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Introduction

The U.S. Fish and Wildlife Service (Service) Fish and Aquatic Conservation Program in Interior Region 9 marks (adipose fin clips) and tags (coded-wire tags) juvenile fish before release from National Fish Hatcheries (NFH) throughout Oregon, Washington, and Idaho. Through annual congressional legislation since 2003, the Service is required to mass mark juvenile hatchery Chinook Salmon *Oncorhynchus tshawytscha*, Coho Salmon *O. kisutch*, and steelhead *O. mykiss* intended for harvest (Further Consolidated Appropriations Act, 2020). Additionally, marking and tagging is often an important component of hatchery evaluation programs and other legal agreements. For example, many hatchery programs in the Columbia River basin are managed as part of the production detailed in the 2018–2027 United States v. Oregon Management Agreement. The agreement is a part of a legally binding court order and incorporates fishery management including marking and tagging rates for hatchery programs. The Region 9 marking programs annually mark 29 different hatchery stocks across a large geographic area, ranging from the Olympic Peninsula to the Snake River basin in Idaho. The period for marking is constrained by several factors including release timing, fish size, water temperature, disease prevalence, hatchery carrying capacity, and marking program capacity.

While manual marking trailers are used to mark fish, clip quality and tag retention are dependent on staffing the trailers with experienced markers (Hand et al. 2010). In recent years, it has become difficult to consistently hire and retain experienced markers for the manual trailers. AutoFish System trailers (Northwest Marine Technology, Anacortes, Washington; auto trailers) are the preferred method of marking most hatchery stocks due to improved clip-quality, tag-retention, and speed. Additionally, auto trailers reduce the need to anesthetize and manually handle all fish, potentially improving fish health. The Region 9 marking program currently has five auto trailers available for marking and an additional four manual marking trailers (manual trailers).

Given the limited number of auto trailers and staff available, the number of fish that need to be marked, the geographic scale at which the hatchery facilities are located, and the constrained period for optimal marking at many facilities, developing a schedule to mark fish is a complex endeavor. Often, the optimal marking period at one facility conflicts with the optimal period at another facility. In recent years, the use of auto trailers has been stretched to capacity, with double shifts (i.e., a morning and an evening shift of marking in one day) being used at some locations. Any changes to the marking schedule (e.g., fish health issues at a particular facility or mechanical breakdowns of the trailers or hatchery facilities) has a ripple effect on subsequent marking at other facilities. Marking staff may also work overtime, accrue compensatory time, and work on weekends to try to accommodate any changes to the schedule, putting a strain on staff when they have to repeatedly adjust their schedules, travel, and put in extra hours.

The Region 9 Marking Committee sought to develop an understandable and flexible process to produce an annual marking schedule for all stocks within Region 9 hatchery programs, as well as adjust scheduling in-season when unforeseen events occur. Our method focused on developing an unbiased, metric-based process to produce a marking schedule that

accounted for hatchery and marking programs considerations related to scheduling. We used elements of a Structured Decision Making process to help us clearly identify marking considerations and think about how multiple considerations interact when developing an annual marking schedule (Hand 2020). Although the breadth of considerations and number of hatchery programs may prove too vast to produce an optimized schedule with our limited resources, we wanted to provide a process with clear justification and transparency to help alleviate potentially controversial issues and outline a process to resolve those issues. For our process, we assumed each hatchery program had to be marked and all programs had equal priority. We do not annually adjust (i.e., increase or decrease) the number of marking trailers or permanent staff available and, therefore, did not consider adjusting them in our scheduling process. The health and wellness of all staff is our primary priority and is always an overriding factor to consider when scheduling marking and tagging activities.

