Management in Practice

Yes, we CANZ: initial compliance and lessons learned from regulating vessel biofouling management in California and New Zealand

Chris Scianni1,*, Katie Lubarsky2,3, Lina Ceballos-Osuna1 and Tracey Bates2,4
1Marine Invasive Species Program, California State Lands Commission, 100 Howe Ave., Suite 100 South, Sacramento, CA, 95825, USA
2Biosecurity New Zealand, Ministry for Primary Industries, 34-38 Bowen Street, Pīpītea, Wellington, 6011, New Zealand
3Scripps Institution of Oceanography, University of California, San Diego, La Jolla, California 92093, USA
4Maritime New Zealand, 11/1 Grey Street, Wellington Central, Wellington, 6011, New Zealand

Author e-mails: Chris.Scianni@slc.ca.gov (CS), clubarsky@ucsd.edu (KL), Lina.Ceballos@slc.ca.gov (LC), Tracey.Bates@maritimenz.govt.nz (TB)
*Corresponding author

Abstract
In 2017 and 2018, California and New Zealand introduced new regulatory regimes for the maritime shipping industry by implementing and enforcing regulations for biofouling management. Both sets of regulations reflect the principles of the International Maritime Organization’s Biofouling Guidelines and are designed to encourage proactive biofouling management to reduce the likelihood of nonindigenous species introductions. During the first year of enforcement, maritime shipping vessels that were subject to the respective regulations made similar numbers of arrivals at California (2,515) and New Zealand (2,556) ports. California and New Zealand regulators also conducted similar numbers of biofouling inspections during this time: 505 in California and 498 in New Zealand. Most instances of noncompliance in both jurisdictions were a result of incomplete understanding of these new regulations, however provisions to provide flexibility and education ensured the maritime shipping industry had opportunities to learn about the requirements, improve compliance, and reduce learning curves. An important lesson learned for both jurisdictions was the importance of extensive and targeted outreach to the various stakeholder groups that play a role in achieving compliance and effective risk reduction. The lessons learned and noncompliance trends identified during the first year of inspections in California and New Zealand provide valuable insights for consideration in light of the current review of the IMO Biofouling Guidelines and moves to develop biofouling requirements in other jurisdictions.

Key words: invasive species, nonindigenous species, policy, biosecurity, inspections, shipping, pathway management

Introduction
Commercial shipping has long been recognized as a potential pathway for the introduction of aquatic nonindigenous species (NIS) into coastal and estuarine waters worldwide, through the mechanisms of ballast water and vessel biofouling (Bishop 1951; Elton 1958). However, until Carlton (1985) shined a light on the “biology of ballast water”, modern shipping practices had escaped biosecurity scrutiny. The international regulatory community followed that light toward a newfound commitment to manage biosecurity...
Figure 1. Timeline of major ballast water and biofouling policy advances in California, New Zealand, and at the International Maritime Organization.

Risks posed by ships through a variety of regulatory actions (Figure 1), including the adoption of:

- U.S. Nonindigenous Aquatic Nuisance Prevention & Control Act (1990)
- New Zealand voluntary ballast water guidelines (1992)
- International Maritime Organization (IMO) Guidelines for the Control and Management of Ships’ Ballast Water to Minimize the Transfer of Harmful Aquatic Organisms and Pathogens (1997)
- New Zealand’s mandatory Import Health Standard for Ballast Water (1998)
• California’s Ballast Water Management for Control of Nonindigenous Species Act (1999)
• IMO International Convention for the Control and Management of Ships’ Ballast Water and Sediments (2004)

These voluntary and legislative actions were focused almost exclusively on ballast water management, as were other legislative or regulatory actions taken during the 1990s and early 2000s (e.g., Australia introduced mandatory ballast water management requirements in July 2001). Regulatory focus on vessel biofouling as a biosecurity concern lagged, even as estimates of the contribution of biofouling to existing NIS translocations globally were being developed and highlighted (Ruiz et al. 2000, 2011; Hewitt and Campbell 2010).

Coordinated international efforts to address biofouling management began in 2006 when the issue was first formally discussed at the IMO. After several years of deliberation and consideration of best practices and desired outcomes, the IMO’s Marine Environmental Protection Committee adopted the voluntary Guidelines for the Control and Management of Ships’ Biofouling to Minimize the Transfer of Invasive Aquatic Species (hereafter referred to as IMO Biofouling Guidelines; IMO 2011). The IMO Biofouling Guidelines are centered around the development and implementation of a vessel-specific Biofouling Management Plan (BFMP) and Biofouling Record Book (BFRB) to guide effective proactive and reactive biofouling management. These guidelines were intended to provide a globally consistent approach to vessel biofouling management and facilitate the international community’s efforts to reducing the risk of NIS introduction from oceangoing vessels.

The IMO Biofouling Guidelines were soon followed by several related IMO efforts to improve vessel biofouling management. These efforts include Guidance for Minimizing the Transfer of Invasive Aquatic Species as Biofouling (Hull Fouling) for Recreational Craft (IMO 2012) and Guidance for Evaluating the 2011 Guidelines for the Control and Management of Ship’s Biofouling to Minimize the Transfer of Invasive Aquatic Species (IMO 2013). The effectiveness of the IMO Biofouling Guidelines is being officially reviewed during 2020–21 through the Sub-Committee on Pollution Prevention and Response. The international community is moving slowly and deliberately toward improving biofouling management throughout the global fleet.

