Maine Atlantic Salmon Stock Enhancement Plan
Downeast Coastal Rivers SHRU

Near-Term Stocking Strategies
and
5-year Stocking Plan (2021-2025)

Downeast SHRU Coordinating Committee

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Introduction

The central aim of recovery of the Gulf of Maine Distinct Population Segment (GoM DPS) of Atlantic Salmon is for the population to have a low risk of extinction in the foreseeable future due to threats from either environmental and demographic variation or changes in genetic diversity (USFWS and NMFS 2018). In line with this aim, this plan generally follows a river-specific approach for stock enhancement. In the future, exceptions may be made for rivers either known to have extirpated populations or where populations are too small to be considered viable.

The goals of the Maine Atlantic Salmon stock enhancement program are:

- to maintain populations of juveniles in productive historic rearing habitat,
- to maximize freshwater production of naturally-reared smolts,
- and to maximize the distribution and abundance of adult Atlantic Salmon returns.

The Downeast Coastal Rivers Salmon Habitat Recovery Unit (DESHRU) Stock Enhancement Plan has been developed by Maine Department of Marine Resources (MDMR)[1] scientists in consultation with DESHRU Coordinating Committee members. All stocking recommendations will be presented to the Implementation Team (IT) under the Cooperative Management Strategy (CMS) for review prior to any actions. The objectives of the DESHRU Stock Enhancement Plan Include:

- ensuring quality rearing habitat is utilized by the appropriate river-specific stock and lifestage; and
- spatially and/or temporally segregating enhancement strategies to evaluate the effectiveness of recovery actions to supplement wild salmon populations.

Hatchery production for GoM DPS populations is undertaken at facilities operated by the U.S. Fish and Wildlife Service (USFWS): Craig Brook National Fish Hatchery (CBNFH), Green Lake National Fish Hatchery (GLNFH) and Nashua National Fish Hatchery (NNFH). CBNFH rears broodstock for five populations within the DESHRU (Dennys, East Machias, Machias, Narraguagus and Pleasant); eyed eggs used to supplement populations in the DESHRU are produced solely from broodstock at CBNFH. At this time both GLNFH and NNFH are primarily focused on rearing age 1+ smolts of sea-run Penobscot River origin for release in the Penobscot and Merrymeeting Bay SHRUs.

Two facilities operated by the Downeast Salmon Federation (DSF), the Peter Gray Hatchery (PGH) and the Wild Salmon Resource Center (WSRC), receive eyed eggs of East Machias and Pleasant origin from CBNFH to produce advanced lifestages for the DESHRU (Table 1).

[1] MDMR is the lead state agency in the restoration and management of diadromous fish species and as directed by the Commissioner retains sole authority to introduce Atlantic Salmon into the inland waters of the State (Maine Title 12: §6022).

Stock enhancement objectives for the DESHRU are limited by the bounds of existing production capacity within these facilities. Historical releases of river-specific smolts into the DESHRU have been sporadic and typically averaged 57,000 per river over the past 20 years, except the Narragaugus which received an average of 98,000 from 2016 – 2019. The Coordinating Committee recognizes that stock enhancement strategies that either include, or focus on, the use of age-1 smolts are generally accepted as being the most successful in increasing adult abundance and spawning escapement; however the Coordinating Committee also recognizes the resources required to produce sufficient smolts for one or two rivers within the DESHRU are not available at this time. Resources are also unlikely to become available within the next five years without considerable negotiation on shifting current smolt-rearing priorities away from the Penobscot River.

Using the resources currently available for producing enhancement products for release in the DESHRU, the Coordinating Committee recommend a shift in the current stocking strategy, that focuses almost solely on unfed fry, to one that will pair freshwater lifestages with appropriate width-class stream habitat. After relying almost solely on fry for stock enhancement since the early 1990s it is apparent that although unfed fry will continue to provide a means to prevent extinction near term they *will not produce robust smolt populations necessary to move toward recovery goals*. Over the next five years, greater emphasis will be placed on the use of age 0+ parr in larger width-class habitat in order to increase numbers of semi- naturally-reared smolts emigrating annually. Unfed fry will continue to be a significant component of the enhancement strategy as it has proven successful in maintaining the genetic viability of DESHRU populations.