Considerations

Considerations are factors used to evaluate the feasibility of marking a hatchery program on specific dates and metrics are the variables used to address the considerations. We created a question for each of the five hatchery considerations (Table 1) to help determine optimal marking periods for every hatchery program (i.e., individual stock at a hatchery). While not mutually exclusive or listed in a prioritized order, we broke down the considerations and metrics used to develop a marking and tagging schedule and placed them into hatchery and marking program categories. Ideally, hatchery managers will be able to evaluate each consideration under the hatchery program category independently for every stock that needs to be marked at their hatchery. The marking coordinators will be able to address considerations under the marking program. We provided context for each consideration to justify its inclusion and describe the metric(s) used to address each consideration. The metrics for these considerations help facilitate and justify the scheduling process.

Table 1. Five mark scheduling questions that address hatchery program considerations with respective metric(s) to minimize during scheduling.

Question	Metric
1. When is the optimal release date?	• Number of days fish release is delayed.
2. When are the fish of preferred marking size?	• Amount of growth manipulation at the hatchery. • Number of fish outside of optimal marking size range.
3. When are preferred water temperatures for marking?	• Number of days marking outside of period with preferred temperatures.
4. When has disease been prevalent at the facility?	• Number of days marking during disease prevalence.
5. When do fish need to be split so they do not exceed carrying capacity?	• Amount of splitting before marking.

Hatchery program

Release timing

Hatcheries take into account how the physiological status of fish interact with historical outmigration timing and associated river conditions when determining the release timing of fish. Early or delayed releases can affect migration timing, out-migration survival, fish health, and, ultimately, adult recovery rates. Additionally, we considered smolting to be covered under this consideration because fish are generally released when they are smolts or before smolting. Marking fish during certain periods of the smoltification process is not recommended (A. Goodwin and coworkers, 2014 memorandum to J. Collins, U.S. Fish and Wildlife Service, on marking and tagging recommendations). The Service also strives to mark and tag all fish at least 30 days before release to treat potential fish health issues after marking while realizing it is not always possible (i.e., fall Chinook Salmon; Goodwin et al., memorandum). Ideally, fish would be allowed to recover from the stress of marking and tagging events for at least seven days before release. This recovery time also provides staff an opportunity to assess fish health before to release (R. Brunson, 2005 memorandum, U.S. Fish and Wildlife Service, on fish health guidelines for marking and tagging). The number of days that fish releases are delayed due to marking constraints should be minimized when developing a schedule.

Fish size

Marking of fish within an optimal size range increases efficiency, tag retention, and mark quality for both auto and manual trailers. Auto trailers are generally more efficient than manual trailers because they often mark more fish over a given period using fewer staff (Jesse Rivera, U.S. Fish and Wildlife Service, personal communication). Auto trailers operate best near the mean range of their operating parameters. Greater variation in the length distribution of the hatchery population can lead to an increase in the number of fish missorted by the system. These missorted fish (i.e., fish too big or too small; out-sized) are either not processed by the system and sit in the collection tray or receive poor marks and are rejected. Subsequently, these out-sized and rejected fish must be hand marked which can decrease process efficiency. Fish that are outside of the optimal size range are more difficult to mark or tag in manual trailers as well. Small fish are difficult to pick up, and larger fish are harder to anesthetize and efficiently handle while marking. Additionally, fish outside of the optimal size range typically do not fit properly in tagging machine head molds during manual tagging, leading to poor tag placement and lower tag retention rates. A median size head mold is used when manually tagging, so manual tagging does not handle variability in fish sizes as well as auto trailers.

Auto trailers run best when fish size is 190–50 fpp (~68–100 mm total length) and size variation is limited (<6.0% CV), but they can process fish from 250 fpp to 20 fpp (~58–142 mm total length). Manual tagging trailers can be used across a wider range of fish sizes because they are not limited by hardware, but operate better when fish are 190–50 fpp. To meet these size criteria, growth manipulation may occur within a hatchery program. However, growth manipulation that drastically alters the natural growth profile of fish may have adverse effects throughout their life history. Accelerating growth at specific times of year may increase precocity rates. High precocity rates may have negative effects on wild populations by increasing the number of non-migratory precocious parr and mini jacks, thus reducing the number of out-

migrating juvenile hatchery fish. These population alterations can lead to skewed sex ratios with more hatchery males contributing to natural spawning and fewer hatchery adult returns. Therefore, marking and tagging should be scheduled to a) minimize the number of fish outside of the target size range, and b) minimize the amount of growth manipulation required at the hatchery to achieve target fish size.