Alongside the IMO’s action to develop voluntary guidance, mandatory biofouling management regulations were being considered at certain national (e.g., New Zealand) and state (e.g., California) levels. California’s Legislature amended the state’s Marine Invasive Species Act in 2007 to place a mandate on the California State Lands Commission (the Commission) to develop and adopt biofouling management regulations (California Legislature 2007). In New Zealand, the Ministry for Primary Industries
(MPI) commissioned a multi-year vessel biofouling survey in 2004, which eventually formed the basis of a risk analysis (Bell et al. 2011) to inform the development of a national biofouling standard (Georgiades et al. 2020). Scientists and regulators at these agencies worked closely in collaboration with each other and with colleagues in Australia to develop regulatory strategies that were aligned as much as possible and were consistent with the voluntary guidelines being developed at the IMO.

**California’s Biofouling Regulations**

After several years of gathering data on existing vessel maintenance and operational practices and surveying biofouling on vessels arriving at California ports, the Commission began formally developing regulations in coordination with a technical advisory group in 2010. After many years of discussions, continued data collection, and stakeholder engagement, a final set of regulations titled *Biofouling Management to Minimize the Transfer of Nonindigenous Species from Vessels Arriving at California Ports* (hereafter referred to as the California Biofouling Regulations) was adopted and became effective on 1 October 2017 (see Title 2, California Code of Regulations Section 2298.1 et seq.). Prior to these regulations becoming effective, the Commission conducted an outreach campaign that included a guidance document with a plain language description of the regulations and answers to frequently asked questions (see Commission 2017a), a webinar (see Commission 2017b), outreach documents created for vessel crews to be distributed during inspections, and several public meetings with industry representatives across California. An additional webinar was broadcast and archived in October 2018 to provide clarity on requirements for which noncompliance was common during the first several months of inspections (see Commission 2018).

Similar to the IMO Biofouling Guidelines, California’s regulations are centered around the development and implementation of vessel specific BFMPs and BFRBs (Table 1). Vessels that are regulated by the Commission (i.e., vessels 300 gross registered tons and above that are capable of carrying ballast water) and that arrive at a California port are required to have a BFMP and BFRB on board after the completion of the first regularly scheduled dry docking (or delivery for newly constructed vessels) on or after 1 January 2018. The California Biofouling Regulations include specific requirements for the contents of BFMPs and BFRBs, including consistency with the IMO Biofouling Guidelines, details about the antifouling systems in use, and planned actions to manage biofouling associated with specific niche areas (i.e., biofouling hot spots that are often un- or under-protected). The California Biofouling Regulations provide for a 60-day grace period to be issued for vessels that have been found in violation of one or more of the regulatory requirements. No enforcement action is taken during this grace period; instead, the vessel is allowed 60 days to correct the deficiency(ies).
Table 1. Overview of general regulatory components in California and New Zealand. BFMP refers to Biofouling Management Plan. BFRB refers to Biofouling Record Book.

| Vessel types subject to requirements | California only | Both | New Zealand only |
|-------------------------------------|----------------|------|-----------------|
| Vessels over 300 Gross Registered Tons that are capable of carrying ballast water | | | All other vessels that arrive to NZ after visiting the territorial waters of another country |

**Documentation requirements**

1. Marine Invasive Species Program Annual Vessel Reporting Form (submitted once annually).
2. BFMP (must include specific criteria regarding antifouling coatings and management of niche areas)
3. BFRB

**Inspection procedure**

- Inspection of documentation for compliance with requirements
- Physical verification of suspected noncompliant vessels identified during documentation inspection.

**Compliance actions**

- 60-day grace period for vessels that incur violations during first inspection after becoming subject to requirements. Vessel will be compliant if deficiency is corrected prior to first arrival after the 60-day period. If deficiencies are not corrected, the vessel will receive a Notice of Violation.
- Compliance action determined based on biosecurity risk posed by vessel, and may include actions such as itinerary restriction, directions for haul out/dry dock (when available), or directions to obtain additional evidence (i.e., hull inspection).

**Options for vessels that cannot comply**

- Submit petition for alternative management to Division Chief for approval
- Propose Craft Risk Management Plan (CRMP) for approval by MPI

*No specific requirements for the form of the documentation submitted, as long as evidence is sufficient to show that the hull is clean on arrival.*

The Commission began inspections to audit documents of vessels that were subject to the California Biofouling Regulations on 1 August 2018, and initially prioritized all vessels subject to these regulations for inspection on their first arrival at a California port (see Figure 2 for prioritization and inspection process). All data presented here were collected from inspection reports from 1 August 2018, through 31 July 2019, and corresponding annual mandatory vessel-submitted reporting of maintenance and operational practices.

