WPI

Designing wayfinding signage for the Sandwich Fish Hatchery

A Major Qualifying Project Report

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This report represents the work of one or more WPI undergraduate students submitted to the faculty as evidence of completion of a degree requirement. WPI routinely publishes these reports on the web without editorial or peer review.

Abstract

The Sandwich Fish Hatchery offers visitors to Cape Cod, Massachusetts, a glimpse into the process of hatching and raising trout. The facility, operated by the Massachusetts Division of Fisheries and Wildlife (MassWildlife) since 1912, supports recreational freshwater fishing on the South Shore, the Cape, and the Islands of Massachusetts. The Sandwich Hatchery is popular with visitors, however, the staff does not have enough resources to offer guided tours. Therefore, I collaborated with MassWildlife to design wayfinding signs for a free-choice, self-guided visitor tour of the Hatchery. To achieve this goal, I established principles of wayfinding and signage, researched wayfinding and self-guided tour case studies, developed concept designs for wayfinding signage for a self-guided tour, received expert feedback, and finalized wayfinding signage based on the feedback. The overarching aim of the project was to streamline visitor foot traffic at the Hatchery, answer visitors' frequently asked questions, and encourage public use of MassWildlife's recreational fishing resources (especially fishing clinics, licenses, and maps).

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1. Introduction

The Sandwich Fish Hatchery, located on Cape Cod, Massachusetts, is one of the oldest public fish hatcheries in North America. The Hatchery was founded by the Massachusetts Division of Fisheries and Wildlife in 1912 to restore salmon populations for commercial and recreational harvest. Like other fish hatcheries, the Sandwich Fish Hatchery breeds, hatches, and raises fish (or any variety of aquatic organisms) to release into bodies of water. The aim of fish farming, also known as aquaculture, is to increase freshwater or marine stocks to support ecological conservation efforts, commercial and subsistence harvest, and/or recreational fishing opportunities. Over the years, the Sandwich Fish Hatchery's mission has centered around providing recreational trout fishing opportunities in Eastern Massachusetts.

Today, the Sandwich Hatchery is a popular destination for over 20,000 Cape Cod locals and tourists every year. Visitors are welcome to stroll around the idyllic grounds free of cost and see the hundreds of thousands of trout raised there every year. The Hatchery creates an opportunity for visitors of all backgrounds to learn about aquaculture, especially how hatcheries relate to conservation ecology and outdoor recreation in Massachusetts. Unfortunately, offering guided tours (especially during the peak visitor season) is not feasible for the Hatchery staff. Although a trailhead kiosk provides information about trout biology and the history of fish rearing and freshwater stocking programs in Sandwich, visitors often want to learn more.

The goal of this project is to support visitors at the Sandwich Fish Hatchery by researching and designing a self-guided tour interpreting the Hatchery’s facilities and advertising local freshwater fishing opportunities. Pertaining to the Hatchery, the research portion of this project includes

historical research, expert testimony, and direct observation and photography of the Hatchery. Pertaining to the signage and content development, the research portion of this project includes literary analysis of signage and wayfinding journal papers, fisheries and non-fisheries self-guided-tour case studies, and background research about hatchery operations (including analysis of other public and private fish hatchery tours). The final deliverable provides information to answer frequently asked questions and external links to MassWildlife's fishing resources. The aim is to offer a more welcoming, engaging, educational, and enjoyable experience for Hatchery visitors without tapping into the staff's limited resources.

2. Background

A Global Perspective on Freshwater Fish Hatcheries

Rivers, lakes, wetlands, and other freshwater bodies are some of the most biodiverse ecosystems on Earth, supporting more than 9% of the planet's known species (one-third of all vertebrate species) on less than 1% of its surface (Williams‐Subiza & Epele, 2021). In addition to providing habitat for terrestrial and marine species, freshwater ecosystems sustain human communities. For example, algae sequester carbon and produce oxygen to breathe, aquatic microorganisms filter water to drink, and fish supply food to eat. Freshwater ecosystems provide spaces for recreation, natural resources for economic opportunities, and biotic/abiotic factors to support culture, education, and science (Lynch et al., 2023). Nevertheless, they are vanishing.

Global biodiversity is declining throughout freshwater, marine, and terrestrial ecosystems at a magnitude and rate denoting mass extinction (Tickner et al., 2020). However, anthropogenic climate and non-climate stressors culminate in freshwater ecosystems, making them disproportionately vulnerable to biodiversity loss (Williams‐Subiza & Epele, 2021). As global atmospheric temperatures rise due to greenhouse gas emissions, freshwater temperatures rise, and precipitation patterns shift, negatively affecting freshwater abundance. Freshwater ecosystems are further degraded by pollution, water diversions, and species invasions, or they are lost entirely to land use changes including industrial and residential development, agriculture, and natural resource extraction (Dudgeon et al., 2006; Williams‐Subiza & Epele, 2021). In the past 50 years, freshwater vertebrate populations alone have declined by 83%, more than twice the rate of marine and terrestrial vertebrate populations (Williams‐Subiza & Epele, 2021).

Aquaculture is one approach to mitigating the freshwater biodiversity crisis. Farming aquatic organisms such as fish, shellfish, and algae for human consumption can increase food production without depleting wild populations. (NOAA, 2020). Aquaculture also has the potential to sequester carbon and clean waterways (NOAA, 2020). Meanwhile, farming threatened and endangered aquatic species in captivity for stocking can help restore diminishing wild populations (Bourne, 2014). Captive-reared trout, for example, have an 83% egg survival rate compared to wild-reared trout, which have a 3% egg survival rate (Colorado Parks and Wildlife, 2015).

A Brief History of the Sandwich Fish Hatchery

For 12,000 years or more, Indigenous communities along the coast of Massachusetts stewarded its freshwater and marine fisheries. On Cape Cod, archeological evidence points to Indigenous aquaculture practices, such as stocking freshwater bodies with marine fish and mollusks through man-made channels to the ocean. The subsistence and economic opportunities of the marine fishery far exceeded those of the freshwater fisheries for Indigenous Peoples and early colonists, however commercial freshwater fishing eventually took hold (Bolster, 2008; Speck & Dexter, 1948).

By the mid-19th century, freshwater fish stocks were in decline due to commercial overharvest and habitat loss or degradation from industrialization. Furthermore, concerns were raised about migratory fish populations (particularly salmon and shad) whose freshwater breeding grounds had been blockaded by dams. In 1866, a report to the Massachusetts Legislature concluded that

interstate rivers would require conservation policies to restore migratory fish populations. The report proposed methods including bypass systems for dams, water pollution prevention, artificial breeding programs, banning certain commercial fishing nets, and enforcing regulated fishing (Cardoza, 2015).

In response to the 1866 report, an Act of the Legislature was passed, establishing a Board of Commissioners of Fisheries and, incidentally, the agency that evolved into the Massachusetts Division of Fisheries and Wildlife. The Board constructed or purchased nine fish hatcheries, including one in Sandwich in 1911 (operations began in 1912) and one in East Sandwich in 1914 (Cardoza, 2015; Lovell, 2015). Over the years, the East Sandwich and Sandwich hatcheries raised Atlantic Salmon, Coho salmon, brook trout, brown trout, and rainbow trout. The East Sandwich Fish Hatchery was abandoned in 1990, but the Sandwich Fish Hatchery remains operational (Cardoza, 2015).

Figure 2.1: A worker at the Sandwich Fish Hatchery in the early 20th century tosses food into a pool bubbling with fish. (Courtesy of the Sandwich Town Archives)

Today the Sandwich Fish Hatchery raises three species of trout and one hybrid. They maintain broodstock brook and brown trout, which produce fertilized eggs for new generations of brook, brown, and tiger trout, the species' sterile hybrid. They receive fertilized rainbow trout eggs from broodstock hatcheries operated by the US Fish and Wildlife Service. The Hatchery staff meticulously rear the trout 365 days a year for two and a half years, when they reach about 12 to 14 inches in length. Between spring and fall stocking, the Hatchery staff releases more than 75,000 trout into freshwater bodies on the South Shore, Cape Cod. and Martha's Vineyard (Folco, 2012; Hay, 2022).

