatile organic compounds (VOCs) during the production process. Fibreglass – impregnated with resin to create the hard shell of the surfboard – accounts for approximately 5 per cent of the carbon emissions impact of surfboard manufacture. Fins meanwhile, are predominantly made from petroleum-based plastic, and entail further carbon emissions in production. Beyond carbon emissions and dependence on petroleum products, waste management is an issue in shaping workshops: one estimate is that approximately a third of all raw materials entering a typical workshop end up on the workshop floor or disposed as garbage (Staiger and Tucker 2008).

Depending on how close workshops are located to blank suppliers, there are also emissions associated with transporting blanks – although these are nowhere near as significant as the emissions that result from physical production of the blanks in the first place. When Clark Foam (which at the time supplied about 80 per cent of the surfboard market in the United States) closed on Blank Monday, the sudden downturn in the supply of blanks exacerbated short-term emissions impacts as American workshops sought blanks supplies further afield, including east coast Australia.

Although no science has been conducted that quantifies such impacts exactly, the case does anecdotally illustrate how environmental sustainability issues are entangled in complex geographies of regulation and supply: hence enforcement in one location (California) aimed at improving environmental performance can merely offset those impacts to other locations (Australia, Asia), and perversely generate other kinds of impacts such as transport-related carbon emissions needed to ensure consistency of supply. From a sustainability perspective, there are constant trade-offs such as these that are a function of the shifting geography of manufacturing goods. In time, new PU moulding factories, including US Blanks, Foam E-Z, Arctic Foam and Just Foam emerged to fill the void left when Clark and Walker Foam closed. Surfboard workshops in southern California now spread their blank orders across several suppliers to ensure there is not a repeat of Blank Monday. Nevertheless significant differences exist across jurisdictions within and beyond the United States in the degree and enforcement of environmental protection regulation.

Environmental health impacts

Our research also documented physical health problems common among surfboard-makers, from aches and pains associated with manual work, to more serious health predicaments linked to the environmental toxicity of input materials. Acute problems were especially common among older participants who have worked in the surfboard industry for long periods of time. Pre-1960s surfboard-making relied on the use of hardwood timbers, lacquers and plant-based waxes to waterproof surfboards. Although there were no such things as occupational health and safety standards back then, materials used were mostly organic and reasonably safe. In the contemporary surfboard industry commercial workshops use volatile synthetic materials and chemical components that harm workers.

Blanks contain materials with active ingredients or components that are irritating to the body and in some cases harmful to long-term health. The foam used in surfboard blanks is composed of fine reactive polymer compounds. When shaping by hand or using automated machines the blank releases small particles of polyurethane or polystyrene foam into the surrounding air. If inhaled, foam particles can become blocked in airways and cause respiratory illness or inflammation of the airway.

Likewise, glassers use liquid resins to fill and finish coat boards, catalyst to harden the resin and acetone to polish and clean up spills. Dangerous fumes are easily inhaled and glassers regularly come into physical contact with potentially harmful chemicals. Formaldehyde helps the resin absorb deeply into the fiberglass cloth. Over the last decade several medical studies have examined the exposure of workers to formaldehyde across a number of different industries (including funeral workers who used formaldehyde to embalm bodies), and there are alarming health problems resulting from regular and prolonged exposure (Hauptmann et al 2009). Among workers using formaldehyde is an increased frequency in cases of, and mortality from, myeloid forms of leukaemia. According to one medical study prolonged exposure to formaldehyde heightens the risk of contracting cancers of the hematopoietic and lymphatic systems – particularly myeloid leukaemia, which affects the bone marrow (Beane Freeman et al 2009). Surfboard-makers work with or are in close proximity to dangerous chemicals and hazardous materials: the resins, catalyst, glues, paints, acetones and inevitable clouds of foam dust that permeate every factory. Such substances are often inhaled in small quantities every day or come into direct contact with the body. Asthma and respiratory complaints were the most frequently discussed among our interviewees, considered the result of extended exposure to fumes released by resins, catalysts and acetones.

New materials and possibilities

At the time of writing the surfboard industry continues to use predominantly PU foam and fiberglass for surfboard-making – accounting for up to 90 per cent of commercial production. The Blank Monday episode, followed in 2007 by the liquidation of another large blank supplier, Walker Foam, sparked surfboard-makers to experiment with the use of different types of foam and resin combinations, recycled ingredients and bamboo and hemp cloths. Beyond concerns over speed and strength, some new construction materials are also being sought for environmental reasons. In some workshops, trialling different materials is being driven by an environmental and health consciousness relating to PU foam and resin in combination with attempts at reducing weight and creating more enjoyable boards.