**New Zealand’s Craft Risk Management Standard for Biofouling**

Following an initial period of research and risk analysis between 2004 and 2007, New Zealand identified the management of biofouling-related NIS as a key priority and consulted upon approaches to manage this biosecurity risk in 2010. This consultation was followed by further research and a cost-benefit analysis, which informed the development of the *Craft Risk Management Standard for Biofouling on Vessels Arriving to New Zealand* (“CRMS-BIOFOUL”; MPI 2014). The CRMS-BIOFOUL was signed, and became effective, on 15 May 2014, with a four-year lead-in period during which compliance with the requirements was voluntary. This lead-in period was...
put in place to ensure stakeholders had sufficient time to prepare for the mandatory enforcement of the requirements and to allow MPI time to develop the appropriate guidance to support compliance with the standard. Prior to the mandatory enforcement of the CRMS-BIOFOUL on 15 May 2018, MPI implemented an extensive stakeholder outreach program, which included stakeholder meetings, the development of guidance documents and fact sheets, and organized media and social media campaigns.

Unlike the California Biofouling Regulations that apply only to larger vessels, the CRMS-BIOFOUL applies to all classes of vessels (including recreational vessels and human-powered craft). The CRMS-BIOFOUL requires vessel operators to take preventive measures to manage biofouling prior to arrival and defines an outcome to be met, requiring all vessels to arrive to New Zealand with a “clean hull.” To comply with the standard, vessel operators must be able to provide documentation showing that at least one of the three measures outlined in the standard has been undertaken:

- The hull and niche areas have been cleaned within 30 days prior to the vessel’s arrival
- The vessel has been continually maintained following best practice (e.g., IMO Biofouling Guidelines)
The hull and niche areas have been treated with an approved treatment (currently the only approved treatment is immediate haul out and cleaning at an approved facility on arrival)

The CRMS-BIOFOUL also defines what is considered a “clean hull.” This definition is based on the thresholds outlined in Georgiades and Kluza (2014) and differs based on a vessel’s intended itinerary in New Zealand.

Vessels that cannot meet the requirements by demonstrating that one of the above measures has been undertaken can apply for an MPI-approved Craft Risk Management Plan (CRMP), which outlines alternate measures that achieve an equivalent level of risk management as those outlined in the CRMS-BIOFOUL.

Vessels show compliance with the CRMS-BIOFOUL by submitting evidence to MPI, prior to arrival, demonstrating that one of the three measures described in the standard (or in the vessel’s CRMP) has been undertaken. MPI prioritizes inspection effort based on risk indicators associated with each vessel arrival, focusing the majority of inspection effort on vessels that have the potential to present a higher biosecurity risk, and inspecting a smaller percentage of vessels with low risk biofouling indicators (Figure 2). Data presented in this paper reflect inspections undertaken on commercial merchant and passenger vessels during the first year of enforcement of the CRMS-BIOFOUL, from 15 May 2018 until 14 May 2019. Under the legislative framework that allows MPI to manage biosecurity risks, inspection may be an audit of documents or physical inspection using divers or remotely operated vehicles.

Lessons learned from California and New Zealand (CANZ)

One goal of this paper is to provide and compare inspection and compliance trends for commercial merchant and passenger vessels that are subject to regulations in California and New Zealand. This comparison will focus on the first full year of compliance inspections and implementation for both California and New Zealand. These vessels represent a subset of the total population of vessels regulated by these jurisdictions but were selected here because both sets of requirements overlap for this broad group of vessel types. Another goal of the paper is to highlight the lessons learned from the first movers on mandatory biofouling management regulations and to provide recommendations for the IMO and other jurisdictions that may be considering the adoption of mandatory biofouling management regulations.

Results and discussion

Vessel populations

California

There were 11,015 merchant or passenger vessel arrivals at California ports during the first year of inspections to assess compliance with the California
Biofouling Regulations (i.e., between 1 August 2018, and 31 July 2019), however only 2,515 arriving vessels (22.8% of total) were required to comply with the regulations because they had completed a regularly scheduled dry docking, or were delivered as a new vessel, on or after 1 January 2018 (Figure 3).

New Zealand

In comparison to California, where fewer than a quarter of the arrivals were subject to the new biofouling regulations, all of New Zealand’s 2,556 commercial merchant and passenger vessel arrivals were required to comply with the CRMS-BIOFOUL between 15 May 2018 and 14 May 2019. Although the total number of arrivals in California was more than four times the total arrivals in New Zealand, the number of vessel arrivals subject to the respective regulations were remarkably similar. The CRMS-BIOFOUL applies to all vessels, not just the commercial merchant and passenger vessels compared above; as such, 663 recreational vessels (e.g., yachts) also arrived into New Zealand and were subject to the regulations but were not included in our analyses.

Risk profiling and preventive management

California

All vessels are required to submit the Marine Invasive Species Program Annual Vessel Reporting Form (AVRF) to the Commission 24 hours prior to arrival at the first California port in each calendar year. The AVRF includes information on a vessel’s:

- Antifouling coating application
- Marine growth prevention system
- In-water cleaning actions
- Typical speed
Figure 4. Distribution of the percentage of antifouling coating service life elapsed for vessels arriving at California and New Zealand ports during the first year of inspections for each jurisdiction’s biofouling regulations.

- Freshwater port calls
- Occurrences of idle periods of 10 days or more

Although inspections were prioritized toward each vessel's first California port arrival during the first year of implementation, these AVRF data were used for research-based risk profiling and will soon be used for pre-arrival risk-based prioritization.