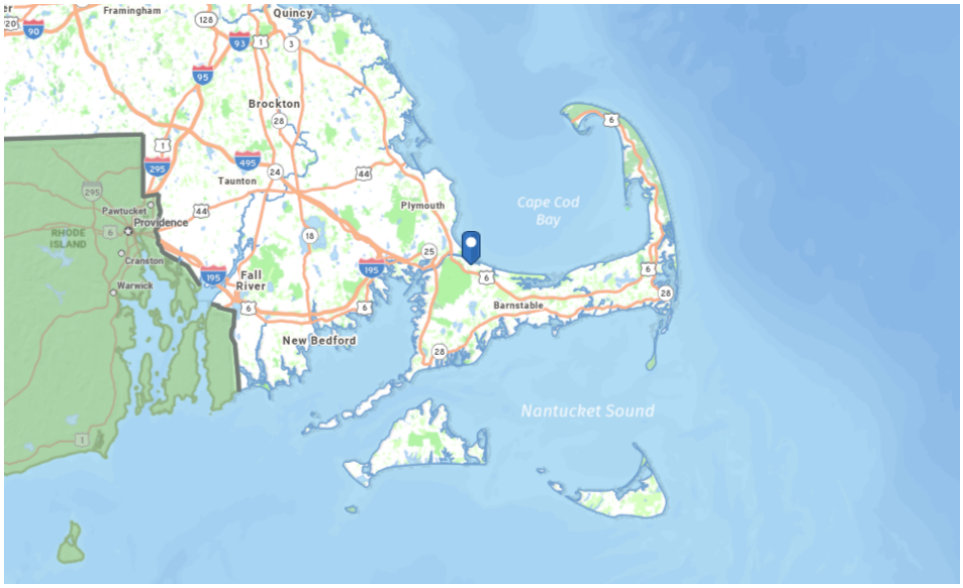

Figure 2.2: A map of southeastern Massachusetts depicts the South Shore, Cape, and Islands. A pop-up point marks the location of the Sandwich Fish Hatchery. Generated 2 April 2023; using ArcGIS.

Wayfinding, Signage, and Interpretive Self-Guided Tours

Wayfinding

Wayfinding, according to *The Society for Experiential Graphic Design (SEGD)*, "refers to information systems that guide people through a physical environment and enhance their understanding and experience of the space" (What Is Wayfinding?, 2014). Information systems include signage, symbols, directions, maps and other navigational aids, and environmental cues such as landmarks or layouts (shown below) (What Is Wayfinding?, 2014; Mehta & Auffrey, 2022). These systems enable people to plan and execute movements to reach one or more unfamiliar destinations in a new environment (Bock & Borisova, 2022).

Figure 2.3: A wayfinding sign in Shackford Head State Park, Maine uses a directional symbol to point visitors to a conspicuously maintained footpath through the brush (Downeast Fisheries Trail, n.d.).

Wayfinding systems that help people find their way through a building or outdoor environment can save time and reduce stress and confusion. In some cases, such as roadway signage, wayfinding systems are important to keep people safe (Mehta & Auffrey, 2022). They can also be important for organizations to regulate the flow of visitor foot traffic, for example, guiding shoppers to stores in a retail environment or away from visitor-restricted areas in a healthcare environment (Bock & Borisova, 2022; Richter, 2019).

Successful wayfinding systems consider the needs of the general public, including individuals with mental and physical disabilities. Routes must be easily identifiable and practical, especially for individuals using a walking aid. Signs must be consistent and readable for individuals reading at different heights, including wheelchair users (shown below). Content should aim to be

understandable without prior knowledge to individuals of many ages and backgrounds. Furthermore, messages should be uncomplicated and lighthearted for individuals with mental disabilities. The text should be highly legible, considering individuals with decreased sign-reading abilities (Ward, 2017).

Figure 2.4: A wheelchair user reads from a handicap-accessible sign in Kenai Fjords National Park, Alaska (Harpers Ferry Center for Media Services, 2009).

Signage

Signage, a collective display of communicative signs, is a key component of wayfinding. *SEGD* recognizes four classifications of signage: directional, informational, identification, and regulatory. Directional signage provides instructions for the observer to reach one or more destinations. Informational signage, also known as interpretive signage, interprets things via text and/or graphics. Identification signage labels points of interest. Regulatory signage, which is

least specific to wayfinding, establishes rules and restrictions. The classifications may be effective individually or combined (shown below) (Richter, 2019).

Figure 2.5: An interpretive/directional sign in Tsútswecw Provincial Park, British Columbia introduces a "Story Trail" and maps the path and points of interest; instructions to access audio stories along the path via QR codes are provided (Dickson, 2019). (Courtesy of CBC News)

A sign must be detected before it can be read and processed. Factors of sign visibility include scale, photo/colorimetric and temporal properties, and qualities of the surrounding environment. (Note: Some organizations and agencies, including MassWildlife, maintain brand standards that are paramount in the design process.) Increasing the size of a sign may enhance its visibility, however, excessively large signs may be impractical or detract from the surrounding visual environment. Similarly, increasing the brightness of a sign enhances its visibility, however, excessively bright signs have decreased legibility. A smaller sign that contrasts with the surrounding visual environment is likely to be more visible than a larger sign that blends in. While color can enhance visibility, having more than three main colors on one sign face may cause the opposite effect. Borders are also more likely to enhance visibility. (Bullough, 2017).

Once a sign is detected, it should facilitate readability and understanding. Factors to consider relative to sign legibility also include photo/colorimetric properties and qualities. Increasing the positive contrast between a sign's text and background to a 12:1 luminance ratio—higher-luminance letters and a lower-luminance background—enhances legibility (Bullough, 2017). It is important to note that text-to-background contrast decreases on outdoor signs which fade due to sun exposure (Sundar et al., 2019). Furthermore, typography and word selection determine sign legibility. Many serif and sans serif fonts are equally legible, although the most legible characters are about equal in height and width. Intricate and outline fonts are illegible compared to common and solid fonts. Larger text is more legible; uppercase text, heavier font weight, and adding one inch of letter height per five feet of difference between a sign and an observer may enhance legibility at a distance. Mixed-case text is most legible for normal reading while uppercase-only text may be more legible for headings. The use of short, common words also enhances legibility. Additionally, messaging should be brief and cover only up to 75% of a sign face (Bullough, 2017).

Figure 2.6: A bright, multicolored interpretive sign at the Smithsonian Gardens in Washington, D.C. uses positive contrast (purple text on a yellow background) and negative contrast (white text on a red background), serif and sans serif fonts, mixed-case and uppercase-only texts, and bolded and unbolded text; text covers less than 75% of the sign face ("Anacostia Community Museum Garden Interpretive Panels," 2019).

Prompting desired responses in observers through signage requires systematic planning. To model the relationship between signage design and human responses, researchers at the Carl H. Lindner College of Business, University of Cincinnati, devised a Conceptual Framework for Signage Communication. The framework (pictured below) indicates that the combination of objective and subjective features of signs, contextual variables, and person traits elicit conscious and unconscious processes in observers. In turn, these processes determine cognitive, affective, and behavioral responses (Kellaris & Machliet, 2016).

