Management Guidelines for Surfing Resources

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THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

eCoast
eTakutai

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Disclaimer

These guidelines have been prepared by researchers from University of Waikato, eCoast Marine Consulting and Research, and Hume Consulting Ltd, under the guidance of a steering committee comprising representation from: Auckland Council; Department of Conservation; Landcare Research; Lincoln University; Waikato Regional Council; Surfbreak Protection Society; and, Surf Life Saving New Zealand.

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The authors have used the best available information in preparing this document. Nevertheless, none of the organisations involved in its preparation accept any liability, whether direct, indirect or consequential, arising out of the provision of information in this report. While every effort has been made to ensure that these guidelines are clear and accurate, none of the aforementioned contributors and involved parties will be held responsible for any action arising out of its use. These guidelines should not be taken as providing a definitive statement for any particular user's circumstances. It is an overall recommendation that users seek expert advice in both the management of surfing resources and the use of these guidelines.

As new techniques and approaches are established, they will be incorporated into revised editions of these guidelines. Feedback on the content and use of these guidelines is welcome and can be provided via email: info@surfbreakresearch.org

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1 Introduction

These guidelines provide background information and specific methodologies to assist in the sustainable management of surfing resources. The guidelines are aimed at assisting:

- authorities charged with implementing policies and plans,
- resource users and applicants to manage expectations and responsibilities with respect to resource consent requirements where proposed activities may affect surfing resources.
- stakeholders to understand how developments might affect the amenity value of surf breaks and the responsibilities of those proposing the developments.

The guidelines are one product of a 3-year-long project funded by the Ministry of Business, Innovation and Employment (MBIE) (Atkin *et al*., 2017)[1]. While the content has been informed by inputs from consultation with stakeholders, a steering committee and independent reviewers, the final content is that of the authors.

1.1 Background

Surfing is a watersport where the participant is propelled along by a wave. The history of surfing is long compared to many sports, with Polynesians partaking in wave riding well before European contact. It was described by Joseph Banks who reported seeing Maohi (Indigenous Tahitians) riding wooden boards while visiting Tahiti aboard HMS Endeavour during the first voyage of James Cook. In Aotearoa New Zealand surfing was a past time of the Māori people. It was carried out using a variety of craft, including boards, or kopapa, and even bags of kelp (poha) (Beattie, 1919; Best, 1924).

Interest in surfing grew following demonstrations to Wellington locals by the Hawai'ian surfer Duke Kahanamoku in 1915 (Figure 1.1). By the 1920s and 1930s in Aotearoa New Zealand, people were riding solid wooden boards and the Surf Life Saving movement began using heavy plywood skis to paddle through the surf and assist in rescues. In 1958 a visit to Piha by two American lifeguards, Bing Copeland and Rick Stoner, introduced the concept of surfing on smaller boards and riding across the face of the wave and helped locals to manufacture their own boards. By the late 1960s, the surfboard building industry was flourishing and building boards that allowed greater speed and more complex manoeuvres.

[1] www.surfbreakresearch.org

Figure 1.1: Duke Kahanamoku (left; Macmillan Brown Library, 2017) introduced surfing from Hawaii to Aotearoa New Zealand in 1915. The right image shows Duke with Ngati Tuwharetoa chief Te Heuheu Tukino V (from Osmond, 2010).

Today the growing numbers of people surfing has arisen from advances in technology bringing an ever-growing diversity of surf equipment including long boards, short boards, body boards, Stand Up Paddleboards (SUPs) and foil boards; tide and wave forecasting services via the worldwide web and mobile devices that allow users to target specific locations and sea states; and equipment such as wetsuits allowing activities to continue throughout the winter. The growth in surfing as an activity has been accompanied by the development of a surf culture reflected in the people, language fashions and lifestyle of participants.

Today surfers can no longer be simply regarded as “surf bums”. They appreciate their surf breaks and environment not just for the waves but also for spiritual and cultural aspects and because of this they have a strong sense of ownership of surf breaks (Usher, 2017). They represent a wide cross section of society and as frequent visitors to the coast have an inherent understanding of coastal processes and can play a valuable role as coastal protection stakeholders (ASBPA, 2011).

Surf breaks are unique and valuable components of the coastal environment. They have cultural, spiritual, recreational, economic and sporting value for many people. They are highly utilised assets that contribute to tourism, economic development and amenity values. Surfing has experienced rapid growth over the last three decades. Economists McGregor and Wills (2016) indicated that surf breaks contribute more than US$50 billion to global economic activity each year, and that recognition by the international surfing community of a new surf break can result in up to 3% economic growth in the area. In Aotearoa New Zealand, surfing is an important component of the large tourism industry, both for experienced international surfers looking to surf the world-class breaks and have the remote wilderness experience that is increasingly hard to find overseas, and for the surfing lessons/beginner industry.

The demand for space and resourcing around surf breaks and the recognition of their value has resulted in surf breaks becoming increasingly recognised in Aotearoa New Zealand coastal resource management. This is consistent with developments occurring internationally (see Ball (2015) and references therein).

An increased focus on mechanisms to protect surf breaks has followed from numerous cases of degradation worldwide, including human activities that compromise wave quality, access to breaks, water quality, and associated landscape, social and cultural features (Scarfe *et al*., 2009a, 2009b). The argument of those who openly wish to protect and preserve the integrity of surf breaks, such as the surf break Protection Society[2], Save the Waves[3] Surfrider Foundation[4] and Surfers Against Sewage[5], recognises that a range of benefits are associated with these unique places that transcend the recreational value of just “riding the wave”. These benefits depend on maintaining the integrity of natural processes that influence surf break environments, and on a variety of aspects important to surf break users including accessibility and environmental health (Peryman and Orchard, 2013) and their sustainable management (Scarfe *et al*., 2009a,b; Borne and Ponting, 2017; Borne, 2018).

The management of surf breaks in other countries has been addressed by, for example, the creation of Surfing Reserves in Australia since 2006, laws passed in Hawaii in 2010 to protect breaks on Oahu and the World Surfing Reserves (WSR) programme[6] launched in 2009. The WSR programme works by way of a self-nomination process, whereby communities can apply to Save The Waves to be considered for designation, and the application undergoes a review that considers the wave(s), surrounding environment, culture and surfing history, and capacity/local support.

Aotearoa New Zealand provided protection to 17 Surf Breaks of National Significance (Figure 1.2) by specifying them in the New Zealand Coastal Policy Statement 2010 (NZCPS). Compared to the approach of other countries, this provided immediate legislative protection and gave authorities a clear mandate and key role in the preservation and management of these unique and natural resources for future generations.

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[2] http://www. surf break.org.nz
[3] https://www.savethewaves.org
[4] https://www.surfrider.org/
[5] https://www.sas.org.uk/
[6] http://www.worldsurfingreserves.org/

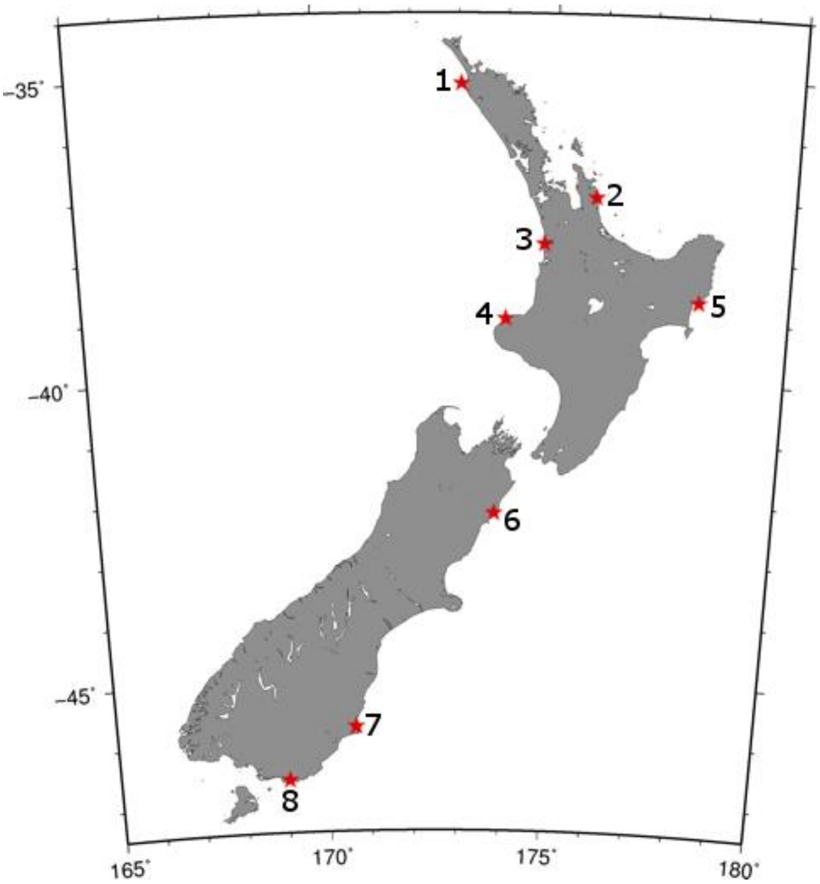


Figure 1.2: Locations of Aotearoa New Zealand's Surf Breaks of National Significance. 1) Peaks - Shipwreck Bay, and Pines – Super tubes – Mukie 2 – Mukie 1. 2) Whangamata Bar. 3) Manu Bay, Whale and Indicators. 4) Waiwhakaiho and Stent (Road – Backdoor – Farmhouse). 5) Makorori Point – Centres, Wainui (Stock Route – Pines – Whales), and The Island. 6) Mangamaunu and Meatworks. 7) The Spit (Aramoana), Karitane and Whareakeake. 8) Papatowai.

The Department of Conservation (2017a, b) undertook a review of the NZCPS and found that "*the precise identification of surf breaks of national importance has reduced disputes around their identification, raised their profile as a national resource and resulted in councils investing in facilities to support their use*". During the Board of Inquiry to develop the NZCPS it was noted that "*the economic value of surfing to tourism and the social benefits should not be underestimated*" (Board of Inquiry, 2009a, b; Department of Conservation, 2017a). Furthermore, the Board of Inquiry recorded that some of "*New Zealand's surf breaks are nationally and even internationally significant, attracting visitors from around the world, as well as providing a variety of surfing opportunities including some for learning on nursery surf breaks. The quality of the wave can potentially be compromised by developments in the swell corridor*[7,8] *seaward of the break, and the enjoyment of surf breaks by surfers compromised by*

7 See Section 1.2 Legislative Context.
8 Note a swell corridor is also referred to as a swell *window*, particularly outside of New Zealand.

discharges, limitations on access, and changes to natural character". A key strength of the Aotearoa New Zealand policy is that surf breaks are delimited by the definition in the NZCPS that takes account of activities that can affect the surf break in the wider area of the swell corridor and the land-based activities in the catchment.

The NZCPS itself does not provide specific guidance on how to manage a surf break. Despite this, some regional authorities in Aotearoa New Zealand have commissioned the collation of background information on surf breaks in their regions as part of preparing specific policy provisions within their respective planning frameworks.

Skellern *et al*. (2013) observed that the constraints affecting this process include inadequate information on the resource, a lack of methodological guidance on site baseline characterisation and monitoring, and political pressure to prioritise other resource management (e.g. freshwater management and land-use). There are also constraints for community organisations who rely on volunteers and meagre financial resources to effectively engage in the process. This capacity constraint has a direct bearing on the effectiveness of the planning process, resulting in decisions often being made on a case by case basis at hearings for specific developments, which often lead to inadequate coastal management decisions (Skellern *et al*., 2013).

1.2 Legislative Context

The Resource Management Act 1991 (RMA) is the primary legislation for managing the effects of activities on Aotearoa New Zealand's surf breaks. The NZCPS is prepared under the RMA and gives effect to the purpose of the RMA (sustainable management) for the coastal environment. Regional Policy Statements, Regional Plans, Regional Coastal Plans, District Plans and Unitary Plans each have to give effect to the NZCPS (Makgill and Rennie, 2011). If the NZCPS does not address an issue, then recourse can be made to the Purpose and Principles set out in Part 2 of the RMA. The "coastal environment" is not specifically defined in the NZCPS, but the NZCPS does provide guidance for its interpretation on a case by case basis. However, a constituent part of the coastal environment is the Coastal Marine Area (CMA). The RMA defines the CMA as the foreshore, seabed, and coastal water, and the air space above the water:

(a) of which the seaward boundary is the outer limits of the territorial sea;

(b) of which the landward boundary is the line of mean high-water springs, except that where that line crosses a river, the landward boundary at that point shall be whichever is the lesser of:

i. 1 kilometre upstream from the mouth of the river; or

ii. the point upstream that is calculated by multiplying the width of the river mouth by 5.

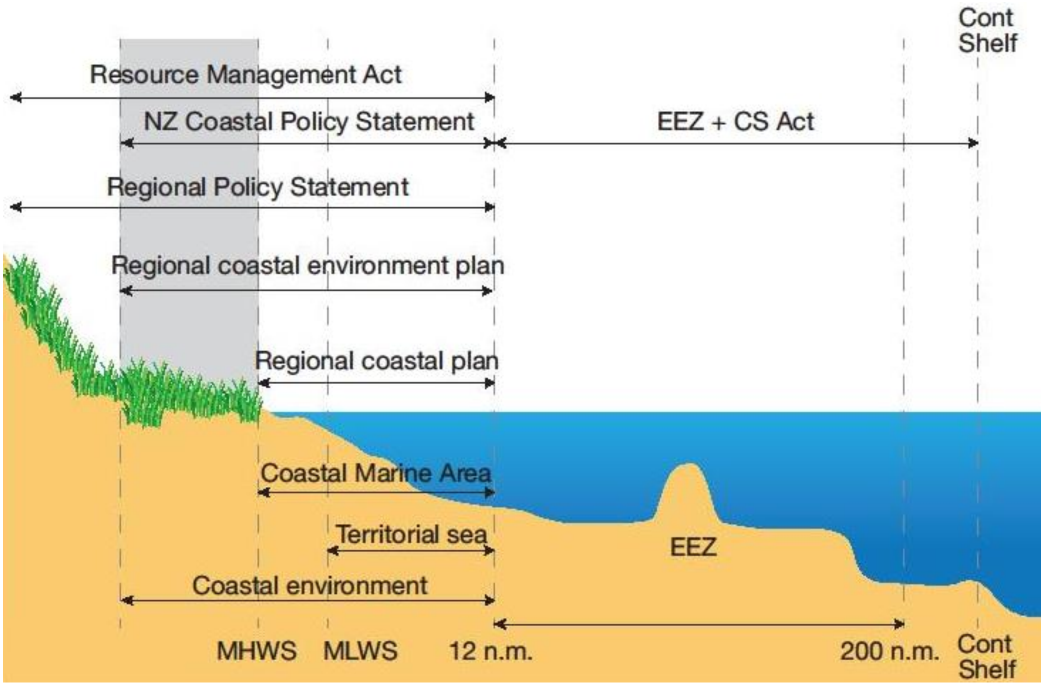


Figure 1.3: Coastal management zones in Aotearoa New Zealand. MHWS = Mean High Water Springs. MLWS = Mean Low Water Spring. EEZ = Exclusive Economic Zone. Cont Shelf = Continental Shelf. EEZ + CS Act = Exclusive Economic Zone + Continental Shelf (Economic Effects) Act 2012. N.m. = Nautical miles (image: NZCPS Guidance note).

The scheduled 10-yearly revision of the New Zealand Coastal Policy Statement 1994 attracted input from surfers and surfing organisations. The resulting submissions provided recommendations for the definition of a "surf break" and provisions for surf break protection (Board of Inquiry, 2009a). These recommendations were largely adopted within the NZCPS 2010 as Policy 16, which explicitly identifies the 17 Surf Breaks of National Significance in Aotearoa New Zealand, as:

Policy 16: Surf Breaks of National Significance:

Protect the surf breaks of national significance for surfing listed in Schedule 1, by:

(a) ensuring activities in the coastal environment do not adversely affect the surf breaks; and

(b) avoiding adverse effects of other activities on access to, and use and enjoyment of the surf breaks.

NZCPS defines a surf break as:

> *A natural feature that is comprised of swell, currents, water levels, seabed morphology, and wind. The hydrodynamic character of the ocean (swell, currents and water levels) combines with the seabed morphology and winds to give rise to a* ***'surfable wave'****. A surf break includes the* ***'swell corridor'*** *through which the swell travels, and the morphology of the seabed of that wave corridor, through to the point where waves created by the swell dissipate and become non-surfable.* ***'Swell corridor'*** *means the region offshore of the surf breaks where ocean swell travels and transforms to a* ***'surfable wave'****.* ***'Surfable wave'*** *means a wave that can be caught and ridden by a surfer. Surfable waves have a wave breaking point that peels along the unbroken wave crest so that the surfer is propelled laterally along the wave crest.*

1.2.1 Surf Breaks and Surfing Resources

While much of Aotearoa New Zealand's coastline has a wave climate conducive to surfing, not all coastlines are configured to break waves in a way conducive for surfing. Scarfe (2008) estimates that of the 18,200 km of coastline in Aotearoa New Zealand, there is, on average, one surf break every ~40 km. To exacerbate this scarcity, surf breaks can be dependent on specific wave heights, periods and direction, which may, in turn, be reliant on random or rare events such as tropical cyclones, which may also need to combine with specific tidal heights and wind directions.

Surf breaks are complex natural resources and good management decisions for surf breaks are based on a foundation of understanding. There is a body of surf science literature focused on the characteristics of surf breaks and how their dynamic nature is determined by the seabed morphology and substrate, waves, tides, wind and sediment transport (Appendix A). In addition, substantial information exists regarding the amenity and monetary value of surf breaks (Appendix B).

The most comprehensive set of research completed for physically defining surf breaks is that of Mead (2000), and the published work of Mead and Black (2001a, b, c). These works focus largely on the physical attributes, such as the types of surf break and the way in which waves break. Appendix A provides detail on surf science and the physical aspects of surf breaks. Despite the body of engineering literature available to quantitatively evaluate a surf break and breaking waves, when it comes to user enjoyment, ideal surfing conditions are diverse and subjective.

This subjectivity is not just a function of surfing ability and/or a like/dislike for a particular wave shape. There are other aspects that need to be considered when characterizing a surf break. Orchard (2017) reviewed literature related to surf break management in Aotearoa New Zealand. One of the outcomes was a framework for assessing a surf break's significance. Beyond wave breaking characteristics, it included a surf break's rarity and uniqueness, naturalness (environmental setting) and wilderness values[9], amenity values, levels of use, economic value, and historical/heritage/cultural associations.

Surfers don't just surf for 'the thrill of the ride'. The sense of freedom of riding the wave, the connection with the elemental forces of the wave, the aesthetics of the surrounding landscape, the social interactions with friends, the history of their connection to the break, and the coastal environmental quality all contribute highly to the surfing experience. As a consequence, all these factors need to be accounted for in managing the resource and threats against it.

It is the combination of physical processes (the surf break), sense and feeling, and experience that make up a **surfing resource** (Appendix B). It is therefore important to recognise the requirement to manage the resource holistically and not to treat aspects of this resource in isolation (e.g. the surf break). In this document surf breaks refer to physical feature described in the NZCPS; a surfing resource includes not only the surf break but aspects that make it a natural resource.

1.2.2 Surfing Resources and Policy

The NZCPS 2010 relates to the Resource Management Act (RMA) in that surf breaks are natural and recreational amenity resources that contribute to the natural character of the coastal environment. Access to surfing resources and their use and enjoyment are important to the social and economic well-being of people and communities, and yet they are vulnerable to adverse effects from activities in the coastal environment.

As noted above, the NZCPS covers the coastal environment which extends landward of the CMA, usually to at least the nearest ridgeline. This is to facilitate integrated coastal management across the management responsibilities of local governments responsible for

[9] Policy 15 of the NZCPS advises to consider aesthetic values including memorability and naturalness.

preparing and administering unitary, district and regional plans covering terrestrial and freshwater areas landward of MWHS and the regional coastal plans that apply to the CMA (Makgill and Rennie, 2011). The landward component of the coastal environment is essential for dealing with, amongst other things, the maintenance of water quality and access to surf breaks (Perryman and Skellern, 2011).

The landward component is an area where regional policy statements can provide guidance to district plans. Catchment planning and coastal spatial planning can assist with managing landward aspects that may affect surf breaks (e.g. dams and sand/gravel extraction that can alter sediment supplies to the coast, catchment runoff that can degrade water quality etc.), as well as in the CMA. There is clear direction in the NZCPS that such issues must be recognised:

Policy 1: Extent and characteristics of the Coastal Environment

1. *Recognise that the extent and characteristics of the coastal environment vary from region to region and locality to locality; and the issues that arise may have different effects in different localities.*
2. *Recognise that the coastal environment includes:*
    a. *the coastal marine area;*
    b. *islands within the coastal marine area;*
    c. *areas where coastal processes, influences or qualities are significant, including coastal lakes, lagoons, tidal estuaries, saltmarshes, coastal wetlands, and the margins of these;*
    d. *areas at risk from coastal hazards;*
    e. *coastal vegetation and the habitat of indigenous coastal species including migratory birds;*
    f. *elements and features that contribute to the natural character, landscape, visual qualities or amenity values;*
    g. *items of cultural and historic heritage in the coastal marine area or on the coast;*
    h. *inter-related coastal marine and terrestrial systems, including the intertidal zone; and*
    i. *physical resources and built facilities, including infrastructure, that have modified the coastal environment.*

The landward boundary of the Coastal Environment is not quantitively defined in the NZCPS, and the actual extent of the Coastal Environment has been left to authorities to define. Consideration should be given to including in the definition inland waterways and coastal hinterland, since developments in these areas can impact water quality, access to and surf break morphology.

The offshore jurisdictional range for authorities at a regional level is the edge of the territorial sea, 12 nautical miles from land. This is also the offshore boundary of the RMA; and therefore NZCPS. Activities outside the territorial sea, that fall into a surf break's swell corridor, and have the potential for adverse effects (e.g. large-scale seabed mining, petroleum recovery), are essentially beyond the influence of the NZCPS.

Policy 16 clearly identifies two major aspects as being important to the management of surf breaks, namely the physical aspects of surf break environments, and aesthetic and cultural aspects important to users of those environments. The policy does not specify that users need to be surfers; there may be other users of the water space including spectators who participate from a distance.

Policies 13 and 15 of the NZCPS provide further mandate to preserve and/or protect surf breaks. Policy 13 '*Preservation of natural character'* includes surf breaks as part of the natural character of the coastal environment, noting that *Other aspects of natural character, such as 13(2)(a) 'natural elements, processes and patterns' and 13(2)(h) 'experiential attributes, including the sounds and smell of the sea; and their context or setting'* are also relevant to surf breaks. Policy 15 '*Natural features and natural landscapes'* is also relevant, as surf breaks are specifically identifiable as natural features within the seascape.

It is clear that the relevance of the NZCPS to the management of surfing resources transcends Policy 16 and the 17 Surf Breaks of National Significance. Consideration must also be given to Policies 2, 13 and 15 of the NZCPS with regard to the surf break users and a collaborative approach, natural features that comprise surf breaks, and associated natural character. Therefore, the management of surfing resources should be considered at a national, regional and local level.

