

## The Hidden Effects of Parasites in a Changing Ocean

Trematode parasites are a fascinating group of species which occur in almost all types of marine habitat and infect many ecologically and commercially important marine organisms. They possess complex life histories that involve multiple host species, often radically change morphology as they move between hosts, and can dramatically alter the performance of infected organisms.<sup>1</sup> Trematode infection can regulate host population density by sterilising hosts, altering host foraging behaviour, and/or by increasing the likelihood of infected individuals being consumed by the next host in the parasite's life cycle.<sup>2</sup> This plethora of biological interactions means that trematode parasites are an extremely important component of all marine ecosystems and are embedded in these systems to a greater degree than most species.

As with all marine organisms, trematodes are affected by human-mediated changes to the global oceans – for example, warmer temperatures, less available oxygen, increased seawater acidity. Of course, given the complex nature of host–parasite interactions, the effects of such changes to the marine environment could have equally complex consequences for disease dynamics. The potential for such substantial change to the role of trematode parasites caused by a changing marine environment can best be understood by following a single parasite species through a complete life cycle.

Adult trematodes live within the *definitive host*, the site of sexual reproduction. These hosts are often large fish, marine mammals or shore birds, and as such are often not directly affected by climate change – they have sufficient physiological ability to tolerate changes in seawater temperature, pH or oxygen content. However, the adult parasites often reside in the gut of the definitive host, absorbing nutrients that the host consumes. Consequently, if the food supply of the definitive host is reduced by climate change, through lower abundance of prey species, there could be a knock-on effect on the performance of the parasite – for example, reduced reproductive output caused by starvation. Sexual reproduction produces parasite eggs which invariably exit the definitive host via faeces, which then hatch into miracidia (small mobile larvae) when the eggs contact seawater. Miracidia seek out and infect the *first intermediate host*, almost always a marine snail. Eggs and miracidia are the first life-stages of the parasite to come into direct contact with seawater, and are therefore a potential weak link in the parasite's life cycle if climate change causes seawater to become too warm, hypoxic and/or acidic for these organisms. If climate change negatively affects these life stages, the overall

performance of the parasite may suffer – fewer eggs will hatch and fewer miracidia will survive long enough to find and infect a snail.

Once within the snail, successful miracidia transform into a sporocyst, a sac-like structure that generates genetically identical cercariae (another small, swimming larvae – see Figure 1), which emerge periodically from infected snails to seek out the next host in the parasite’s life cycle. Of all the hosts in the parasite’s life cycle, the first intermediate host is potentially the most vulnerable to climate change; snails are relatively primitive organisms that do not possess sophisticated physiological mechanisms to deal with elevated temperature or reduced seawater pH. Consequently, they exhibit higher levels of mortality in these conditions than definitive hosts. In addition, trematode infection sterilises host snails, and is often associated with greater mortality in infected individuals. The stress of infection plus the stress of climate change has the potential to interact synergistically in host snails, compounding the effects of each single stressor.

Cercariae, much like the miracidia, are vulnerable to changing environmental conditions as they are also directly exposed to seawater upon emergence from their host. Cercariae are, however, more numerous than miracidia, as each sporocyst can produce thousands of cercariae per day. Cercariae are produced in such large numbers to compensate for the low chance of success in finding the next host in the life cycle. Much research has gone into exploring the response of cercariae to simulated climate change,<sup>3</sup> although it appears that cercariae belonging to different species of trematode exhibit significantly different tolerances to many climate change-related stressors.<sup>4</sup> Interestingly, cercariae also represent a significant food resource for non-host organisms, especially as they are produced in such large numbers.<sup>5</sup> If cercariae survival is reduced by climate change, then these non-host organisms will have less food to eat.

To complete their stage of the transmission process, cercariae must find and infect the *second intermediate host*, often a bivalve, crustacean or small fish. Cercariae penetrate the second intermediate host and form a resting cyst (also known as a metacercariae – Figure 2) in the host’s muscle tissue, where they await a predation event that will transfer the parasite from the second intermediate



Figure 1. A trematode cercaria.