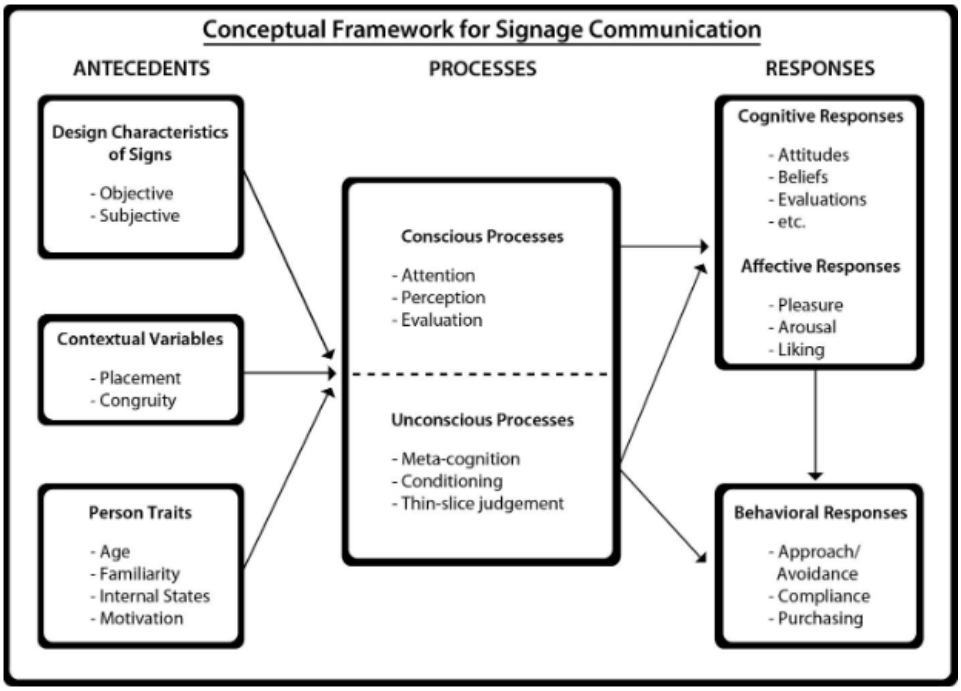

Figure 2.7: A model linking sign design/context and person traits to human responses via conscious and unconscious processes (Kellaris & Machliet, 2016).

The framework prompts the sign designer to consider the "antecedents" of an observer's mental processes. First, consider design characteristics. Objective characteristics such as size/shape, materials, colors, brightness, font, message content, and others, are detailed previously in this section. Subjective characteristics include perceived attractiveness, interestingness, legibility, quality, novelty, et cetera (Kellaris & Machliet, 2016).

Second, consider the physical context of the sign. Signs placed far from the observer are likely to be less visible and legible, decreasing attention and processing. Sharp viewing angles also decrease legibility and processing. Signs placed in the observer's periphery (as opposed to their direct field of view) are likely to only be perceived by one hemisphere of the brain (rather than both). Signs will be perceived differently based on their immediate surroundings and how they relate physically and visually to that space. Observers are more likely to make positive

evaluations of a sign that is congruent with its environment (shown below). Although, slight incongruities may be perceived as creative or novel (Kellaris & Machliet, 2016).

Figure 2.8: A sign at Altadena Triangle Park, CA imitates the shapes and colors of the surrounding visual environment; a dotted border is visually striking and enhances visibility (Amigos de los Rios, 2016).

Third, consider the characteristics of observers, as detailed briefly in the previous section. Age affects vision and cognitive speed. Familiarity with the message content affects information processing and retention. Internal states, such as elevated or depressed moods, also affect information processing; in fact, observers may not be receptive to information that could lower their current mood. Observers with low motivational predispositions may need external motivation to process sign content as readily as observers with high motivational predispositions. Furthermore, observers' attentional states affect information processing because their attention is divided between stimuli in a sign's surrounding environment (Kellaris & Machliet, 2016).

The framework then prompts the designer to consider an observer's conscious and unconscious mental processes. Conscious processes such as attention, perception, evaluation, and retention of information produce an array of cognitive (i.e. thoughtful) and affective (i.e. emotional) responses. These responses subsequently inform any variety of behavioral responses, from buying a product to sharing what they learned with others. Unconscious processes, such as processing fluency, may lead directly to cognitive, affective, and behavioral responses. For example, if a sign is easy to comprehend, an observer is more likely to judge the information positively, be receptive to it, trust it, and remember it (Kellaris & Machliet, 2016).

Ultimately, this conceptual framework guides the sign designer's decision-making process. Understanding that observers will have many intermediary responses based on design, context, and content and filtered through mental processes (Kellaris & Machliet, 2016).

Self-Guided Tours

A review of ten interpretive self-guided tour case studies (development reports, concept designs, and tour booklets) for parks, wildlife refuges, colleges, museums, and other sites revealed two preliminary tasks for designing a self-guided tour. First, establish the organization's specific goals relative to the visitor experience. Second, establish the appropriate methodology to meet those goals. Exemplary tours are cited in the next two paragraphs; the complete list of ten case studies is listed in the Appendix.

Self-guided tours may be implemented to satisfy a multitude of goals from advertising an organization's goals to reducing burdens on its staff (Autore, 1984). The case studies in this

review emphasize the opportunity for public education and engagement. Self-guided tours can be effective educational tools because they allow a larger number of visitors to explore and learn about a facility regardless of staff resources (Beverstock et al., 2014). Furthermore, allowing visitors to tour a facility at each individual's pace can improve information retention and overall visitor-friendliness (Autore, 1984). Physical self-guided tour materials, such as signs, maps, and brochures, enable the organization to advertise links to its website, social media, and other information and resources (*Downeast Fisheries Trail*, 2012).

Research methods for designing interpretive self-guided tours often include direct observation, historical research, collecting previous plans, mapping, and receiving feedback (Schaefer, 2016). First, the space is observed by walking around it and watching how others walk around it. Notes, photographs, and videos may be taken for reference throughout the methodology. Second, historical research about the space and the surrounding area is collected in the form of documents, photographs, and maps. Third, previous plans or studies for similar projects in the area are revisited. Fourth, particularly for large-scale interpretive tours, maps of the space and wayfinding routes are designed. Fifth, expert feedback is gathered from community members impacted by the project (Schaefer, 2016).

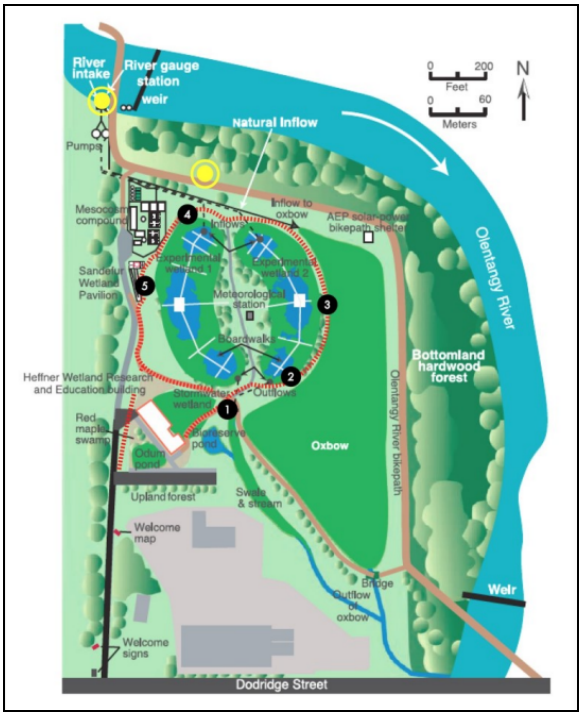

Figure 2.9: A map of the Olentangy River Wetland Research Park, OH, modified with routes and checkpoints for an interpretive self-guided tour (Beverstock et al., 2014).

Hatchery Tours in North America

National, state, tribal, and private hatcheries produce a variety of aquatic species throughout North America. To increase public interest, engagement, and education, many hatcheries offer on-site guided or self-guided tours. Some hatcheries offer virtual tours, often in the form of a video, which can be viewed on YouTube and other public video-sharing websites. A review of 30 virtual fish hatchery tours across the U.S. and Canada revealed five key topics for a comprehensive fish hatchery tour: **the organization or agency that operates the hatchery, the fish-rearing process, the infrastructure (including water), the fish stocking process, and**

recreational fishing opportunities. Exemplary tours are cited throughout the next five sections; the complete list of 30 virtual tours is listed in the Appendix.