Water temperature

Salmonids are cold-water poikilotherms, making water temperature an important consideration when scheduling marking activities. Considerations during marking related to water temperature include fish physiological thermal tolerances, disease susceptibility, species and age, and smoltification / migration timing, among other potential factors (Appendix A. Water temperature considerations). By assessing these factors, we can determine the preferred water temperature range to mark individual fish stocks at a particular facility that will minimize fish health risks (Table A.1; Table A.2). Then, we can minimize the number of days marking activities occur outside the periods of preferred temperature at individual facilities by reviewing predicted and historic water temperature regimes. Although we primarily focused on water temperature for scheduling purposes, there may be additional water quality issues to consider at individual facilities, such as turbidity or temperature of receiving water if different then rearing temperature.

Disease history

Ideally, marking would not occur when fish are diseased. Marking fish when disease is present in the population can lead to further health risks. Marking and tagging activities are stressful on fish, making them more susceptible to disease. Fish that already have diseases may successfully recover, but any disease issues may be exacerbated by the added stress from marking and tagging. Marking when disease is present may also exacerbate disease spreading through actions such as crowding. It is important to identify disease history at a facility so marking and tagging activities can be scheduled during periods when the probability of disease presence is minimized.

Carrying capacity

Individual hatcheries have recommended rearing capacities for different stocks of fish that target optimal conditions. When outside the range of recommended capacity, fish health and behavior may be affected. At certain densities, water chemistry and oxygen levels may become suboptimal for growth and create stressful or even lethal conditions. Fish density can also influence feeding efficiency, disease transmission, and fin condition. A number of variables and indices are used to quantify capacity at each hatchery that should not be exceeded. One way to address capacity issues is by splitting fish into different rearing vessels to decreasing rearing density. Marking trailers may be used to split fish into separate rearing vessels before carrying capacity is exceeded. Splitting fish into their final rearing vessels during marking reduces stress on the fish by reducing the total amount of handling (i.e., handling fish separately during splitting and marking as opposed to marking and splitting at the same time) and increases hatchery and marking operational efficiency (e.g., moving more fish-carrying pipe and crowding more raceways). Although, program specific indexes may allow for higher densities, general

guidelines for carrying capacity are to not exceed a density index of 0.2 and a flow index of 1.0 (Brunson, memorandum). Density and flow indices can be projected for a given hatchery program based on historic hatchery data and hatchery manager knowledge. Given this information, the probability of being outside the preferred carrying capacity range should be minimized when scheduling marking and tagging activities.

Marking program

Marking programs need to balance efficiency and effectiveness to achieve program objectives while limiting the strain on marking and hatchery staff. Increased efficiency leads to a reduction in the time it takes to complete marking activities and resources required to complete those activities. The metrics we sought to minimize for an efficient marking program included a) the number and distance of trailer moves; b) the number of temporary staff; c) the use of manual marking trailers; d) the amount of overtime and compensatory time; and e) the number of double shifts.

Excessive trailer moves between facilities reduces efficiency by increasing cost and reducing the amount of time trailers are available because they are in transit. Excessive moves may also increase the risk of disease transfer between facilities and the logistical complexity related to transportation. Generally, minimizing the distance and number of trailer moves increases marking program efficiency. However, moving trailers between facilities repeatedly may be desirable if it minimizes the incidence of idle trailers that could improve marking efficiency elsewhere.