Egg planting, a previously employed strategy to encourage early in-river experience/selection and ease logistical constraints for planting unfed fry, will only be used if egg availability is sufficient to supplement all vacant physical rearing habitat in a drainage with unfed fry and 0+ parr, when the highest quality rearing habitat does not receive natural spawning, and/or where spawning has occurred below CSE to maximize use of the spawning habitat.

Stock enhancement actions are conducted by MDMR in cooperation with USFWS, and DESHRU stakeholders. MDMR directs Atlantic Salmon population monitoring activities throughout the DESHRU. As a component of the MDMR-NOAA Cooperative Agreement (MDMR and NOAA 2016), MDMR operates a Life Cycle Monitoring Station (LCMS) on the Narraguagus River to evaluate trends in juvenile abundance, smolt production, adult returns, spawning escapement and distribution, and smolt-to-adult return rates (SARs) (See 'Evaluation of Stock Enhancement Recovery Actions'). Continued operation of the Narraguagus LCMS serves as an index of relative success of recovery actions in similarly managed watersheds across the DESHRU. Additionally, the DSF partners with MDMR and NOAA to operate a LCMS on the East Machias River. Objective data provided by both LCMSs guide this stock enhancement plan and recommendations of the DESHRU Coordinating Committee in consultation with stakeholders.

Hatchery Rearing Capacity, Methods and Anticipated Annual Production

CBNFH annually collects approximately 1,100 age 1+ or 2+ parr from DESHRU populations (plus an additional $\pm$ 200 for the Merrymeeting Bay SHRU) for use as future broodstock; three year-classes of breeders are used to produce eyed eggs and unfed fry. The number of parr collected may vary per population in the future based on genetic measures, however a maximum limit of 1,300 age 1+ or 2+ parr will be maintained (D. Buckley, personal communication). Current broodstock levels (annual collection of $\pm$ 200 age 1+ or 2+ parr per DESHRU population) are sufficient to prevent extinction, maximize juvenile production in high quality rearing habitat and ensure adequate numbers of large parr can be recaptured for use as future broodstock.

Egg availability may fluctuate given annual parr broodstock collections, maturation rates, fecundity, and egg survival; however, it is estimated annual eyed egg production will average 1.440M (Table 1).

All lifestages released will represent the maximum available genetic diversity from the originating broodstock. The estimated annual production for each lifestage *is not additive*; for example, the 1.230M unfed fry that can be produced at CBNFH *is not additive* to the 1.440M eyed eggs. The estimated 1.440M eyed eggs are the starting point for all older lifestages except gravid and post-spawn adults.

Table 1. Rearing facility, history, release timing and estimated annual production for each lifestage of Atlantic Salmon available for release in Gulf of Maine Distinct Population Segment rivers. Facilities abbreviations: CBNFH – Craig Brook National Fish Hatchery, GLNFH – Green Lake National Fish Hatchery, MDMR – Maine Department of Marine Resources, NNFH – Nashua National Fish Hatchery, PGH – Peter Gray Hatchery, WSRC – Wild Salmon Resource Center.