Most of the arriving vessels that were subject to the California Biofouling Regulations during the first year of inspections had relatively new antifouling coatings, with a mean coating age of 0.94 ± 1.04 (SD) years. The relatively young age of these antifouling coatings is likely a result of the phased implementation schedule that only applies to vessels that complete a dry docking, or are delivered as a new vessel, on or after 1 January 2018. Similarly, 83.7% of the vessel arrivals had coatings that were within the first quarter of their expected coating lifespan, or service life (Figure 4). Passenger vessels had the greatest percentage of coating service life elapsed (65.8% ± 45.0%; mean ± SD), and tank vessels had the smallest (12.0% ± 8.4%). The young age of these coatings and the low percentage of service time elapsed suggest that these coatings were still effective at minimizing biofouling. A small portion (3.9%) of the arriving vessels, however, had coatings that exceeded their service lives and were likely ineffective (Figure 4).

The most common antifouling system strategy employed for vessels subject to the California Biofouling Regulations was the use of biocidal coatings (86.4% of the arrivals). Foul-release coatings were rarely used by themselves (0.1%) but were used more often in combination with biocidal coatings as
part of a mixed strategy (9.9%) (Figure 5). This mixed strategy was primarily employed by passenger vessels (64.7% of passenger vessel arrivals).

The amount of time a vessel spends idle can contribute to biofouling accumulation, even with a relatively young coating. It is, therefore, important for risk profiling purposes to understand the prevalence of long stationary periods for the arriving vessels that are subject to the California Biofouling Regulations. These 2,515 arriving vessels had a total of 1,161 idle periods of 10 days or more since their last dry docking or in-water cleaning (Figure 6). Although most (936) of these idle periods were between 10 and 19.9 days, 44 of the idle periods were 30 days or more in length. Tank vessels accounted for the largest portion of the total number of idle periods, with 549 separate idle periods of 10 days or more reported across the 481 tank vessel arrivals. Passenger vessels reported zero long idle periods across all 384 of their arrivals.

New Zealand

Prior to arrival in New Zealand, all vessels must complete a standardized declaration that includes high-level information about biofouling management practices. The data collected from this declaration inform pre-arrival risk profiling and include, but are not limited to:

- Date of application of the current antifouling coatings
- Date until which the antifouling coating is effective
- Number of times in the past 12 months that the vessel has remained idle for 10–19 days, 20–29 days, and ≥ 30 days

MPI is often able to extract information regarding the antifouling coating strategy used, however, this information is only available for vessels inspected by MPI as these data are not included in the declaration.

Most vessels arriving in New Zealand had relatively new antifouling coatings, with 53% of vessels in the first half of their antifouling coating’s...
Figure 6. Number and breakdown of reported vessel idle periods of ten days or more for vessels arriving at California (A) and New Zealand (B) ports during the first year of inspections for each jurisdiction’s biofouling regulations. Bar charts refer to the distribution of idle periods of given durations within vessel type categories. ATB refers to articulated tug-barges. OSS represents offshore supply ships.

service life (Figure 4). The mean percentage (± SD) of service life elapsed across all vessel classes was 47.5% ± 28.0%. Tugs, barges, and articulated tug-barges (ATB), collectively referred to as the ATB/Barge/Tug category, had the oldest antifouling coatings on average (56.7% ± 15.5% of service life elapsed), while Navy ships had the newest (22.0% ± 6.0%). The New Zealand vessel population is likely to be more reflective of a typical vessel fleet (i.e., a fleet with the full range of possible antifouling coating ages) because implementation was not phased in by dry docking date, as was the case in California.

The use of biocidal coatings was the most common antifouling coating strategy, employed by 67% of vessels inspected during the first year (Figure 5), while a much smaller proportion used foul-release coatings (2.8%) or a mix of different coating types (3.2%). The antifouling systems used for the remaining vessels are unknown. When only considering those vessels where the antifouling coating strategy was known, the breakdown for New Zealand (and California) was 90% biocidal (91% in CA), 4.1% foul-release (1.2% in CA), and 4.6% mixed strategy (10% in CA). While biocidal strategies were most commonly used across all vessel types, passenger vessels were most likely to employ other strategies with 6.5% using foul-release coatings and 35.5% using a mixed approach. Although biocidal coatings were the
primary coating strategy in both California and New Zealand, the fact that 10% of the vessels in California and 6% in New Zealand used foul-release or a mixed strategy suggests variable strategies for different types of vessels and operational profiles.

In the 12 months preceding their arrival to New Zealand, the 2,556 arriving vessels had a total of 6,042 idle periods of 10 days or more (Figure 6). Most (4,917) of these idle periods were between 10 and 19.9 days, however, 685 were between 20 and 29.9 days in length and 440 were 30 days or more. ATB/Barge/Tugs had the greatest number of idle periods, relative to arrival numbers, with 22 idle periods of 10 days or more across just four arrivals. Passenger vessels had the lowest number of idle periods relative to arrival numbers with only 11 idle periods of 10 days or more across 139 arrivals. These long idle periods experienced by vessels operating in California or New Zealand are concerning from a biosecurity perspective, as they can lead to more extensive biofouling accumulation (Floerl and Coutts 2009; Davidson et al. 2020).

**Inspection, compliance, and lessons learned**

**California**

Commission staff conducted 505 inspections to audit documents and assess compliance with the California Biofouling Regulations during the first year of inspections (1 August 2018 through 31 July 2019). These 505 inspections represent 20% of the arrivals for vessels that were subject to the California Biofouling Regulations (Figure 7). Commission inspectors prioritized the first arrival for each vessel that was subject to the regulations; subsequent arrivals did not trigger an inspection unless follow-up was necessary due to initial non-compliance.