Efficiency of the program may decrease while strain on the program increases when more temporary staff are required. Experienced staff attain better tag retention rates and fin clip quality at a faster rate compared to new markers (Hand et al. 2010), but they are increasingly harder to find. Moreover, retaining manual markers is difficult because of the stationary and repetitive nature of the work over extended periods. Reducing the number of temporary staff also reduces the amount of time trailer operators spend training new markers, thus contributing to a more efficient operation. Generally, one primary operator and two manual markers staff an auto trailer. Although, an auto trailer may be operated with a minimum of two staff (i.e., the primary operator and one experienced manual marker). Manual trailers require between 6 and 12 manual markers per trailer. The limited number of staff required to operate an auto trailer is another reason for its preferred use. For these reasons, the program generally seeks to minimize the number of temporary staff hired and undesired use of the manual trailers. We recognize that, in some instances, hiring of temporary staff could provide benefits not considered above, such as working with co-managers to provide employment opportunities and strengthen partnerships. In these situations, the benefits of hiring temporary staff may outweigh the costs of potential decreased mark and tag quality and efficiency.

Marking program staff often work long hours for large portions of the year. Because of this, significant amounts of overtime or compensatory time are incurred, leading to staff burnout and decreased program efficiency. During the busiest part of the marking schedule, trailer operators are often required to work in excess of a normal, 40-hour week. Workdays regularly exceed nine hours because trailer operators must arrive early to prepare marking trailers before

the arrival of temporary markers and stay later to clean up and shutdown trailers. Fatigue can become an issue when working extended hours and weekends to complete projects and potentially affect mark quality and employee safety. To alleviate these issues when scheduling marking activities, the program tries to minimize the number of overtime/comp hours worked per person per pay period.

Trailer operators spend several weeks of the summer on travel status to complete marking projects at hatcheries they cannot commute to on a daily basis. Many of the projects require staff to be in travel status for two full weeks including the weekend, and their personal and family lives may suffer. Employees usually prefer to minimize their overnight travel when possible. When preferred by employees, the program tries to minimize the amount of time an individual is on travel status.

Double shifts are sometimes used to accommodate limited marking timeframes but may reduce program efficiency by increasing staff fatigue and turnover. Double shifting requires all marking staff to work outside of normal business hours, including starting before dawn and working late into the night. Working during these times may strain an employee's personal life and general health. Increased fatigue can lead to increased safety risks for staff and more mishaps at the hatchery that could potentially affect fish health. Low light and dark conditions can increase the risk of tripping, falling, and other hazards. Potential accidents may not be noticed immediately due to limited visibility and the limited staff working. Moreover, no hatchery staff are on duty in the early morning or night to help if any issues were to arise. For these reasons, the program tries to minimize the amount of double shifts.

Schedule development process

The annual mark scheduling process begins by determining what resources are available to complete marking activities, defining the optimal period for marking individual hatchery programs, and determining how long it would take to efficiently mark each hatchery program. In Region 9, we have four auto trailers stored at Spring Creek NFH that are primarily scheduled by Columbia River Fish and Wildlife Conservation Office (CRFWCO) staff, and one auto trailer stored at Quilcene NFH that is primarily scheduled out by Western Washington Fish and Wildlife Conservation Office (WWFWCO) staff. There are three additional manual marking trailers operated by CRFWCO staff and one operated by WWFCO staff. Six trailer operators are staffed within CRFWCO and two within WWFWCO. Annually, various contracts and agreements are executed by each office to hire the required number of temporary manual marking staff based on scheduling needs.

The five time-periods generated by five hatchery program consideration questions (one from each of the question; Table 1) will be used to determine the optimal marking period. For each hatchery program, this period will be prior to fish release, before carrying capacity issues, when fish size is optimal, when water temperatures are preferred, and when disease prevalence is low. An example of the Dworshak NFH spring Chinook Salmon program demonstrates how all five of the hatchery program considerations help to identify an optimal marking period between mid-August and mid-September (Figure 1). The marking program will determine the duration it takes to efficiently mark an individual hatchery program under preferred conditions and detail

the proposed resources required to mark fish based on defined metrics (Table 2). Once the preferred marking period and duration to complete marking for all hatchery programs are defined, we can schedule programs for marking based on the availability of marking resources (marking considerations). We realize the optimal marking period may not be achievable for every program because of overlapping optimal periods among hatcheries and limited resources. The specific metrics under each consideration will be used to guide draft marking schedule development by considering the interactions between all hatchery programs and marking programs together to determine the best available options.