1.2.3 The Rights of Mana Whenua (local iwi)

Māori have special recognition within Aotearoa New Zealand legislature as Crown partners under the 1840 Treaty of Waitangi agreement. The Treaty of Waitangi was signed as an agreement between the Crown and Māori chiefs. At the time of signing, the Treaty ensured Māori equal participation within society, partnership in the governance of Aotearoa New Zealand, and the protection of Māori interests (Durie, 1998). By contrast, the governments subsequent policies following the signing went against those principles (Durie, 1998; Walker, 2004).

Nevertheless, the Resource Management Act 1991 recognises the Treaty of Waitangi [s8], the relationship between Iwi and water [s6(e)], and the role of kaitiakitanga [s7(a)] in managing

Aotearoa New Zealand's' natural resources (Grace, 2010). Alongside the recent Treaty settlements process, there is an increased recognition of "*Māori values as a fundamental driver for restoration as well as a basis for the ongoing involvement of Iwi in the regulation and sustainable management of natural resources*" (Grace, 2010, p. 1). Appendix C contains a link to *Mana Whakahono ā Rohe Guidance* produced by Ministry for the Environment, which details how local authorities and local iwi can work together on environmental issues under the RMA.

Within an international context, Māori rights are also recognised through the United Nations Declaration on the Rights of Indigenous Peoples 26 and 32 (The United Nations General Assembly, 2007, art. 5). Article 26 affords Indigenous peoples the right to own, use, and control their traditional lands and resources which they have traditionally owned, occupied or otherwise used or acquired, and that 'States' shall give legal recognition and protection to these lands and resources with due respect to the customs and traditions of the indigenous peoples concerned (The United Nations General Assembly, 2007). Article 32 affords Indigenous peoples the right to determine and develop priorities and strategies for the development or use of their lands and resources (The United Nations General Assembly, 2007).

Finally, Policy 2 of the NZCPS recognises that tangata whenua (local people of the land) have traditional and continuing cultural relationships with areas of the coastal environment, and that opportunities must be provided for Māori involvement in decision making and the exercising of kaitiakitanga (guardianship) over Iwi (tribal) waters.

In light of these legislative measures, the role that local Iwi provide as kaitiaki (guardians) of their rohe (region) is imperative to the management of surf breaks. Indeed, Māori and Iwi place great importance on the environmental protection of their rohe (Selby, Moore, and Mulholland, 2010). In this sense, collaborations with local Iwi can provide leverage and support throughout the process. To conclude, any engagement process with stakeholders needs to acknowledge the relationship between the Crown and Māori, by taking account of the principles of the Treaty of Waitangi, and kaitiakitanga in relation to the coastal environment and Policy 2 of the NZCPS.

1.3 Significance and Surf Breaks

The NZCPS does not provide criteria for defining what constitutes a Surf Break of National Significance, nor does it adopt any position on the stratification of surf breaks and their significance (i.e., into national, regional or local significance). The basis for the selection of 17 Surf Breaks of National Significance in the NZCPS 2010 was the Wavetrack New Zealand

Surfing Guide (Morse and Brunskill, 2004), with breaks rated 10 out of 10 on the author's 'stoke rating" being selected as nationally significant, Papatowai and 'The Spit' at Aramoana, which both rated 8, being included. Papatowai's inclusion was because of its growing international profile as a high-performance big wave break, and Aramoana's because of an administrative misunderstanding during the development of the NZCPS, with the 'The Spit' on the Wairarapa coast, which is rated as 10/10, being the original nomination.

Figure 1.4: Papatowai in Aotearoa New Zealand's deep south is a Surf Break of National Significance, recognised, outside of the original assessment criteria, because of its unique characteristics as a big wave surfing venue (image: Mark Stevenson).

Stratification is a matter for councils, local Iwi and their communities to determine, and the process and terminology that have been applied to date have varied around the country. The use of "regionally" and "locally" significant is a relatively new development in terms of surfing resource management (Orchard *et al*., 2019). This approach of stratification is consistent with planning documentation were the different authoritative levels recognise the appropriate features of significance. For example, district plans would recognise features of local significance.

When natural resources and values need protecting, they are assessed, and the level of protection is usually linked to their value. If everything is deemed significant, then the level of protection is often diluted. However, a surf break, or simply a stretch of coastline where surfing occurs, is more often than not significant to an individual, a group, or community. Comprehensive stakeholder and community engagement should be used to establish the level of significance on a case by case basis.

It is worthwhile noting that: *"It was the intention of the Board of Inquiry to the NZCPS to have an inclusive approach, in that the list is not finite, and more surf breaks may be added over time, and surf breaks are recognised as outstanding natural features in their own right (page 130 Vol 2 BOI to NZCPS) providing they meet the definition of a surf break in the glossary of the NZCPS and have been identified."* The NZCPS schedule of Surf Breaks of National Significance may be added to when it is next reviewed (scheduled every 10 years). It is very likely that candidates for addition to the NZCPS schedule will come from the breaks that councils identify as regionally significant.

1.4 Purpose of these Guidelines

Under the NZCPS, councils are tasked with considering how they will give effect to mapping and identifying natural character and natural features in regional policy statements and plans. Relevant to this and reinforcing the need for guidelines is the following statement by the Board of Inquiry for the NZCPS: "*We conclude that there should be no criteria in the policy [NZCPS 2010] for selecting further surf breaks of national significance given that there could be developments in the methodology in identifying and rating natural surf breaks"*.

These guidelines were originally developed as part of an MBIE funded project (Appendix D) that aimed to build a knowledge base on surf breaks and to develop management guidelines to support the effective implementation of the NZCPS. The guidelines provide: information on the legislative and social context of surf breaks; an understanding of the physical characteristics of surf breaks and how they function; a description of factors that can compromise their amenity value; specific methodologies for management of surfing resources for authorities and consent applicants; information to assist with the identification, study, monitoring and sustainable management of surf breaks.

Coastal infrastructure (e.g. ports, erosion protection structures), the supply, transport generation and transmission of electricity, aquaculture and the extraction of minerals are activities important to the social, economic and cultural well-being of people and communities (Policy 6 NZCPS). These guidelines aim to facilitate the sustainable implementation of these requirements.

The guidelines also aim to manage the expectations of resource users and developers with respect to consent requirements where proposed activities are likely to affect access to, and the amenity value of surf breaks. The guidelines will provide stakeholders with greater clarity on how activities in the coastal environment may affect a surfing resource and the responsibilities of those undertaking the activities.

Section 2 of these guidelines provides specific direction for authorities responsible for management of surfing resources. The first set of steps are designed to support council officers identifying, mapping and characterising surf breaks in their region. Threats and risk assessment guidance is provided to facilitate prioritising resources and preparing a “watch list” of surf breaks. Guidance is given on incorporating surf break protection into policy and plans. Methodologies for baseline studies and monitoring are described.

Section 3 provides steps for resource users and consent applicants who need to assess the potential impact of a development on the amenity value of a specific surf break (s) as part of a consent application. While the starting point may be information from Council, more often than not specific studies will be required as specified in the first set of steps.

Further details relating to the steps in Sections 2 and 3 are provided in Section 4, and additional supporting documentation is available in the appendices.

Case Study: Piha’s shifting sands

Image: Craig Levers

Under optimum conditions Piha Bar breaks adjacent to Taitomo Island (also called “Camel Rock” or “The Beehive”) across the bay toward Lion Rock. The Inside Bar provides lefts and rights and is best surfed on an incoming tide, from mid-tide onwards. Further landward is The Ditch, a high tide “reform wave”. Conjecture indicates that The Ditch no longer functions as it did in the past because of an abundance of sand in the bay.

Beach surveys that show the dunes all along the shore are growing taller and prograding seawards. Anecdotal evidence indicates that sand has infilled the Pataki Rip channel. Together these effects may have altered the circulation pattern close to shore, changed the configuration of rip channels and sand banks. The perceived result is that these changes have had a detrimental effect on the quality of the surf break.

Opinion is divided and the extent to which these effects are natural or anthropogenic are debateable. Some opinion has it that dune conservation works are the culprit. Dunes have been shaped and planted to combat coastal erosion. This has caused the dunes to prograde seawards and grow taller. It is perceived by some that while the sand is locked up in the dunes it is no longer available to build the sand banks offshore. Others would have it that the dune conservation has encouraged sand build up on the beach and in the nearshore. However, the influx of sand into the bay could also be part of a natural process. Dune progradation is occurring all along South and North Piha at decadal time scales and not just in the areas where dune conservation efforts have taken place. There is anecdotal evidence that the influx of sand into the bay is part of pulses of sand driven north along the coast by the waves, as evidenced by progradation occurring first at Karekare Beach and then at Piha.

2 Guidelines for Authorities

Use this guideline to gain a region-wide perspective and broad overview of surf breaks in a region, collect data on values and threats to prioritise efforts and resources, and identify specific measurements to make on breaks. Detailed descriptions and reasoning behind each of the following steps are provided in Section 4.

2.1 Step 1: Identify Surf Breaks

Table 2.1 shows the key steps to build a surf break database.

Table 2.1: Identification of surf breaks(See Section 4.2 for further details)

Objective: Build a database of all surf breaks		
Components		**Resources, Tools and References**
1	Review of surf/beach guides.	Bhana (1996) Morse and Brunskill (2004) Rainger (2011) NZSurf Guide (2013)
2	Stakeholder consultation through interviews and/or survey, should include: • Determination of the actual surfing area • Access points to the break • Surf break parts/sections, including common and colloquial names • Discussion around observed changes in the Coastal Environment	Peryman (2011a, b) Edwards (2012) Atkin *et al*. (2017) Reineman (2017) Orchard *et al*. (2019)
3	Map the location of the surf breaks and define a Surf Break Area (SBA). The SBA may host a single surf break or multiple surf breaks. The landward extent of the SBA can be delineated using the LINZ 1:50,000 coastline, the offshore extent where surfable waves break using a combination of knowledge gained from Components 1 and 2, maps in surf guides, satellite imagery and aerial photographs.	Components 1 and 2 Google Earth (satellite/photography) Land Information New Zealand (aerial photography) Atkin *et al*. (2015) Atkin and Mead (2017)
4	Compile the information in a database along with additional information such as photos of the break	
5	Categorise the significance of surfing resources	Orchard *et al*. (2019)

<u>Outcome and Actions</u>

- Broad understanding of surf break characteristics in the region.
- Ensure information is recorded in relevant databases.

2.2 Step 2: Construct Swell Corridors

By defining swell corridors for surf breaks an authority creates a planning tool, similar to coastal hazard mapping. A swell corridor dataset can aid the decision-making process and be used to identify sites where activities such as aquaculture, dredge spoil disposal and wave energy infrastructure could block or modify waves travelling through the swell corridor. Table 2.2 shows the key steps to determine swell corridors.

Table 2.2: Construct swell corridors (See Section 4.3 for further details).

Objective: Construct Swell Corridors.		
Components		**Resources, Tools and References**
1	Define swell corridors and buffer zones. Undertake numerical modelling of the offshore region to determine the area offshore of a surf break where ocean swells travel and transform into surfable waves.	Atkin *et al*. (2015) Atkin and Mead (2017) Atkin and Greer (2019)
2	Compile the information in a GIS database and make available to public.	Geographical Information Systems Google Earth

Outcome and Actions

- Swell corridors are delineated for surf breaks in the region.
- Ensure information is recorded in relevant databases.

2.3 Step 3: Threats and Risk Assessment

Table 2.3 shows the key steps in undertaking a risk assessment. Table 2.4 categorises activities and threats according to their source; whether they originate in the catchment and connecting waterways (rivers or estuaries), in the vicinity of the surf break itself, offshore from the break in the swell corridor, from natural events or social/cultural/technological change. It also provides examples from Aotearoa New Zealand and overseas where surf breaks have been affected and/or been assessed. This lists of activities and impacts are not definitive. Table 2.5 through to Table 2.8 can be used to determine a surf break risk rating.

Activities and threats range in scale from local to global and are location dependent. They have different time frames, the effects can be permanent or temporary, and while some effects can be mitigated, many cannot. They can have negative and positive effects on wave quality and the surf break environment - while some engineering works can have a positive effect on surf breaks (by design or accident) the effects can also be negative. Some threats are more common at specific geomorphic types of surf breaks (e.g. channel dredging, issues with boat traffic, and water quality are more common to river/estuary bar breaks).

Threats to surf breaks may also be threats to Māori and Iwi interests in the environment and their role in exercising kaitiakitanga. In this respect the interests of surfers align closely with Māori conservation views (refer to Selby, Moore, and Mulholland, 2010).

The value of a risk assessment is that it allows authorities to develop a "watch list". The watch list facilitates decision making and assists with prioritisation of resources for activities such as monitoring (Section 2.5) and the allocation of resources. Any surf break, surfing resource or SBA receiving a risk rating of extreme (Table 2.8Table 2.8) requires immediate action and resources should be directed to enabling Baseline Studies (Section 2.5) if not already undertaken; and, Baseline Monitoring (Section 2.6) should be initiated immediately should the consequence be major or catastrophic (Table 2.6).

Table 2.3: Surfing resource threats and risks(See Section 4.4 for further details).

Objective: Threats and Risk Assessment		
Components		**Resources, Tools and References**
1	For each surfing resource compile known facts and issues	Section 2.1 e.g. Table 2.4
2	Score surf break area on sensitivity and vulnerability	Table 2.5 Appendix A Appendix B
3	For each surf break, determine consequence for each activity/process	Table 2.6
4	For each surf break, determine likelihood of impact each activity/process	Table 2.7 Section 4 discussion/case studies
5	For each surf break, determine risk rating for each activity/process	Table 2.8
6	Prioritise surfing resources based on risk rating	
7	Initiate baseline characterisation and monitoring for top priority locations	Section 2.5 Section 2.6 Atkin *et al*. (2017)

Outcome and Actions

- Establish risk rating for each activity for each surf break.

Table 2.4: Various activities that pose a threat to surf break amenity.The list is not definitive.

Activity, Threat and/or Source	Potential Effects on Surfing Resources	Examples/References	Potential Mitigation Options
Hinterland, Catchment and Waterways			
Forestry	Sediment runoff into waterways creating sediment plumes in the CMA and reducing water quality in an SBA. Increased number of felled trees and branches in an SBA poses a health and safety risk to users. Additional sediment may benefit some surf breaks. Discolouration of waters following rain events. Impacts on the natural setting/ wilderness experience, and also impacts on ecological aspects at a surf break.	Resource Management (National Environmental Standards for Plantation Forestry) Regulations 2017	Manage stormwater, sediment and wood debris runoff using forestry industry best practice techniques.
Quarrying	Water quality issues as above.		Suitable silt and stormwater management, including the application of sediment ponds
Material extraction in waterways (e.g. dredging)	Sediment plumes in waterways delivered to SBA. Changes to sediment transport pathways.	Whangamata Bar, NZ Matakana Island, NZ	Best practice management should be applied, including measures such as silt curtains and bunding, and extraction methods such as cutter-suction that reduce sediment plumes into the surrounding waters.
Port and marina construction, development and maintenance	Alterations to tidal prism can change hydrodynamics and, subsequently sediment transport regime; and morphology. Direct and indirect alterations to refraction patterns. Delta breaks particularly susceptible. Increased vessel activity: vessel wakes reduce wave quality; sharing of space and access points. Requirement for dredging activities (see Dredging). Water quality issues associated with marina and increased boat activity. Noise associated with construction activities.	Whangamata Bar, NZ (Atkin *et al*., 2017) Mundaka, Spain (Liria *et al*., 2009)	Undertake field and modelling studies to predict effects of the developments and modify design to minimise impacts. Determine baseline conditions and monitor changes. Enforce speed limits for vessels using entrance channels. Educate users on sharing space.

Restriction of access by landowners	No access through private agricultural land. Industrial and residential developments in the CMA.	Whiterock, NZ Broad Bench, UK The Ranch, USA	Negotiate access as mitigation and condition of consent.
Runoff from rural and urban point and diffuse sources	Runoff contaminated with animal waste from farms; and discharges for outfalls, drains and septic tanks give rise to water quality issues. Can result in increased algal growth on rocky shore presenting a slip hazard to users of an SBA.	Manu Bay/Whale Bay (Atkin *et al*., 2017)	Manage runoff at source. Follow Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas (Ministry for the Environment, 2002).
Transgressive dune field: Planting or; development.	Inhibits delivery of material to an SBA either directly, or indirectly to the local sediment cell.	Shipwreck Bay, NZ St Francis Bay, South Africa	Undertake studies to determine whether sand supply is important to surf break functionality and manage planting accordingly.
In and around an SBA			
Beach nourishment	Changes in seabed morphology. Alters existing sediment budget. Effects can be positive or negative. Beach can overfill with sediment. Short-term water quality issues. Short-term access restrictions to SBA during works.	Gold Coast, Aus. Benedet *et al*. (2007) Dally and Osiecki (2018)	Undertake field investigations and modelling of coastal processes and iterate with proposed fill volumes and placement to produce desired outcome.
Construction of jetties, groynes, breakwaters, boat ramps and other hard structures in the nearshore	Structure can change the seabed directly and/or coastal processes. Significant knock on effects. Changes in wave quality can be both positive and negative. Complete or partial occupation of the SBA. Water quality issues during construction. Loss of natural character and change in landscape.	Manu Bay, NZ Ti Point, NZ Bastion Point, Aus. Kirra Point, Aus. Scarfe *et al*. (2003)	Undertake field investigations and modelling of coastal processes and iterate with proposed structure designs to minimise effects.
Dune planting programs	Reduced access by fencing off areas of the dune/beach. Building up the height and volume of the dunes restricts views. Limits cross shore exchange.	Piha, NZ (Dahm, 2013) North Narrabeen, New South Wales, Aus.	Provide walkway access to beach. Set limits on height of dunes. Promote native dune species.

Nearshore dredge operations	Removes sand directly from the nearshore bars and leaves (temporary) pits in the seabed. May alter wave refraction.	Pakiri, NZ Hilton (1989)	Undertake field investigations and modelling of coastal processes to predict and quantify effects to inform decision making.
Reclamation	See construction of jetties, groynes, breakwaters, boat ramps and other hard structures in the nearshore.	Wellington Airport Extension, NZ Mangamaunu Point, NZ Kuta Beach, Indonesia	See construction of jetties, groynes etc.
Recreational fishing	Conflicts between users sharing space, access, and occupation of specific areas. Entanglement of surfers in lines and tackle from boat and beach fishers, including remotely operated fishing devices (e.g. Kontiki). Burley can attract dangerous marine animals (e.g. sharks). Vehicular traffic on beach.	Manu Bay, NZ Whangamata Bar, NZ Atkin *et al*. (2017)	Educational signage at access points to beach.
River/Stream training	Changing or fixing the location of beach streams which naturally meander back and forth along the shore and along the beach may reduce the complexity of the nearshore. Can result in less ephemeral features and the creation of new established surf breaks.	Piha, Auckland, NZ Dahm (2013)	Undertake investigations of coastal processes to predict effects and inform decision making.
Shoreline armouring	See construction of jetties, groynes, breakwaters, boat ramps and other hard structures in the nearshore. Major effect from reflection of wave energy on both beach erosion (accelerated) and surfing wave quality.	St Clair, NZ	See construction of jetties, groynes etc.
Nearshore, Offshore and Swell Corridor			

Aquaculture	Wave are attenuated when passing through structures. Reductions in wave height and possible changes to wave direction. Can affect wave quality directly by modification to incident wave climate; and indirectly by altering existing coastal processes and sediment transport regime, resulting in change to the seabed. Increase in dangerous animals (e.g. sharks). Direct or partial occupation of SBA. Water quality issues. Access limitations.	Martha Lavinia, Aus. Taylor and Dempster (2016) Plew (2005)	Field investigations and modelling of coastal processes and iterate with options for farm structure in the model to minimise effects.
Dredging of port/harbours approach channels	Modification to incident waves. Sediment trap reducing littoral transport. Altered seabed configuration. Water quality.	Port of Tauranga, NZ Port of Napier, NZ Centreport, NZ	Field investigations and numerical modelling of coastal processes and iterate with options for channel alignment/depth/width/length in the model to minimise effects.
Dredge spoil disposal	Mounds on the seabed affect waves by refraction, diffraction and shoaling. Altered seabed configuration: impacts on incident wave conditions; impacts on SBA morphology; over filling of beaches; erosion if not placed correctly. Water quality. See Beach nourishment. Can result in positive impacts.	Aramoana, NZ Whareakeake, NZ Main Beach, NZ Superbank, Aus. Cronulla, Aus. (Pitt, 2009; 2010)	Field investigations and modelling of coastal processes and iterate with various option for mound dimensions and location to minimise effects at the SBA.
Large scale seabed mining	Pits and mounds in/on the seabed affect waves by refraction/diffraction Can result in changes to surfing wave quality either directly by modifying wave climate or indirectly through changes to sediment transport. Water quality issues.	South Taranaki Bight, NZ (Hume et., 2013; Mead, 2013)	Field investigations and modelling of coastal processes and iterate with various option for pit/mound dimensions and location to minimise effects at the SBA.
Oil Spills	Health and safety risk.	Rena Incident (New Zealand Coastal Society, 2014)	Follow oil spill prevention standards.

		New Zealand Marine Oil Spill Readiness and Response Strategy 2018-2022	
Wind or wave energy arrays	See Aquaculture. Potential to affect multiple surf breaks.	The Wave Hub, UK (Black, 2007) Port Fairy, Aus. (Flocard and Hoeke, 2017)	Field investigations and modelling of coastal processes and iterate with options for array structure in the model to minimise effects.
Social and technological			
Beach closure for events	Temporary occupation of SBA and nearshore (e.g. SLSNZ events, Surf Competitions, Training, Memorials, Festivals etc.). Competition for space. Exclusion from SBA to those not part of the event- raises "right to surf" conflicts. Water quality and littering issues associated with event.		Notify events well in advance via news channels and social media. Organised clean up after events.
Different surfing abilities	Learner surfers pose a significant health and safety issue due to a lack of experience and control. This is critical at more challenging surf breaks where an inexperienced surfer can be quickly out of their depth. Common occurrences are related to positioning and users getting in each other's way, the inability to control equipment especially around take off zones and when duck diving waves. Advanced surfers taking all the waves.	www.aotearoasurf.co.nz	Educate users about surfing etiquette: how to behave in the surf. Signage and education to push learners to safer areas.
Different surfing (water) craft	Shortboards, longboards, body boards, foil boards, Stand Up Paddleboards (SUPs), kite surfers, sail boarders, kayaks, surf/wave skis, body surfers all compete for water space and waves. Can result conflicts between users and injury.	Smallman (2018)	Educate users about surfing etiquette: how to behave in the surf.

Improved equipment	Improved wetsuits allow surfers to remain in the water for longer meaning less turnover of users and more users in the water at one time. New craft for wave riding being developed.	Bourne and Ponting (2017)	Bylaws and designating areas (e.g. specific areas for foil boards).
Improved facilities, infrastructure and access	Paved roads to sites lead to more users. New or improved facilities onshore (e.g. parking and toilets) make the experience more user friendly. More accessible air travel. The result may be overcrowding. Increased usage of surf breaks and the potential for conflicts at popular spots.	Manu Bay, NZ Seal Rocks, Aus.	Educating users about surfing etiquette.
Increasing surfer population	Overcrowding. Environmental damage through litter and damage to intertidal habitat. Potential for conflicts at popular spots.	Bourne and Ponting (2017)	Provision of facilities for parking, rubbish disposal, and camping. Signage and clearly delineated access routes.
Management requirements	Potentially exposes Surf Breaks of Local Significance and secret spots.	Atkin (2017) Orchard *et al*. (2019)	Designate broad areas without specifying particular breaks (e.g. Known Surfing Areas).
Overcrowding	Puts pressure on lesser known surf breaks. Leads to conflict between users. Pressure on existing facilities.	Bourne and Ponting (2017)	Improve facilities and signage educating users about surfing etiquette.
Surf forecasts and knowledge	Improved ability to predict good surfing conditions results in overcrowding when conditions are good; potential for conflicts at popular spots.	Mach *et al.* (2018)	
Surf tourism	See Improved facilities, infrastructure and access. Overcrowding.	Bourne and Ponting (2017)	
Use of SBA beyond surfing	See Recreational Fishing. Beach closure for (non-surfing) events.		Bylaws and dedicated areas (e.g. Ski lanes).