Much of the innovation in ecologically sustainable surfboards has emerged from California – where environmental regulation has been strictest. Following the Blank Monday crisis, two brothers Rey and Desi Banatao (who both had materials science degrees) founded Entropy Boards in Santa Monica, California. Together they developed a new recipe for a 'bio-board', in which sugarbeet oil replaced polyurethane, and hemp cloth replaced some of the fiberglass in the glassed shell (Stone 2008). Sugarbeet oil is almost identical to PU in a chemical sense, but in processing uses less toxic chemicals. Under the brand name Super Sap, Entropy now markets epoxy resins partially made from the waste by-products of the pulp, paper and biofuels industries, with biological content between 25-50 per cent of the material. It claims reductions in overall carbon footprint of at least 50 per cent compared with traditional petroleum resins. Other workshops have meanwhile experimented with recycled polystyrene and alternative ingredients, and fins made from bamboo and recycled plastic and carpet that are glassed-in permanently to the board (rather than made in such a way that they connect to the board using plastic fin boxes). PU foam sourced from algae has been developed and adopted by Arctic Foam (sponsors of John John Florence), who have plans to produce on a commercial scale this year.

Supporting such experimentation, a new labelling scheme, ECOBOARD, has been introduced by a new non-profit benchmarking agency, Sustainable Surf (established in 2011 by Michael Stewart and Kevin Whilden). Akin to food and energy star labelling schemes, ECOBOARD aims to provide more transparent information to consumers that purchase certified boards that have been produced in a manner that minimizes impacts on workers and the environment. Verified ECOBOARDS must be made from blanks containing a minimum of 25 per cent recycled foam or biological content; with resin made from a minimum of 15 per cent bio-carbon content with low or zero VOCs; or made from an alternative material altogether, principally wood, which reduces or eliminates dependence on petroleum-based foam and resins (http://www.sustainablesurf.org/ecoboard/benchmark/). At the time of writing ECOBOARD had been endorsed by the U.S. based Surf Industry Manufacturers Association (SIMA), and some 33 workshops had signed up to produce boards using the ECOBOARD labelling and accreditation (Bradstreet 2013). Of these, most were in southern California, clustered in the heart of the industry's established territory: in San Clemente, Oceanside and San Diego. A scattering of other workshops make ECOBOARD certified surfboards on the U.S. east coast, as do a couple in southwest UK. To the best of our knowledge, none are registered in Australia.

Also from the southern California hub, the 'Waste to Waves' program encourages consumers to collect and recycle EPS foam (typically found as packing material when purchasing a new TV or appliance) via surf shops who host collection boxes (see http://wastetowaves.org/2011/11/how-it-works/). EPS materials are then collected by a company called Marko Foam – a blanks manufacturer who retrieves the material when delivering new surfboards to the same shops – and reprocessed into surfboard blanks. This process still requires energy to blow the EPS material into a blank (hence generating carbon emissions) but, it is claimed, significantly reduces the ~70 percent of impacts in the production of virgin EPS that come from the extraction and processing of raw materials used to make foam (http://www.sustainablesurf.org/ecoboard/technology/).

In the southwest UK, a conglomerate of composite materials manufacturers have formulated resins for a PU foam core blank ('Ecoblank') made from 40 per cent castor oil, as well as a UV-cured resin system ('EcoComp UV-L resin') with more than 90 per cent linseed oil content (Staiger and Tucker 2008). Resulting ecoboards, made locally, use hemp fibre instead of fibreglass. The manufacturers claim that the ecoboard contains 55 per cent renewable content, and that the linseed UV cure system wastes less resin than conventional polyester due to the long pot life of the substance (the curing process does not begin until the resin is exposed to UV light). Using these materials, workers are not exposed to VOCs and acetone is not required for clean up.

Meanwhile, the revival of wooden surfboards – fuelled by the growing 'retro' movement and vintage surfboard collector scene – has provided another alternative. Full lifecycle analysis suggests that timber production results in fewer CO_2 and other environmentally damaging emissions than PU foam boards (Hole 2011). Timber construction also reduces petrochemical dependence and eradicates VOC toxicity issues involved in PU (Grees 2014), but it does introduce new irritants associated with wood dust. Wood dust is much less toxic, but still requires everyday management. Glues and lacquers are still used.