Any vessel found to have a violation was issued a 60-day grace period and was flagged for a follow-up inspection during the first California arrival after the expiration of the grace period. Two hundred and two of the 505 inspections (40%) resulted in 60-day grace periods issued (Figure 7), with approximately one-third of these for multiple deficiencies. Most of the deficiencies (72%) were related to the requirement to include, within the BFMP, the expected lifespan of the anti-fouling coating(s) applied on the vessel. Approximately 44% of the grace periods were issued, in part, for incomplete BFMPs or BFRBs, and another 22% included deficiencies related to the description of how biofouling would be managed in niche areas. Most of the niche area violations involved missing descriptions for how out-of-water support strips (i.e., dock block areas) would be managed. Commission staff conducted 87 follow-up inspections of vessels after the expiration of their 60-day grace period, finding that 84 of these vessels had corrected all their deficiencies and were fully compliant. A Notice of Violation was sent to the owners of the other three vessels, and the vessels were categorized as a high inspection priority until the deficiencies are...
corrected. Commission staff are revising existing enforcement regulations to establish monetary penalties for violations of the California Biofouling Regulations to provide enforcement flexibility when necessary.

Learning curves for both the shipping industry and regulators were expected during the early implementation process. One industry learning curve was general awareness of the suite of requirements within the California Biofouling Regulations. These were the first set of comprehensive regulations targeted exclusively at biofouling management to be implemented, creating a whole new regulatory regime to which the industry had to respond. Even with California’s phased implementation, this new paradigm came quickly for the industry, and as expected, understanding of all the requirements was not immediate. These results suggest that inclusion of provisions like California’s grace periods and follow-up inspections provide the industry with adequate time to fully learn and implement the required components while also holding them accountable.

The second industry learning curve was the development of effective vessel-specific BFMPs. The intent of the California Biofouling Regulations, and the IMO Biofouling Guidelines they were modeled after, was for vessel owners or operators to develop biofouling management strategies that were tailored to individual vessels (i.e., what are the vessel-specific risks and how can they be specifically managed?). Generic management language (e.g., “inspect and clean as necessary”) was prevalent across many of the BFMPs inspected in California. These non-specific management descriptions were
presumably intended to satisfy the regulatory requirements to detail how specific areas of the vessel will be managed. However, the non-specific nature of these descriptions will inevitably lead to either confusion or inaction for vessel crews who must implement the BFMP. In other words, the lack of accountability associated with generic descriptions provides no guidance on:

- When to conduct an inspection
- What to look for during an inspection
- The level of biofouling that will trigger action to “clean as necessary”
- How often to clean and to what extent

The California Biofouling Regulations did not specifically identify these components of an effective BFMP, instead they require consistency with the BFMP described in the IMO Biofouling Guidelines. This approach, while necessary to ensure international consistency, can be bolstered by including minimum standards for biofouling management descriptions.

Commission staff experienced a learning curve as well: determining the amount of outreach necessary to fully raise awareness within the shipping industry about the requirements contained in the California Biofouling Regulations. It became clear soon after implementation that “enough outreach” was unattainable for this type of new regulatory regime. Despite in-person industry meetings in California, global web-based webinars, distribution of a guidance document, and constant vessel outreach during inspections, there was still progress to be made. An additional webinar after the first year of implementation, focused specifically on vessel owners and operators and highlighting common deficiencies found early on, in addition to the continuous outreach efforts during inspections, helped bridge the gap.

New Zealand

New Zealand inspected 498 commercial merchant and passenger vessels during the first year of enforcement of the CRMS-BIOFOUL (15 May 2018 through 14 May 2019), representing approximately 19% of the 2,556 total arrivals (Figure 7). One hundred percent of recreational vessels were inspected as all these arrivals fell into the stricter long-stay category (long-stay vessels are those coming to New Zealand for more than 20 days or visiting places that are not approved as ports). Prior to arrival, each vessel was risk-assessed based on pre-arrival documentation sent to MPI. Inspection effort was allocated based on this risk assessment, with all high-risk and long-stay vessels inspected, and a smaller proportion of medium- and low-risk vessels were randomly selected for inspection. If a vessel was able to show that one of the three measures outlined in the CRMS-BIOFOUL had been met, it was considered compliant (Table 1). However, if there was insufficient evidence to show that one of the measures had
been met, or the evidence indicated that the vessel is fouled beyond the allowable “clean hull” thresholds, then the vessel was referred to MPI’s border staff for potential compliance action (Figure 2). Vessels that failed the inspection based on a deficiency in the documentary evidence provided (e.g., low quality documentation, generic biofouling management plan) and that also had low risk biofouling indicators did not require compliance action and were instead issued educational material by MPI border staff.