Lifestage	Facility	Rearing History	Release Timing	Estimated Annual Production
Eyed Egg	• CBNFH	Produced from up to 120 females per population. Eyed eggs are at least 35% developed; timing of development is dependent on water temperatures during spawning and incubation. Eggs can be transferred or planted until 42% development.	January – March	• CBNFH: 1.440M
Unfed Fry	• CBNFH • PGH • WSRC	Reared from the eyed egg stage through hatch and swim-up entirely in the incubation rearing units. No food will be introduced. Unfed fry will be released between 85% and 100% development.	Late April - May	• CBNFH: *up to* 1.230M • WSRC: *up to* 100K
Fed Fry	• CBNFH • PGH • WSRC	Unfed fry will be introduced to feed at 80% developed; optimal feeding temperature is above 10°C. Fed fry will be released between 100% and 140% development.	Late April – Early June	• WSRC: *up to* 100K
Age 0+ Parr	• GLNFH • PGH • WSRC	GLNFH accelerated age 0+ are reared as part of the age-1 smolt program; they are typically larger than wild parr at the time of release. Production of ambient parr at GLNFH is under investigation. PGH age 0+ parr are reared using techniques developed in the UK and exposed to ambient river conditions during incubation and early life history. PGH parr are comparable in size to wild parr at the time of release.	September - November	• GLNFH accelerated: *up to* 250K • GLNFH ambient: unknown • PGH: *up to* 800K • WSRC: unknown
Large Parr	• CBNFH	Various juvenile or sub-adults raised from captive age 1 parr as future broodstock.	As needed	• Variable
Age 1 Smolt	• GLNFH • NNFH	GLNFH smolts are reared from eyed eggs originating from CBNFH. Eyed eggs are treated with heated water during the early months of incubation to advance development. At approximately 10 months up to 250K parr are graded out of the future smolt population (see GLNFH accelerated age 0+ above) and released or transferred. The remaining salmon are reared for an additional 7 months prior to release. NNFH rears up to 100K graded out parr from GLNFH to the smolt stage for release in the GoM DPS	April	• GLNFH: *up to* 650K • NNFH: *up to* 100K
Gravid Adults	• CBNFH	May be released as a recovery action or to manage biomass. Primarily comprised of previously spawned adults, typically age 4 or 5. Equal sex ratios are released when feasible	Late September – mid October	• CBNFH: variable • MDMR: 900+
	• MDMR	Future project entailing the release of gravid adults from nearshore conservation net-pens as a recovery action to increase abundance of natural spawners		
Post-spawn adults	• CBNFH • GLNFH	Spent broodstock released post-spawning; releases may include small numbers of immature or barren adults	Late November – Early December	• variable

Lifestage Descriptions, Release Methods, Historical Use, and Relative Merits

The decision to use one or more lifestages to supplement wild Atlantic Salmon populations has advantages and disadvantages relative to achieving the objectives of the DESHRU stock enhancement plan. The following describes rearing practices, stocking densities, and summarizes performance metrics for each lifestage utilized in the DESHRU.

Eyed-eggs

Objective: Populate high quality rearing habitat to produce juvenile populations with early in-river experience that is synchronized with natural emergence timing. A secondary objective is populating habitat reaches that have limited accessiblity during the spring fry release period.

Release method: Eyed-eggs are planted in sub-drainages of the DESHRU where natural spawning occurs but remains below conservation spawning escapement (CSE). Eyed-eggs are planted in naturalistic artificial redds produced by boring a cone into spawning habitat using a water pump. Eggs are deposited through the cone into the gravel at a minimum of 2.4 eggs/m^2; equivalent to minimum deposition by wild spawning to achieve CSE. Artificial redds are segregated from naturally-produced redds (See 'Buffering Natural Reproduction').

Historical use: The eyed-egg lifestage has been widely used in the Merrymeeting Bay SHRU over the last decade, serving as the primary stock enhancement strategy for the Kennebec River and Sheepscot River drainages. Recently, eyed eggs have been planted in select reaches within the Narraguagus, Pleasant, Machias, and Dennys rivers in the DESHRU.

Relative merits and use in future enhancement: Juvenile population assessments indicate eyed-egg planting produces a wide range of abundance of age 0+ and large parr. However, smolt production from stocking of eyed eggs [MMBSHRU, Sheepscot River] has underperformed compared to stocking of unfed fry (Bruchs 2020). Smolt production resulting from eyed egg planting averaged 0.36 smolts/unit (2015 – 2019; mean 800) versus an average 0.61 smolts/unit (2009 – 2014; mean 1,365) produced from the release of unfed fry (Table 2).