Organization

Most of the 30 virtual tours examined in this review are guided by a hatchery manager or technician. The guide often begins by welcoming virtual visitors to the grounds (sometimes using popular local landmarks and directions to the hatchery from major highways for reference), introducing themselves, and introducing the organization or agency that operates the hatchery (Wyoming Game and Fish Department, 2018). The tone is usually friendly and informal (California DWR, 2020).

> *"Hello, I'm Bret Barngrover, Superintendent of the Daniel Fish Hatchery with the Wyoming Game and Fish Department. The Daniel Hatchery is located approximately 12 miles north of Pinedale, Wyoming. Today I'll be showing you guys around the hatchery, the fish we raise, and the technology we use to raise those fish, so follow me and we'll show you around our facility" (Wyoming Game and Fish Department, 2018).*

The guide often shares a brief history of the organization, when it was constructed, and its current mission (DEEP Video, 2021). For example, some hatcheries were built to restore and conserve fish populations that had been threatened, endangered, or extirpated by anthropogenic stressors (Friends of NW Hatcheries - Leavenworth, WA, 2021; Minnesota Department of Natural Resources, 2014). Some were built to provide commercial or recreational fishing opportunities without depleting fish populations (Michigan DNR, 2013; Colorado Parks and Wildlife, 2021). Others were built to supply pet stores and bait shops (Illinois-Indiana Sea Grant,

2021). The majority of hatcheries in this review aim to support both fisheries conservation and fishing opportunities. In a few cases, the guide notes food security, cultural, or economic benefits of fish-rearing programs, how fishing license purchases fund conservation management, and the potential for improved physical, mental, and social health by going fishing.

> *"[The Winthrop National Fish Hatchery] was built to compensate for lost natural fish production caused by the construction of the Grand Coulee Dam. The population of spring Chinook native to our Mid-Columbia River is listed under the Endangered Species Act, partially due to dam construction. We aim to supplement the population so that there are some fish available for harvest. [...] One of our responsibilities is to provide salmon to tribes to make up for the loss of one of their vital traditional food sources caused by the construction of the Grand Coulee Dam" (Friends of NW Hatcheries - Leavenworth, WA, 2021).*

More logistical information about the organization or agency is sometimes included, such as visiting hours, rules and regulations to follow while at the hatchery, and where to find more information (Wyoming Game and Fish Department, 2011; Colorado State Patrol, 2020).

Fish Rearing

From blue catfish to common goldfish, each of the 30 virtual tours in this review includes the names of the fish species reared at the hatchery (Kentucky Department of Fish & Wildlife Resources, 2020; Illinois-Indiana Sea Grant, 2021). Depending on the length of the tour, the guide may explain how to identify the different species, or even how to distinguish males and females within a species, based on their physical and behavioral traits (California DWR, 2020;

Wyoming Game and Fish Department, 2011). Images or videos are typically a part of the description. The guide may also explain how the hatchery managers know which species to rear and how many of each species are produced annually (Wyoming Game and Fish Department, 2018; Colorado State Patrol, 2020).

> *"The female's mouth and head are more rounded. You can tell the male not by the size, not by the color, but by the hook jaw. The female mouth stays more rounded, she's more kissable. The male fish is going to get a hook jaw, which we call a kipe. So that hook jaw actually begins to grow during the spawning season. They actually use those kipes and those teeth for fighting off other males when they are establishing nesting rights in the river system" (California DWR, 2020).*

Hatcheries rear fish at various life stages separately but simultaneously (Colorado Parks and Wildlife, 2021). For example, a trout hatchery will have representatives for five life stages in the form of eggs, hatchings, larvae, juveniles, and adults (Wyoming Game and Fish Department, 2011). Alternatively, the guide at a salmon hatchery may describe six because ocean-run and river-run adults of the same species are different colors and shapes (Stillaguamish Tribe Natural Resources, 2021). Often, the tour guide shows species at different life stages, making note of the stage at which they are released from the hatchery (Wyoming Game and Fish Department, 2018). How quickly the fish grow and how long they are raised before they are stocked are typically explained (Arizona Game And Fish, 2016).

Some hatcheries harvest eggs from wild-caught fish while others produce eggs from broodstock fish (Wyoming Game and Fish Department, 2011; Colorado Parks and Wildlife, 2015; Arizona Game And Fish, 2016). Most of the virtual tours for hatcheries harvest or produce their own eggs feature videos and a lengthy description of the spawning process (Wyoming Game and Fish

Department, 2011). The guide will likely describe the steps of the process including stripping eggs from females, taking yolk and embryo samples from the eggs, stripping milt from males, and fertilizing the eggs by gently stirring them, for example, with a wild turkey feather (Colorado Parks and Wildlife, 2015). Offering a virtual tour of the spawning process, which takes place only a few weeks to a few months out of the year for most species, provides a unique educational opportunity for visitors.

> *"To spawn the fish, we put them into a tub of water that is mixed with an anesthetic. This makes the fish relaxed and much easier to handle. Then, we gently run our hand down the adult female's belly to make her release her eggs. Each female can produce anywhere from 700 to 4,000 eggs per year depending on her age and species. Milt from an adult male is obtained in the same way and is mixed with the eggs to fertilize them. Unlike salmon, trout don't die after spawning, and we can use them year after year " (Wyoming Game and Fish Department, 2011).*

Whether they are wild or produced from broodstock, eggs require a significant amount of work before and during incubation (Wyoming Game and Fish Department, 2011). The guide may explain that egg work and incubation have to take place in a highly-controlled hatch house to prevent outside pathogens from infecting and killing developing fish (Wyoming Game and Fish Department, 2020). They may describe other threats such as dead eggs which destroy surrounding eggs (Idaho Fish Game, 2020). Longer tours may include descriptions of the different types of incubators and demonstrations of how they work (Alaska Department of Fish and Game, 2020). Offering a virtual tour of the hatch house also provides a unique educational opportunity for visitors because these buildings are closed to the public (Wyoming Game and Fish Department, 2020).

> *"We put [the eggs] in upwelling incubators, and when they get to the eyed egg stage, we take the eggs out of the jars and run them through an egg-picking machine. The machine will sort the live eggs from the dead eggs. […] At that point, we take the good eggs and put them back into the incubators. After about another three weeks of development, the eggs will start hatching. As they hatch and develop and absorb the yolk sack, they will swim out of the incubators into these vats" (Idaho Fish Game, 2020).*

In order for hatcheries to produce the desired amount of fish biomass efficiently, the fish are fed as soon as they are developed enough to eat (Wyoming Game and Fish Department, 2018). The guide for nearly every virtual hatchery tour describes what and how fish are fed, for example, how much and how often the fish are fed and whether they are fed by hand or by machine (Arizona Game And Fish, 2016; Alaska Department of Fish and Game, 2020). The guide may note if visitors are allowed to hand-feed the fish (Michigan DNR, 2013).

> *"We raise around 250,000 to 300,000 pounds of fish every year, and to raise that many fish, we feed about 250,000 to 300,000 pounds of fish food each year" (Wyoming Game and Fish Department, 2018).*

Few of the 30 virtual tours examined in this review explore fish anatomy and scientific research in detail. For longer tours, the guide might describe the form and function of the fins, gills, snout, and internal organs including the lungs, heart, and digestive system (Stillaguamish Tribe Natural Resources, 2021). They may explain how and why biologists collect data on hatchery fish, for example, through tagging, surveying, and studying tissue, scale, or otolith (ear stone) samples (Lummi Natural Resources: Outreach and Education, 2021).