Table 2.5: Surf Break Sensitivity Rating. It is commonplace in the marine environment for the seabed to be made of a range of particle sizes. These guidelines have not considered mud bottom breaks.

	Potential Break Type	**General Material Size**	**Wave Quality Reliance on Sediment Transport Regime**
1	Rock Ledge; Reef	Consolidated Rock	Low
2	Reef; Point	↓	↓
3	Point; Beach; Delta	↓	↓
4	Beach; Delta	↓	↓
5	Delta	Fine Sand	High

Table 2.6: Consequence of activity

Consequence of activity	**Category**	**Definition**	**Example**
Catastrophic	1	Permanent/irreparable damage to/loss of the whole surf break(s)	Occupation of SBA Major reclamation Port construction
Major	2	Activity permanently effects access to and/or enjoyment of a surfing resource; and/or activity results in on-going health and safety issues; and/or potential for physical changes to a large part of the SBA; and/or a permanent change to the natural character, aesthetic or wilderness attributes of the surfing resource.	Complete loss of access to break (except by sea) Reduced ride length. Reduced wave quality Wastewater outfall Coastal protection works Coastal landscape altered by coastal development
Significant	3	Activity temporally effects, for sustained periods of time, access to and/or enjoyment of a surfing resource; and/or activity results in health and safety issues. No physical impacts	Turbid water Contamination Regulated access Ski-lane
Minor	4	Activity temporally effects access and/or enjoyment to a surfing resource for relatively short periods of time (e.g. <24 hours). No physical impacts	Beach closure for sporting events/surf carnival

Table 2.7: Likelihood of impact

Likelihood of impact	Category	Definition
Very Likely (Permanent/ Frequent)	A	Will obviously occur frequently and/or permanently, activity being undertaken in SBA; examples exist of impact; and/or a sensitivity rating: 5
Likely (Frequent)	B	Potential for activity to occur frequently, activity being undertaken in or near to SBA; and/or similar examples exist; and/or sensitivity rating: 3-4
Moderate (Occasional)	C	Potential for activity to occur, activity being undertaken near to SBA or within catchment; and/or examples exist; and/or sensitivity rating: 2-3
Unlikely (Remote)	D	Activity unlikely to occur, activity being undertaken outside of catchment and/or embayment; no examples exist; and/or sensitivity rating: 1-2
Highly Unlikely (Rare)	E	Activity highly unlikely to occur, activity being undertaken outside of catchment and/or swell corridor no examples exist; and/or sensitivity rating: 1

Table 2.8: Risk Rating

Risk Rating Table					
		Catastrophic-1	Major-2	Significant-3	Minor-4
Very Likely	A	Extreme	Extreme	Extreme	High
Likely	B	Extreme	Extreme	High	Moderate
Moderate	C	Extreme	Extreme	High	Low
Unlikely	D	Extreme	High	Moderate	Low
Highly Unlikely	E	High	High	Moderate	Low

2.4 Step 4: Surfing Resources in Policy and Plans

To effectively manage surfing resources, they must be incorporated into the appropriate legal and planning frameworks.

Table 2.9: Incorporating surfing resources into council planning documents (See Section 4.5 for further details).

<table>
<tr><th colspan="3">Objective: Incorporate surfing resource policy into the relevant parts of regional policy statements, coastal plans and regional coastal plan</th></tr>
<tr><th colspan="2">Components</th><th>Resources, Tools and References</th></tr>
<tr><td>1</td><td>Draft provisions for policy and plans that relate to:
o Nationally, regionally and locally significant surf breaks (as required)
o Outstanding natural character or high natural character
o Natural landforms in the coastal environment</td><td rowspan="2">Resource Management Act:
• Section 5; Section 6; Section 7
NZCPS 2010:
• Policy 2; Policy 6; Policy 13; Policy 15; Policy 16
Taranaki Regional Council (2016)
Auckland Council (2018)</td></tr>
<tr><td>2</td><td>Draft provisions for policy and plans regarding activities in the coastal environment relevant to surfing resources.</td></tr>
<tr><td>3</td><td>Have policy reviewed (include local Iwi) with an aim for inclusion in the next revision of plan/policy/document.</td><td></td></tr>
</table>

2.5 Step 5: Baseline Studies

Optimise the use of limited resources by undertaking studies/measurements at high priority sites. Activities that have the potential to impact on surf breaks will require monitoring conditions as part of the resource consent(s). See Appendix E for further details on surf break conditions and monitoring.

Table 2.10: Baseline monitoring (See Section 4.6 for further details).

Objective:		
Components		**Resources, Tools and References**
1	Select high priority sites for baseline studies based on risk rating, incorporate into annual and long-term plans.	Steps 1 to 3 above
2	Select monitoring methodology based on the potential threats.	See Appendix E Technical experts
3	Initiate monitoring as soon as possible in order to collate enough baseline data to characterise the surf break and determine natural variation.	
4	Compile the information in a database and make publicly available.	Geographical Information Systems Online data portals

Outcome and Actions

- Baseline monitoring established for priority surf breaks in the region
- Ensure a suitable and safe data archive is being used to secure baseline monitoring data.
- Note, other than ensuring that the monitoring data is fit for purpose, data analysis can be undertaken at any stage in the process (e.g. at a later stage when funding is available; by an independent consultant for surf break characterisation to support a resource consent). However, the suitability of a data collection programme is often best determined once data is analysed; therefore, early implementation of monitoring is extremely beneficial.

2.6 Step 6: Monitoring to Assess Change

To determine change occurring at a surf break (whether through natural processes or human-induced) there needs to be continuity in monitoring (Section 2.5) so that new data can be compared to baseline data. Data sets need to be sufficient so that short-term change, long-term change and natural variability can be identified.

Table 2.11: Monitoring change at a surf break (See Section 4.6 for further details).

Objective:		
Components		**Resources, Tools and References**
1	Select monitoring methodology based on the potential threats and the baseline monitoring data.	Appendix A Appendix E Technical experts
2	Analyse baseline data to characterise the surf break(s) and/or other associated variables (e.g. water quality, wave height attenuation)	
3	Analyse the monitoring data using the same methodologies as applied to the baseline data	
4	Compare the monitoring data to the baseline data to assess change	
5	Response to measured change. If change is detected, then the first consideration is whether or not the change is natural or human-induced.	See Appendix E Resource Consent Conditions Adaptive management Abatement orders

Outcome and Actions

- A monitoring database
- Secure monitoring data

Case Study: Shellfish and surf breaks

The Firth of Thames has a series of surf breaks that work during both short period wind-generated swell and longer period tropical cyclone swells. These breaks are unique in that they work when very few other breaks are surfable and are close to the growing Auckland population. Due to the steep gravel nature of the seabed at most of these surf breaks, the short-period waves can break with high intensity. Large aquaculture farms within the swell corridors of these breaks have the potential to negatively impact on these breaks by reducing wave heights. There is little understanding of wave transmission and attenuation through mussel farms. Given the uncertainty of the impacts on these surf breaks, appropriately design monitoring of wave attenuation and adaptive management strategies need to be applied. For instance, appropriate conditions of consent will need to consider wave measurements offshore and inshore of the proposed 460 ha mussel farm, before and after it is put in place in order to determine impacts on wave heights. Impacts could be managed through adaptive management such as managing stocking densities on the mussel droplines, which influences the level of wave attenuation.

Image: Marlborough District Council

3 Guidelines for Resource Users and Consent Applicants

This section of the guidelines aims to provide instruction on surf break characterisation and impact assessment to those who wish to undertake resource use and development activities within the CMA, inland waterways, catchment and coastal hinterland that may impact on a surf break(s).

The studies required to ensure sustainable management practice will depend on the site characteristics and nature of any activity. The steps prescribe in this section are broadly similar to that outlined in Section 2. However, a more in depth and site-specific understanding of the surf break's characteristics is required in order to assess potential and actual impacts and determine any requirements for conditions if necessary.

As described in Section 1.2, there are several aspects of surf breaks and surfing resources that are relevant to the RMA and the NZPCS, as well as regional and district plans, and these aspects require varying levels of protection from activities that may impact on them. This means that surf breaks must be considered in the Assessment of Environmental Effects (AEE) for resource consent applications.

Case Study: The Bar Saga

Whangamata Bar lies at the entrance to Whangamata Estuary and is one of 17 Surf Breaks of National Significance. There is ongoing debate as to whether the quality of the surf break has been compromised by anthropogenic activities, in particular the maintenance dredging programme for the entrance channel to the marina inside the harbour.

Image: J. Milek

Construction of the marina began in September 2008 and was completed by October 2009. Access to the marina along the channel required dredging of approximately 32,000 m^3 of material. Periodic maintenance dredging is employed to ensure the channel retains a depth of ~1.5 m below Lowest Astronomical Tide. Initial dredging was set at 2,000 to 3,000m^3 per annum, but has risen and in 2010 was consented at 10,000 m^3. While there are morphological differences in the bar's overall shape pre- and post-marina development, due to a lack of appropriate monitoring data it is debatable as to whether these differences are natural or in any way connected to the marina development. In 2012 the Surfbreak Protection Society (SPS) presented a report to the Hauraki Gulf Forum which triggered a review of the maintenance dredging consents. The review initiated a 4-year photographic study from 2013-2017 which SPS believe shows a direct link between dredging activity and morphological change in configurations of the flood and ebb tidal deltas and the tidal inlet throat which directly affect surf quality.

3.1 Identification of Surf Breaks, Swell Corridors and Threat/Risk Assessment

Table 3.1 provides key steps to assistant in resource consent applications.

Table 3.1. Identification of surf breaks, swell corridors and threat/risk assessment

Objective: Consent Application Requirements		
Components		**Resources, Tools and References**
1	Check with consenting authority for existing resources relevant to surf break management.	Regional, district and unitary authorities Department on Conversation www.surfbreakdata.org See Section 2 2.1
2	Identify surf breaks that may be affected by the proposed activity(s).	Technical expert
3	Complete any components in Steps 1 to 3 (Section 2) that have-not already been undertaken by consenting authorities relevant to the surfing resources in question.	See Section 2
4	Undertake a thorough literature review for relevant cases to determine actual and potential impacts	Technical expert
5	Engage a specialist in surfing resources to assist in completing the requirements of the resource application and provide relevant information for stakeholder engagement.	Technical expert
6	Stakeholder engagement – engage with stakeholders (including, but not limited to, local Iwi, surfers, resource managers, local businesses, etc.) as early as possible in the process. Collect data on attribute values of surfing resources.	Section 4.1 Appendix B Appendix C Orchard *et al*. (2019)
7	Cultural Impact Assessment	Section 4.5 Appendix C
8	Undertake an Assessment of Environmental Effects concerning the surfing resource(s).	Appendix E
9	Consider the actual and potential impacts identified in the AEE and propose, mitigation measures, conditions that include monitoring and how adaptive management will be implemented.	Appendix E

3.2 Detailed Characterisation

Detailed characterisation is not only required to gain a high-level understanding of the mechanics of a surf break, but to determine criteria/thresholds levels with respect to conditions of resource consents. Detailed characterization will require technical input from and expert. Detailed characterization and monitoring are intrinsically linked (Section 2, Step 5 and Step 6); monitoring to some degree has to be undertaken to develop detailed characterization; the learnings from which will likely inform further monitoring.

These recommendations are an extension of Section 2: Guidelines for Authorities; however, it is likely that the methods presented in this section are, or will initially, be applied to specific surfing resources.

Table 3.2: Detailed characterisation

Objective: Detailed Characterisation of Surf Breaks		
Components		**Resources, Tools and References**
1	Up to date surfer knowledge transfer.	Stakeholder engagement Section 4.1
2	Initiate monitoring and data collection as soon as possible.	Scope as per Section 2.5 – baseline studies
3	Undertake detailed desktop assessment.	literature review and historical shoreline change wwww.surfbreakdata.org
4	Analysis of collected data.	Technical expert
5	Establish calibrated numerical model(s).	
6	Construct calibrated swell corridor.	Atkin and Greer (2019)
7	Determine wave breaking characteristics.	Appendix A Technical expert
8	Determine surf break formation and maintenance mechanisms.	

Should the resource consent be granted which has the potential to impact on a surf break(s), then appropriate consent conditions will be specified (see Appendix E – Conditions for Resource Consents). Such conditions will include monitoring to assess change (as set out in Section 2.6 above), and adaptive management provisions to avoid, remedy or mitigate any impacts detected by monitoring.

4 Additional Information for Users

This section provides further detail and discussion around each of the guideline steps/components provided in Sections 2 and 3.

4.1 Stakeholder Engagement

Any required stakeholder engagement should include local Iwi, surfers, authorities, local businesses, residents and property owners. Appendix C details considerations and provides useful resources for engagement with Mana Whenua.

Stakeholder meetings/workshops should be undertaken early in the process to both inform stakeholders and gain a thorough understanding of surf break characteristics. Information such as the area(s) being used, usage/frequency, values and other information pertaining to the form and function of the surf break(s) should be recorded as minutes and provided back to stakeholders for comment, which will, more often than not, provide a greater level of detail. These meetings/workshops provide an opportunity to discuss elements relevant to a CIA (Section 4.5).

Figure 4.1: Stakeholder consultation is critical to the successful development of surf break management strategies. Aerial photos annotated with information about surf break characteristics, usage, threats and coastal processes are useful tools to inspire and focus discussion.

4.2 Identification of Surf Breaks

City, district and regional councils, and unitary authorities are collectively responsible for the management of Aotearoa New Zealand's waterways, catchments, coastal hinterland and CMA. The responsibilities of these authorities in regard to surfing resources is twofold. Firstly, there are ongoing obligations to resource management under the NZCPS and associated unitary, regional and district plans. Secondly, authorities, to varying extents, are responsible for and/or involved in, the consenting of activities.

A consistent theme in Policies 13 and 15 of the NZCPS is the identification assessment of natural features and natural landscapes of the coastal environment with particular regard to "*natural science factors, including geological, topographical, ecological and dynamic components*" (Policy 15).

There is a wealth of information available online and in published literature regarding surfing locations. Surf and beach guides are a good starting point (e.g. Bhana, 1996; Morse and Brunskill, 2004; Rainger, 2011; NZSurf Guide, 2013 etc.). However, these guides may not provide information on all surfing resources within a particular area.

Surfers, especially those that are local to and/or have a history with a particular area of surfing can acquire in depth knowledge about the coastal environment and about wave resources in particular (Reineman, 2017). Engagement with such stakeholders is imperative to identifying surf breaks and understanding value attributes (Orchard *et al*., 2019). Undertaking surveys (in person, online) or workshops is very valuable in extracting surf break information from the surfing community (Peryman, 2011a, b; Atkin *et al*., 2017; Reineman, 2017). Organisations such as Boardriders Clubs, Surf Life Saving NZ (SLSNZ), Surfing NZ and the Surfbreak Protection Society (SPS) are ideal starting points. However, it should be noted that these organisations are not representative of the whole surfing community and many local surfers may not be affiliated. Therefore, additional effort is required to engagement with the wider surfing community, such as the use of surveys, publicly advertised workshops, and snow-ball sampling strategies whereby stakeholders identify other potential participants for engagement (Salganik and Heckathorn 2004).

During the Department of Conservation's *Review of the effect of the NZCPS 2010 on RMA decision-making* (Department of Conservation, 2017a, b), it was noted to the review group by the surfing community that some surf breaks around Aotearoa New Zealand are more significant than those listed in Schedule 1 of the NZCPS; and that there is a reluctance to identify surf breaks as this would expose them to a larger group of users.

The general inclination of surfers to keep the number of participants at a surf break to a minimum is a ubiquitous issue in surfing resource management. "Secret Spots" are perceived as being known to a few, closely guarded and/or challenging to access (Orchard *et al*., 2019). Following the identification of surf breaks that fall in to the “secret spot” category, Atkin and Mead (2017) recommended, with a view to avoiding discord within the surfing community by exposing specific surfing locations, identifying Known Surfing Coastlines (KSCs), were surf breaks along these coastlines could fall under the title of Surf Breaks of Local Significance (SBLS). This approach is ambiguous and non-descript, with the aim of concealing specific details regarding the surf breaks and maintaining their “secret” status. At the same time this method bookmarks their existence should management decisions concerning a section of coast be required (Atkin, 2017). Orchard *et al*. (2019) have likened the approach of Atkin (2017; after Atkin and Mead, 2017) to the ‘silent file’ approach used by Ngāi Tahu for culturally sensitive sites that tangata whenua do not want publicly disclosed (Tau *et al*., 1990).

Delineation between varying levels of significance and priorities is a strategy often favoured by authorities as it assists with prioritisation of resources. Whilst the NZCPS 2010 does not provide a specific mandate to identify regional and local surf breaks within Policy 16, other policies (13, 15) certainly foster such an approach. Categorising surf breaks as nationally, regionally or locally significant, as well as identifying ‘nursery breaks’ was discussed in the Board of Enquiry (2008a, b) for the development of the Proposed NZCPS 2010; and is reviewed in Orchard *et al*. (2019).

Taranaki Regional Council are the only authority to have defined Aotearoa New Zealand’s first ‘Nationally Significant Surfing Area’ (Taranaki Regional Council, 2016; Orchard, 2017). This approach is a sizable step up from the regionally significant Surf Break Areas of Atkin *et al*. (2015) and Atkin and Mead (2017) that hosted multiple surf breaks and recognized that the wider area of surf breaks holds significant economic, social and amenity value. Furthermore, it is a step towards a national surfing reserve as developed in Australia (Farmer and Short, 2007) and the World Surfing Reserves (Skellen *et al*., 2009; 2013; Short and Farmer, 2012) that are being accredited globally.

The approach taken by authorities in delineating surf breaks, if any, should be undertaken on a case by case basis. The delineation of surf breaks at national, regional and local levels is viewed by some stakeholders as inappropriate. The concern being that the locally significant bracket may offer less protection in policies and plans. An assessment needs to reflect on the attributes of a surfing resource discussed in Orchard *et al*. (2019) (see Section 1.2.1; Appendix B); and also consider the most sustainable way of managing surfing resources.

4.3 Swell Corridors

A swell corridor is defined in the NZCPS as "*the region offshore of a surf break where ocean swell travels and transforms to a 'surfable wave*". A swell corridor is essentially an offshore extension of a Surf Break Area (Atkin and Greer, 2019).

To date, determination of swell corridors has been a numerical modelling exercise (Figure 4.2), with the aim of creating a spatial dataset to aid in the management of surf breaks. A swell corridors data base provides a useful planning tool for authorities when considering the potential impacts of activities in the CMA. The process is similar to regional scale coastal hazard zoning, in that this information can be applied as the first order assessment, and a more in depth, site-specific assessment should be undertaken during any resource consenting process.

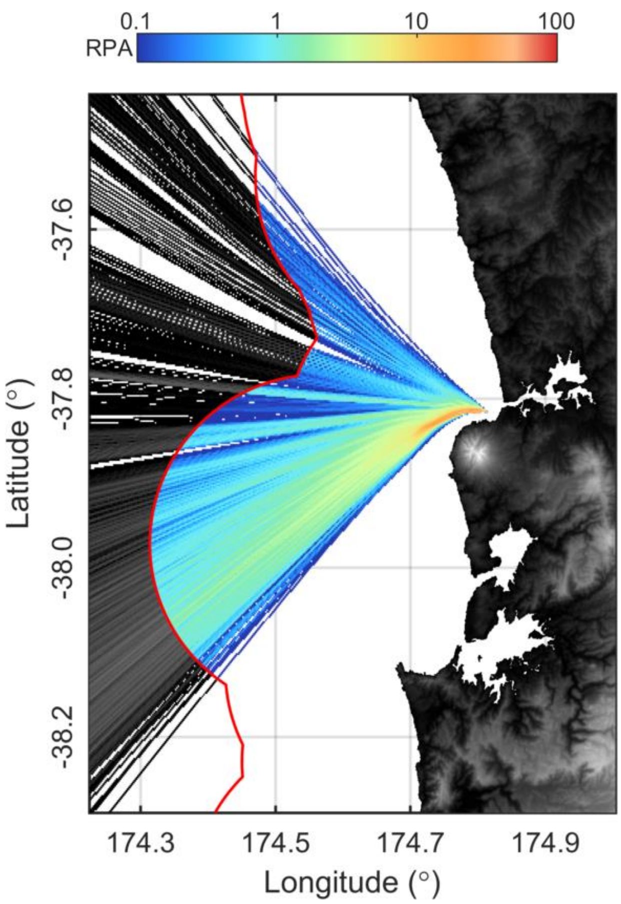


Figure 4.2: Swell corridor presented as Relative Percent Activity (RPA) determined by streamlines from numerical model output for Manu Bay. Data outside the territorial sea (red line) is shown in greyscale (Atkin and Greer, 2019).

In developing a first order assessment tool for Surf Breaks of Regional Significance in the Waikato (e.g. Figure 4.3), Atkin and Mead (2017; after Atkin *et al*., 2015) used an uncalibrated numerical modelling framework. In the case of Atkin and Mead (2017) the extent of the swell corridor and adjacent buffer zone were determined based on percentage occurrence of a particular wave condition. Buffer zones were included for the following reasons (in no particular order): to account for Policy 3 of the NZCPS: A precautionary approach; while numerical modelling is an appropriate tool for studies such as this, the model used here has not been calibrated; numerical modelling is always limited by some form of grid resolution; and, any developments proximal to an established SBA have the potential to affect wave conditions within that SBA (e.g. a seawall adjacent to, but not inside an SBA may cause wave reflections and alterations to wave breaking properties within the SBA). Atkin and Greer (2019) present and discuss different methodologies for constructing swell corridors. For a detailed assessment they use a Relative Percentage Activity (RPA) that considers the contribution of different areas to surfable conditions for a surf break.

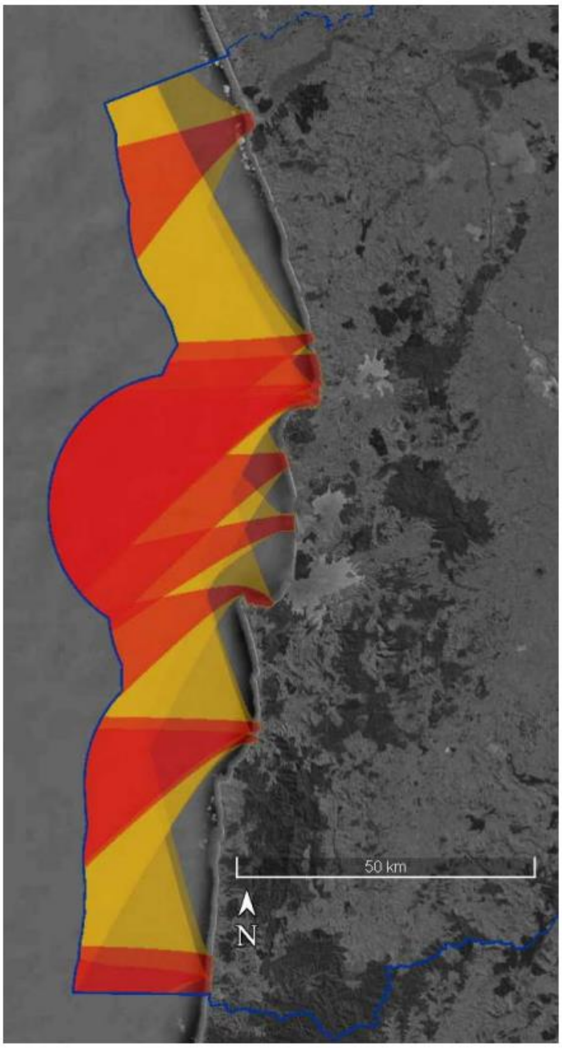


Figure 4.3: Planning tool for Waikato Regional Council constructed by Atkin and Mead (2017).The image shows swell corridors (red) and buffers zones (amber) GIS layers for Surf Breaks of Regional Significance on the Waikato region's west coast. The blue line is the regional boundary (blue).