Moreover, wood entails a different set of upstream issues, connecting surfboard-making to forestry management and transport-related issues associated with the timber trade. Among the timbers commonly used in contemporary surfboard-making are balsa (*Ochroma pyramidale*, sourced overwhelmingly from Ecuador), which featured heavily in earlier eras of board manufacture. A fast-growing, short-lived tropical tree, supplies of naturally grown balsa became strained in the 1950s and 1960s with the boom in surfing, alongside other parallel industrial uses (such as in aircraft manufacture). Nowadays balsa is plantation grown in Ecuador, harvested after 6-10 years of growth. It is not listed as threatened ecologically according to the Convention on International Trade in Endangered Species (CITES) or the IUCN Red List of Threatened Species. It is, however, expensive – limiting commercial applications.

An alternative, paulownia (*Paulownia tomentosa*), is increasingly being used in surfboard-making. It too is fast-growing and light, and not threatened according to CITES or the IUCN Red List – and can be harvested in some cases after only five years. In some areas it is even considered an invasive species. Surfboard-makers in Australia are increasingly turning to paulownia, and some interviewed in this research had recently become involved in plantation cultivation of paulownia in Far North Queensland (which has suitable climate, rainfall and soil), in order to improve supplies. Tom Wegener, a well-known Australian shaper renowned for advances in wooden surfboard construction, uses paulownia (he is also at the time of writing completing a PhD on sustainability issues associated with surfboard-making). The market for wooden boards is growing, though is unlikely to replace composite fibre surfboards given manoeuvrability and performance problems. It nevertheless is becoming a viable niche, and one that connects surfers to both the culture's traditional heritage in Hawai'i, and a more 'organic' relationship with the environment.

Subcultural origins and economic constraints

Despite growing environmental and health awareness, and experimentation with new and alternative materials, many unsustainable practices and dangerous behaviours within workshops continue, and magnify risks. In this final discussion in the chapter, we argue that inhibiting sustainability improvements are factors linked to the industry's informal DIY origins, which has given rise to a distinctive – and limiting – mix of economic structure and subcultural norms.

Pioneer surfboard-makers began in the heady days of the 1940s and 1950s. Surfboard-making scenes were do-it-yourself pseudo-industries operating first from Hawaiian beaches, and then out of garages and sheds in California and Australia. Informal, experimental, and almost completely unregulated, board-making became a part-time accompaniment to days spent surfing, drinking and hanging out. Surfboards were made out of necessity, rarely with business acumen. Early surfboard-making was characterized by coastal cultural life and small-scale 'backyard' production. After World War II, surfing – particularly its Californian variant – began its progression towards mainstream social acceptance and western consumerism. As more people took up surfing in the 1950s and 1960s, and as tourism in all three Pacific regions boomed, the market for surfboards grew locally. Several early surfboard-makers found they could make respectable livings from crafting boards for local waves. Early innovators became renowned 'legends' of the sport and master craftspeople. Subsequent generations of innovators and hand-shapers followed and reflected generational changes in preferred surf breaks and styles.

The resulting economic structure is one where a small number of 'lead' firms fuel technical (and in the context of this chapter, environmental) innovation in board design, while a much larger number of comparatively anonymous, usually smaller-scale operators and local do-it-yourself board-makers satisfy demand for surfboards tailored to local conditions. Their boards might never feature in pro-tour competitions yet they are very much a part of surfboard-making as a grass-roots industry.

In regard to environmental sustainability, this structure is reflected in the degree of experimentation, adoption of alternative materials, and persistence of old 'habits'. In southern California, where environmental consciousness, stricter regulation and sheer market size are combined, there are a number of lead firms pioneering sustainability initiatives. Elsewhere, and especially in Australia, sustainability has lagged behind, and PU foam boards remain stubbornly the norm.

Complicating this picture is that local distinctiveness and close connection to a subcultural scene limits both the size of surfboard-making firms and their capacities to invest in new materials, techniques and facilities. Prioritising relationships with local customers, shaping boards by hand and customizing orders are all much-cherished characteristics of the traditional format, but they do limit business expansion, and thus the capacity to leverage debt in order to invest in new, more sustainable materials and facilities.

One Australian workshop interviewed for this research (for whom we wish to protect anonymity) put in place 'best-practice' environmental and workplace safety and conditions in the early 2000s, by investing many hundreds of thousands of dollars in a purpose-built, ground-up designed production facility. Capacity expanded accordingly, but debt taken on board in order to finance the best-practice operation exposed the firm to greater levels of risk. Higher volumes were necessary to meet debt repayments, which meant increasing reliance on marketing and advertising, engaging in dodgy retail consignment agreements and 'ghost shaping arrangements' (whereby they shaped unbranded boards that were subsequently sold in megastores with big brand decals), and higher risk strategies to expand export markets beyond the loyal local surfing community.