For vessels with a failed inspection and high- or medium-risk biofouling indicators, MPI border staff directed a compliance action via a Notice of Direction (NOD), instructing the vessel master to take a particular action to manage the risks associated with a non-compliant (or potentially non-compliant) vessel. If more information was needed to demonstrate the level of fouling on a vessel, MPI issued a NOD prior to the vessel’s arrival, requiring the vessel to obtain further evidence in the form of a hull inspection conducted on arrival to the first port. If the hull inspection showed that the vessel met the “clean hull” thresholds, then the vessel was issued education about the CRMS-BIOFOUL requirements and allowed to complete its intended itinerary in New Zealand. Vessels that have submitted documentary evidence demonstrating non-compliance with the CRMS-BIOFOUL, or which are inspected on arrival and found to be fouled in excess of the “clean hull” thresholds, may be issued a NOD directing compliance action commensurate with the risk posed by the fouling on the vessel. Depending on the risk posed by the vessel, MPI may direct the vessel to restrict its itinerary to a certain number of days/ports or to manage the fouling at an MPI-approved facility in New Zealand. At the time of writing, the largest dry dock in New Zealand can only accommodate vessels up to 170m in length, so this option is only available for smaller vessels. For the purposes of this paper, vessels that were issued a NOD for an itinerary restriction or a direction to dry dock following an MPI-directed hull inspection have been recorded to reflect the final compliance action.

Of the 498 commercial merchant and passenger vessel inspections undertaken during the first year of enforcement of the CRMS-BIOFOUL, 415 vessels (83%) were found compliant based on documentation submitted to MPI, while 83 vessels failed the initial inspection (17%). Following additional assessment by MPI’s border staff, 19 of the 83 vessels that failed the initial inspection required a NOD to manage the non-compliance. Vessels that were issued NODs were typically those that had documentation that indicated non-compliant levels of fouling, had high risk indicators, or were repeat offenders. These vessels represented 22.9% of those that failed the initial inspection, 3.8% of all vessels inspected, and 0.7% of the total vessel arrivals during the first year of enforcement. The most common compliance action directed during this time period was itinerary restriction (n = 16), while two vessels were directed to obtain additional evidence, and
one vessel was directed to dry dock (Figure 7). Although these were not included in the comparative analysis with California, 663 recreational vessels also arrived in New Zealand during the first year of implementation and only two failed inspection. Both failures were based on physical inspections of their hulls and both vessels were directed to haul-out and clean.

Most vessels that complied with the CRMS-BIOFOUL requirements did so by providing evidence that best practices for hull maintenance had been followed (n = 330; 79.5% of the 415 compliant vessels). Fifty-six (13.5%) complied by cleaning the hull and niche areas within 30 days prior to arrival, while treatment on arrival was the least used measure, with only two vessels (0.5%) electing to comply using this option. The remaining 27 vessels (6.5%) complied by adhering to an MPI-approved CRMP. Most inspection failures were due to issues with the evidence supplied to MPI: 26 vessels failed inspection because the evidence submitted was insufficient to show that one of the measures was met (31.3% of failures); 22 vessels failed because no evidence was submitted to MPI for inspection (26.5%); and 13 failed due to poor quality of evidence submitted (15.7%). Other reasons for failure were evidence showing that fouling in excess of the “clean hull” thresholds was present on the vessel (n = 20; 24.1%) or that best practices had not been followed (n = 2; 2.4%).

Prior to the enforcement of the CRMS-BIOFOUL, MPI undertook an intensive communications campaign to raise awareness of the requirements within the shipping industry and among other relevant stakeholders (e.g., providers of hull inspection services, port operators). To reach as many stakeholders as possible, this campaign utilized several different types of media, including media releases, social media posts, plain-English fact sheets and guidance materials, and in-person meetings with key contacts. In parallel, MPI also conducted an internal training program aimed at familiarizing border staff with biofouling risk factors and promoting consistent decision-making across the country. While both the shipping industry and MPI still experienced a learning curve around what best practice management practically entailed, and how to document it appropriately to demonstrate compliance, this intensive communications effort is recognized as a strong contributor to the high compliance rate during the first year of enforcement. Importantly, MPI has continued to provide ongoing advice and educational materials to vessel operators since enforcing the CRMS-BIOFOUL to promote ongoing compliance and education to operators on how to proactively manage biofouling.

Similar to California, New Zealand noted a high instance of generic (i.e., not vessel-specific) BFMPs. While New Zealand does not have specific requirements for the content of BFMPs as California does, developing a vessel-specific BFMP is considered a core principle of best practice hull maintenance under the CRMS-BIOFOUL and the bulleted list of suggested components for biofouling management descriptions presented earlier are
necessary for an effective BFMP. Similarly, the quality of records of biofouling management (in a BFRB or by other means) submitted to show compliance varies widely. In particular, the quality of hull inspection reports is highly variable, with many reports providing insufficient evidence on the level of fouling in niche areas and/or including few or low-quality photos. While New Zealand has developed guidance for hull inspection evidence, it has been recognized by both MPI and the industry that incorporation of similar guidance into the IMO Biofouling Guidelines would increase uptake and consistency in reporting.

Conclusions

Regulatory agencies at the state, national, and international levels made a commitment during the 1990s and early 2000s to address maritime shipping-related NIS introduction risk with an early focus on ballast water. Using the lessons learned from the experience of regulating ballast water management, California and New Zealand introduced a new paradigm in 2017 and 2018 with the implementation of the California Biofouling Regulations and New Zealand’s Craft Risk Management Standard for Biofouling. Despite initial success, evidenced by high compliance rates after the first year of implementation, these new regulatory regimes expectedly carried learning curves and lessons learned for both the regulators and the regulated industry.