4.4 Threats and Risk Assessment

Surf breaks are threatened by a wide variety of activities that can occur both naturally in the environment and from direct human impacts. Identifying potential and existing threats to surf break amenity requires a geographically wide consideration of activities, not only in the place where waves are being ridden but also in the associated swell corridor, surrounding waters, and on the adjacent land. It also requires consideration of the effects on "surfing capital"; the four factors that shape the surfing experience namely: 1) physical features and surfers' awareness of the quality of waves, 2) the frequency and quality of waves, 3) the coastal and marine environment and 4) the social and cultural issues associated with places (Lazarow 2010; Bourne and Ponting, 2017, p125).

Once a surf break has been identified, an assessment of the surrounding environment and an understanding of the kinds threats that are likely to occur in this environment is required. It is likely that the activities and developments that have the potential to threaten a surf break are broad and varied, and can include construction of new structures, disturbance of the seabed and foreshore, water quality and ocean outfalls, restricted access, changes to sediment supply and tidal currents.

Structures and disturbance of the physical environment that have the potential to impact on a surf break include activities and developments offshore (e.g. aquaculture, renewable energy, dredge disposal, seabed mining), in the nearshore and on the foreshore (e.g. ports, marinas, piers, coastal protection structures), within estuaries and harbours impacting on tidal prisms (e.g. marinas, causeways) and land-based developments that impact on water quality (e.g. wastewater treatment, processing plants, changes in land-use (e.g. urbanisation). It is likely that many of the risks and threats are ubiquitous across a region (Atkin and Mead, 2017). However, it is also likely that some surf break areas will be at risk to specific activities.

Surf breaks located proximal to harbours and estuaries are likely to be dependent on the hydrodynamics associated with the enclosed waters to maintain surfing conditions (e.g. Whangamata Bar); these types of surf breaks can be extremely sensitive to changes. Alterations to an enclosed water body by dredging activities or reclamation will change the tidal prism, and this can have knock on effects on local sediment transport processes; noting that attribution of these changes may be difficult to discern from natural variability and natural long-term evolution without well designed monitoring.

Water quality at surf breaks is linked with waterways and enclosed waters (harbours/estuaries). There are locations where storm or wastewater discharge to surf break areas; and if not directly, then currents can transport contaminated waters into SBAs. Discharges from forestry and farming activities occurring tens of kilometres inland and can be delivered to an SBA through waterways (e.g. Figure 4.4). These factors need to be considered when assessing the risks to surfing resources (Skellern *et al*., 2013).

Figure 4.4: Potential effects of land management. Allowing stock to access waterways has the potential to affect the environment in many different ways, some of which are keenly observed and felt by surfers who spend prolonged periods of time in the receiving waters. The effects are readily observed at delta breaks where rivers and estuaries discharge sediment and pollutant laden water into the coast. Left image shows waterway with no riparian separation (image: PhotoNZ) and right image an undisclosed river bar looking an uninviting shade of brown despite the high-quality waves on offer (image: J. Aubertin).

When determining the threat of an activity, the vulnerability and sensitivity of the receiving environment need to be considered. S*ensitivity is the degree to which the system responds to stresses, which are deviations of environmental conditions beyond the expected range; and* vulnerability is the probability that a feature will be exposed to a stress to which it is sensitive (Zacharias and Gregr, 2005).

When assessing risks to surfing resources the likelihood of an event leading to a consequence that is harmful to the environment needs to be considered. The threats presented in Section 2.3 provide a good starting point to assess risks to surfing resources., However, there are likely to be other site-specific activities and processes that have not been included. The likelihood of the activity having an impact on a surfing resource, including, but not limited to, surfing wave quality, coastal processes, access and amenity value, naturalness (environmental setting) and wilderness values, levels of use, economic value, and historical/heritage/cultural associations, also needs to be assessed.

It should be noted that activities can also impact on a surfing resources in a positive way, with improvements to fundamentals such as access and water quality. There is a history of engineering works improving surfing conditions, and in some cases creating a new surf break where there was none before (e.g. there are some occasions where coastal engineering works such as training walls, sand-bypassing and groynes/breakwaters have enhanced or created new surf breaks). However, this can be at the expense of existing resources, and the history between surfing resources and engineering works is largely dominated by degradation and destruction (Scarfe *et al*., 2009b). Many threats can be addressed, at least to some degree, by some management intervention action at source. Others, such as natural changes in wave climate or overcrowding at breaks due to population increase, cannot.

4.5 Cultural Impact Assessment

A useful tool to obtain iwi perspectives on a proposed environmental activity is a Cultural Impact Assessment (CIA). A CIA is a planning tool that helps to facilitate Māori participation in the planning process. The CIA report documents Māori cultural values, interests and associations with an area or a resource, and the potential impacts of a proposed activity on these. A resource consent applicant may commission a CIA and the report is regarded as technical advice. A CIA is not a statutory requirement for a resource consent application. However, an assessment can assist the applicant and consenting authority in responding to issues affecting local iwi. In this respect, a CIA can:

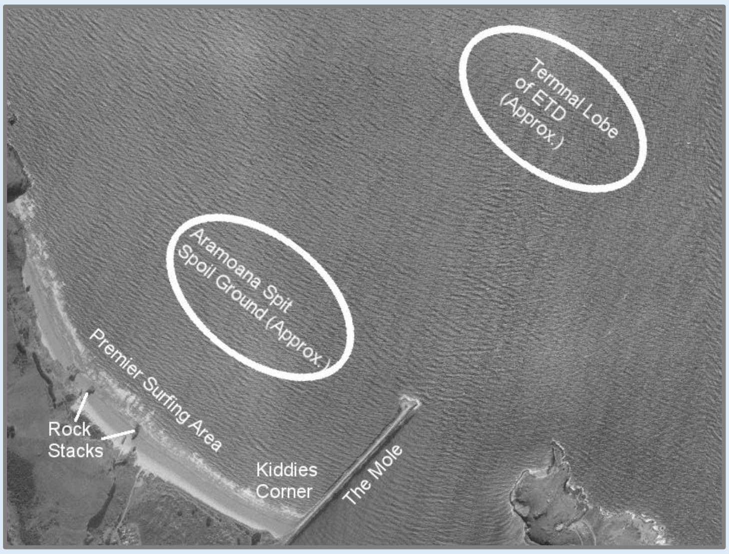
- Identify the effects of a proposed activity on local iwi cultural associations with the environment.
- Identify or assist identification and formulation of methods to avoid, remedy or mitigate adverse effects on cultural values and associations.
- Suggest what conditions of consent could be applied if consent is granted.
- Provide iwi with comprehensive information and improved understanding of the proposed activity.

A CIA can complement the attribute value data, and threats and risk assessment data to provide a rich assessment of the diverse values and interests that community/iwi/hapū have for surf breaks from varying perspectives. The development of a CIA is important as NZCPS Policy 2 requires councils to acknowledge Māori values and include them as part of the decision-making process. See Appendix C for resources relating to CIAs.

4.6 Surfing Resources in Policy and Plans

While Policy 16 does not state that regionally or locally significant surfing resources should be accounted for, the overarching ethos of the NZCPS is sustainable management and it provides polices to protects all surf breaks by ensuring recognition is given to outstanding natural character and natural features (See Section 1.2 Legislative Context). To date there is a significant list of cases in Aotearoa New Zealand where impacts on surf breaks have been recognised and incorporated into the AEE's for resource consent application and/or challenged in Environment and High Courts. These cases have not been restricted to the surf breaks named in Policy 16 of the NZCPS (2010), and include Town Reef (Napier), Kaituna Cut (Bay of Plenty), Mangamaunu (Kaikoura; SBNS), Takapuna Reef (Auckland), Whangamata Bar (Coromandel; SBNS), several breaks along the western Firth of Thames (Auckland), the Corner and Lyall Bay (Wellington), Taylor's Mistake (Christchurch), Whareakeake and Aramoana (Dunedin; SBNS), Titahi Bay (Wellington), Waiwhakaiho (Taranaki) and Waipaoa River Mouth (Gisborne).

Case Study: Dredge spoil surf



The Spit at Aramoana is one of the 17 Surf Breaks of National Significance. The wave quality is largely determined by the way in which waves are preconditioned by offshore bathymetry. Primarily, waves are focussed on the terminal lobe of the ebb tidal delta at the entrance channel to Otago Harbour; secondarily wave crests are modified on a historical nearshore spoil ground. The main threat to the surf break at Aramoana is the disposal of material in the nearshore spoil ground. Disposal began here in the early 1980s, at which time some of the best surfing conditions were reportedly experienced. Early in the 21st century there was a general concern that Aramoana was no longer providing the high-quality surfing waves that it had in the past. It was considered by some that continual addition of sand not only impacted the secondary preconditioning processes, but that the embayment had become over-full with sand forming a large shallow platform in the nearshore. After objections to a consent for increased disposal quantities a working party was formed comprising of representatives from Te Runanga Otakou, Kati Huirapa Runanga ki Puketeraki, Department of Conservation, Otago Regional Council, Surfbreak Protection Society, South Coast Board Riders Association, Aramoana Conservation Trust and Port Otago Limited. The working party agreed to a 3-year temporary permit with greatly reduced disposal at the nearshore site, combined with a monitoring and modelling investigation to determine the impacts of nearshore disposal at Aramoana. No dredge material was placed at Aramoana for the first 2 years, during which time it was perceived by all parties involved that surfing conditions had improved.

The consistent themes in Policies 13 (preservation of natural character) and 15 (natural features and natural landscapes) are identification and ensuring that there are specific objectives, policies and rules. It is recommended this approach is taken with surfing resources.

"*Planning approaches based on recognising a list of surf breaks of higher relative importance than others are a potential mechanism for achieving policy objectives, and similar concepts have been applied to the management of other natural resources"* (Orchard, 2017, p.11).

As previously discussed, while a hierarchy may work for some authorities, others may choose an alternative approach, individual break identification or such as a blanket protection for all surfing resources in the region. The latter may be applicable if it is simply too complex to discern between levels of significance, or there are so few surf breaks in a region that they all regionally significant.

4.7 Baseline Monitoring

Baseline monitoring is required in order to determine whether or not an activity impacts on a surfing resource. Baseline monitoring is focussed on the collection of data that can be used to characterise the surf break (i.e. length of ride, wave climate, tidal phases, peel angle, breaking intensity, local seabed morphology etc.). Baseline monitoring methods can include:

- Remote video data collection – this is most cost-effective method of collecting surf break data, which can be used to determine peel angles, ride length, optimum conditions, typical take-off and break location(s), infer seabed morphology, shoreline position and provide information such as number and type of users;
- Hydrographic surveys – repeat collection of bathymetric data provides information on the variability of the seabed;
- GPS tracking of surfers – can be applied to determine peel angles, ride length, take-off area, sections of the wave, and entry and exit points to the surf break;
- Beach profile monitoring – can use traditional surveying methods or Light Detection and Ranging (LiDAR);
- Numerical modelling – calibrated numerical models can be used to simulate the existing surf break during various wave events, as well as consider the potential impacts of any changes to the existing environment that may impact on the surf break (e.g. nearshore dredge disposal mounds, harbour channel deepening, offshore sand-mining, shoreline protection structures etc.);
- Water quality monitoring – activities such as nearshore dredge disposal, dredging, stormwater outfalls, wastewater outfalls, aquaculture, forestry, farming and urbanization can potentially impact on water quality.

Due to the natural variability and seasonality of the marine environment it is important to collect baseline monitoring data for as long as possible; multi-year datasets provide information on the effects of longer-term oceanographic variation such as El Nino/La Nina. See Appendix E for further discussion on surf break monitoring.

Water quality standards should follow Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas (Ministry for the Environment, 2002). However, sampling sites must be proximal to surfing areas, which can be significantly different to bathing areas (e.g. in a river mouth not central to beach), and should target the pollutant (e.g. some pollutants will be mixed throughout the water column, others may be in the upper layers (wastewater/stormwater is less dense than seawater), or lower layers (e.g. hypersaline water from desalination is denser than seawater)).

Surf break monitoring data can provide other valuable information for coastal management. For instance, remote video cameras can provide statistics on users of the coastal space (not only of surfers, but other water and beach users), erosion/accretion trends, the movement of rips and bars (e.g. safety issues), and information on extreme events and coastal hazards. There is an opportunity to incorporate surf break baseline data collection into any long-term environmental monitoring strategy.

4.8 Considerations for Consenting Authorities

A consenting authorities' obligation under the RMA (104(1)(b)) is to have regard to the NZCPS 2010. *The NZCPS 2010 will not determine whether or not an application is notified but may assist in identifying relevant effects to consider in a notification determination.* Appendix E provides information regarding consent conditions that can be applied to ensure that an activity does not adversely affect a surfing resource. The consent conditions required will vary from site to site and the responsibility to ensure compliance with the consent conditions will often fall to an authority's coastal expert. Considerations for the consenting process include:

- A precautionary approach should be taken if there is any potential for impacts on a surfing resource. In almost cases there will no data available on the existing resource.
- It is the conditions of consent that are fundamental to ensuring that not only is the monitoring design appropriate to detect and quantify effects, but also include methods that counter these effects through avoidance, remedying or mitigation.
- A correctly undertaken CIA will ensure iwi perspectives are included in the consenting process.
- Activities well outside of the CMA can potentially impact on surfing resources, both inland and offshore. Consideration in the context of the NZCPS should be given to

surfing resources where an activity is being undertaken on or adjacent to any waterway in the coastal hinterland.

- Impacts on surfing resources need to be evaluated on a case by case basis and the consequence of cumulative impacts need to be considered.
- Surf science is a very specialist field and it is likely that most coastal scientists will have little to no experience or exposure to surf science as it is not readily taught at any institution in Aotearoa New Zealand. Depending on the nature of the consent application, it may be prudent to engage a specialist surf scientist with a track record in studying natural surf breaks and surf break mechanics.
- The RMA controls specific uses of natural and physical resources through the requirement of a resource consent. In order to gain resource consent for specific activities, an Assessment of Environmental Effects (AEE) is required in an application.
- Water quality issues are significant for surfers, and more so than average water users, as they are often exposed to the environment for prolonged periods of time. Many surf breaks are located next to or near to rivers and estuaries, and it is common practice in Aotearoa New Zealand to direct stormwater in to the nearshore. Water quality standards should follow *Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas* (Ministry for the Environment, 2002). However, sampling sites must be proximal to surfing areas, which can be significantly different to bathing areas (e.g. in a river mouth not central to beach), and should target the pollutant.

4.9 Detailed Characterisation

Detailed characterisation of a surfing resource requires an amalgamation of various investigative methods to determine peel angles, ride length, optimum conditions, breaking intensity and the variety of other surf break characteristics (breaking intensity, take-off zone(s), sections, etc.).

Numerical modelling is a valuable and cost-effective approach, and a critical step in detailed characterisation is model calibration. Calibration is achieved by the collection of environmental data at the site of interest. In the case of surf breaks, this would primarily include wave, current and water level data; calibration may also benefit from the collection of wind and pressure data.

To establish an accurate wave climate (e.g. Figure 4.5), a combined model that simulates water level, currents, wind and waves is required. This calibrated, combined model can be used to develop boundary conditions for more detailed models that consider complex wave breaking and sediment transport processes. In addition to surf break characterization, any changes to waves and currents induced by a proposed activity have the capacity to impact on the seabed morphology at a surf break. Therefore, sediment transport and morphological modelling are a critical step in a surf break AEE.

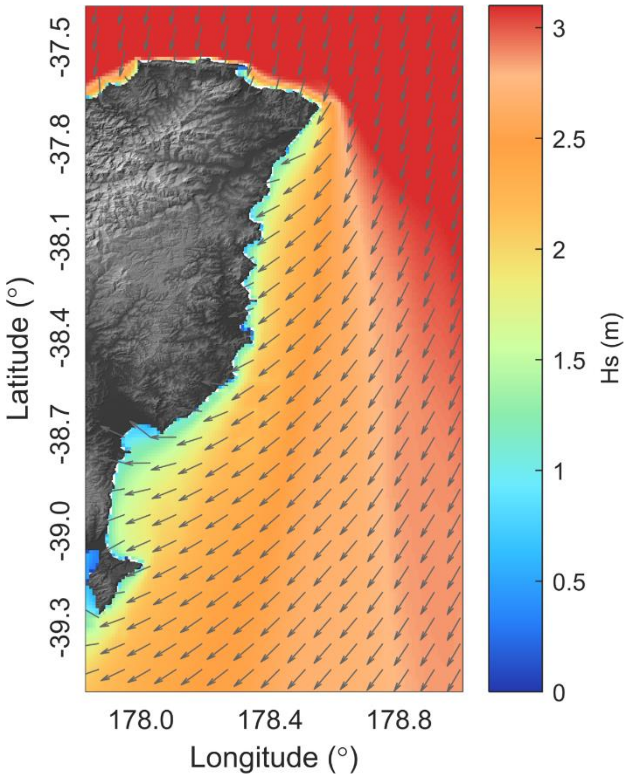


Figure 4.5: Example of numerical model output of wave height (left colour bar) and direction (arrows) around the East Cape during Tropical Cyclone Ivy's passage down the east of the North Island in 2004.

Wave breaking is extremely dynamic and a numerical model using higher-order approximations of the processes of wave propagation, shoaling and breaking is required. Higher-order numerical models are generally referred to as phase resolving models[10]. These models look at waves individually, rather than in an averaged way like those models used to simulate wave climate. Certain situations will require Computational Fluid Dynamics (CFD). A common branch of CFD is Smooth Particle Hydrodynamics (SPH). These types of models run 3-dimensional simulations of particles and can provide a further insight in to the dynamics of surfing waves. SPH is particularly useful for understanding situations where waves exhibit high breaking intensities over low seabed gradients. This type of scenario can be the result of

[10] Some phase resolving models are based on the Boussinesq approximation. Therefore the terms are often used in tandem, however, there are non-Boussinesq-type phase resolving models.

disruptive focusing or wave reflections, or a combination of both. Where post processing of phase resolving models would indicate low breaking intensities over the low seabed gradients, SPH output can exhibit wave shape in line with what is observed in reality.

Sediment transport modelling is complex and requires data relating to the sediment types at the study site and input conditions from a combined model. However, taking in the context of coastal processes and in situ measurements, in some cases they are an invaluable tool to aid with the understanding and characterisation of surf breaks. There are different approaches to sediment transport modelling, with characteristic and reduced wave climates being employed to simulate long term morphodynamics. Ultimately, sediment transport modelling considers how (beach) morphology changes over time, this can then be used in conjunction with detailed wave breaking models to determine how these changes effect surfing wave quality. Because sediment transport modelling looks at changes to the seabed, an appropriate method for validating the model is to undertake repeat hydrographic surveys to collect bathymetric data.

Case Study: Bigger planes, smaller waves

At Lyall Bay in Wellington there are several peaks for surfing along the beach. The premier surf break is a left-hander called “The Corner” (also known as “The Wall”). The Corner is a modified beach break that benefits from wave preconditioning by the interaction of incident wave crests with the airport runway sea wall. In 2015, plans were announced to extend the airport runway into the bay by 350 m to accommodate larger airliners. The extension will cover and destroy the rarely surfed big wave spot of Airport Rights, and reduce surfing amenity throughout Lyall Bay. Initial impact studies indicated that there will be a reduction in the number of good surfing waves. Anecdotal evidence suggests that the wave quality in the “The Corner” has, over the past years, already been negatively affected by several factors including a reduction in the reflectivity of the wall as sheet piling has been progressively covered in rock rip rap, a widening of the rock revetment, and a carpark extension. Changes to the nearshore wave climate are likely to result in changes in wave-driven currents, which may alter the seabed morphology, and consequently surfing waves as they propagate shoreward. Whether the impact will be negative or positive is currently unknown and not yet investigated adequately. A multipurpose reef has been proposed as mitigation for the loss of surfing amenity.

The most practical and useful times for collecting bathymetric data are whilst instrumentation is deployed to collect environmental data. This allows a direct evaluation between bathymetric data and actual (not simulated) forces (waves, water level and currents) that drive shoreline change.

The versatility of a calibrated numerical model is enhanced by additional data collection that can be used to validate the model outputs and will also often be necessary for baseline monitoring data. For example, remote video imagery can be used to validate particular swell events in terms of wave peel angles, and GPS tracking of surfers can provide additional confidence in surf break characterization and numerical modelling by identifying aspects such as take-off zones and ride lengths. As detailed in Appendix E remote video and GPS tracking are an important part of surf break monitoring.

5 Summary and Outlook

These guidelines provide a background to mapping, assessing and quantifying surfing resources within Aotearoa New Zealand. The document aims to clearly present stakeholders with the considerations concerning surfing resources for use in either preparation of consent applications, assessing submitted consent applications, or in submissions on applications.

The guidance provided is within the context of the Resource Management Act 1991 and the NZCPS 2010. Planning and policy documents are likely to require explicit recognition of surf breaks, and provisions for surfing resources are likely necessary for their protection and management as natural resources in Aotearoa New Zealand.

The main body of this document sets out a framework to aid in managing surfing resources. For authorities the key steps are:

Step 1 Identifying and mapping surf breaks
Step 2 Mapping swell corridors
Step 3 Identifying threats and risk assessment
Step 4 Incorporating surf break provisions into policy and plans
Step 5 Baseline studies
Step 6 Baseline monitoring

For Resource users and consent applicants the key steps are:

Step 1 Identification of surf breaks, swell corridors and threat/risk assessment
Step 2 Detailed characterisation

There are a number of key concepts and ideas that require consideration:

- Surfing resource boundaries are part of a shared ecosystem encompassing the beach, the sea, the catchment and stakeholder interests.
- Surfers are coastal environment stakeholders, they form influential lobby groups (e.g. SPS), and others are traditional resource custodians (Iwi).
- Surfing capital, the four factors that shape the surfing experience are 1) physical features and surfers' awareness of the quality of waves, 2) the frequency and quality of waves, 3) the coastal and marine environment, and 4) the social and cultural issues associated with places.
- Different sites are valued for different aspects (wilderness, big waves or easy access)
- Surfers do not only surf for 'the thrill of the ride'. The sense of freedom of riding the wave, the connection with the elemental forces of the wave, the aesthetics of the

surrounding landscape, the social interactions with mates, and the coastal environmental quality all contribute highly to the surfing experience. As a consequence, all these factors need to be accounted for in managing the resource and threats against it.