> *"[The hatchery staff] takes a little hole punch of the opercle. This little*

> *piece of flesh will be sent to the Department of Fish and Wildlife's genetics lab. They will test that little piece of skin to find out if this particular salmon is originally from the South Fork of the Nooksack River. [...] Most of the time, the salmon know where to come back to, but occasionally they get lost. Taking these DNA samples lets us know where the salmon originally came from" (Lummi Natural Resources: Outreach and Education, 2021).*

Infrastructure

Although they share a common objective, to rear fish, each hatchery in this review maintains slightly different fish-rearing facilities. Most often, the guide will give an overview of the outdoor and indoor infrastructure (Wyoming Game and Fish Department, 2020). Outdoor infrastructure includes the pods or raceways where visitors are most likely to see the fish during an in-person visit. The guide may explain the importance of sun shades or netting to protect the fish from harsh UV rays and predators such as birds and small mammals (Wyoming Game and Fish Department, 2019; California DWR, 2020). Indoor infrastructure includes the tanks or troughs where fish fry are raised until they are big enough to be moved outdoors (Wyoming Game and Fish Department, 2020).

Water and water infrastructure are central to aquaculture, and very few of the tour guides in this review neglected to discuss them. They may explain the source of the water (often one or more wells) and show the pumps and the filtration mechanisms required to move the water throughout the facility and make it suitable for rearing fish (Alberta Environment and Protected Areas, 2013; Wyoming Game and Fish Department, 2018). Other common topics include water quantity, temperature, oxygen concentration, and recycling. The tour guide may also explain how much

energy goes into the facility and the generators required in case of a power outage (Wyoming Game and Fish Department, 2020).

> *"The first four tanks you see behind me [...] are run exclusively off of our well water, the water you saw that was treated with the filter system. Dubois hatchery is a partial recirculation facility. In order to produce the pounds that we need to get out of here (we produce about 30,000 pounds a year), we have to reuse the water. So the first third of all these pods run off primary water; the other two-thirds are run off of reuse water" (Wyoming Game and Fish Department, 2020).*

Fish Stocking

Many of the tours in this review include a description and videos of the stocking process. Videos may show how the fish are corralled to one side of their enclosure, netted into a tank mounted to a stocking truck, transported to a body of water, and released (Arizona Game And Fish, 2016). The guide may explain whether the hatchery relies more on pumps or manpower to stock the fish (Wyoming Game and Fish Department, 2021). Some showcase how the hatchery stocks fish by bush plane, helicopter, ATV, foot, and even horseback (Alaska Department of Fish and Game, 2020; Colorado Parks and Wildlife, 2015).

> *"Inland Fisheries stocks over 400 lakes, rivers, and streams throughout Nova Scotia. Fish are delivered by tanker truck, up to 12,000 per load. The number of fish stocked depends on local conditions. For every hectare, we add between 50 and 100 fish" (Nova Scotia Government, 2015).*

Fishing Opportunities

In this review of virtual fish hatchery tours, the final key topic is information for visitors to start fishing. The guide may reiterate the location of the hatchery and the region it stocks as well as the names of local water bodies and handicap-accessible fishing areas (Minnesota Department of Natural Resources, 2014; Wyoming Game and Fish Department, 2018).

> *"The fish stocked from the William Jack Hernandez Sport Fish Hatchery are delivered by a committed staff dedicated to stocking Southcentral Alaska's waters to create, improve, and diversify Alaska sport fishing opportunities" (Alaska Department of Fish and Game, 2020).*

Newer tours (posted around 2020 to 2023) often share the URL for the organization's website and links or handles to its social media. The guide may direct visitors to specific sites where they can learn more about the hatchery, buy a fishing license, or keep track of when and where the hatchery stocks fish (Outdoor Oklahoma, 2020; Wyoming Game and Fish Department, 2021).

> *"Thanks for visiting the fish farm today. I hope you enjoyed your virtual tour. You can find us online at ozarkfisheries.com or on social media, Instagram and Facebook, at Ozark Fisheries" (Illinois-Indiana Sea Grant, 2021).*

3. Methods

Objective 1: Establish principles of wayfinding and signage.

I began my literature review of wayfinding and signage using the Interdisciplinary Journal of Wayfinding and Signage. I recorded key points into concept maps using the online graphic design tool Canva.

Objective 2: Examine case studies of self-guided tours.

I collected research articles and case studies from scholarly databases, including Scopus, JSTOR, PubMed, and Google Scholar. Search terms pairing "visitor" AND "wayfinding," or "interior wayfinding" OR "indoor wayfinding," with "hatchery," "aquarium," "zoo," "museum," "state park," "national park," "nature trail," et cetera provided thousands of results spanning a broad range of research.

Using Google Scholar and keywords including "self-guided tour" AND "visitor" with "fish," "wildlife," or "nature," I collected mainly thesis reports of self-guided tours (and other visitor education initiatives) at aquariums, fish and wildlife refuges, and fish hatcheries; I recorded key points into concept maps using the online graphic design tool Canva.

For visual references, I searched Google Images for photographs of wayfinding and interpretive tour signs installed at historic sites, nature trails, urban walking trails, parks, and college campuses.

After compiling a substantial bibliography of resources on wayfinding and interpretive self-guided tours, I shifted the focus of my research from scholarly databases to YouTube. I searched for and watched videos of fish hatchery tours from fish and wildlife management agencies and private organizations. I made another concept map specifically for topics discussed in hatchery tours.

I conducted archival research of MassWildlife and the Sandwich Fish Hatchery through *A History of MassWildlife: 1866-2012* by James Cardoza, *Sandwich, a Cape Cod Town* by Russell A. Lovell, and the Town Archives at the Sandwich Public Library.

Objective 3: Develop concept designs and content for wayfinding signage.

I visited the Sandwich Hatchery on several occasions to walk around the grounds, take notes of sites for wayside signs, and collect photos (shown below) and videos. I developed a concept design for a self-guided interpretive tour of the Sandwich Fish Hatchery based on my research and direct observation using the online graphic design tool Canva. The concept design included a series of wayfinding signs and a mobile web element.

Figure 3.1: A wintertime visitor at the Sandwich Hatchery walks in a northeast direction along the pools.

Figure 3.2: The current information kiosk depicts 100 years of aquaculture at the Hatchery (left) and trout life cycles and identification (right) behind cloudy acrylic.

Objective 4: Seek feedback on concept designs (sign design and content).

I held a 45-minute focus group with the project sponsors at MassWildlife and the Sandwich Fish Hatchery to determine weaknesses and areas of improvement within my concept design. The meeting was attended by:

Adam Davies, Sandwich Fish Hatchery Manager

Jim Lagacy, Aquatic Resource Education Coordinator

Nicole McSweeney, Assistant Director of Outreach & Education

Courtney Nicolson, Outreach and Marketing Coordinator

Todd Richards, Assistant Director of Fisheries

Emily Stolarski, Communication Coordinator

I presented each slide of my concept design to the attendees. I described my reasoning behind content and design choices and periodically asked whether the attendees had questions or comments. By the end of the focus group, the following questions were addressed:

1. Does anything about the concept design confuse you?
2. Is there anything you expected to see in the concept design that you did not?
3. Do you agree with the idea to use wayfinding signs to streamline foot traffic, answer frequently asked questions, and link to MassWildlife resources; meanwhile, an optional mobile web element describes the tour with greater detail and external resources?
4. Would you like to see more or less text and images per sign?
5. What other MassWildlife resources would you like to see included in the wayfinding signs?

I also held a 30-minute meeting with WPI professor and former sign designer Derren Rosbach for a visual critique of my concept design. The following questions were addressed:

1. How would you improve the signs' visibility and legibility?
2. Are the sign faces visually attractive?
3. What design elements could be improved upon?

Objective 5: Refine concept designs according to feedback.