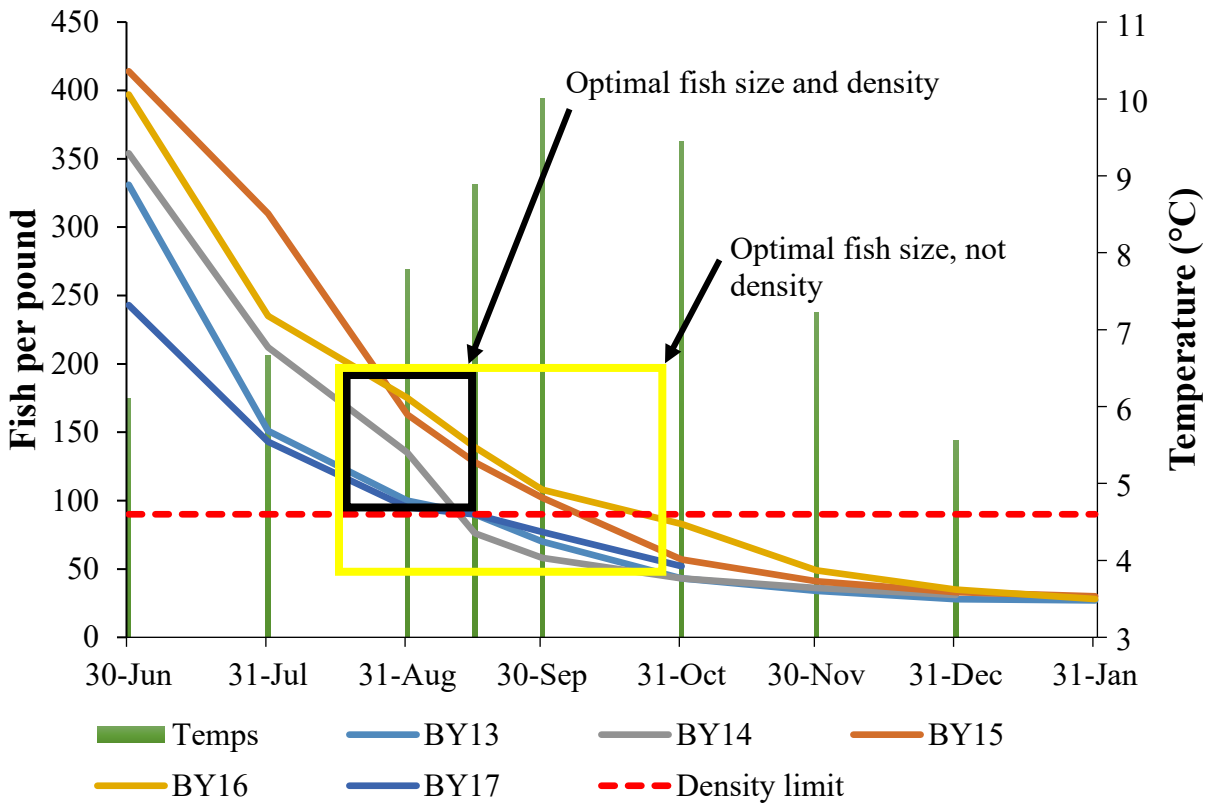

Figure 1. The use of historic growth curves, water temperature, and carrying capacity to identify an optimal marking period for spring Chinook Salmon at Dworshak NFH. In this case, the marking period is affected by fish size (~190–50 fish per pound) and hatchery carrying capacity considerations. Water temperature does not appear to be a restricting consideration (always below 13°C). Without the data, we will assume the disease history consideration is not restricting. Release timing is scheduled to occur the following spring and is not a restricting consideration. The yellow box outlines the period when fish size is optimal and does not consider hatchery carrying capacity. Based on the number of fish initially ponded into raceways and density indices at Dworshak NFH, fish need split into more raceways when they reach 90 fish per pound or they will exceed carrying capacity. The black box outlines the period when fish size and hatchery carrying capacity are optimal. In this example, hatchery considerations would target marking to occur between mid-August and mid-September. Data provided by Dworshak NFH.

Table 2. List of metrics to minimize when the marking program is considering how long it will take to efficiently mark a hatchery program.

Metrics
• Number and distance of trailer moves.
• Number of temporary staff hired.
• Use of the manual trailer.
• Amount of overtime, compensatory time, and weekends worked.
• Amount of time on travel status.
• Number of double shifts.

Using these considerations and metrics, we can plan a marking schedule on an annual basis. Changes to a hatchery program that could affect the marking schedule should be provided to the marking program coordinator annually by the end of December, or as soon as changes are identified. After the marking program coordinator identifies the optimal marking period for each hatchery program in coordination with hatchery managers, the coordinator will work through marking program considerations to provide a draft marking schedule for review annually by the end of January. Scheduling marking activities outside of initially identified optimal periods for hatchery programs will be justified using a combination of one or more of the metrics listed under the considerations. Comments on the draft schedule should be received by the end of the second week of February to allow time to make schedule adjustments. If adjustments to accommodate the hatchery program and marking program cannot be identified between marking coordinators and hatchery managers, justification based on the metrics for each consideration will be documented and elevated through the chain of command for prioritization.