Figure 2. A trematode metacercaria.

host to the definitive host – the definitive host eats the second intermediate host, thus completing the parasite’s life cycle. In the same way that sporocysts can increase mortality in infected snails, too many cysts and the second intermediate host may also die; here again, we see the potential for stress caused by parasites to interact with or compound stress caused by climate change.

We can clearly see that at every stage of the parasite’s life cycle, both parasite and host are vulnerable to the stressors associated with climate change. It is a surprise, therefore, that the combined effects of parasitism and climate change are not studied more often. This may in part be due to the underestimation of the effect of parasites in natural systems. Almost all stages of the trematode life cycle are too small to see with the naked eye, and some researchers equate this small size with a small potential effect.<sup>6</sup> This neglect may also be due to the equilibrium that is often reached between parasite and host. While parasites take energy from hosts by definition, the death of the host does not really benefit the parasite – ultimately, that’s where their food comes from. From an evolutionary perspective, this has led to the development of many host–parasite relationships that do not end in the death of the host, but rather a kind of equilibrium where hosts are negatively affected by parasites, but are not killed by them.

However, in a rapidly changing marine environment, we must remain vigilant to note previously stable relationships that become unbalanced. Significant, mass die-offs have been recorded that were a direct result of trematode infection combined with extreme environmental events (such as heatwaves<sup>7</sup>). It seems wise to begin evaluating all components of the host–parasite life cycle for evidence of potentially dramatic synergisms that could result in equally dramatic shifts in our marine ecosystems.

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## Drawing to Discern Parasites

Of all identified species, 30-50 percent are defined as parasitic.<sup>1</sup> Parasite ubiquity, however, does not equate to widespread popularity or criticality. This extends even to animal rights mentalities, which, Giovanni Aloï writes, typically seek “sameness” between humans and animals.<sup>2</sup> Much like “insects, amphibians, fish, reptiles,” parasites simply do not “lend themselves to straightforward anthropomorphism,”<sup>3</sup> lacking a comfortable relatability through which human attention may be endeared.

As described by Bronwyn Hayward in *Sea Change: Climate Politics and New Zealand*, climate change (operating as variable “atmospheric and oceanic processes across time and space”) sits far outside the comforts of daily human experience.<sup>4</sup> Without familiar human affinities as entry points, a kindred struggle for attention can be identified between the issue of climate change and the world's parasites. It is disappointing, but not surprising therefore, that consideration of interactions between the two are deficient. Michel Serres, exploring metaphorical, biological and philosophical manifestations of parasitism in his book *The Parasite*, emphasises the compartmentalised nature of parasitology and its difficult “conceptual syntheses.”<sup>5</sup> This evaluation (first published in 1980) remains applicable, with parasitology rarely integrated into current marine ecology research – even less so within the field of ocean acidification (OA).

While wider visibility of the two interacting fields is limited, channels of visualisation within OA-parasitology research are numerous and variable. Tools used in research (including artificial CO<sub>2</sub> tanks, microscopy, cameras and fluorescence) enable collective visualisation, whereby gradual changes – otherwise inaccessible from the perspective of a single human researcher – can be recorded, revealed and observed. Each of these channels offer representations of not only trematode parasites, but also their interactions with acidifying environments and intermediate hosts. Utilising analogous approaches within the studio environment, the video *Drawing to Discern Parasites* proposes a system of drawing whereby the visualisation of parasitic forms, the agency of water and time-based change can be investigated.