Taking into account the expert feedback I received from MassWildlife and Sandwich Hatchery staff, I finalized wayfinding signs using the desktop publishing software Adobe InDesign.

4. Results

Principles of Wayfinding, Signage, and Self-Guided Tours

A review of wayfinding and signage literature resulted in the identification of key considerations when designing interpretive wayfinding signage for the Sandwich Hatchery. First, visitors will process and respond to signage based on its design, content, and context as well as their personality traits. Second, visitors will need to be able to orient at individual signs and move between them. Third, texts and images can be used to communicate to visitors, as well as instructions or links to access more information and resources. See Figure 1 (below) for an abridged version of the literature review outcomes.

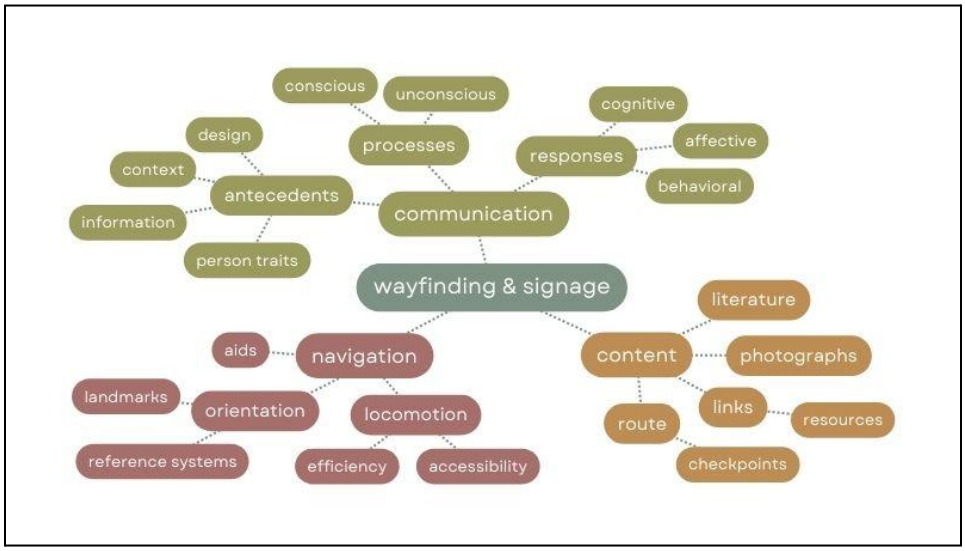

Figure 4.1: A conceptual diagram mapping key elements of wayfinding and signage.

A review of self-guided tours at fish hatcheries, historical sites, nature trails, museums, and other sites resulted in the identification of key considerations when designing a self-guided tour for the

Sandwich Hatchery. First, interpret the organization that operates the Hatchery, the fish that are reared there, the pools and other infrastructure, the stocking process, and local fishing opportunities. Second, consider how to engage visitors so that they can have an educational experience and come away with positive attitudes about the facility. Third, take time to observe and research the history of the site and seek feedback from individuals who will be affected by the project. See Figure 2 (below) for an abridged version of the literature review outcomes.

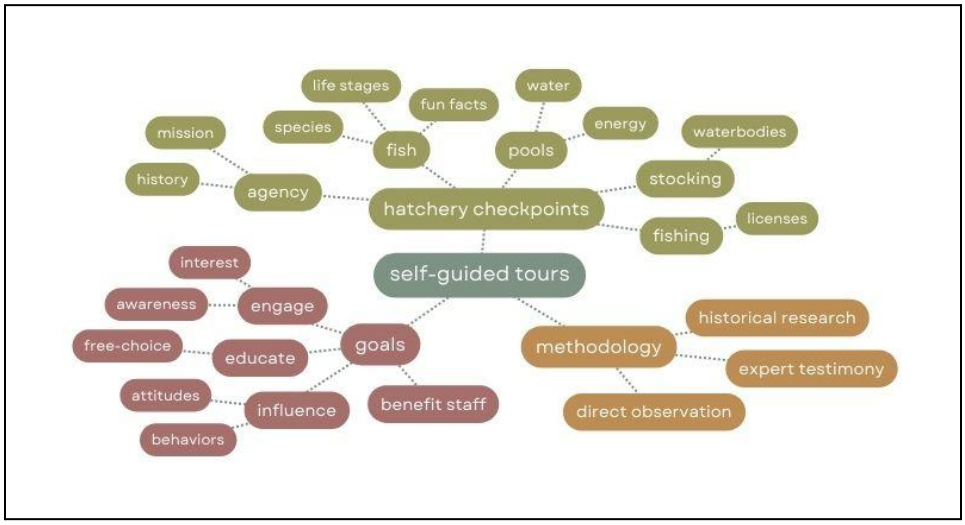

Figure 4.2: A conceptual diagram mapping key elements of self-guided tours.

Concept Designs for a Wayfinding System

Method 3 resulted in concept designs for a wayfinding system including one orientation sign plus ten wayside signs and plans for a mobile version of the system. These designs were presented during a focus group to the project sponsors (listed in the Methods section) for feedback. Table 1 (below) presents an abridged list of design and content choices based on the literature reviews and presented to the sponsors.

Design	Considerations
Size	● Common for interpretive wayfinding signage ● Conspicuous without being visually awkward or causing physical obstructions
Shape	● Rounded shape mitigates corrugated plastic corners from bending/breaking due to foot traffic
Orientation	● Portrait orientation reduces the sign's footprint along narrow paths ● Vertical orientation increases conspicuity from a distance without increasing overall size
Colors	● Meets brand standards ● Simultaneously conspicuous against and complementary to the green/gray visual landscape ● Border increases conspicuity
Typography	● Meets brand standards ● Uppercase-only headings and mixed-case body text increase conspicuity and legibility ● Positive contrast increases legibility
Stations	● High-contrast numerical system increases conspicuity ● Topics based on a thorough review of hatchery tours
Information/ Messaging	● Minimal text covers less than or equal to 75% of the sign face ● Novel fun facts and trivia promote engagement and enjoyment ● Uncomplicated language facilitates learning ● QR codes make it easy for visitors to access more information including MassWildlife resources
Map	● Illustration facilitates orientation ● Numerical system facilitates navigation
Route	● Efficient path streamlines foot traffic and encourages visitor use ● Logical order of topics promotes visitor understanding ● Conspicuous sign spacing promotes visitor usage ● Accessible for visitors with walking aids

Table 4.1: Preliminary sign design and content choices.

An issue with the orientation sign plans (shown below) emerged during the focus group with the sponsors. A welcome sign is already placed at the end of the parking lot (outside the building with the white roof) during the peak visitor season, but it needs to be replaced.

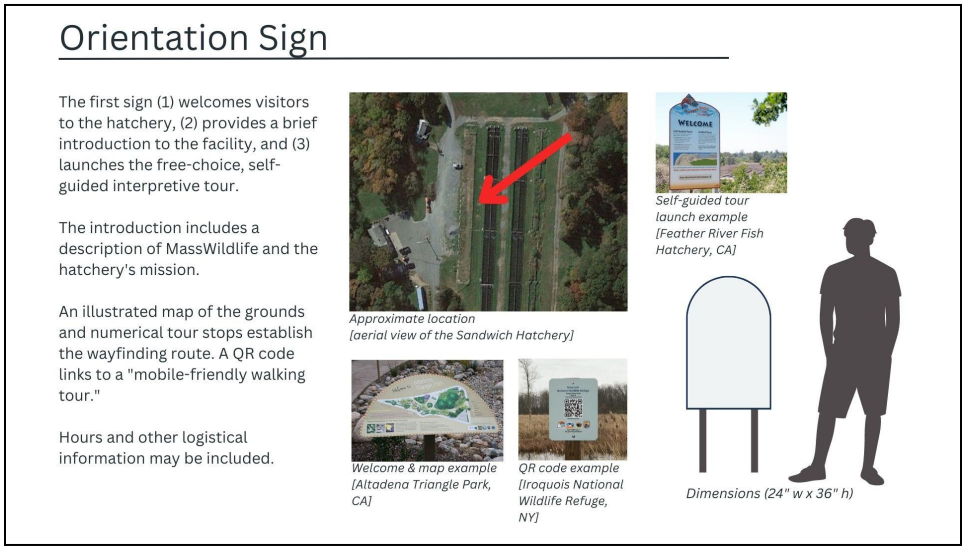

Figure 4.3: Plans for the orientation sign.