In-season changes to the marking schedule are more difficult to make due to the various considerations that went into making the initial schedule to minimize the identified metrics, the complexity of consideration interactions between programs, and the shorter timeframe to make the changes. However, the same process will be used to make any in-season changes to the schedule. Changes to the schedule during the marking season are inevitable and often affect one or more metrics. To decide on in-season changes, we will use the same review process hatchery managers and marking program coordinators used to develop the pre-season marking schedule.

Conclusion

Our process may not necessarily provide an optimized schedule due to the complexity of the considerations and hatchery programs, but it does provide a transparent, metric-based process that could be further refined using other techniques to prioritize metrics and/or develop an automated optimization software tool. In 2018, a survey was sent out to hatchery managers seeking information on optimal, earliest, and latest start times (Appendix B. 2018 marking period survey). The process used by individual hatchery managers to define the start times may have differed, but many of the same considerations we outlined were likely used. Using our process will allow for a more standardized, transparent, and complete understanding of how to determine marking times for a hatchery program. It would be desirable for hatchery managers to complete the process for all their hatchery programs the first year this process is used and make any necessary changes annually as noted in the outlined process.

Optimizing the process could involve producing a value function for each hatchery program and weighting individual hatchery and marking program metrics. Value functions for hatchery programs may include prioritizing individual programs at the regional level based on harvest, conservation, and scientific value. Prioritization of considerations and metrics, and tradeoffs between scheduling alternatives is not a straightforward task. Weighting these considerations is one means of prioritization. Hatchery managers and the marking committee could use methods like swing-based weighting to weight (i.e., prioritize) individual programs, considerations, and metrics.

Finally, while we did not account for all possible considerations, additional considerations could be adapted to fit within the general considerations listed above or added separately in the future. For example, hatcheries may have construction projects one year that further limit the period marking could occur; construction projects generally limit the carrying capacity at the hatchery and would fit under that consideration.