This workshop's trade went well initially, but then soured with the global economic downturn and a (then) high Australian dollar. The firm could not keep up with debt repayments, and sold their state-of-the-art facilities at a considerable loss (upwards of US$200,000). They subsequently downsized the business – moving to a more modest space rented alongside another surfboard-maker, without the high-end best-practice environmental features, and focusing their product only towards the local surfing crowd. This failed experiment in up-scaling production with best-practice facilities demonstrates the risks associated with stretching beyond a traditional local, craft base. In surfboard-making, on-going viability depends on tight social relationships between makers and customers, even if that means production (and profit) remains ultimately constrained. The very same constraints prevent substantive investment in new plant, machinery and alternative materials needed to improvement environmental sustainability performance.

Meanwhile, despite many advances in new and alternative materials, the dependence on PU foam and polyester resins remains remarkably difficult to shift – a consequence of both shapers' and surfers' preferences for that combination of materials. Alternative materials still struggle for legitimacy and credibility within the subculture – a direct parallel to other culturally-based industries such as guitar-making (Gibson and Warren, forthcoming) where a set of entrenched expectations among user groups guides the 'tradition' of manufacturing an unchanging 'type form' (Molotch 2005). In other words, when a successful 'formula' develops for how a product should look and be made, it can prove very difficult to revolutionize.

This explains why ECOBOARDS made from recycled EPS have struggled against the traditional PU, with many surfers preferring the 'feel' of PU. For elite surfers – and the millions that follow them – surfing is in essence about wave performance: 'A Nascar driver doesn't particularly care how many miles per gallon his souped-up Chevy Malibu gets, and surfers likewise obsess about speed. For half a century that has meant building boards out of polyurethane' (Woody 2012). There is even a scientific basis for the on-going preference for PU: testing on the flexural qualities of alternatives confirms poorer performance. Hemp cloth laminates fail to protect cores as well as fibreglass, and bio-foam has lower core shear strength in comparison to PU foam (Johnstone 2011). Despite growing environmental awareness among surfers, Marko Foam's Envirofoam blank makes up only 10 percent of its total sales (Woody 2012). As Clay Peterson, an owner of Marko Foam, simply puts it, 'It's difficult to get some of those old-timers to switch and embrace the new technologies' (quoted in Woody 2012).

Old habits also die hard within surfboard-making workshops. Until 20 years ago many shapers and glassers did not wear dust or breathing masks. Pungent chemical fumes were frequently inhaled for the entire duration of the working day. This was typical in an era when surfboard-making was highly informal, unregulated and operated out of backyard sheds and garages. Frequency of exposure was high. Tony, a glasser on the east coast of Australia, was oblivious to such dangers:

> It was stupidity when I think about it now, and I get angry at myself. But at the time, you were busy glassing away and after a while you don't even smell the fumes. Resin has no odour to me anymore and I have become totally desensitized. It took someone to walk in here one day and they said to me 'put a fucking mask on' because the resin is really thick and strong. I realized I didn't even smell it. That was the problem, my sense of smell is now nearly gone.

Safe work practices in surfboard workshops often took a back seat to the time demands of finishing a new board, as Dean, a glasser in Australia, explained:

> When I started you wouldn't always bother putting a face mask or a respirator on when you were glassing. Taking it off, putting it back on, wiping away the sweat because it was bloody hot. You were just thinking about getting the board done, you know. Inhaling all those chemicals; I mean even the resin we applied we found out that formaldehyde was the active ingredient. When you got it on you, you would get a burning sensation around your eyes and it made your throat sore to breathe. Where it touched your skin would be all red spots. Fuck, I mean that is a pretty good sign you're doing some damage to yourself isn't it? And here we were with it covered all of us, bloody breathing it in.

Dean's previous employer sourced their resin from a local chemical supply company that still used formaldehyde as an active ingredient. It was the cheapest option. The link between the chemical and forms of cancer have started to worry him:

> I can't help but think about it [getting sick]. It worries me a lot actually. I feel like the clock is ticking; you've got to try and put it out of your mind but I've read things on the Internet that explained the chances of getting cancer and that does really play on my mind. It's just the reality of it, being so naive to the dangers of what you're doing.