Action items:

- *Place the orientation sign on the left side of the end of the parking lot.*

Several issues with the wayside sign plans (shown below) emerged during the focus group. Changing the placement of the orientation sign affects stations #1 through #3. Stations #7 and #8 are located in an off-limits area. The trailhead kiosk—including information about the history of the Hatchery and trout species—will be taken down soon. Also, signs that face the rising/setting sun will fade more rapidly.

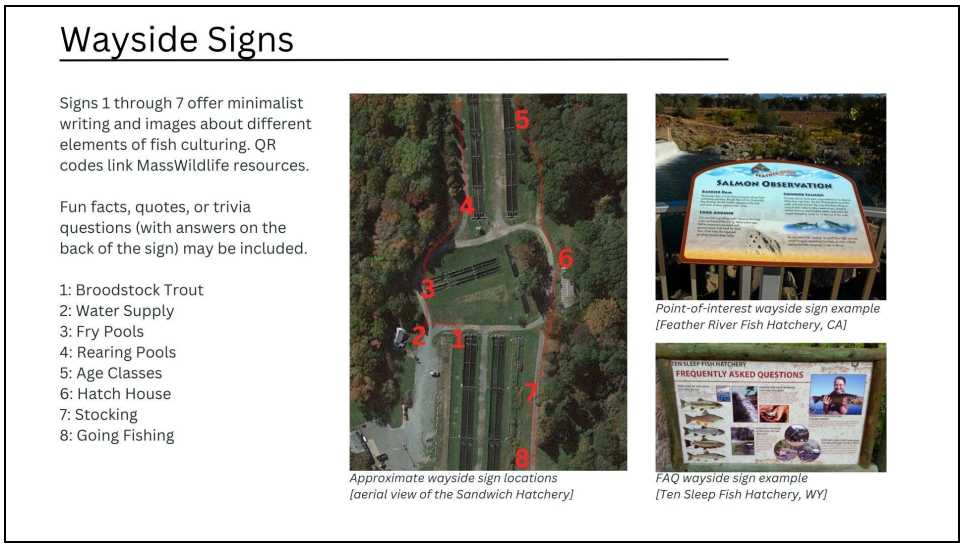

Figure 4.4: Plans for the wayside signs.

Action items:

- *Rearrange the first several stations based on the placement of the orientation sign.*
- *Rearrange the last several stations based on areas where visitors are allowed.*
- *Add two more signs to the tour (one for the Hatchery's history, one for trout species).*
- *Plan to face signs east/west, wherever possible.*
    - *Illustrate the map based on whichever direction the orientation sign will face.*

After critiquing plans for the orientation sign and the wayside signs, I presented my designs for the sign faces and mobile tour (shown below). I described the mobile version of the tour as matching the physical signs numerically and sequentially, but in greater detail and article format; I suggested that images and videos show more about the hatching and stocking processes and that audio clips of the Hatchery staff share fishing tips and stories.

Feedback for the sign designs and content was largely positive. The idea that signs have minimal information (3 – 5 FAQs) with QR codes linking to more information was well-received. However, there were concerns about whether visitors would be able to differentiate between QR codes for the mobile tour and QR codes for other resources. It was decided that more information about MassWildlife and its mission would be pertinent, as well as information about freshwater fishing opportunities for non-trout species in the area.

Figure 4.5: Designs for the orientation sign, the first wayside sign, and the mobile version of the tour.

Action items:

- *Re-design the QR code system for better differentiation between the mobile tour and other MassWildlife resources.*
- *Add MassWildlife's mission to the orientation sign.*
- *Add a map of the area with nearby fishing opportunities on the fishing sign.*
    - *"[Pond name] is [distance in miles, length of drive] from the Hatchery."*
- *Include fishing information about non-trout species.*

Finalized Wayfinding Signage

The wayfinding system is designed precisely for the Sandwich Hatchery. The route is efficient and accessible according to the layout of its grounds. The sequence of topics is logical and consistent with the arrangement of its facilities. A map and numerical system facilitate orientation and goal-directed movement.

The signage considers how visitors process and respond to design characteristics, as outlined by Kellaris & Machliet (2016) in the Conceptual Framework for Signage Communication. Non-rectangular shapes create visual interest (and reduce the likelihood of bent or broken corners). Borders increase visibility. The typography and color palette promote legibility through positive contrast (and meet brand standards). The brief and uncomplicated text facilitates reading and understanding by visitors of diverse backgrounds, ages, and abilities. Et cetera.

The self-guided tour is free to use at the visitors' pace, as well as educational, engaging (using images and "Fish Facts" or "Trout Trivia"), and potentially influential (promoting the use of MassWildlife's recreational fishing resources). Meanwhile, the staff may spend less time answering frequently asked questions. A review of 20 fish hatchery tours combined with direct observation and expert testimony of the Sandwich Hatchery contributed to the selection of stations along the tour.

Figure 4.6: Orientation sign design (1/1).

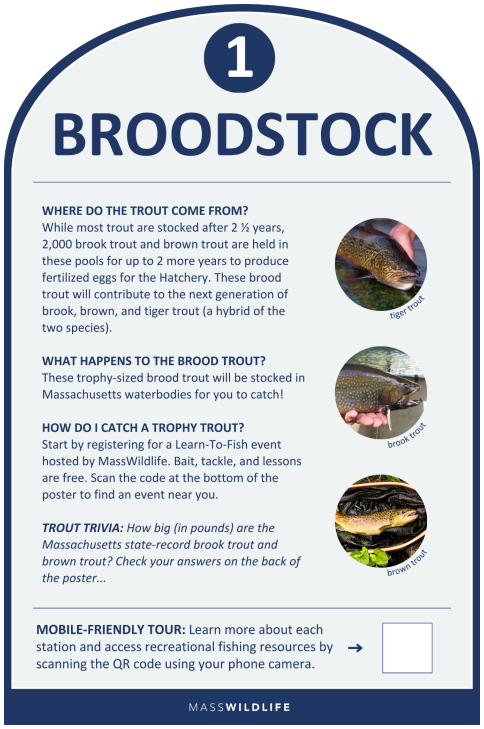

Figure 4.7: "Broodstock" wayside sign design (1/10).

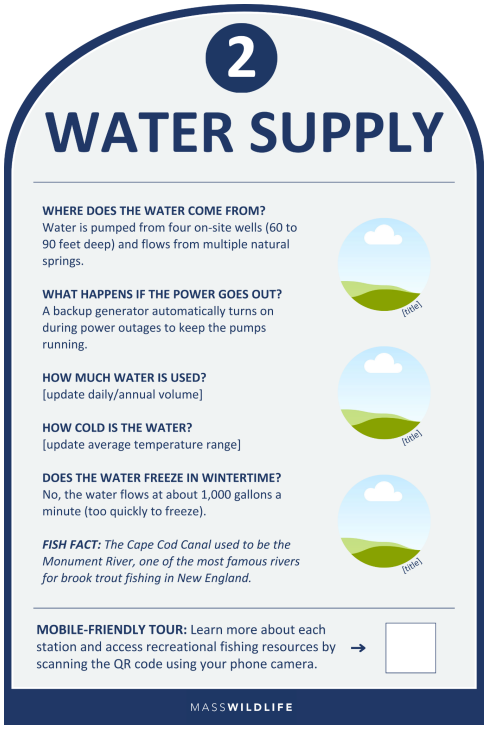

Figure 4.8: "Water supply" wayside sign design (2/10).