It is generally specific to an animal, an organism or even an organ. During its cycle it can be carried from one vector to another, but the path taken, which is rather improbable and well-selected, remains constant.<sup>6</sup>

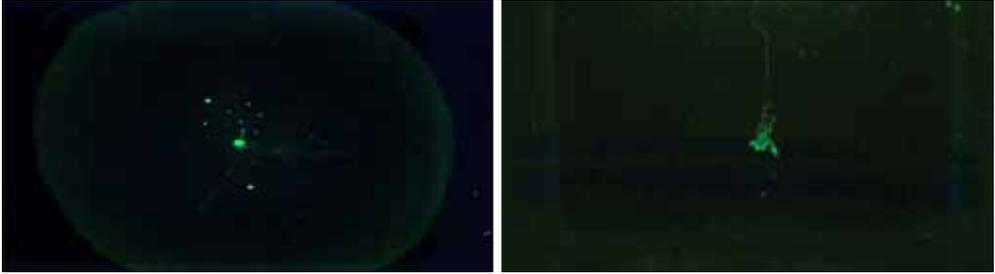


Figure 1. Madison Kelly, *Drawing to Discern Parasites*, 2018, 17 mins 31 seconds (still). Looped video documentation of acrylic pigment drawing in water.

The parasitic life cycle (as constant) forms the core rule of the drawing, upon which changing conditions subsequently impact. Drawings of life-cycle stages associated with the parasite's intermediate hosts (sporocysts and rediae, cercariae and metacercariae) are made on the surface of a water-filled tank. Assuming the role of first intermediate host, the marine snail also temporarily assumes the role of parasitic home. Acidified living conditions for host species, in tandem with related OA effects on host/parasite relationships, can cause "alterations in community biodiversity and ecosystem structure."<sup>7</sup> Rates of snail shell growth under such stress are visualised in the lab via fluorescent staining. In comparing studio tank and intermediate host as habitable, temporary spaces for parasites, fluorescent green pigment is also used as a drawing medium.

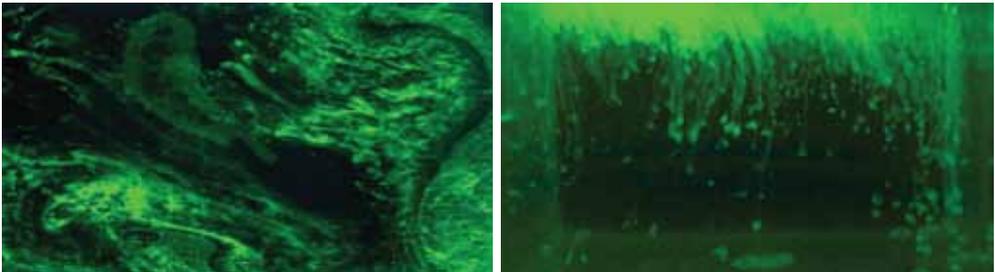


Figure 2. Madison Kelly, *Drawing to Discern Parasites*, 2018, 17 mins 31 seconds (still). Looped video documentation of acrylic pigment drawing in water.

Over the course of an hour, the drawing is produced in darkness, made visible to the drawer by surrounding UV blacklights. Wires draw up pigment. Careful contact with the water's surface allows a controlled leaching of colour and the eventual formation of parasitic morphs. Though initially still, cumulative mark-making on the water's surface introduces new forces to the tank. Serving the continuity of a represented life cycle, the placement of pigment must become increasingly predictive, responsive to the changing environment. Writing of turbulence, Serres describes "a stable and unstable phenomenon where liquid moves and stays ... the organism-my-body-is now an exchanger of time. At this point ... several chronies intertwine."<sup>8</sup> Earlier marks sink. "Parasites" dissolve as they move laterally, then shift to vertical depths within the drawing space. Past marks entangle with new, and a green glow accumulates.

According to Colin MacLeod, "one of the main challenges in parasitological research is maintaining a complete parasite life cycle under controlled lab conditions."<sup>9</sup> In *Drawing to Discern Parasites*, the

same struggles are experienced. The “minuscule evaluations” followed by “immense catastrophic effects”<sup>10</sup> that Serres ascribes to parasitic theory are fulfilled, as pigment fills the drawing and all decipherable forms are lost. The drawing, as personal, durational action in the studio, reaches conclusion and must find continued, altered life as filmed documentation.