- Surfing is a growing sport, as are water activities, so competition for space will increase.
- Threats to surf breaks come from the land and sea and for cultural reasons.
- It is possible to enlist the help of the general public to collect information on surf breaks (referred to as citizen science).
- Numerical modelling is a powerful tool to understand the effects of changes in the surf break environment to a high level of detail.
- Output from monitoring is inherently limited because of the high degree of natural variability. Long term changes to our wave climate drive interannual changes to morphology and the characteristics of wave conditions at surf breaks, and anthropogenic changes need to be greater than natural changes to allow detection of anthropogenic effects.

Looking ahead, and as the number of participants using surf breaks continues to grow there will be more pressure on the known surfing resources. This will result in a change of use, whereby users frequent lesser known surf breaks to enhance their own enjoyment. Access to the lesser known and ‘hard to get to surf breaks” may also be facilitated by access via new roads or watercraft. In some areas the reverse may happen and access to know surf spots may be restricted. It is therefore recommended that the list of surf breaks and the value rankings for breaks in a council region should be reassessed prior to each iteration of the coastal plan and/or at a time frame deemed suitable by the council that allows for breaks to be included on time scales consistent with population growth, and demographic and social change.

6 Glossary

Big wave surfing – a sub-discipline of surfing focussed on riding the largest of waves. This sometimes requires the use of larger than average surf boards or for surfers to be towed-in to the wave by a jet ski (personal watercraft). Big wave surfers undertake specialist training and the sub-discipline has fewer dedicated participants. Big wave surfing locations are relatively sparse in time and space with very particular seabed configurations and incident swell conditions required. A big wave surf break can be referred to as **Bombora**.

Clean – best conditions for surfing and occur in conjunction with light or offshore winds (i.e. there are no local winds creating additional swell components; see below; see Appendix A). Mixed swells occur when there are several wave direction and period components occurring at the same time. Clean swell has a narrow spectral width, while mixed seas have wide spectral width.

Iwi – the largest Māori social unit. Iwi can be translated as 'tribe'. All Iwi throughout the Aotearoa New Zealand have a vested interest in their respective geographical region.

Kaitiaki - a person, group or being that acts as a guardian, carer or protector.

Kaitiakitanga - the exercise of guardianship by the Iwi of an area in accordance with Māori values and customs in relation to natural and physical resources and include the ethic of stewardship.

Offshore wind – wind direction and wind strength are important factors with respect to surfing wave quality. Typically, light local winds provide ideal surfing conditions. Offshore winds, that is a direction heading out to sea, perpendicular to wave crests, can "**clean**" waves faces making for improved surfing conditions, the direction of offshore wind, which is always stated as direction coming from (e.g. southerly), is considered the optimum wind condition. It should be noted that preferred wind direction is as subjective as surfing wave quality and comes down to participant choice.

Peak – the part of the wave which breaks first and so is also known as the take-off. Wandering or shifting peaks means that there is no defined take-off zone.

Peel – surfers require a clean unbroken wave face for performing surfing manoeuvres. In order to ride the wave for as long as possible, the wave must peel where the breaking part of the wave crest translates laterally across the face of the wave. This is opposed to a wave that breaks simultaneously along its length, which is referred to as a "close-out". Waves can peel fast or slow.

Rohe – is the region or land that forms the tribal boundary of a particular Iwi.

7 Acronyms

AEE – Assessment of Environmental Effects

CIA – Cultural Impact Assessment

CMA – Coastal Marine Area

GPS – Global Positioning System

KSC – Known Surfing Coastline

LiDAR – Light Detection and Ranging

MBIE – Ministry for Business, Innovation and Employment

NZCPS – New Zealand Coastal Policy Statement

RPA – Relative Percent Activity

RMA 1991 – The Resource Management Act

SBA – Surf Break Area

SBLS – Surf Breaks of Local Significance

SBNS – Surf Breaks of National Significance

SBRS – Surf Breaks of Regional Significance

SUP – Stand Up Paddleboard

WSR – World Surfing Reserve

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Appendix A. **Physical Surf Science**

A.1 Introduction

Since the first relevant surfing specific studies back in the 1970’s (Walker, 1972; Kelly, 1973), the collective global knowledge regarding the multiple disciplines of the surfing consciousness has grown considerably. While social, cultural and economic (“Surfonomics”) studies are imperative to an understanding of surfing resources, this appendix describes the physical science which forms the foundation for surf breaks characterisation and management.

The history of physical surf science is firmly embedded in oceanographic research and classic surface wave theory; and for that reason, some basic oceanographic concepts are presented. The rest of this appendix is presented to give the reader a basic understanding of surf break composition; quantification of surfing waves; and, factors effecting surfing wave processes. “*Understanding and quantifying the various features that combine to produce a surfing break at a particular location are implicit to the determination of the impacts of any potential alterations to a particular break*” (Mead and Borrero, 2017).

A.2 Basic Oceanographic Concepts

This section provides introductory information to surface wave theory to assist readers in understanding the processes occurring at surf breaks. At most surf breaks, the waves that are ridden are wind generated. Some exceptions include those surf breaks that rely on boat wakes (which, at time of writing, there were none known of in Aotearoa New Zealand) and standing/river waves.

Surface waves in deeper water are characterised in the same classical way as that of transverse, sine waves (Figure B-1). Wave height is the distance, or the change in vertical height, between the peak or crest and trough of the wave; (where the crest is the top, or most elevated part of the wave, and the trough is bottom or lowest part) in-between consecutive wave crests. Wave amplitude is half the wave height. Wavelength is the horizontal distance between consecutive crests (or troughs). Wave period is the time interval for two successive peaks (or troughs) to pass a fixed point in space.

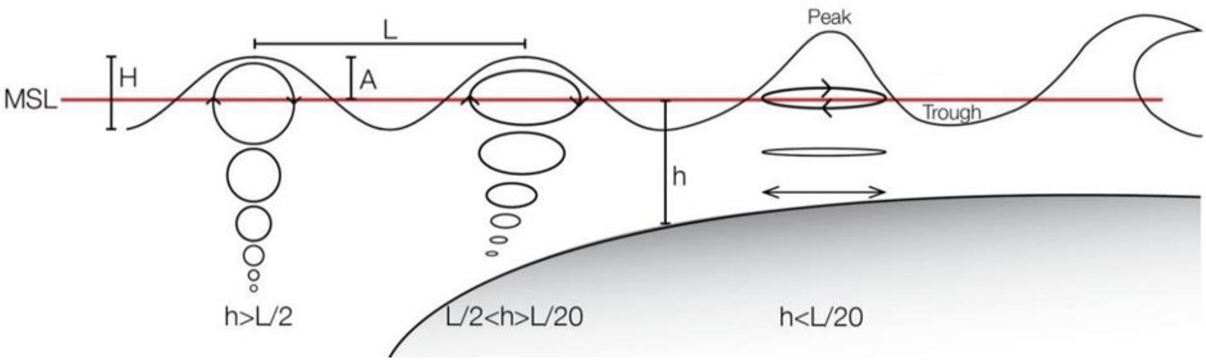

Figure B-1: Simplified, not to scale diagram of basic wave theory and nomenclature; showing wave height (H) relative to mean sea level (MSL), wave amplitude (A), wavelength (L), depth (h) and the characteristics of wave orbits.

Waves are generated by wind blowing over a water bodies surface. Surfing waves can be generated by weather systems several 1000’s of kilometres away from the surfing location; or they can be surfed with in the same weather system that generates them.

Regardless of the generation source and location, the fundamental processes are:

1) propagation - the movement of energy through the medium of water as waves.
2) refraction – the modification and often redistribution of wave energy as the waves interacts with the seabed.
3) shoaling – reduction in the speed of waves, resulting in increases in wave height steepness.

4) breaking – the dissipation of wave energy as it becomes unstable.

Processes 2, 3 and 4, for the most part in terms of surfing, and with a number of caveats, are reliant on the configuration of the seabed. This is because the energy within an individual wave is not just present with in the surface but is transferred down through the water column at all times to a depth that is representative of the wavelength (Figure B-1).

Wave orbitals are the common, theoretical interpretation of this energy transfer down through the water column. When a wave is in a depth of water that is shallow enough for the wave orbitals to interact with the seabed, which is taken as being less the half of a wavelength, it will start to transform.

These transformations are governed by the way a wave interacts with the seabed because this interaction moderates the speed at which can travel; wave speed (celerity) is dependent of water depth, the shallower the water, the slower the wave speed. Changes along a wave's crest in the speed it can travel results in refracting (or bending; Figure B-2). These same interactions control the extent of shoaling a wave undergoes, and the shape of the seabed in profile is responsible for the style and shape in which a wave will break.

Wiegel (1964) and later Galvin (1968) described wave breaking type as one of four terms: spilling, plunging, collapsing or surging (Figure B-3). Battjes (1974; after Galvin (1968); after Iribarren and Nogales, 1949) presented critical transitional values for each breaker type where the seabed slope (S), the offshore wavelength ($L\infty$) and the offshore or inshore wave height (Hb or $H\infty$) can be used to predict the dimensionless Iribarren number (or surf similarity parameter): $\zeta = S/(H/L)0.5$

The seabed slope is critical in the Iribarren number. Of the different types of breaking waves prescribed it is those that are spilling and plunging that are most useful for surfing, with those in the plunging category most sort after by surfers. It should be noted though that there is significant interested in collapsing waves, or at least surfing breaks that have a collapsing section of element to them.

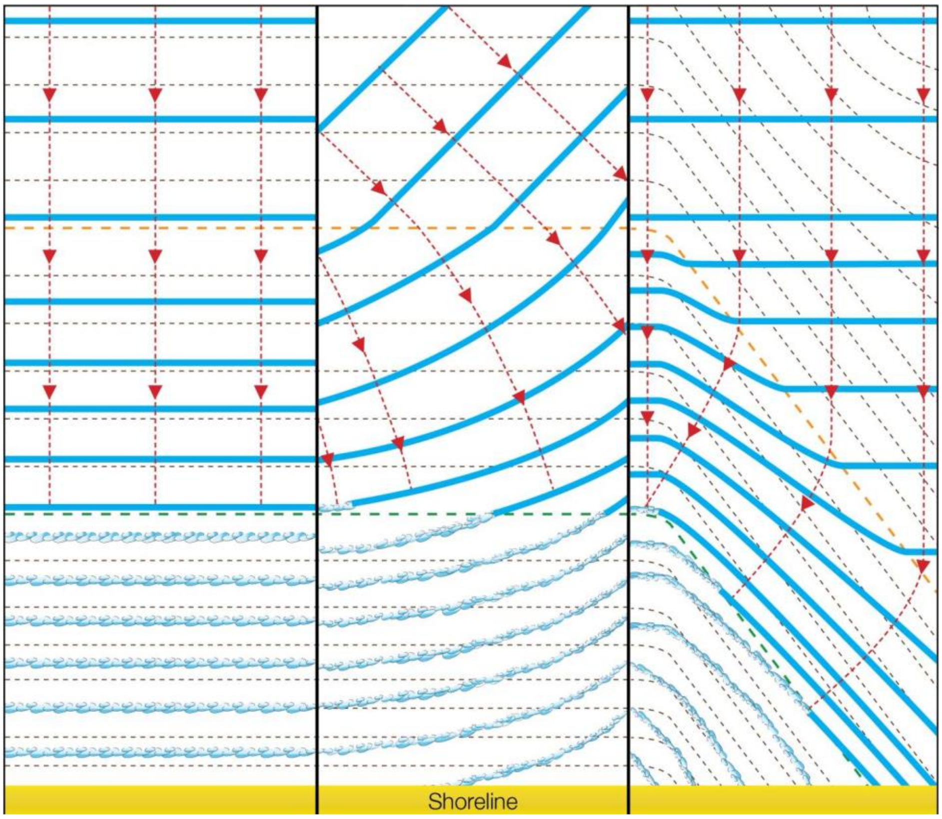

Figure B-2: Illustration of wave refraction, wave rays and breakpoints. Solid blue lines represent waves approaching the coast, red dashed lines are wave rays. Grey dashed lines are isobaths, decreasing in depth toward the shoreline. Orange dashed line represents the isobath at which deep-water waves start the transition to shallow water waves and begin to refract. Green dashed line represents an isobath equal to 0.78Hb, the wave breaking depth. Left: Waves approaching the coast parallel to the local isobaths, no refraction occurs. Wave rays remain parallel and the wave breaks simultaneously along its length. Middle: Obliquely incident waves refract on shore parallel isobaths; the break point translates laterally across the wave face. Right: Waves approaching shore normal, but refraction occurs as the isobaths are oblique to the wave crest (From Atkin, 2010).

This subsection provides a simplified description of the processes that occur as waves travel to a Surf Break Area (SBA). It delivers two fundamental concepts:

- **Waves for surfing come from a range of sources**
- **The seabed, not just with in SBA, is imperative to the processes that create surfing waves**

Butt and Russel (2002) provides further surf science related details on surface wave theory.

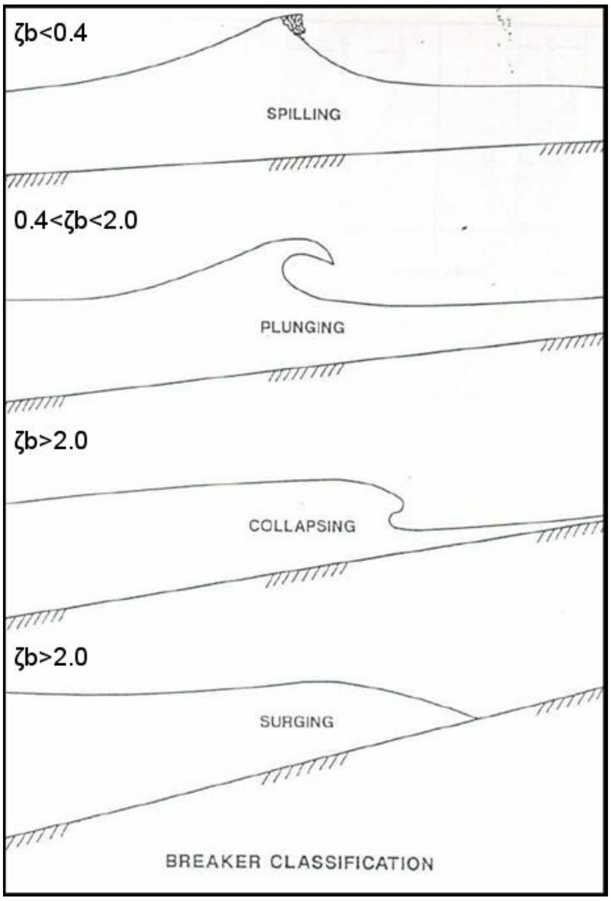

Figure B-3: Breaker type classification (adapted from Battjes, 1974)

A.3 Measurements of Surfing Waves

Wave breaking characteristics are critical to the surfing experience. The body of literature regarding surf science is largely concerned with the wave shape and the speed at which a wave breaks along its crest. When discussing surfing waves, wave shape is referred to as breaking intensity; and, the speed at which a wave breaks is quantified as peel angle. These factors are discussed concisely in Mead and Borrero (2017).

The fundamental concept of wave breaking is that the peak or crest of the wave becomes unstable and is projected forward in the direction of wave travel. This instability is a result of shoaling, where wave height increases, and the wave front becomes steeper; and there is an inequality in the speed at which different parts of the wave are travelling – the drag imposed by the seafloor is greatest close to the seafloor and decreases at the peak/crest causing the top part of the wave to pitch forward and the wave to eventually break.

A.3.1 Peel Angle

Good surfing waves break in a 'peeling' manner whereby the breaking part of the wave translates laterally along a wave crest. The peel angle is defined as the angle between the trail of broken white water and the crest of the unbroken part of the wave (Walker *et al*., 1972, Figure B-4). Peel angle is directly related to the rate at which the breaking part of the wave translates, or the speed at which a wave is breaking.

If a wave breaks along the length of its crest simultaneously the peel angle is zero degrees. This scenario is termed a 'close-out' in surfing culture. If the breaking part of the wave does not translate along the crest at all then the peel angle is 90 degrees. Small peel angles indicate waves that break faster than those with a high peel angle.

Walker (1972) and later Hutt *et al*. (2001) categorised surfing waves in terms of difficulty based on the peel angle. The Hutt *et al*.'s (2001) scheme considers skill levels from absolute beginner to waves beyond the current highest skill level (Table B-1)

Mead and Borrero (2017) note that "while the modern classification scheme is a useful tool… it is based upon a single peel angle value for a particular surf break. In reality, surf breaks can have several 'sections' with different surfing characteristics". Moores (2001) considered the length and peel angles of wave sections for a single surf break using videography techniques. Moores' work validated the scheme of Hutt *et al*. (2001). While the understanding of surf break dynamics was increased, a void on how peel angle changes over space and time still remains.

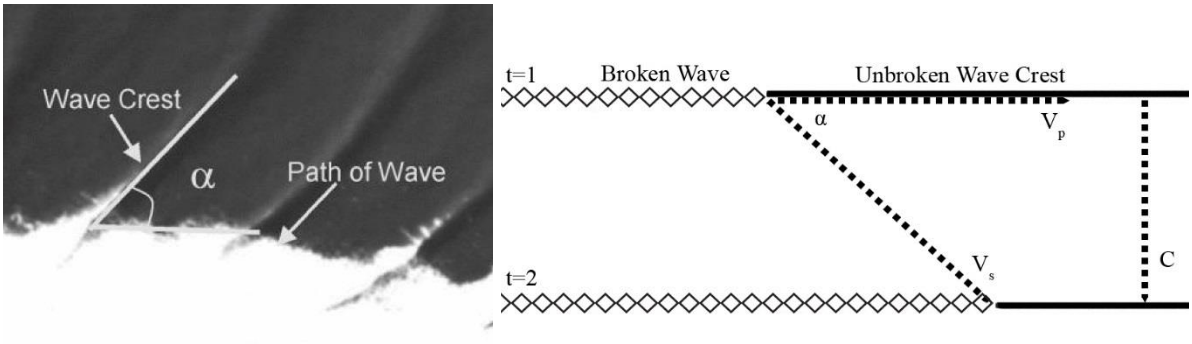

Figure B-4: Annotated aerial photograph (left) and schematic diagram of wave peel angle (α), peel rate (Vp), down the line velocity (Vs) and wave speed (c) (adapted from Walker, 1972; van Ettinger, 2005). (right).

Table B-1: Rating of the skill level of surfers. Ratings are independent of surf break quality or the degree of difficulty of waves (Hutt *et al*., 2001).

Rating	Description of Rating	Peel Angle Limit (deg)	Min/Max Wave Height (m)
1	Beginner surfers not yet able to ride the face of a wave and simply moves forward as the wave advances.	90	0.70 / 1.00
2	Learner surfers able to successfully ride laterally along the crest of a wave.	70	0.65 / 1.50
3	Surfers that have developed the skill to generate speed by 'pumping' on the face of the wave.	60	0.60 / 2.50
4	Surfers beginning to initiate and execute standard surfing maneuvers on occasion.	55	0.55 / 4.00
5	Surfers able to execute standard maneuvers consecutively on a single wave.	50	0.50 / >4.00
6	Surfers able to execute standard maneuvers consecutively. Executes advanced maneuvers on occasion.	40	0.45 / >4.00
7	Top amateur surfers able to consecutively execute advanced maneuvers.	29	0.40 / >4.00
8	Professional surfers able to consecutively execute advanced maneuvers.	27	0.35 / >4.00
9	Top 44 professional surfers able to consecutively execute advanced maneuvers.	Not reach	0.30 />4.00
10	Surfers in the future	Not reach	0.3 / >4.00

A.3.2 Breaking Intensity

Mead and Black (2001a, b, c) recognised that there is a wide range of wave shapes in the plunging category (Wiegel, 1964; Galvin, 1968; Battjes, 1974; Iribarren and Nogales, 1949). Mead and Black's (2001a, b, c) work considered wave conditions and sea floor shape, or bathymetry, of more than 40 international surf breaks. Mead and Black (2001c) showed that a plunging wave's 'vortex ratio' (after Sayce, 1997; Sayce *et al*., 1999) can be predicted using the seabed gradient. The vortex ratio is the length to width ratio of the area underneath the breaking part of the wave (Figure B-5) and indicates the 'roundness' of a wave as it breaks. As the vortex ratio approaches 1, the tube shape becomes more circular and less elongated and breaking is more intense. Breaking waves with smaller vortex ratios are more likely to collapse… Waves with vortex ratios larger than 3, are gently plunging or spilling (Mead and Borrero, 2017).

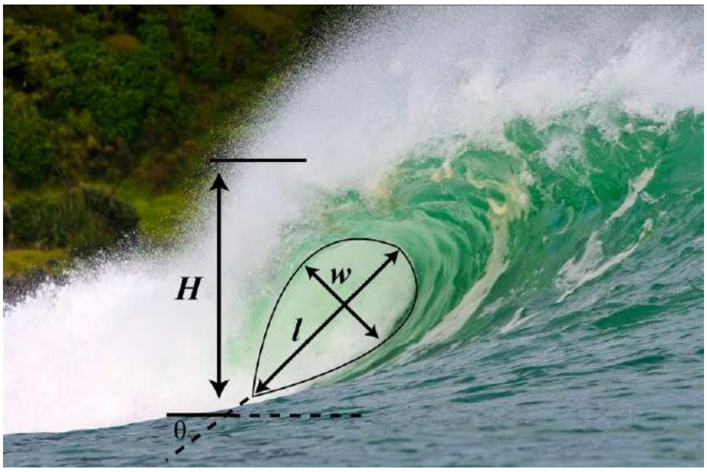

Figure B-5: Curve fitting is applied to the forward face of a crest parallel wave image and used to calculate the vortex length (l), width (w) and angle (q). H is the estimated wave height (from Mead and Borrero, 2017).

Mead and Black (2001c) showed that the orthogonal seabed gradient; which is the gradient along a wave's direction of travel, or perpendicular to the waves crest, and not the contour normal seabed gradient, is most readily applicable to predict breaking intensity. The relationship Mead and Black (2001c) established between the orthogonal seabed gradient (X) and breaking intensity (Y) is:

$$Y = 0.065X + 0.821$$

Table B-2 presents the work of Mead and Black (2001) and relates the shape of different categories of surfing waves with surfing terminology and provides examples of surf breaks fitting each breaking intensity.

Table B-2: B Breaking intensity and vortex ratio with descriptive breaking intensity terms and examples surf breaks (modified from Mead and Black, 2001c)

Intensity	Extreme	Very High	High	Medium/High	Medium
Vortex Ratio	1.6-1.9	1.91-2.2	2.21-2.5	2.51-2.8	2.81-3.1
Descriptive Terms	Square, spitting	Very hollow	Pitching, hollow	Some tube/barrel sections	Steep face, but rarely tubing
Example	Pipeline; Shark Island	Backdoor; Padang Padang	Kirra; Off-the-wall	Bells Beach; Bingin	Manu Bay; Whangamata

A.3.3 Ride length

The time that a surfer spends up and riding is incredibly important to some users, while others would rather have short wave with a very high breaking intensity. Regardless of this subjectivity, it is important to be able to measure the length of surfable waves to establish a baseline characteristic.

Consideration should be given to measuring waves both linearly and in a piecewise fashion. Historical aerial and satellite images provide the most readily accessible resource for measuring ride length. However, comprehensive characterisation from aerial and satellite images may be difficult in some locations as the number of images, and therefore points in time, may be limited; indeed, the images that are available may not have been taken at times of surfable conditions. Remote camera monitoring sites, if set up suitably can provide a large, high temporal and spatial resolution dataset that will capture all conditions. Any images need to be georeferenced and orthorectified to a reasonable degree of accuracy – sub-5 m.