Shipping industry learning curves

Learning curves for the regulated industry are a predictable part of implementing any new regulations, especially when acclimating to an entirely new regulatory regime. Most noncompliance with the California Biofouling Regulations and New Zealand’s CRMS-BIOFOUL originated from an incomplete understanding of the requirements. In California, the primary reason for noncompliance was incomplete BFMPs; specifically, missing information that was required in California but not directly included in the IMO Biofouling Guidelines (e.g., documenting effective coating lifespans and management actions for eight specific niche areas). In New Zealand, most failed inspections were due to insufficient evidence presented to satisfy the CRMS-BIOFOUL.

Easing these early adjustments to new environmental regulations through initial enforcement flexibility is critical to successful implementation. California’s 60-day grace period provision was designed with these expected learning curves in mind. These grace periods served as a mechanism to highlight deficiencies that require correction while also providing flexibility to allow vessel owners and operators to correct deficiencies and become compliant without a monetary penalty. Similarly, New Zealand issues educational material to vessels that fail inspection but do not present a
biosecurity risk in order to increase understanding of the requirements and promote future compliance.

Across both California and New Zealand, generic BFMPs and generic planned management actions for niche areas were highlighted as common issues, as the detail in these plans is insufficient for vessel crews to effectively carry out the biofouling management strategy laid out in a BFMP. To be effective, BFMPs must be specific to the vessel and specific about how biofouling will be managed, including when, how, and to what extent to apply reactive measures.

**Regulator learning curves**

Recognition of the extent of external communication needed for successful implementation was the primary lesson learned by Commission and MPI staff. Despite extensive communication and outreach efforts, both agencies recognized early on that much more was necessary. Targeted messages to different stakeholder groups were crucial components of a successful outreach campaign. Ship owners, operations departments, vessel crews, trade associations, ports, and other regulatory agencies all require slightly different messaging targeted at their direct roles in achieving compliance and risk reduction. Continued efforts to reach these stakeholder groups before and after implementation proved mostly effective at getting the message out but could have been improved upon. International consistency, as far as possible, in requirements and key messaging will contribute to industry awareness and understanding and lead to more widespread uptake and implementation.

The level of awareness of the regulations may have played a role in the difference between the initial compliance rates (60% in California and 83% in New Zealand), reenforcing the idea that more outreach is always necessary. The flexibility provided by the 60-day grace period provision in California was a helpful tool to increase awareness and encourage compliance through direct engagement with vessel crews and owners, as reflected in a compliance rate over 99% after grace period expiration and subsequent inspection.

Although the Commission and MPI consider the implementation of these regulations a success, more work needs to be done to determine the relationship between high compliance rates and a reduction in NIS introduction risk. Standardized surveys of the underwater surfaces of the vessels subject to these regulations in comparison to earlier surveys before implementation (Inglis et al. 2010; Davidson et al. 2010, 2013, 2014) will allow for a better understanding of the impact of these regulations on NIS introduction risk.

The successes and hurdles experienced in California and New Zealand can offer a template for the International Maritime Organization as it reviews the IMO Biofouling Guidelines with an eye toward a possible
Regulating vessel biofouling management in California and New Zealand

convention and for other regional or national jurisdictions in various stages of developing mandatory biofouling requirements. As this new paradigm of biofouling management for biosecurity becomes reality across the globe, coordination among regulators and engagement with the maritime shipping industry will be critical to the success of future regulations and successful reduction in NIS introduction risk.

Acknowledgements

We are grateful to the Commission Marine Safety Specialists and MPI Intelligence and Targeting Team and Border Clearance Services for conducting inspections and collecting data for the respective regulations. Special thanks to Michael Bennenbroek within MPI’s Learning and Development Team for assisting with inspector training, Jackie Mackay and Jonathan Thompson for Commission inspection training to ensure consistent inspections across the state, and Julisa Portugal for collecting biofouling inspection data. Thanks also to Nicole Dobroski, Susie Kropman, and Maurya Falkner for the careful review and suggestions to improve the manuscript. Special thanks to the two anonymous reviewers who provided thoughtful and constructive suggestions on how to improve the manuscript. For any questions regarding New Zealand’s biofouling regulation please contact the Ministry for Primary Industries at standards@mpi.govt.nz.

References

Bell A, Phillips S, Denny C, Georgiades E, Kluza D (2011) Risk Analysis: Vessel biofouling. Ministry of Agriculture and Forestry Biosecurity New Zealand, Wellington, 145 pp, https://www.mpi.govt.nz/dmsdocument/2863 (accessed 10 March 2020)

Bishop MHW (1951) Distribution of barnacles by ships. Nature 167: 531, https://doi.org/10.1038/167531a0

California Legislature (2007) Assembly Bill 740. Chapter 370, Statutes of 2007. http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=200720080AB740 (accessed 11 March 2020)

Carlton JT (1985) Transoceanic and interoceanic dispersal of coastal marine organisms: the biology of ballast water. Oceanography and Marine Biology: An Annual Review 23: 313–371

Commission (2017a) Guidance Document for: Biofouling Management Regulations to Minimize the Transfer of Nonindigenous Species from Vessels Arriving at California Ports. Communication from the California State Lands Commission Marine Invasive Species Program, 12 pp. https://www.slc.ca.gov/wp-content/uploads/2018/08/MISPGuidanceDoc.pdf (accessed 10 March 2020)