In the United States significant steps have been made in California by the State Fire Department and Environmental Protection Agency (EPA) to restrict the use of phenol and formaldehyde as ingredients in the manufacturing of resin, along with TDI. Yet elsewhere restrictions are less stringently enforced.

Meanwhile the surfboard industry still lacks consistent and clear occupational safety guidelines. While safe work inspectors and local environmental protection agencies in most major surfboard-making regions now carry out regular checks, safety standards we observed in workshops still vary considerably. At one factory we visited in Australia large drums of resin and two tubs of acetone sat near the feet of glassers, waiting to be knocked over. Ironically the owner explained how the state regulatory authority overseeing worker safety had recently ordered the company to better ventilate the glassing room and construct a quarantined space where drums of flammable chemicals could be stored. The workshop was threatened with a large fine if they did not implement the changes before the next inspection. However, the regulatory officer was a friend of the owner and had informed him of the next inspection date, meaning the job was not an immediate priority.

In another example, a young employee on Oʻahu who was responsible for polishing and preparing boards had to abruptly leave his job under doctor's advice because the regular exposure to polyurethane foam dust and strong resin fumes in the factory badly inflamed his asthma. The workshop had been told on two separate occasions to install better ventilation in their shaping areas and glassing rooms to reduce unnecessary exposure to foam dust. While 'old' work routines are slowly changing as shapers and glassers become more aware, significant damage has already been done, and the laid-back subcultural atmosphere surrounding the typical local workshop negates attempts at strict enforcement. In Hawaiʻi workshops are very loosely inspected, especially those operating in home garages and backyard set-ups. Workshop owners have a relaxed attitude towards changing procedures for production. In Australia the onus is on individual workers to wear protective masks and equipment, with policing of the workshop space relying on a vigilant owner or manager. Nevertheless, precautions and perceptions may well be gradually changing. In workshops, ventilation systems are now nearly ubiquitous, and facemasks more frequent in daily use.

Meanwhile, some shapers are gradually discovering that there can be a 'sweet spot' between environmentally sustainable materials and board performance. William 'Stretch' Riedel, a well-known shaper from Santa Cruz, CA, now only uses EPS blanks and bioresins. Yet, he says, 'I really didn't start doing this to be green at all. I really went for performance, as I could make lighter, stronger boards. The performance of the materials is really what makes this the greenest. It's really hard to break this board, so the customer is buying one board instead of two or three boards over time' (quoted in Woody 2012). In time other workshops new designs that combine structural and environmental advantages, and that are acceptable within the subculture, are slowly emerging. Michel Bourez's victory at Sunset in the 2014 Vans Triple Crown of Surfing was the first high level victory on a board with ecoboard badging. Kelly Slater's purchase of a majority share of Firewire and use of EPS boards in contests (Snapper, Bells, J-Bay) combines with a developing discourse amongst commentators that EPS boards are lighter, and more responsive, suited to glassy, smaller conditions. These are early examples, but they suggest that a combination of environmental and elite sporting performance is possible, and may in the future become the norm.

Conclusions

Surfboard manufacturing has the potential to become a model industry geared towards minimizing environmental impacts. The ECOBOARD certification program and development of new materials and recycling schemes demonstrates a willingness among some industry figures to do the right thing. Pioneers in sustainable surfboard-making have gained traction linking to issues of carbon emissions and climate change, and appealing to surfers directly in terms of related consequences such as sea level rise, ocean acidification and coral reef extinction.

Nevertheless, there are paradoxes and trade-offs. Wooden boards are the most 'natural' and least dependent on petroleum products, but perform less well in the surf. CNC shaping in larger facilities enable workers to avoid repetitive injuries and usually comes with better ventilation that reduces exposure to dust. But CNC technology deprives hand-shapers of work in an industry where valuable hand-skills were developed over decades.

While tighter environmental regulation is a positive step for ensuring the health and safety of new and future workers in the industry, it varies geographically, shifting the problem from one jurisdiction to another. Awareness is patchy, filtered by the informal subculture surrounding surfing scenes in local communities, and has come too late for others now suffering health problems due to long histories of improper work practices and unsafe factory environments.

Beyond some obvious and low-overhead measures that ought to be adhered to and enforced (ventilation, face mask-wearing), improvements in surfboard sustainability have not been easily forthcoming. Environmental sustainability is not so much prevented by lack of care for the environment or apathy in the industry, than by intersecting technical, regulatory, cultural and economic factors that shape and constrain possibilities.

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