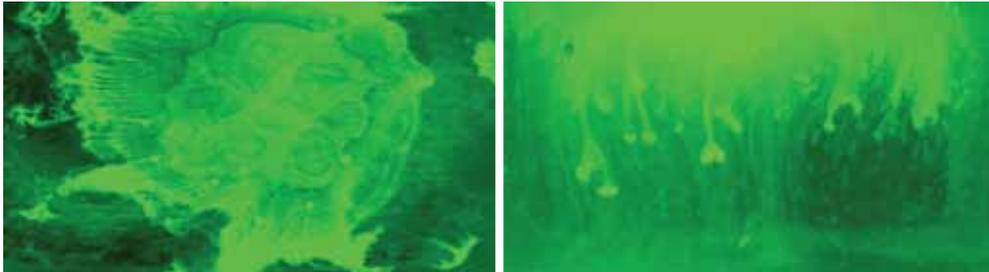


Figure 3. Madison Kelly, *Drawing to Discern Parasites*, 2018, 17 mins 31 seconds (still). Looped video documentation of acrylic pigment drawing in water.

Two angles of the drawing, a top view and side view, are assembled. Edited in tandem, both viewpoints undergo synchronous time shifts, with the drawing of selected parasitic forms shown in real time, and interluding drawing sped up by 450 percent. Long-form change is condensed; cause and effect are presented as rapid phenomena. Played simultaneously on two screens, installed in the corner of the exhibition space, the drawing’s dual spaces are given equal opportunity for consideration. Viewers are encouraged to witness direct relationships between initial action and cumulative outcome. As looping digital document, time and pigment continue to shift, and the noisy green glow repeatedly builds. The trematode representations assume the role of Akira Lippit’s “spectral animals” of the electric age, always receding into the shadows of “consumption and environmental destruction.”<sup>11</sup> Across simultaneous screens, perspectives and time, comfortable observation from either drawer or spectator is insufficient – the drawing proposes a more discerning look towards the parasite and its changing host/home environment.

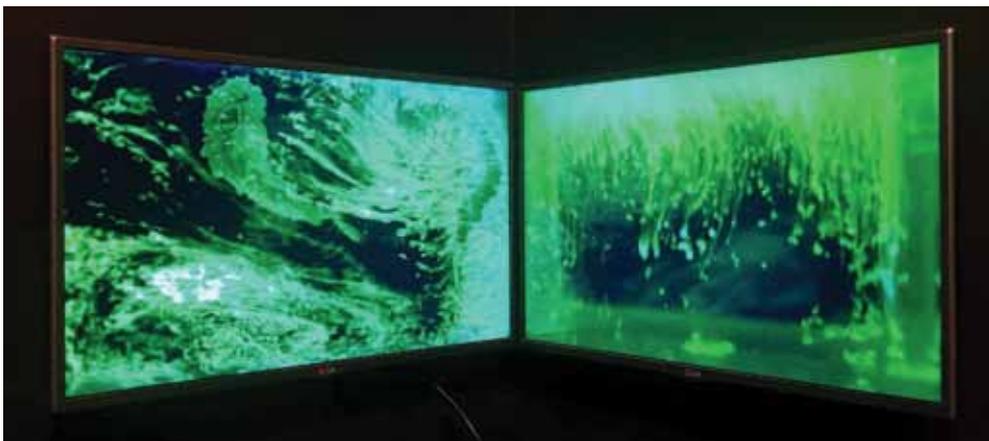


Figure 4. Madison Kelly, *Drawing to Discern Parasites*, 2018, 17 mins 31 seconds (installation view). Looped video documentation of acrylic pigment drawing in water.

It lives sheltered in the body of its host (or on his surface) that is its environment. The outside for it is the inside of another. Thus the parasites has few enemies, for the simple reason that is rarely meets any.

It minimizes its risks by lightly transforming its own body, changing hostility into hospitality, exchanging outside for inside.

Outside it meets challengers; it can be destroyed by the climate that is variable, by history that is improbable.<sup>12</sup>

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