Commission (2017b) Article 4.8 Biofouling Management Regulations: Overview of the Main Components. Webinar. https://www.youtube.com/watch?v=4r6Bi3Bfolc&feature=emb_logo (accessed 10 March 2020)

Commission (2018) Article 4.8 Biofouling Management Regulations: First Year Update. Webinar. https://www.slc.ca.gov/marine-invasive-species-program/webinar-on-california-biofouling-management-regulations-first-year-update/ (accessed 10 March 2020)

Davidson I, Ashton G, Ruiz G, Scianni C (2010) Biofouling as a vector of marine organisms on the US West Coast: A preliminary evaluation of barges and cruise ships. Prepared for the California State Lands Commission, 22 pp

Davidson I, Ashton G, Ruiz G, Scianni C, Brown C, Pagenkopf-Lohan K, Fleischer R (2013) Richness, extent, condition, reproductive status, and parasitism of fouling communities of commercial vessels. Prepared for the California State Lands Commission, 70 pp

Davidson I, Scianni C, Ceballos L, Zabin C, Ashton G, Ruiz G (2014) Evaluating ship biofouling and emerging management tools for reducing biofouling-mediated species incursions. Prepared for the California State Lands Commission, 36 pp

Davidson IC, Smith G, Ashton GV, Ruiz GM, Scianni C (2020) An experimental test of stationary lay-up periods and simulated transit on biofouling accumulation and transfer on ships. Biofouling 36: 455–466, https://doi.org/10.1080/08997014.2020.1769612

Elton CS (1958) The ecology of invasions by animals and plants. Methuen, London, England, 181 pp, https://doi.org/10.1007/978-1-4899-7214-9

Floerl O, Coutts A (2009) Potential ramifications of the global economic crisis on human-mediated dispersal of marine non-indigenous species. Marine Pollution Bulletin 58: 1595–1598, https://doi.org/10.1016/j.marpolbul.2009.08.003

Georgiades E, Kluza D (2014) Science underpinning the thresholds proposed in the CRMS: biofouling on vessels arriving to New Zealand. New Zealand Ministry for Primary Industries Technical Paper 2014/22. Ministry for Primary Industries, Wellington, 18 pp, http://mpi.govt.nz/document-vault/4148

Scianni et al. (2021), Management of Biological Invasions 12(3): 727–746, https://doi.org/10.3391/mbi.2021.12.3.14
Regulating vessel biofouling management in California and New Zealand

Georgiades E, Kluza D, Bates T, Lubarsky K, Brunton J, Growcott A, Smith T, McDonald S, Gould B, Parker N, Bell A (2020) Regulating vessel biofouling to support New Zealand’s marine biosecurity system - A blue print for evidence-based decision making. *Frontiers in Marine Science: Marine Affairs and Policy* 7: 390, https://doi.org/10.3389/fmars.2020.00390

Hewitt C, Campbell M (2010) The relative contribution of vectors to the introduction and translocation of marine invasive species. Australian Department of Agriculture, Fisheries, and Forestry, Canberra, Australia, 56 pp. https://www.marinepests.gov.au/sites/default/files/Documents/relative-contribution-vectors-introduction-translocation-invasive-marine-species.pdf

IMO (2011) International Maritime Organization. Guidelines for the control and management of ships’ biofouling to minimize the transfer of invasive aquatic species. IMO Resolution MEPC.207(62). International Maritime Organization, London

IMO (2012) International Maritime Organization. Guidance for Minimizing the Transfer of Invasive Aquatic Species as Biofouling (Hull Fouling) for Recreational Craft. IMO Resolution MEPC.1/Circ.792. International Maritime Organization, London

IMO (2013) International Maritime Organization. Guidance for Evaluating the 2011 Guidelines for the Control and Management of Ship's Biofouling to Minimize the Transfer of Invasive Aquatic Species. IMO Resolution MEPC.1/Circ.811. International Maritime Organization, London

Inglis GJ, Floerl O, Ahyong S, Cox S, Unwin M, Ponder-Sutton A, Seaward K, Kospartov M, Read G, Gordon D, Hosie I, Nelson W, d'Archino R, Bell A, Kluza D (2010) The biosecurity risks associated with biofouling on international vessels arriving in New Zealand: Summary of the patterns and predictors of fouling. A report prepared for Ministry of Agriculture Biosecurity New Zealand, 182 pp

MPI (2014) Ministry for Primary Industries, New Zealand. Craft risk management standard: biofouling on vessels arriving to New Zealand. CRMS - BIOFOUL. Ministry for Primary Industries, Wellington, 8 pp, https://www.mpi.govt.nz/dmsdocument/11668/send (accessed May 2020)

Ruiz G, Fofonoff P, Carlton J, Wonham M, Hines A (2000) Invasion of coastal marine communities in North America: apparent patterns, processes, and biases. *Annual Review of Ecology and Systematics* 31: 481–531, https://doi.org/10.1146/annurev.ecolsys.31.1.481

Ruiz GM, Fofonoff PW, Steves B, Foss SF, Shiba SN (2011) Marine invasion history and vector analysis of California: a hotspot for western North America. *Diversity and Distributions* 17: 362–373, https://doi.org/10.1111/j.1472-4642.2010.00742.x