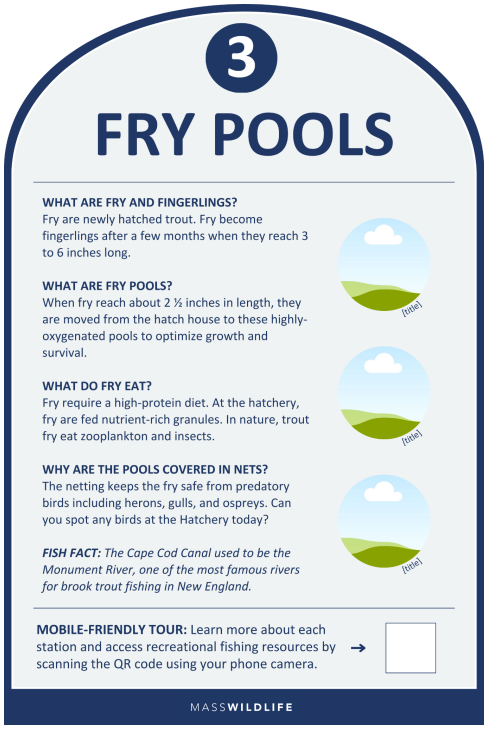

Figure 4.9: "Fry pools" wayside sign design (3/10).

Figure 4.10: "Rearing pools" wayside sign design (4/10).

Figure 4.11: "Age classes" wayside sign design (5/10).

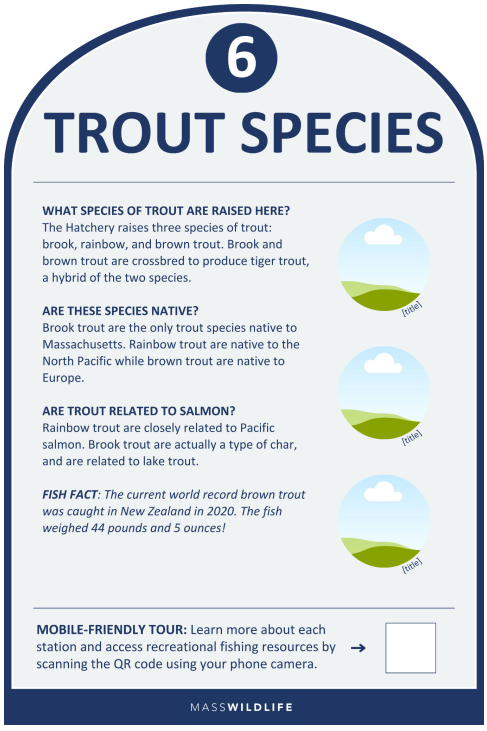

Figure 4.12: "Trout species" wayside sign design (6/10).

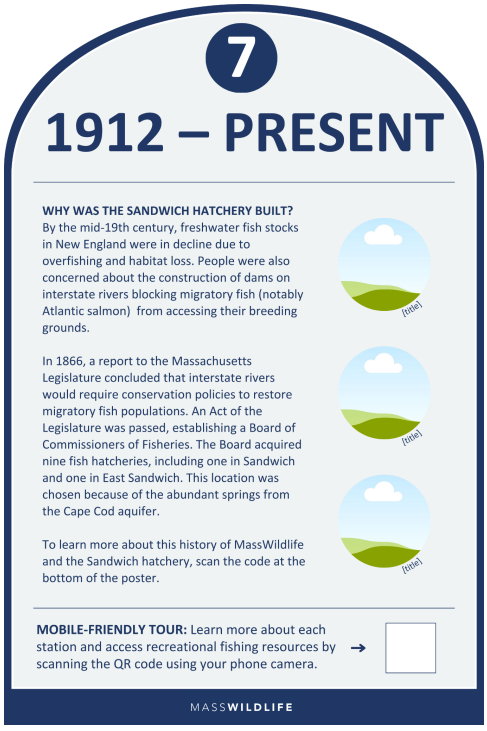

Figure 4.13: "1912 – Present" wayside sign design (7/10).

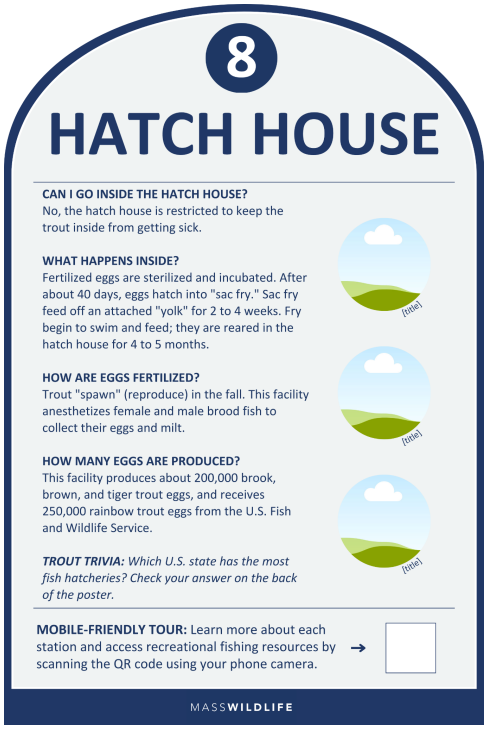

Figure 4.14: "Water supply" wayside sign design (8/10).

Figure 4.15: "Stocking" wayside sign design (9/10).

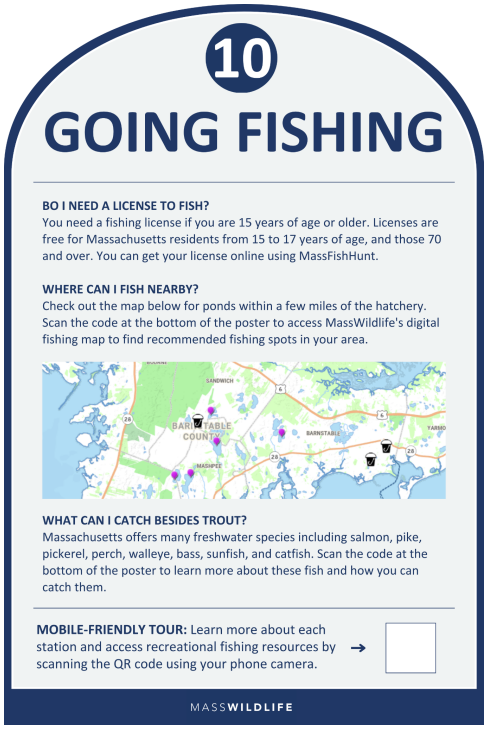

Figure 4.16: "Going fishing" wayside sign design (10/10).

Conclusion

I designed a wayfinding system for a self-guided tour of the Sandwich Fish Hatchery, which is very popular among visitors but lacks interpretive signage. The lack of signage stresses the Hatchery's limited resources by encouraging unpredictable foot traffic and frequent requests for guided tours. I designed 11 signs. One orientation sign welcomes visitors to the Hatchery, introduces MassWildlife and its mission, and launches the self-guided tour. A QR code links to a lengthier, mobile version of the self-guided tour. Ten numerical wayside signs answer frequently asked questions at points of interest around the Hatchery. QR codes link to MassWildlife resources. This system will help engage and educate visitors while reducing stress on the Hatchery's limited resources.

The final deliverable to the project sponsors is an InDesign file in which they can continue to add images and text. Seeing as the sponsors have access to photos and videos taken year-round at the Hatchery for other print and digital materials, compiling images was outside the scope of my work. Further research will also be required to design and develop the mobile version of the self-guided tour. This element will include more detailed descriptions of Hatchery operations plus video and audio clips.

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