The geographical position of surfers utilising GPS (the Global Positioning System) can provide a range of data products (e.g. Borrero *et al*., 2019). There are several commercially available surfing specific products as hardware (e.g. RipCurl GPS Watch, Trace, Garmin) and mobile phone apps (e.g. Waves Tracker, Surf Track) that record a surfer's position during a surfing session. The data collected from these products can be used to characterise waves that are actually surfed – as opposed to hypothetically surfable waves from (most) imagery. There are some issues associated with interpreting the GPS based data. The data is reliant on surfers being capable of completing rides that are representative of the conditions – e.g. not falling off. However, if enough data is collected, filtering methods can be used and statistical characterisation employed to 'clean up' the data (e.g. Borrero *et al*., 2019).

A combination of historical aerial and satellite imagery, remote camera images and GPS mapping of surf rides can be used to develop a comprehensive understanding of where surfers take-off, ride and finish waves at surf breaks. This information provides critical baseline data when coastal developments and activities are proposed with respect to identifying any changes that may or do occur (potential and actual impacts).

A.4 Surf Break Composition

The NZCPS describes a swell corridor as the region offshore of a surf break where ocean swell travels and transforms to a "surfable wave" (Department of Conservation, 2010). Atkin and Mead (2017) and Atkin and Greer (2019) suggest the swell corridor is an offshore extension of a Surf Break Area. Much of the work concerning swell corridors in Aotearoa New Zealand has limited a feature's extent to the Territorial Sea (Atkin *et al*., 2015; Atkin and Mead, 2017; Atkin and Greer, 2019). This spatial restriction is based on the jurisdictional limitation of individual authorities at a regional level. The reality is, in theory, that a swell corridor can be described from the seaward edge of an SBA across an entire ocean basin, because the area offshore that influences a surf break does not stop at the edges of an SBA, nor does it stop directly adjacent to or inland from it.

This subsection introduces the functional surf break components of Mead and Black (2001b); covers the role of offshore preconditioning; and introduces the geomorphic types of surf beak and provides details on how they are created, maintained and their associated sensitivity.

A.4.1 Functional Surf Break Components

The work of Mead and Black (2001a, b) exposed a series of commonly occurring meso-scale geomorphic components from which all surfing breaks are comprised. The components are shown in Figure B-6 and named, ramp, platform, wedge, ledge, focus, ridge and pinnacle. Mead and Black (2001a) categorized the components by those which precondition the wave prior to breaking and those that break the wave (Table B-3). The functional order of components relates to their size (Figure B-7); larger offshore components align waves prior to breaking while smaller inshore components only modify a small section of the wave (Mead and Black, 2001b).

Table B-3: Functions of surfing reef components (modified from Mead and Black, 2001b).

Component	Function	Details
Ramp, Focus	Preconditioning	Modify for other components before breaking
Platform		Convey waves without change
Wedge, Ledge	Breaking	Break waves
Ridge, Pinnacle		Modify breaking waves

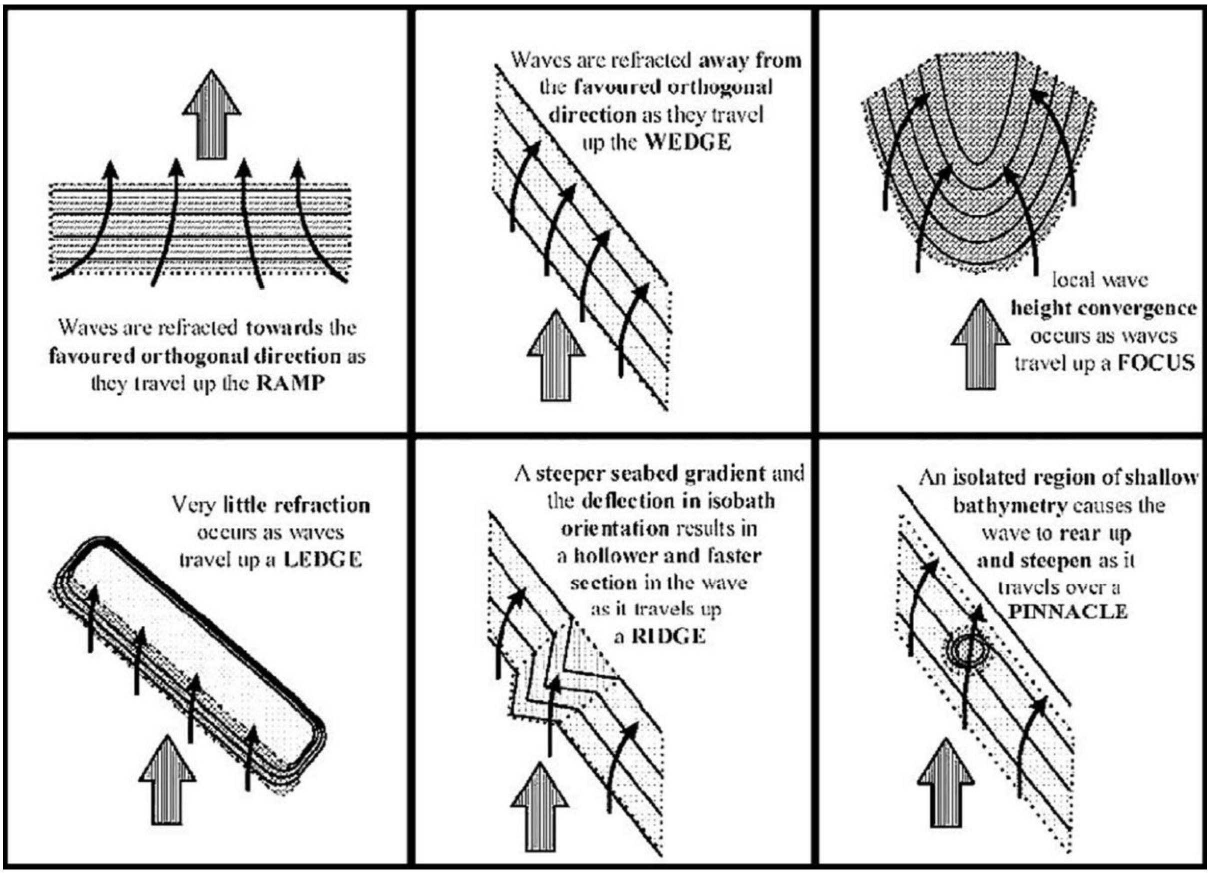

Figure B-6: Functional surf break seabed components. Isobaths of components become shallower in the direction of wave propagation (up the page). The large arrows represent the 'favoured orthogonal direction' (see Mead and Black, 2001a, b, c) and the small arrows represent the orthogonals. Note, the platform has not been included here because it is essentially a horizontal component that does not refract waves that pass over it (from Mead and Black, 2001b).

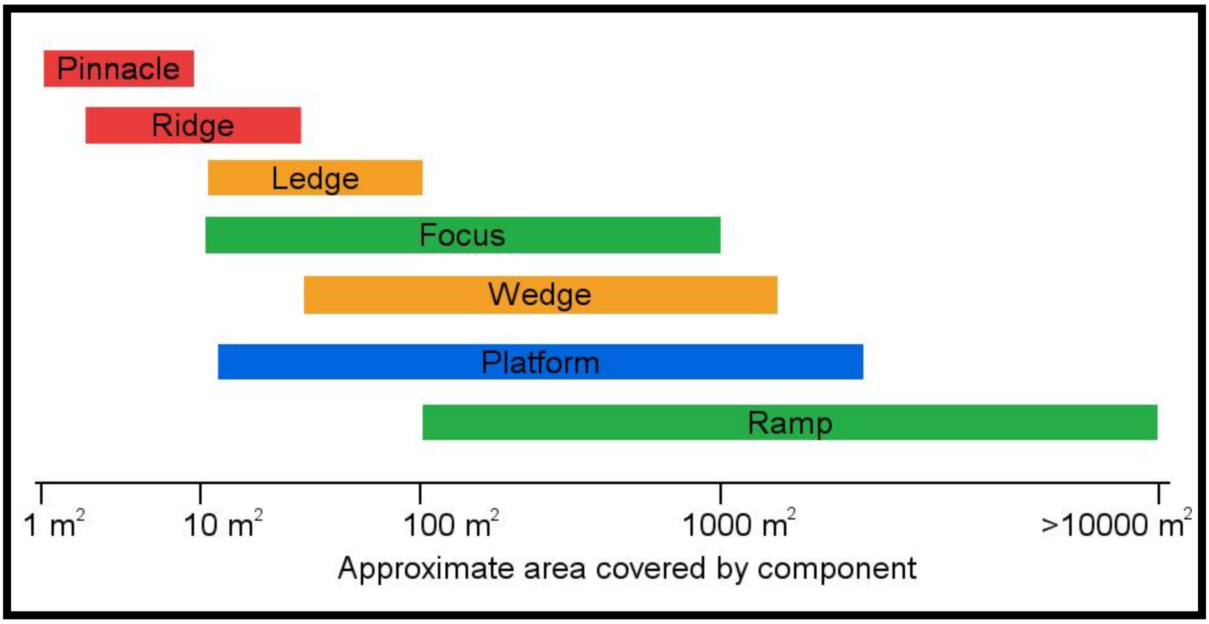

Figure B-7: The functional scales of surfing reef components (modified from Mead and Black, 2001b).

A.4.2 The Importance of Offshore Preconditioning

Atkin and Mead (2011) and Atkin *et al*. (2019) propose a spectrum of preconditioning associated with the focus components; and the role of an offshore feature, that does not induce breaking, can range from disruptive preconditioner to focussing preconditioner. Fully focussing preconditioners have the effect of increasing wave height in their lee, and wave breaking conditions are associated with, often singular, consistent, localised peaks. Whereas a disruptive preconditioner, whilst still resulting in wave height increases, creates chaotic wave-wave interactions through extensive bifurcation of wave crests. The result is numerous, random peaks at the shore.

Both ends of this spectrum create wave height gradients which allow waves to peel in a manner conducive to surfing even when on a planar, featureless beach. Where a particular feature lies on the spectrum will be a function of incident wave conditions, relative to the size of the seabed feature and its ambient bathymetry. Preconditioning within a surf break's swell corridor can occur at significant distances (kilometres) from an SBA. Offshore ridges, sea mounts, the edges of canyons, ebb tidal deltas, large scale offshore banks, to small scale reefs can all contribute to the conditions within an SBA. The influence of these type of features often go unaccredited, as they are not readily observed, and can be a long way from the SBA and often in relatively deep water.

Examples in Aotearoa New Zealand that depend on offshore focussing features include the Nationally Significant Aramoana and Whareakeake, which benefit from focussing and disruption across the ebb tidal delta at the entrance to Ōtākou / Otago Harbour and a dredge spoil disposal ground adjacent to Heyward Point, respectively.

A.4.3 Geomorphological Types of Surf Breaks

Mead (2000) recognised 6 geomorphic types of surf break, namely: coral reef, rocky reef, point break, rock ledge, river/estuarine delta and sand beach. Scarfe (2008) presented expanded descriptions for 5 geomorphic types, choosing to group coral reef and rocky reef together as reef breaks. Scarfe (2008) notes that there is no clear delineation between types. Indeed, it is not only possible for different surf break types to be present in a Surf Break Area, but a single surfable wave could break in association with several different geomorphological types. Furthermore, a surf break of a certain type may be reliant on a seabed feature that is not involved in the breaking of waves but is from a different geomorphic type (e.g. preconditioning from a coral atoll).

Of note is that coral reef, rocky reef, rock ledge and sand beach describe the seabed substrate; whereas point break and river/estuarine delta do not. A point break and river/estuarine could be made up of a mix of rock, boulders or sand; and a point break could be in part made up of coral reef (for example). The concise descriptions of Scarfe (2008) are modified here to provide details on formation, processes and associated sensitivity of the different break types. Examples from Aotearoa New Zealand are provided.

Point Break

Also referred to as headland break, waves refract around a point before breaking. The refraction of waves around a point filters out high frequency waves, which travel past the headland, leaving the longer period waves which are generally more conducive to good surfing conditions. A consequence of refraction is that the direction of the waves in an SBA is usually significantly different to the direction of waves offshore – however, this is not always the case.

A point or headland presents a discontinuity in a stretch of coastline and are often associated with large terrestrial outcrops (Mead and Black, 2001b). They result from being made of harder and less erodible substrate than the adjacent coastline. Whilst a headland itself maybe robust and relatively static, the coastal processes, including sediment transport around such features can be complex (Mead 2000; Phillips *et al*., 2003; Scarfe, 2008).

Point breaks are often characterized by the existence of a mobile sandy substrate, the dynamic nature of which can have an important influence on surf quality. The dependency of surfing wave quality on the sandy substrate will vary at each site. Therefore, point breaks can be considered hypersensitive. At Shipwreck Bay for instance the transgressive dune field across the headland is critical to sand supply to the break. Designating point breaks as hypersensitive could be a conservative designation for some sites, but a prudent one as the mobility of the sandy substrate is very dependent on local coastal processes at a site, and hence individual sites requires studies to determine sediment transport regimes and their relation to surfing wave quality. (e.g. Phillips *et al*., 2003; Philips, 2004).

Examples of point breaks in Aotearoa New Zealand include 10 of the 17 Surf Breaks of National Significance: Whareakeake and Karitane (Otago); Indicators, Whale Bay, Manu Bay (Waikato); {Pines, Supertubes, Mukie 2, Mukie 1}, {Peaks and Shipwreck Bay} (Northland); Stent Road (Taranaki); Makorori Point (Gisborne); and, Mangamaunu (Kaikoura).

Beach Break

At a beach break, waves break in peaks along the beach caused by offshore wave focusing and/or nearshore sand bars and rips. Successive waves can break in different locations depending on the beach morphology, offshore wave spectra (direction, height, period) and wave peakiness. Often good beach breaks have control features offshore or nearshore that stabilise the position of sand bars or dictate wave focusing.

A prerequisite of a beach break is the presence of mobile sediment. A beach break's overall natural morphology will be a function of incident wave conditions. Morphological change will be bound in part to the presence of consolidated features, such as offshore reefs, headlands and landward boundaries. By default, the presence of mobile sediment contributing to the composition of a surf break means it is a sensitive environment that can be altered very readily.

Examples in Aotearoa New Zealand include 2 of the 17 Surf Breaks of National Significance: Wainui Beach (Gisborne) and The Spit (Aramoana; Otago). Other known, truly world class beach breaks in Aotearoa New Zealand include Matakana Island (see Delta Breaks and Offshore Focussing) and an extensive list of Coromandel Beaches;

Delta Breaks

Mead (2000) refers to river/estuarine delta breaks, and Scarfe (2008) to river or estuary entrance bar breaks. Surfers often refer to this typology simply as (the) bar. The formation of material at the seaward end of a river or tidal inlet is known as an Ebb Tidal Delta (ETD). This type is therefore referred to simply as a delta break.

The ebb tidal delta is a body of sand that accumulates where outflowing estuarine or river waters and waves interact to form sand banks over which surfable waves develop. Tidal inlets are influenced by processes such as wave energy, tidal range, tidal prism, direction and rates of longshore sediment transport, sediment supply and nearshore slope, and are subject to change (Scarfe, 2008 and references there in).

The complex, dynamic nature of the ETD environments, combined with the dependence on inland/enclosed waters, which can be subject to all manner of external factors, that are not necessarily associated with nearshore processes, means that delta breaks are considered to be ultrasensitive.

Examples in Aotearoa New Zealand include 3 of the 17 Surf Breaks of National Significance: Karitane (Otago), Waiwhakaiho (Taranaki) and Whangamata (Waikato). Other high-quality delta breaks in Aotearoa New Zealand include Okiwi Bar (Great Barrier Island) and Whakatane Heads (Bay of Plenty). A case could be put forward for a site such as Matakana

Island as a delta break, where waves are pre-conditioned by a very large ebb tidal delta, but not broken on or near the pro delta slope. The result is improved surfing conditions inshore. This is discussed in Offshore Focussing.

Reef Breaks

Many highly regarded surf breaks are reef breaks. This is because the consolidated material of a reef provides consistent wave breaking patterns. The consolidated material can also provide steeper seabed gradients than those possible with unconsolidated material (e.g. angle of repose), often resulting in waves that break with a high intensity. Mead (2000) refers to both coral and rocky reefs. Coral reefs are not found in Aotearoa New Zealand[11], but there are plenty of rocky reefs. The formation of surfable reef breaks can be from numerous processes. In the tropics, coral reef surf breaks can be offshore, isolated, intertidal seabed features with footprints and shapes ideal for surfing (e.g. Cloudbreak - Fiji); other coral reef surf breaks will have been modified by freshwater streams that "cut" sections of reef away creating discontinuities in the coastline (e.g. Teahupoʻo - French Polynesia).

Rocky reefs for surfing are often the convenient result of geological processes, and rocky reef breaks are often associated with an outcrop. Reef breaks are similar to point breaks, except, in general, there is no subaerial land mass, and the processes of refraction compensation, low-pass filtering and crest-straightening are not so apparent, if at all; which is a result of the orientation of geomorphic components to incident wave crests.

Both rocky and coral reef surf breaks are made up of consolidated material which makes them relatively robust in some respects. In Aotearoa New Zealand, rocky reef surf breaks can be considered robust in terms of physical coastal processes. Examples are Tuamoto Island in Gisborne and Papatowai in the Catlins, both Surf Breaks of National Significance. Other regionally significant examples in Aotearoa New Zealand include Daniel's Reef, Goat Island, Kuaotunu and the many quality reef breaks along Taranaki's Surf Highway 45.

Ledge Breaks

In the surfing community, ledge breaks are often referred to as a "slab". While no particular origin to this idiom can be identified, it is assumed the term slab refers to the relatively flat,

[11] Note, coral communities are found in Aotearoa New Zealand but they do not form reef structures suitable for surfing

tabletop like appearance of inshore reef structure. Ledges share many of the attributes of a rocky reef break.

Scarfe (2008) states that steep rock ledges interrupt wave propagation, although this is essentially true of all surf breaks, and coastlines in general. Scarfe (2008) also states that waves come from relatively deep water into very shallow water, modifying the way that the waves break, which is a better description of the sharp seabed transition caused by ledge breaks.

It should be noted that a ledge is also a functional surf break component (Mead and Black, 2001a); and that ledges are readily seen as part of functional component configuration (Mead and Black, 2001b). Wave breaking shape associated with ledge breaks and sections is one of very high intensity (Mead and Black, 2001c), with many globally recognised slabs pushing the boundary from plunging to collapsing. When considering a standalone ledge break, the difficulty and dangers associated with surfing this type means that they are utilised by the few and will often fall into category of secret spot. It is for this reason that no known slab locations are provided here.

Aotearoa New Zealand examples of where a ledge makes up part of a surf break composition are the Nationally Significant Manu Bay – “The Ledge” (Waikato), and Takapuna Reef (Auckland; Mead and Black, 2001b)

A.5 Other Physical Factors

A.5.1 Wave Parameters

Height

Atkin and Greer (2019; after Atkin and Mead, 2017) discuss wave height for surfable conditions in the context of numerical modelling, where thousands of wave conditions are simulated and a suitable threshold to filter the conditions was required. The value used of 0.75 m and was reached by evaluating a range of largely grey literature. In detailed characterisation, minimum wave height for a surf break to become surfable must be evaluated on a case by case basis, since there are a variety of factors that may make a break surfable at smaller or larger wave heights than 0.75 m.

There are some breaks, such as featureless, planar beaches ideal for learning – nursery breaks, that will be surfable in very, very small wave heights. There are other breaks, especially big wave spots where the wave breaking zone has to be a certain distance from shore for the surf break to be safely navigated (e.g. Jardim Do Mar, Madeira), or simply the wave has to be large enough for the wave orbitals to 'feel' deep seabed features that compose the surf break, and require ocean swell several meters height before they are considered surfable. Other surf breaks 'max out' if the wave heights are too large.

Period

Waves with periods of 20 seconds begins to feel the seabed at the edge of the continental shelf (200 m deep) and so begin to change direction and focus/de-focus (through the processes of refraction/diffraction) often 10's of kilometres offshore. Waves with periods of 10 seconds will to begin to feel the seabed and start refracting until the water depth is 55 m.

As a result, period can limit how much wave energy is delivered to a surf break. Long period swell can refract into breaks that are orientated more than 180° away from the offshore direction of the swell, although short period swell cannot. A good example of this effect is at Ahipara on the west coast in the far North Island. Here the breaks are orientated to the northeast, which is 180° around the headland from the direction of the southwest swell, and no matter how large the waves are on the open coast, if they do not have long enough period they simply pass by up the coast without refracting into Ahipara.

Low period waves will refract less than high period waves, and the result will be a filtering or cleaning (Mead, 2000) of the wave spectra. For the coral reef break of Restaurants in Fiji, the complex bathymetry offshore can result in high wave period swells not propagating into the SBA as readily as lower period waves.

Wave period has an effect on the surfing experience with longer wave periods delivering higher breaking intensities often providing more powerful, ‘heavy’ and exciting conditions with steep and/or hollow wave faces. Short period swells are often termed ‘fat’ by surfers because they lack power/breaking intensity and have less steep faces making it more difficult for participants to execute certain manoeuvres or progress through certain sections.

This is reflected in the Iribarren number, where wave length is incorporated into the calculation (see Section 2), where wave height (H) over wave length (L) is included; H/L is the wave ‘steepness’ parameter, which is counter intuitive to a surfer, since ‘steeper’ waves have shorter wave lengths/periods and so have less steep wave faces than less ‘steep’ (longer wavelength/period) waves. This is further complicated by the wave height also effecting the breaking intensity of waves, which can be simply explained as “for a particular wavelength/period, as the wave height increases, the breaking intensity decreases”.

Direction

Wave direction is interesting when considered in terms of a surf break, particularly when considering dendritic coastlines and/or distant wave generation sources. Surfers will regularly consider the direction of offshore waves at a regional or national scale, some consider the general direction of the generating source, such as a cyclone tracking south into the Pacific Ocean from the tropics. Like the cyclone, swell direction is constantly changing in time, but may be characterised. Indeed, some surf breaks require certain swell directions, others will work on a wide range of swell direction, but the quality of surfing waves can change.

Characterising a surf break in terms of wave direction is complex and requires consideration of wave directions at multiple points in both space and time, from generation source through to the SBA. The requirement for this holistic view is particularly evident at SBA’s associated with headlands and peninsulas where wave direction can be significantly different depending on whereabouts it is examined.

A.5.2 Wind

Winds play an important role in both generating and grooming waves for surfing. The best surfing waves are long period waves generated by winds in distant locations. Local winds can play an important role in creating or destroying surfing waves (Pratte *et al*. 1989). The ideal wind is light to non-existent for the cleanest conditions.

When considering winds for surfing, the direction is relevant to wave crest. Despite this relevance, the terms used to describe wind directions in surfing are relevant to the shoreline; which can be parallel to the wave crest, but not in all cases. A wind that blows directly offshore (perpendicular) is conducive to clean conditions and can allow the wave to steepen by delaying breaking. A light offshore wind is also said to groom the wave face to make it smoother (Schrope, 2006). Very strong offshore winds can make the waves difficult to catch, even blow the rider off the back of a wave.