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Appendix A. Water temperature considerations

The objective of this appendix is to recognize water temperature considerations that may influence and inform the marking and tagging scheduling process, not to conduct a comprehensive review of the vast amount of research related to salmonids and water temperature issues (e.g., WDOE 2002, USEPA 2003). When scheduling the marking and tagging of salmonids, several factors influencing fish health, including temperature, need to be recognized. Water temperature plays a major role in fish health because fish are poikilotherms with different physiological thermal tolerances. Water temperature also affects disease susceptibility and smoltification / migration timing. All of these factors may vary by species and age. Generally, physiological thermal tolerances are not as restrictive as temperature issues related to disease susceptibility, so they will not be discussed in detail. Moreover, the best method of disease control is through prevention by reducing risk factors such as handling stress during periods when water temperature is a concern.

McCullought et al. (2001) referenced several studies that stated fish near their preferred temperatures are generally more resistant to disease. A brief review of juvenile steelhead (anadromous form of Rainbow Trout *Oncorhynchus mykiss*), Coho Salmon *O. kisutch*, and Chinook Salmon *O. tshawytscha* temperature preferences was conducted because these are the primary species and age of salmonids marked and tagged in the Pacific Northwest (Table A.1).

Table A.1. Juvenile salmonid temperature preference summary by species.

Species	Juvenile rearing temperature preference
Rainbow Trout (steelhead)	Prefer 12.2–18.9°C with optimal at 13.9°C[1]; prefer 10.0–16.7°C[2]
Chinook Salmon	Prefer 12–13°C[3]; > 19°C leads to reduced feeding and growth, as well as increased problems with disease[4]; maximum growth from 15 to 19°C[5,6,7,8]; 14.4°C optimal for general growth and survival[9]
Coho Salmon	Prefer 6–16°C in cooler stable streams and 7–21°C in warmer streams with more variable temperatures[10]; maximum growth at 17°C[11], 16.6°C[12]

[1]Bell 1986, [2]Piper et al. 1982, [3]Brett 1952, [4]WDOE 2002, [5]Banks et al. 1971, [6]Brett et al. 1982, [7]Hillman 1991, [8]Cech and Myrick 1999, [9]Seymour 1956, [10]Konecki et al. 1995, [11]Shelbourn 1980 as cited in WDOE 2002, [12]Lusardi et al. 2019

Disease prevalence can vary by water temperature and season, and some fish species and ages are more susceptible. A brief review of common salmonid diseases was conducted to provide a general understanding of how disease prevalence can change based on these factors (Table A.2). Because disease history and species vary among marking programs, temperature considerations may vary as well. As general guidelines for marking and tagging of salmonids and health monitoring, we suggest using the upper temperature threshold for the three levels of juvenile rearing disease risk that were recognized by the U.S. Environmental Protection Agency (USEPA 2003). Specifically, targeting temperatures below 13°C to minimize risk with no additional health oversight, marking up to 17°C with additional health oversight, and marking at temperatures up to 20°C only under strict health monitoring. Although not often possible, it

Table A.2. Salmonid disease susceptibility related to temperature, season, and species and age summary.

Disease	Temperature considerations	Season	Species and age
Motile aeromonad septicemia (MAS)	More common at temperatures >10°C during[1]	Often in spring and early summer[1]	-
Furunculosis	Prevalence increases as temperature increases in the spring but can occur at temperatures as low as 6°C[2]	Most often in the spring[2]	Salmonids of all ages are susceptible, Rainbow Trout most resistant[1]
Columnaris	Prevalence increases above 15°C[3,4]	Increases from May to October[3,4]	-
Cold-water disease (CWD)	Most severe at 15°C but mortality decreases above 15°C, occurs at temperatures down to 4°C[5]	Increases in spring[1]	-
Vibrosis	Most severe from 15 to 21°C[2]	Spring and summer[2]	-
Infectious hematopoietic necrosis (IHN)	Most severe at 10°C, generally not above 15°C[1]	-	-
Viral hemorrhagic septicemia (VHS)	Most severe from 8 to 10°C, breakouts occur from 3 to 12°C, generally not prevalent above 15°C[1]	-	Salmonids of all ages, juveniles more susceptible[6]
Infectious pancreatic necrosis (IPN)	Most severe from 10 to 14°C	-	Salmonids of all ages, fish less than six month more susceptible[6,7]
Ichthyophthiriasis (Ich)	Most severe from 18.3 to 21.2°C[8], breakouts often above 15.6°C[9]	-	More common in salmon fingerlings, mainly Chinook Salmon[9]
Ceratomyxosis	*C. shasta* appears to become infective at temperatures around 10–11°C[8], infections and mortality rate increase with temperature[10]	-	Species severity dependent, juvenile Coho Salmon mortality increases with temperature, Rainbow Trout have larger temperature mortality range[10]