The DESHRU Coordinating Committee does not recommend eyed-egg stocking when egg resources are limited as it takes approximately 2.5 and 3.5 times the number of eyed eggs to supplement one unit of rearing habitat when compared to unfed fry and has not shown appreciable results in achieving the goals and objectives of increase both smolt production and an increase in adult returns.

Unfed Fry

Objective: Populate high quality rearing habitat to produce juvenile populations with early in-river experience and reduced rearing in the hatchery. The release of unfed fry, at densities (≤100/unit) established in Maine and New England studies (Mackey and Spencer 2005; Orciari et al. 1994; Rietveld et al. 1971; Trasko 1992; Whalen and LaBarr 1994, USASAC 1992) aims to maximize growth and survival of parr as well as maximize production of high quality smolts.

Stocking unfed fry is currently the primary lifestage used to populate vacant rearing habitat in the DESHRU.

Release method: Hatchery-reared unfed fry are released via point stocking at density of 100 fry per unit of high-quality rearing habitat. Hatchery-reared unfed fry are released in a manner that maintains segregation from naturally produced fry emerging from known redds (See 'Buffering Natural Reproduction').

Historical use: Unfed fry have been the primary stock enhancement strategy since the early to mid-1990s. This strategy was based on recommendations of the Maine Atlantic Salmon Technical Advisory Committee (TAC) which expressed concerns regarding effects of domestication selection and hatchery rearing on smolts, the primary lifestage released in Maine waters through the 1970s and 1980s (Moring et al. 1995; Fay et al. 2006).

Relative merits and use in future enhancement: Stocking efforts using unfed fry have consistently produced abundant populations of large parr in high quality habitat to maintain the genetic diversity of the parent stocks. Smolt production from unfed fry stocking observed in the Narraguagus River averaged 0.22 smolts/unit (2010-2019; Table 2); while this production rate is low compared to estimates based on age 0+ parr releases (discussed below) the early in-river experience may lead to increased fitness and resiliency. However, given the extreme low survival of unfed fry, low numbers of resultant smolts, and poor marine survival a stock enhancement strategy that relies solely on fry should not be considered practical for achieving recovery goals.

Fed Fry

Objective: Populate high quality rearing habitat with more advanced juveniles that may survive at a higher rate (than eyed eggs and unfed fry) and produce juvenile populations with early in-river experience.

Release method: see Unfed Fry above

Historical use: The WSRC has produced fed fry as part of stock enhancement activities in the Pleasant River.

Warm water temperatures at CBNFH, either during spawning or incubation, may cause fry to develop well in advance of their desired release timing at the unfed stage. CBNFH does not have the ability to feed large numbers of fry due to temperature and infrastructure limitations; therefore, fed fry are not targeted for production.

Relative merits and use in future enhancement: Evaluation of the relative performance of this enhancement strategy within the GoM DPS is limited to date. Analysis in the East Machias and Pleasant rivers indicates fed fry stocking produces similar large parr abundance when compared to unfed fry stocking across a range of stream width class and habitat quality (Bruchs 2020;

MDMR, unpublished). The release of significant numbers of fed fry is not a priority objective for stock enhancement.

Age 0+ Parr

Within the age 0+ parr lifestage there are several distinct hatchery rearing strategies: temperature [water] accelerated parr raised at GLNFH; ambient temperature [water] parr raised at CBNFH and GLNFH; and unfiltered ambient temperature [water] parr raised at the PGH.

Accelerated 0+ parr are a byproduct of GLNFH's age-1 smolt program, which entails exposure to heated water for a portion of their life history to accelerate growth. This process produces parr that are larger than those produced either from natural reproduction, from fry releases or ambient rearing conditions. Smaller parr (approximately 110mm) are removed from the population of larger parr (>150mm) during the grading process each fall to optimize densities and promote better growth for future smolts.