Onshore and cross shore winds can ruffle the water surface. These wind directions can introduce high frequency signals to the surfing area, which along with white capping can encourage the onset of wave breaking, which can occur randomly. The result is often undesirable sections that reduce the overall length of the surfable wave. The traditional view of onshore and cross shore winds has been that they are unwanted. However, there has been a shift in the performance level of surfing with one of the most advance manoeuvres, the aerial, benefiting directly from the surfing conditions provided by onshore or cross shore winds. Indeed, advanced surfers, particularly those who surf in a competitive capacity, will target certain wind conditions to train for specific manoeuvres.

There are some surf breaks that are utterly dependent on the wind having blown onshore to create a surfable wave, and when the wind changes direction of subsides the waves follow suit. This often occurs in sheltered and fetch limited areas, such as channels and lakes. A prime example in Aotearoa New Zealand is the Firth of Thames where there are several point breaks and delta breaks that rely on the short wavelength wind waves driven by northly winds. Titahi Bay in Porirua is also a good example, where strong northerlies generate waves and the winds often swing suddenly to the south and quickly clean up the surfing conditions.

In terms of defining a surf break, wind strength and direction are not limiting factors. They can affect the experience, with many participants preferring clean and calm conditions, however if the wave height is large enough to surf, the local wind conditions are ultimately irrelevant (Atkin and Mead, 2017; Atkin and Greer, 2019).

A.5.3 Tides and Currents

This section is concerned with how tides and currents effect surfing waves directly. This section does not consider the complex processes of how tides and currents effect seabed morphology in detail. The tides result in modulation of both water level and currents. Non-tidal currents to consider are those driven by rivers and by the waves themselves (i.e. rip currents).

Water level

As described in Section 2, the processes of wave propagation, refraction and breaking are tightly linked with seabed shape and wavelength. Changes in water level can alter the way in which a surf break functions on a range of scales.

If wave height, period and direction are constant, and wave direction is oblique to depth isobaths, then a lower water level (i.e. low tide) will invoke a greater degree of refraction than a higher water level (i.e. high tide). The result can be that more wave energy is delivered to an SBA (see Section 5.1). Conversely, if an offshore feature, such as a submerged breakwater, bar or coral reef dissipates or redirects wave energy, the influence of the feature will be less at a higher water level and more wave energy can be delivered to an SBA.

Tidal modulation of surfing wave quality within an SBA itself is a frequently discussed topic for surfing enthusiasts. The changes in water level can result in large horizontal changes in the breaking position, with breaking possibly occurring on very different seabed features between high and low tide. The result is that surf breaks become known for working best on a specific tidal phase (e.g. high, low, mid, dropping, rising, etc.), however this designation is very subjective as it is down to user requirements and preference.

There are other phenomena associated with tides that are known by surfers, but not well understood scientifically. For example, the ‘mid-tide push’ is known of on open coasts worldwide and there are data to confirm the occurrence of an increase in wave height during the mid-incoming tidal phase along some coasts. However, why this occurs is unknown, although it is expected that it may in part be due to interaction between the shore-parallel tidal currents and wave propagation which is more shore-normal.

Currents

Surfers utilise rips to make paddling back to the take-off zone easier. At river mouths and delta breaks, outgoing flows will assist in quickly transporting a surfer further offshore. This can in fact can become quite hazardous with currents overpowering surfers and moving them away from a desired position.

Where current direction opposes wave direction, wavelength will tend to decrease (period remains constant) and wave height will increase. The result is often waves with steeper (than usual) faces. This can be quite sought after by some surfers, much like particular water levels. However, these counter currents can also lead to less desirable conditions by making the surface and face of the wave choppy and making it difficult for surfers to maintain position. Yet, it is these currents that contribute to maintaining the seabed features that break the waves in a manner that is conducive to surfing. At delta breaks the currents, in a dynamic equilibrium with waves, will shape the ebb tidal delta; where rip-currents are persistent on open beach breaks they help to maintain the adjacent sand bar.

The effects of tidal currents on wave height at surf breaks is not well understood, however, such impacts need to be considered when characterising a surfing break. An important feature of the surf along the western coast of the Firth of Thames is the effect of the tidal current on wave height and direction (and likely wave directional spreading). This is likely similar to the phenomena that occurs along the Florida coast due to wave/current interactions with the Gulf Stream (e.g. Wang *et al*., 1994) where, the offshore location of the Gulf Stream can greatly affect wave heights at the coast).

Surfers that frequent the western Firth of Thames are aware of this phenomenon (which is sometimes described as reflection off the eastern coast of the Firth, although this is not likely to be physically possible). The importance and magnitude of this kind effect can only be tested through well designed measurement.

An interesting aspect of the effects of tidal height and tidal currents is that tides are mostly driven by the moon, with spring tides occurring at full and new moons (i.e. larger tidal ranges and consequent larger tidal currents). An often-postulated phenomenon is that new swells arrive with the full and new moon. But the moon has no impact on the generation of waves, so this is not likely. However, the spring tides that occur during full and new moons do increase the tidal levels and tidal current speeds, which in turn can have the effect of delivering waves into breaks and focussing wave energy and increasing wave heights at some breaks. In locations where there are strong tidal currents, “full moon swells” are well known (e.g. parts of Indonesia).

A.5.4 Natural Variability and Sensitivity

Surfers say that one of the factors that makes surfing such a challenging and interesting activity is that “no two waves are the same”. This natural variability in wave quality results from any combination of factors including variations in the wave height, period, direction, directional spread, all along with the state of the tide. The factors controlling wave quality can change at seasonal or monthly time scales as when weather events pass through, within a day to hours as swells rise and drop to within minutes to hours as the wind direction changes and the tide rises and falls.

Less obvious is the role that mobile sediments on the sea floor make to the natural variability of a surf break. The movement of seabed material and incident wave conditions is a constant feedback loop with each influencing the other. The most readily observed is the annual change from summer to winter profiles (Wright and Short, 1984)

The introduction of tidally driven currents, riverine input and wind driven sand transport makes for a consistently changing environment. Point breaks and particularly reef breaks, where the seabed is potentially less mobile, may exhibit less natural variation and more consistent wave quality for surfing. However, Phillips and Mead (2008) showed that large changes to the seabed offshore from sand moving along the coast or around headlands can have profound effects on surfing wave quality.

Sensitivity, or the robustness of a surf break to change is a function of the relative complexity of processes and forces maintaining surfable conditions. On top of the seabed configuration, the factors that need to be considered regarding sensitivity are:

- Incident wave climate and exposure.
- Tides and associated currents.
- Sediment transport pathways (including aeolian).

Management considerations:

- Surf breaks located on exposed, high energy coastlines may be, relatively, more robust.
- Surf breaks that rely on sediment transport to maintain surfing wave quality, such as beach breaks, delta breaks and some point breaks will tend to be more sensitive than consolidated rocky reefs.
- Surf breaks located proximal to enclosed waters and waterways, occurring in and around tidal inlets may well be ultrasensitive to change.

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Appendix B. **Surfing Resource**

B.1 Introduction

Orchard *et al*. (2019; after Orchard, 2017) provides a review of the regional significance concept that has evolved from New Zealand's world leading recognition of surf breaks in policy. Policy 16 of The New Zealand Coastal Policy Statement 2010 describes a surf break as:

> *A natural feature that is comprised of swell, currents, water levels, seabed morphology, and wind. The hydrodynamic character of the ocean (swell, currents and water levels) combines with the seabed morphology and winds to give rise to a* ***'surfable wave'****. A surf break includes the* ***'swell corridor'*** *through which the swell travels, and the morphology of the seabed of that wave corridor, through to the point where waves created by the swell dissipate and become non-surfable.* ***'Swell corridor'*** *means the region offshore of the surf breaks where ocean swell travels and transforms to a* ***'surfable wave'****.* ***'Surfable wave'*** *means a wave that can be caught and ridden by a surfer. Surfable waves have a wave breaking point that peels along the unbroken wave crest so that the surfer is propelled laterally along the wave crest.*

It is widely recognised that a surf break is much more than just a physical feature. Surf breaks have a long social history and a strong associated culture (Kelly 1973; Skellern *et al*. 2013). A surfing resource includes not only the surf break but aspects that make it a natural and social resource. Here the fundamental attributes that contribute to a surfing resource are described (after of Orchard *et al*., 2019), in alphabetical order. The physical process attributes have not been included.

B.2 Primary Attributes

Amenity value

A surf break has direct amenity value by providing a resource for recreational activities. Surf breaks provide amenity value as focal point for other amenities, so the value extends to onlookers (e.g. Peryman and Orchard, 2013). Orchard (2017) considers the pleasantness of the location including aesthetic aspects such as the beauty or memorability of a location. With increased popularity comes improved access and facilities. Negative impacts on surfing amenity may impact not just on surfers but also visitors, the local community and businesses (Lazarow *et al*., 2008).

Economic value

At a local level surf-related tourism can be the corner stone of many coastal communities, with everything from accommodation to local mechanics benefitting from the quasi-ephemeral boost in population. Surf based industries benefit directly, with surf schools/lessons catering for the masses or individuals, and surf shops supplying hardware, equipment and branded apparel. Surfing is associated with lifestyle and as such is used as a marketing tool for anything from beverages to credit cards. A significant monetary value associated with surfing resources is real estate. Neubauer (2006) showed relationships between distance to a surf break and house price in New Zealand (shorter distance = higher price), with higher quality waves accentuating the relationship. McGregor and Wills (2016) attribute increases in property prices and rental costs to tourism associated with surfing resources. Scorse *et al*. (2015) show that at Santa Cruz proximity to a surfing resource is a statistically significant contributor to overall home value, and that houses are on average US$106,000 more valuable than an equivalent home a mile away.

The economic value of a surf break is a useful and easy to understand statistic for non-surfers and is frequently the starting point for negotiations when considering the effects of coastal developments or activities. However, putting a dollar value on a surfing resource is difficult because while studies have shown that a single surf break can be responsible for generating millions of dollars per annum, a price cannot be put on certain of the value categories (e.g. sense of wellbeing). Studies of “surfonomics” provide a range of techniques and methodologies to capture the non-market values and wider economic impacts and significance of the sport of surfing (Scorse and Hodges, 2017).

Education

Appendix A provides details on the differences between particular surf breaks and the requirements of different users. Some surf breaks may be of a low performance value to skilled surfers but extremely valuable to learner surfers (e.g. a "nursery break"). Other breaks will provide specific wave breaking conditions for the development of young competitors. Beyond performance though, surf breaks provide a focal point for confidence building and encourage people to participate and socialise in a supportive environment.

Historic, heritage, and cultural associations

Policy 1 of the New Zealand Coastal Policy Statement recognises the cultural and historic heritage in the coastal marine area. Surf breaks are focal points for historical and heritage values. Across Aotearoa New Zealand there are numerous, long standing board riding and surf lifesaving clubs. Aotearoa New Zealand has numerous surfing competitions, some of which are open to international competitors. Orchard *et al*. (2019) also state the importance to contemporary coastal culture, the contribution to the local sense of place, and tangata whenua values associated with the surf break.

Policy 2 of the New Zealand Coastal Policy Statement recognises that tangata whenua have traditional and continuing cultural relationships with areas of the coastal environment. Waiti and Awatere (2019) identify these cultural relationships amongst kaihekengaru (Māori surfers') and their importance for creating a sense of place that is underpinned by a Māori worldview.

Level of use

This attribute recognises the regularity with which people choose to use a surf break, and also considers the numbers that use it; these two aspects are not mutually exclusive. For example, a particular surf break may not be surfable under many conditions, but when conditions are surfable it is used by many surfers. This attribute also accounts the diversity of users and the different types of watercraft used there.

Naturalness

Recognises the degree to which the surf break is free from modifications to the natural environment e.g. in relation to the presence of particular flora and fauna, and absence of man-made structures and pollutants (Orchard *et al*., 2019).

Rarity

This considers a surf break's utility within a geographical boundary. There are a range of surf breaks based on geomorphology (Mead 2000; Scarfe, 2008; Appendix A). However even different surf break types can deliver different surfing conditions and therefore experience. A surf break can be considered in terms of suitability for different participants of surfing e.g. learners, big wave surfers, long boarders, body boarders etc. A surf breaks rarity should also be considered in the context of all other fundamental attributes (e.g. a coastline with plentiful surf breaks but one with an outstanding fundamental attribute(s) out of character with the region). Papatowai was considered by the NZCPS board of Enquiry to be a Surf Break of National Significance because of its recognition as one of Aotearoa New Zealand's few big wave surfing venues.

Uniqueness

This attribute also considers a surf break's utility within a geographical boundary. This considers a surf breaks usability at times when all other breaks are unsurfable. It may be a surf break that picks up all available wave conditions while at other surf breaks the waves are too small to surf; or it may be offshore when all other surf breaks experience onshore winds (see Appendix A). This attribute considers the relationships between surf breaks in different weather and swell conditions.

Wilderness value

This attribute is synonymous with a subcategory of Surf Breaks of Local Significance and 'secret spots' which are perceived as being known to a few, closely guarded and/or challenging to access (Atkin, 2017; Atkin and Mead, 2017). Wilderness value transcends these secret spot associations with the level of remoteness and/or isolation being important. One appeal of high wilderness value is the, expected, lower number of users, which is a function of knowledge but also the commitment required to access a location.

B.3 Community Values

Peryman and Orchard (2013) evaluated major categories of value associated with surf breaks from the perspective of the coastal communities from Gisborne (Peryman, 2011a) and the Bay of Plenty (Peryman, 2011b). Table C-1, adapted from Orchard *et al*. (2019), presents these categories with contributing aspects to provide background.

Surfing resources play a key role in many coastal societies by facilitating social interactions and experiences associated with a high quality of life. For Boardriders clubs the surfing resource is the focal point of their activities and the social platform is very broad, with internal and external competition, team building, and family contributions and activities; across a full range of age groups.

Some users associate surfing resources with spirituality and a sense of wellbeing; others simply with a livelihood that directly draws from the well reported economic benefits of surfing resources in the coastal environment (Lazarow *et al*., 2009; Nelsen *et al*., 2007; Nelsen *et al*., 2013). Hales *et al*. (2017) describe the term “Surfing Capital” as the four factors which shape the surfing experience being: 1) the physical features of and surfer’s awareness of, the quality of waves for surfing, 2) the frequency of quality waves, 3) the coastal and marine environment and 4) socio-cultural issues that are associated with coastal places.

Table C-1. Categories of value associated with surf breaks identified from community surveys in the Bay of Plenty and Gisborne regions. Adapted from Orchard *et al*. (2019).

Theme	Value categories	Contributing aspects
Social	Physical and mental health benefits	Surf breaks are host to many user groups who participate in many different forms of recreation with positive qualities for physical and mental health for people of all ages and walks of life
	Educational value	Surf breaks are venues for skills learning, including encouragement of young / learner surfers to participate, hold contests, and socialise in a supportive environment
	Enabling social interactions	Surf breaks support a diverse range of interactions that contribute to a social fabric that extends into wider communities
	Lifestyle value	Surf breaks contribute to healthy, family-orientated and community-based lifestyles
	Spiritual value	Surf breaks are a source of spiritual energy and a place to exercise spirituality important to individual health and community well-being
	Experiential and amenity values	Surf breaks contribute to scenic and naturalness values important to recreational users, onlookers, coastal inhabitants and visitors
		Surf breaks contribute to visual and oral expressions of place – interconnected to wider landscape and seascape values
		Surf breaks contribute to the nature and memorability of experiences in the coastal environment
		Raw and undeveloped natural landscapes and seascapes contribute to the opportunities for wilderness experiences
		Built access and facilities can contribute to surf break amenity though are not always desirable
Cultural	Cultural use and enjoyment	Access to, use and enjoyment of surf breaks are important aspects of the link between coastal culture and surf break environments
	Places of cultural significance	Many surf breaks are associated with important cultural or heritage associations and some are considered ‘sacred treasures’
Economic	Commercial activities and economic effects associated with surf breaks	Surf-related tourism and surfing industry activities are important to local, regional and national economies
		Surfing is extensively used in the marketing and promotional activities and contributes to the branding of many commercial products as well as visitor and lifestyle destination
		The contribution of surfing to healthy lifestyles has physical and mental health benefits that contribute to economic considerations
Environmental	Natural features and life-supporting systems	A range of physical aspects of the both terrestrial and aquatic environment contribute to the existence, character, and uniqueness of surf breaks
		The ecology and ecological health of surf breaks, adjacent areas, and upstream catchments can influence use and enjoyment
		Surf breaks have environmental educational value as sites for experiencing aspects of the coastal environment

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Appendix C. **Engagement with Māori**

The following links provide resources on appropriate and meaningful methods for engaging with local iwi. While these resources are mostly aimed at Council use, the underlying principles and methods are applicable for developers. The resources consider our collective obligations under the Treaty of Waitangi, Resource Management Act 1991 and New Zealand Coastal Policy Statement 2010.

Auckland Regional Council: Lessons for successful Mana Whenua engagement

http://knowledgeauckland.org.nz/assets/publications/Lessons-for-successful-Mana-Whenua-engagement-FINAL-WEB.pdf

Bay of Plenty: Iwi Resource Management and Engaging with Māori

https://www.boprc.govt.nz/plans-policies-and-resources/policies/operative-regional-policy-statement/rps-implementation-strategy/iwi-resource-management/

https://www.boprc.govt.nz/media/717746/engagement-toolkit.pdf

Waikato Regional Council: Māori Engagement Framework

https://www.waikatoregion.govt.nz/assets/WRC/Council/Policy-and-Plans/11340016-Maori-Engagement-Framework-Guide.pdf

Department of Conservation: New Zealand Coastal Policy Statement – Policy 2

https://www.doc.govt.nz/about-us/science-publications/conservation-publications/marine-and-coastal/new-zealand-coastal-policy-statement/new-zealand-coastal-policy-statement-2010/policy-2-the-treaty-of-waitangi-tangata-whenua-and-maori/

The Ministry for the Environment: Effective participation in resource consent processes: A guide for tangata whenua and Mana Whakahono ā Rohe guidance

http://www.mfe.govt.nz/publications/rma/effective-participation-resource-consent-processes-guide-tangata-whenua

http://www.mfe.govt.nz/publications/rma/mana-whakahono-%C4%81-rohe-guidance

Inspiring Communities

http://inspiringcommunities.org.nz/wp-content/uploads/2018/01/Working-with-Tangata-Whenua_IC_2018.pdf

Cultural Impact Assessment examples:

Rena Long-Term Environmental Recovery

Pukekohe Wastewater Discharge Application

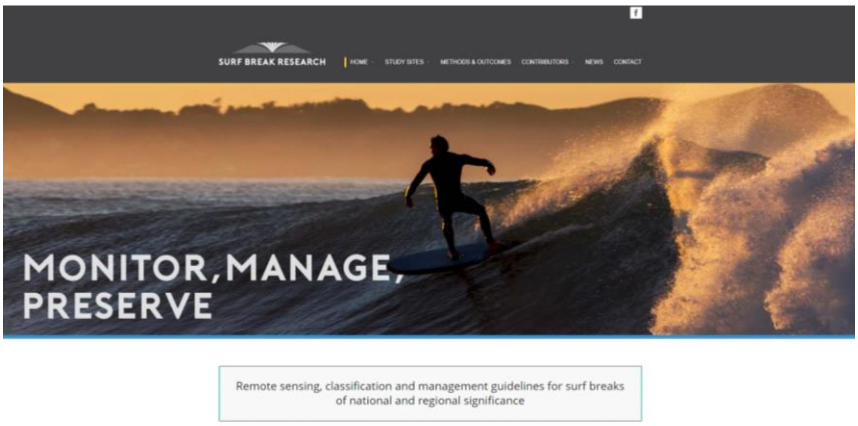
Appendix D. Remote Sensing, Classification and Management Guidelines for Surf Breaks of National and Regional Significance

In 2015 the University of Waikato, Hume Consulting Ltd and eCoast formed a collaboration to address a knowledge gap in the management of surfing resources. “Remote Sensing, Classification and Management Guidelines for Surf Breaks of National and Regional Significance” was a 3-year, Ministry for Business, Innovation and Employment funded project under the targeted research investment mechanism, and Enhanced Environmental Decision Making and Behaviour Change Investment Priority.

The project considered natural resources around the coast of Aotearoa New Zealand that are publicly accessible to all. The overarching aim of the project was to construct a baseline database of surf break physical parameters and processes at 7 of Aotearoa New Zealand’s nationally and regionally significant surf breaks; and to develop sustainable management guidelines which will uphold the integrity of the New Zealand Coastal Policy Statement 2010.

Seven surf breaks were selected for detailed study to encompass the range of different types of surf breaks and the variety of threats to surf breaks within Aotearoa New Zealand. Stakeholder meetings were conducted for each site to collect data and local knowledge relating to cultural, geomorphic and historical background. An important step prior to the stakeholder meetings involved consultation with tangata whenua (local Māori, people of the land) who have kaitiakitanga (guardianship) of each area in order to seek approval for conducting research within their rohe (tribal boundaries), ensure that the research aims and methods aligned with the local Iwi’s values and beliefs and to determine how each surf break is valued and used by Iwi.

Technical data collection was achieved through the use of remote camera stations at each site. The stations collect images of the study sites 7 days a week, 365 days a year. Automated systems process the data and extract important physical parameters. Multiple bathymetric surveys of the seabed at each site were undertaken. The data collected during this project is freely available from an online data portal; with the capacity to add new breaks in the future.



Appendix E. **Consent Conditions and Monitoring**

E.1 Overview

As described in Section 1.2 (Legislative Context) of these Guidelines. surf breaks are relevant to several aspects of the Resource Management Act 1991 (RMA), particularly the purpose and principles of the Act, the purpose of Regional Policy Statements and the purpose of regional plans. The RMA is Aotearoa New Zealand's main piece of legislation that sets out how we should manage our environment (http://www.mfe.govt.nz/rma). The RMA was created to achieve a more coordinated, streamlined, and comprehensive approach to environmental management, and is focused on the sustainable *management* of natural and physical *resources* such as land, air and water; as set out in Section 5 of the Act 'Purposes and Principles'.

The RMA controls specific uses of natural and physical resources through the requirement of resource consent. To gain resource consent for specific activities, an Assessment of Environmental Effects (AEE) is required as part of the application for resource consent. The AEE should include all potential impacts on the environment (see Table 2.4 of these Guidelines for a comprehensive, but not exhaustive, list of potential impacts on surfing resources), assess the level of the potential impacts, and how any adverse impacts can be avoided, remedied or mitigated.

An important component of the resource consent process are the conditions of consent, which are a specific set of procedures and tasks that an applicant must undertake to determine the level of any potentially adverse impacts (usually through environmental monitoring) and/or procedures to be undertaken in order to avoid, remedy or mitigate any adverse impacts on natural and physical *resources (such as surf breaks). A well-written set of conditions that captures the potential and actual impacts and how they should be monitored and the adaptive management procedures that can be applied to* avoid, remedy or mitigate any adverse impacts is fundamental to the successful management of surfing resources.

There are several useful guidelines available for the development of resource consent conditions, such as those provided by Quality Planning[12] (e.g. http://www.qp-test.org.nz/):

"*It is critical that resource consent conditions are drafted carefully to ensure:*

- *they are within the law*

[12] Quality Planning is a collaboration between the New Zealand Planning Institute (NZPI), the Resource Management Law Association (RMLA), Local Government New Zealand (LGNZ), the New Zealand Institute of Surveyors (NZIS), the New Zealand Institute of Architects (NZIA) and the Ministry for the Environment (MfE).