[1]Lim and Webster 2001, [2]Evelyn et al. 1998, [3]Austin and Austin 1993, [4]Wakabayashi 1993, [5]Holt et al. 1993, [6]Wolf 1988, [7]Traxler et al. 1998, [8]CDWR 1988, [9]Bell 1986, [10]Udey et al. 1975

would also be ideal to maintain 7–10 days near thermal homeostasis to mitigate stress prior to marking and tagging activities and reduce risk of opportunistic diseases.

Temperature issues related to release timing and smoltification may also influence the marking and tagging schedule. If fish are going to smolt and be released soon after tagging, there should be time for the fish to recover for a week prior to release while still being released when temperatures are below 11–13°C. During the smolification process, ATPase levels may be reduced if temperatures exceed 11–13°C which may inhibit their migration to saltwater (McCullough et al. 2001). The effects of decreased ATPase activity has also been linked to increased predation probability (Kennedy et al. 2007).

If marking is required in water temperatures that are not optimal, stress on fish can still be reduced by limiting the amount of handling and closely monitoring anesthesia. One example is the reduced handling required by using an auto trailer compared to manual marking the fish. Some fish will be sedated regardless of the trailer type used (e.g., outsized fish in an auto trailer), and proper anesthesia can reduce stress of handling even though immune function may be decreased for several days following an anesthetic event. Another example is limiting the number of times fish that are moved or crowded. Timing of activities may also be adjusted to avoid handling during warmer periods of the day.

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Appendix B. 2018 marking period survey

Table B. 1. Results from a 2018 survey of hatchery managers defining optimal, earliest, and latest start dates for marking (adipose fin clipping) and coded-wire tagging by hatchery and species (spring Chinook Salmon [SCS], summer steelhead [SST], Coho Salmon [COS], fall Chinook Salmon [FCS], and winter steelhead [WST]).

Hatchery	Species	Optimal	Earliest	Latest
Carson	SCS	1-May	22-Apr	22-May
Dworshak	SCS	2-Sep	25-Aug	21-Sep
Dworshak	SST	15-May	15-May	20-Jul
Eagle Creek	COS	21-Jun	1-Jun	14-Jul
Leavenworth	SCS	15-Jun	7-Jun	22-Jun
Entiat	SCS	1-Aug	21-Jul	8-Aug
Winthrop	SST	21-May	21-May	21-May
Winthrop	SCS	1-Jul	21-Jun	8-Jul
Winthrop	COS	1-Aug	21-Jul	8-Aug
Little White Salmon	SCS	15-Mar	22-Feb	1-Apr
Little White Salmon	FCS	15-Apr	1-Apr	1-May
Makah	FCS	15-Apr	15-Mar	1-May
Makah (Cook)	WST	22-May	22-May	1-Nov
Makah (Tsoo-Yess)	WST	1-Oct	1-Oct	1-Nov
Makah	COS	1-Apr	1-Apr	1-Apr
Quilcene	COS	21-May	15-May	15-Jun
Quinault	COS	1-Jun	1-May	1-Jun
Quinault	WST	10-Jun	15-May	1-Jul
Warm Springs	SCS	1-May	15-Apr	1-Jun
Willard	FCS	15-Jun	1-Jun	1-Jul
Willard	COS	Flexible	1-Jun	31-Oct