- *compliance with the conditions will result in any adverse effects being limited to the extent anticipated by the decision-maker*
- *the consent holder and other parties understand exactly what the requirements are, and*
- *if necessary, enforcement can be undertaken.*

As a consequence, the drafting of resource consent conditions is extremely important."

E.2 Why Consent Conditions?

Conditions of consent come in a variety of forms. With respect to surf resources, they most often address effects that have the potential to change the characteristics of the surf break, although effects on water quality and access to surf breaks are also potential impacts. It is therefore fundamental that baseline data to quantify the characteristics and mechanics of the surf break and surfing waves is collected. In addition, many potential impacts on surf breaks due to various activities on the coast and within the swell corridor are presently unknown due to lack of research. This means that baseline monitoring is critical to determine impacts.

In this section, three examples are presented to show how impacts on a surfing resource can occur, and how their management can be improved by appropriate baseline data collection and suitable conditions of consent.

E.2.1 Aramoana

The impacts of nearshore dredge disposal on the nationally significant surf break of Aramoana at Otago Harbour entrance was controversial when renewals for the dredge disposal resource consents were due in 2013. Aramoana is a high-quality beach break where the offshore ebb-tidal delta focusses waves in to peaks, or 'A-frames' (See Guidelines Glossary), which provide hollow peeling waves (See Appendix A). The surfing fraternity were divided as to whether the nearshore disposal enhanced this focussing effect, enhanced wave quality, or whether the nearshore disposal had led to the beach being over-filled with sediment resulting in a reduction of wave quality (See Appendix A). Similarly, numerical modelling of the combined effects of the offshore delta focussing and nearshore disposal mound focussing were interpreted differently by different experts (some positive and others negative).

Through mediation between the Surfbreak Protection Society (SPS) and Port Otago Ltd, a temporary 3-year permit was granted which greatly restricted the volume of nearshore disposal to determine the impacts of nearshore disposal; it was reduced from 200,000 m^3 to

50,000 m^3. Furthermore, no nearshore disposal was permitted during the first 2 years. Through a combination of remote video monitoring, repeat bathymetric surveys, numerical modelling and surveys of local surfers, it was found that surfing wave quality had markedly improved. This improvement correlated to a reduction in the volume of sand within the Aramoana embayment as it naturally moved westward and around the point. As a result, better management of nearshore disposal at Aramoana is being implemented through restricted disposal volumes. In addition, the location and shape of the disposal mound have been modified to a configuration more conducive to high quality surfing (see example conditions below).

E.2.2 Aquaculture

Wave attenuation through offshore mussel farms has the potential to reduce wave height at the surf breaks. Unlike impacts such as enrichment of the seabed under mussel farms, where degrees of enrichment and the effects of this are well studied, there is very little understanding of the impacts of wave attenuation through mussel farms, which could be positive or negative.

It is known that mussel farms will attenuate short period waves such as local wind-generated waves. The attenuation qualities of kelp beds are positive and well known to surfers; in terms of surfing conditions, this attenuation of short period waves results in ‘cleaner’, more favourable conditions. However, there is also the potential to reduce wave heights, which in some areas that have only small wave climates and rely on short period waves for surf breaks to operate this attenuation is a negative impact. Therefore, appropriately designed monitoring is required to determine and quantify impacts on surf breaks where offshore aquaculture developments are within their swell corridors (see example conditions below).

E.2.3 Whangamata

The impacts of a marina development on have been very controversial. Whangamata Bar is one of Aotearoa New Zealand’s Surf Breaks of National Significance under Policy 16 of the New Zealand Coastal Policy Statement 2010 (NZCPS), was described by the Hawaiian surfing legend Gerry Lopez as the ‘gem of the South Pacific’, and falls in the most ‘sensitive’ category of surf break, a delta break .

The marina entrance channel was opened to the sea in 2009. The area of the harbour deepened to develop the marina represents an increase in the tidal prism of the estuary, which in turn has the potential to modify currents at the mouth of the estuary and impact on the ebb tidal delta. The ebb tidal delta is the primary functional seabed component that comprises the

Whangamata Bar surf break. While there is no doubt that detrimental changes to the morphology of “The Bar” occurred during the time that the marina was opened to the sea (i.e. there were negative impacts to the surf break’s wave quality in terms of ride length and peel angle), there is insufficient and inadequate monitoring data to confidently determine that it was caused by the marina development, or whether it could have been associated with particular storm events at the time and natural changes in the bar. The reason for the lack of conclusions was because:

a) There was insufficient characterisation of the surfing break prior to the development so changes to wave quality could not be quantified.
b) There was insufficient baseline monitoring to determine natural variation of ebb tidal delta and the area in and around the Surf Break Area (SBA).
c) The monitoring methodology was only directed at one component of the surf break with relatively sparse data capture (i.e. bathymetry surveys every 6 months).
d) The level of investigation was poor as it lacked even a general understating of surf science and surfing resource management

E.2.4 Summary

Comprehensive baseline monitoring is required to quantify surf break mechanics and surfing wave characteristics. Baseline monitoring should be followed by monitoring of any effects to the mechanics and characteristics during and post development or activity (as set out in Sections 2 and 3 of these guidelines). A year of baseline monitoring is considered the minimum, while multi-year baseline data collection will increase confidence in our quantification and understanding of a surf break.

To manage our nationally and regionally significant surf break resources, remote monitoring should be a permanent activity undertaken by the authorities responsible for these sites. Some surf break monitoring methods also have multiple benefits and can assist in a range of areas for regional and local authorities; remote video cameras for example, provide a variety of information about a surf break and its characteristics, and can also be used to consider a range of other parameters such as user numbers (not only of surfers, but other water and beach users), erosion/accretion trends, rips and bars (e.g. safety issues), and extreme events and coastal hazards.

E.3 Baseline monitoring

Baseline monitoring is required in order to determine whether or not an activity(s) impacts on a surf break. Baseline monitoring is focussed on the collection of data that can be used to characterise the surf break (i.e. length of ride, optimum wave height, optimum tidal phase, peel angle, breaking intensity, local seabed morphology, wave height at surf break in comparison to offshore wave conditions, etc.). Baseline monitoring methods include:

- Remote video data collection – this is most cost-effective method of collecting surf-break data, which can be used to determine peel angles, ride length, optimum swell/tide/wind conditions, typical take-off and break location(s), as well as infer seabed morphology and provide further information such as number of users (for all users of the space), beach change, rips and bars.
- Surveys of bathymetry – repeated surveys provide information about changes to the seabed. The use of single or swath bathymetry is dependent on the surf break configuration and the presence of particular features, and the type of activity the conditions of consent are being drafted for.
- Beach profile monitoring– repeat beach profiles, which cover the intertidal and subaerial areas, can use traditional surveying methods or LiDAR, and should overlap with hydrographic survey data.
- GPS tracking of surfers – the geographical position of surfers utilising GPS (the Global Positioning System) (See Appendix A Section 3.3) can be applied to determine ride length, take-off area, sections of the wave, and entry and exit points to the surf break
- Oceanographic data collection – wave statistics (height, period, direction etc.) and in some cases currents at a surf break provide information that can be related to long-term data sets to develop a pre-activity dataset of waves conditions
- Numerical modelling – calibrated numerical models can be used to simulate processes of the existing surf break. Simulations can include various swell events and consider the potential impacts of any changes to the existing environment (e.g. nearshore dredge disposal mounds, harbour channel deepening, offshore sand-mining, etc.).
- Water quality monitoring – activities such as nearshore dredge disposal, dredging, stormwater outfalls, wastewater outfalls, aquaculture, forestry, farming and urbanization can potentially impact on water quality. Water quality standards should follow Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas (Ministry for the Environment, 2002; or later editions). Sampling sites must be proximal to surfing areas and target the pollutant.

There is natural variability in the swells that propagate through a swell corridor to a surf break. In some cases, there is natural variability in the bathymetry of the swell corridor and SBA. The requirement to understand this natural variability fosters the need to collect a long, high resolution baseline dataset. The longer a baseline dataset, the more confidence there is in the characteristics and mechanics of the break during a range of conditions.

For example, swells from the northeast may be dominant during summer and autumn months, while southerly swells dominate the winter and spring seasons, which is synonymous to the east coast of the South Island). These different swell directions result in different wave characteristics such as peel angles, wave breaking intensity, wave height and ride length (see Appendix A for detailed definitions of surfing wave characteristics). By monitoring and quantifying this variability, a specific range of parameters can be defined as the baseline characteristics of a break (e.g. wave peel angles are typically between 55 and 65° during northeast swell and 60-70° during southeast swell).

Similarly, beach breaks may have characteristics driven by seasonal wave climate and/or different combinations of wind/wave events. For example, on the north western coast of the North Island, the larger swells of winter and spring often result in shore parallel bars and troughs. This “longshore bar trough” configuration is not often conducive to good surfing conditions. Over the summer months, during which time the wave climate is generally lower energy, the trough often fills in which is associated with better surfing conditions. In addition, and in combination with this seasonal morphodynamics, the variability of the wind/swell conditions can play a large role in surfing wave quality. During periods of prolonged southwest wind and waves (the predominant conditions on the north western coast) shore parallel bars can extend unbroken for long distances along the beach. The result is very few places to surf waves with sufficient quality along the beach. However, when there is a lot of variability in the wind and wave conditions, with periods of winds from the northwest transporting sand back to the south, the number of breaks in the shore-parallel sand bars increases markedly resulting in increased opportunity for good surfing locations. Due to the natural variability and seasonality of the marine environment it is important to collect baseline monitoring data for as long as possible; multi-year datasets provide information on the effects of longer-term oceanographic variation such as El Nino/La Nina.

Sections 2 and 3 of these Guidelines describes the appropriate step within the surf break assessment of the AEE that will lead to the development of specific Conditions of Consent that will *capture the potential and actual impacts, how they should be monitored and the adaptive management procedures that can be applied to* avoid, remedy or mitigate any adverse impacts. These steps are supported by additional information in Section 4 and a comprehensive set of appendices.

E.4 Impact Monitoring and Adaptive Management

Through the resource consent process an AEE should provide the assurance that effects to a surf break (actual and potential) are either less than minor to insignificant, or that any effects can be managed through avoidance, remedying or mitigation before granting resource consent. To determine whether or not the consented activity is having any impact on the potentially effect surf break(s), the monitoring undertaken for baseline data collection is continued and these data are then compared to the baseline data.

It is the conditions of consent that are fundamental to ensuring that:

- **the monitoring design is appropriate to detect and quantify effects**
- **that methods are established that counter any effects through avoidance, remedying or mitigation.**

Countermeasures are incorporated into conditions through a variety of methodologies that are termed adaptive management. Adaptive management relies on detecting effects through monitoring, quantifying these effects so that if a ‘trigger’ is met a countermeasure is undertaken, often with further detailed investigations being undertaken.

In many cases, the first response to a trigger being detected is an in-depth analysis of the data that has been collected since the baseline was established, and a more rigorous round of monitoring (e.g. a potentially unscheduled bathymetric survey to confirm the changes observed with other monitoring such as remote video). Triggers for surf break impacts can include, but are not limited to, changes in peel angles, wave breaking location, ride length, crest uniformity, water quality, breaking intensity, wave height and/or direction; and changes in the amount of time that waves are surfable at the break.

If a trigger level is reached measures in the Environmental and Adaptive Management Plan (EAMP) are applied to avoid, remedy or mitigate the impact. For example, a trigger can be set for wave height attenuation due to large scale offshore aquaculture. The effects can be mitigated by counter measures (adaptive management) such as reducing stocking densities within the marine farm; determined by staging the development with incremental increases on stocking densities. Another example of a trigger is a change in sea floor shape, or bathymetry, observable through repeat bathymetric surveys. This is particularly important where previous investigations have indicated that the amount of material in the beach system is important for the quality of the waves at a surf break; this has been applied to the management of Port Otago’s nearshore disposal ground at Aramoana. At Whareakeake, wave breaking on the offshore dredge disposal ground breaks the waves and impacts on wave crest uniformity (which is important at point breaks such as Whareakeake), and so a minimum height of disposal mound has been specified in the conditions, with heights above this triggering a reduction in disposal on the crest of the mound (adaptive management). At Taylor's Mistake in Christchurch, there is potential to impact on both water quality and bathymetry at the break due to nearshore maintenance dredge disposal for the Port Lyttleton entrance channel. Monitoring of water quality and with remote cameras is being undertaken to measure these effects.

Should water quality levels be triggered, then adaptive management measures can include disposal during conditions when currents/winds transport the sediment plume offshore. A trigger due to changes in bathymetry due to sediment moving shoreward from the disposal mound will require a re-think with respect to the nearshore disposal site such as relocation (only one site was investigated for the resource consent application); the AEE concluded that this would not occur, while further modelling work as part of mediation between the Port and the Surfbreak Protection Society indicated that sediment would migrate shoreward. The examples presented here are summarised in Table D-1.

Table D-1: Summary table of example activity-trigger-response to be used in adaptive management.

Activity	**Large Scale Offshore Aquaculture**	**Dredge Spoil Disposal**	**Dredge Spoil Disposal**
Trigger	Wave height attenuation	Change to seabed morphology (i.e. depth isobath position)	Wave breaking on disposal ground
Response	Reduce stocking densities	Use of disposal ground temporally halted	Establish threshold for height disposal mound
Potential retrospective avoidance	Incremental increases on stocking densities	Estimate maximum disposal ground capacity in terms of surfing wave quality; combined with pre-disposal surveys	Establish seabed height threshold for wave breaking; combined with pre-disposal surveys

E.5 Example Conditions of Consent

This section presents some examples of appropriate conditions of consent for activities in Aotearoa New Zealand. The first example is concerned with aquaculture proposed for the Firth of Thames, the second looks at the conditions of consent imposed on the Port of Otago for their “Project Next Generation”; lastly, the more recent conditions of contest for the Lyttelton Port Company. The conditions of consent in these examples were developed specifically for type of activity and receiving environment. Conditions of consent will need to be addressed on a case by case basis.

E.5.1 Firth of Thames

There is presently very little information and understanding with respect to the extent of wave attenuation as waves propagate through mussel farms, or other aquaculture related structures. Wave attenuation has the potential to impact on wave height at the break, as well as wave-driven currents at the shore which in turn may impact on the sediment transport regime and seabed features that comprise the surf break.

The following conditions were recommended to determine impacts on the surfing resources in the Firth of Thames:

Wave Monitoring

- *The monitoring programme for long and short waves shall investigate the impact of the proposed marine farm on waves from the [directions identified from swell corridor investigations] of the farm site. The likely programme shall be undertaken using two wave monitoring devices, being any of the following models of devices; Aquadopp, Vector, Aqua pro, ADCP-waves, or Directional Waverider or a device with comparable or better ways of measuring capability.*
- *Wave monitoring devices shall be installed at two locations; one offshore and one inshore of the proposed farm site prior to any development at the site. The wave monitoring devices shall be installed at the same depth below the sea surface. The devices shall measure and record the direction and height of waves with periods of three seconds and longer. The devices shall collect data for a continuous period of at least two months and include at least two wave events. The data collected shall be analysed to determine if there is any directional difference in attenuation of wave height based on direction across the site.*
- *The monitoring described above shall be undertaken prior to farm development (baseline data), at 50% development and at 100% development.*

- *If the data analysis from the monitoring of the developed farm (either at 50% or 100%) shows that there is a significant directional difference and/or attenuation of wave height based on direction across the site in comparison to baseline data, then the consent holder shall provide a report to the Team Leader Monitoring South outlining the implications of this on coastal processes and surfing amenity on the western Firth of Thames coast, including proposing any remediation that may be required and a programme for continued monitoring.*
- *If the data demonstrates that there is no significant wave dampening effect from the farm structures, the monitoring can cease.*

E.5.2 Port Otago

At Aramoana and Whareakeake, the 3-year temporary dredge disposal consents that allowed Port Otago to gain a much better understanding of the mechanics of these two Surf Breaks of National Significance, a 20-year resource consent was applied for and granted. The new consent includes an extensive increase in the disposal site offshore of Whareakeake (Heyward disposal mound was increased by approximately 5x). This increase permitted better management of the morphology of the disposal mound that effects the surf break. The consent also included conditions regarding the bathymetry at the Whareakeake and Aramoana (specific depths and depth contour locations), and continued remote camera data capture:

Dredging Volumes and Bathymetric Monitoring

7. *(i) The consent holder shall record the following information in relation to the disposal of material at each of the three disposal sites.*

   (a) the volume of dredging material in each disposal event;
   (b) the volume and percentage of each material type in each event;
   (c) the source geographic claim location information;
   (d) the GPS location (WG84 format) of the event;
   (e) the date and time of disposal; and
   (f) a cumulative total of the volumes of disposal (including material type) from the commencement of the consent.

   (ii) The records shall be kept and submitted to the Consent Authority on an annual basis, no later than the anniversary of the date of the commencement of this permit in report format, including digital records that allow for GIS plotting.

8. *As a minimum, the consent holder shall undertake annual bathymetric surveys of the seabed at each of the disposal site locations and the beach areas inshore of the these which have the potential to be affected by the disposal. All bathymetric surveys*

shall have an accuracy of 0.25 metres vertically. The extent and frequency of the bathymetric surveys may be amended with the agreement of the Dredging Working Party and the Consent Authority.

A. *Bathymetric surveys shall be undertaken for the Shelley Beach site that clearly indicates the degree of change to the seabed in the surveyed areas.*
B. *Bathymetric surveys shall be undertaken for the Heyward Point disposal site to check the dimensions and depths of the mound and spur features are within the following limits:*
   - *(i) The mound within the cells PB5, 6, 7, PD5, 6, 7 is maintained in its present location and is not less than 9.5 metres below mean sea level;*
   - *(ii) The 12 metre depth contour surrounding the mound is greater than 300 metres in diameter;*
   - *(iii) That minimal disposal occurs on the spur area within cells PC1, 2, 3, 4 and PD1, 2, 3, 4 illustrated on Figure 1 as attached as Appendix 1 to this consent; and*
   - *(iv) That the balance of material is spread out evenly.*

Advice Note – The limits have been specified to ensure that the mound is managed in a manner that avoids it becoming too high above the natural seabed level, or the sides of the mound becoming too steep. This is required to avoid the creation of wave interference patterns and wave crest disruption at the Whareakeake surf break.

C. *Bathymetric surveys shall be undertaken for the Aramoana disposal site to check the positions of the 5, 6, and 7 metre depth contours are consistent with the historical positions illustrated on Figure 2, Figure 3 and Figure 4 as attached as Appendix 1 to this consent.*

   Where there is departure from the specified contour levels at the Heyward Point or Aramoana disposal sites, a review of the bathymetric surveys shall be undertaken by a suitably qualified expert in coastal processes to identify the potential for adverse effects on wave and sediment transport, and the adaptive management process outlined in Condition 18 shall be commenced.

9. *A visual or photographic record of surf conditions shall be maintained and archived for the Aramoana and Whareakeake surf breaks. This shall be made available and reviewed as necessary by the Dredging Working Party, in the event that the adaptive*

management Condition 18[13] is triggered and the Dredging Working Party identifies a potential surf quality issue. These data are to be recorded through webcams or alternative technology as agreed with the Dredging Working Party. Visual recording may be discontinued in the future, with the agreement of the Working Party and the Consent Authority.

10. *Beach profile surveys for the Aramoana, Kaikai, Whareakeake, Long Beach, Pūrānkaunui, Warrington Spit, Karitane and Shelley Beach shall be undertaken annually by a suitably qualified expert in coastal processes for the first five years from the date of the commencement of this permit and thereafter once every five years for the term of this consent. A beach monitoring report shall be provided to the consent authority following each profile survey with an assessment of the rate and extent of sediment accumulation at the beaches in Blueskin Bay and the effect of disposal activities on erosion or accretion of the beach. Where this report identifies any adverse effects potentially attributable to disposal activities, the adaptive management process outlined in Condition 18 shall be commenced.*

E.5.3 Lyttleton Port Company

In Canterbury there is the potential for nearshore maintenance dredge disposal by Port Lyttleton Company to impact on both water quality and bathymetry at Taylor's Mistake and possibly other surf breaks. Following an appeal by the Surfbreak Protection Society, the following conditions were included in the resource consent for maintenance dredge disposal:

14. SURFING LIAISON GROUP (SLG)

14.1 Not less than three months prior to the first Dredging Campaign, the consent holder shall establish the SLG by inviting representatives from the surfing community described in condition 14.3 (a) and (b) to participate in a SLG.

14.2 The purposes of the SLG are:

(a) To enable the consent holder and the surfing community to share information relating to surf wave quality and the exercise of this consent; and

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(b) *To discuss the monitoring required by this consent, insofar as it relates to the effects of exercising this consent on the Surfbreaks.*

14.3 *Invitations to participate in the SLG shall be extended to:*

(a) *The Surfbreak Protection Society who shall be entitled to appoint up to* 2 *representatives to the SLG; and*

(b) *Local surfers who shall be entitled to appoint up to* 2 representatives to the SLG.

14.4 *The consent holder shall be entitled to appoint up to 3 representatives to the SLG.*

14.5 *Once established, the consent holder shall offer to hold meetings of the SLG prior to the commencement of each Dredging Campaign under this consent.*

14.6 *The consent holder shall provide no less than two weeks' notice of all SLG meetings, provide a venue and agenda for the meetings, and shall keep minutes of those meetings and distribute them within five working days but otherwise the costs of participation in the SLG shall lie where they fall.*

15 BATHYMETRIC MONITORING AND ASSESSMENT

15.1 *The consent holder shall five years after the first Dredging Campaign review the results of the bathymetric monitoring required under condition 7.19 and evaluate whether Dredge Spoil deposition and associated mound height at the offshore maintenance disposal ground is consistent with the modelling outputs contained in the Met Ocean Solutions Ltd Report (dated November 2017).*

15.2 *Where the evaluation carried out under condition 15.1 determines that the mound heights are inconsistent with the modelling outputs contained in the Met Ocean Solutions Ltd*

Report (dated November 2017), the consent holder shall engage a suitably qualified and experienced expert to:

(a) *Review the bathymetric data;*

(b) *Rerun the model;*

(c) *Evaluate and provide reasons for the discrepancy between the bathymetric data and the modelling outputs; and*

(d) *Evaluate any changes to the predicted effects on Surfbreaks.*

15.3 *The consent holder shall provide a report to the SLG and the Consent Authority on the results of the review of the bathymetric monitoring* completed under condition 15.1, and, if required, any review and evaluation completed under condition 15.2.

15.4 *The consent holder on request from the representatives of the Surfbreak Protection Society or the local surfers on the SLG shall convene a meeting to discuss the contents of the report* prepared under condition 15.3, and consider whether any management actions or whether any additional monitoring is needed.

15.5 *Recommendations made by the SLG and adopted by the consent holder shall be incorporated into the report prepared under condition 15.3 and the revised report shall be provided to the SLG and the Consent Authority. Any recommendations that are not adopted are to be included in the report together with the reasons why they were not adopted.*

15.6 *The report prepared under condition 15.3 shall be completed no later* condition 15.1 and any revised report shall be completed within two months of any meeting held under condition 15.4

7 MONITORING

7.27 Prior to the commencement of the first dredging campaign the Consent Holder shall install a system to capture and archive a video or photographic record of the surf conditions at Taylors Mistake surf break and shall maintain the system for the duration of this consent. The visual or photographic record shall be recorded via a remote web-based camera system with suitable resolution and field of view to enable extraction of georeferenced images for all of Taylors Mistake Surf Break. The data and images shall be made available to the SLG, solely for the purposes of informing the processes and outcomes of conditions 15.2, 15.3 and15.4.