Ambient parr from CBNFH are reared using untreated (neither heated nor chilled) water and range in size from 122mm to 136mm fork length at time of release. Small numbers of river-specific ambient parr (<20K) have been produced at CBNFH.

Ambient parr produced at the PGH are reared following techniques developed in the United Kingdom which relies on untreated river water; the river water is neither heated nor chilled to expose the salmon reared at the facility to diel and seasonal temperature cycles. PGH parr range in size from 80mm to 108mm fork length at time of release.

Age 0+ parr emigrate as smolts at three age classes: age-1 or p8 (emigrating 8 months after emigrant), age-2 or p20 (20 months after release), and age-3 or p32 (32 months after release). Scale analysis from Narraguagus River adult returns indicates that older age classes (p20 and p32) return at higher rates than younger age classes (p8) (USASAC 2020).

Objective: Populate habitat where unfed or fed fry stocking has not produced age 1+ parr densities at numbers comparable to natural reproduction and/or there are significant populations of competitive non-native fish (primarily young-of-the-year Smallmouth Bass).

Release method: Age 0+ parr are stocked into vacant habitat in September and October. Einum and Fleming (2001) and Symons and Heland (1977) both suggest that parr stocking densities be kept near the natural carrying capacity of the habitat. Recommended parr stocking densities range from 17/unit (Allen 1969) to 40/unit (Elson 1975). Recent evaluations of Maine data demonstrate higher age 0+ parr densities at a site result in higher age 1+ parr densities the following year (Mackey and Spencer 2005, DSF 2020). As a result of these analyses, stocking densities in Maine rivers have ranged from 10 to 120 age 0+ parr per unit.

Historical use:

GLNFH accelerated age 0+ parr: Smolt production data from the release of accelerated parr is limited to two cohorts on the Narraguagus River; one each in 2017 and 2018. Stocking densities

were within established limits (see 'Release method' above). Accelerated 0+ parr produced an estimated emigrating population of 1,783 ± 203 hatchery origin smolts in spring 2019 (1.46 smolt/unit; Table 2). Smolts emigrating in 2019 were predominately (79.7%) age-1 (p8); stocked in fall 2018. An additional 20.3% of the emigrating hatchery origin smolt population was comprised of age-2 (p20) smolts resulting from stocking in fall 2017.

CBNFH ambient age 0+ parr: CBNFH previously produced low numbers (12K to 17K) of ambient 0+ parr for release in the Sheepscot (2006-2020) and Narraguagus (2007 and 2008) rivers. Stocking densities were within the recommended range established in literature referenced above. Ambient parr produced at CBNFH predominantly emigrate at age p8 (mean 62.3%; 2005-2019). Smolt production rates from the strategy averaged 1.54 and 1.21 smolt/unit on the Sheepscot and Narraguagus River, respectively (Table 2).

PGH ambient age 0+ parr: The PGH, in collaboration with MDMR and USFWS, has released ambient age 0+ parr as the primary stock enhancement strategy in the East Machias River drainage since 2012. PGH parr are released at increased densities, 45-120 parr per unit of habitat versus the previously stated recommendations of 17-40 parr per unit, as part of an experimental program to determine a smolt recruitment curve to optimize stocking densities. Smolt production rates from PGH 0+ parr stocking have averaged 0.60 smolt/unit.

Relative merits and use in future enhancement

GLNFH accelerated age 0+ parr: The availability of accelerated 0+ parr is variable, depending on the strain and number of age-1 smolts under production. The majority of the accelerated age 0+ parr will smoltify the following spring (age p8); others may spend another year or two in freshwater before migrating to sea (age p20, age p32). This older component of the hatchery population, when available, may provide a significant increase in older age class semi- naturally reared smolts and increase returns of sea-run adults based on observations in the Narraguagus River in 2019 (USASAC 2020). Accelerated 0+ parr are now available for the Machias River as a by-product of rearing smolts for the Machias River component of MDMR's Salmon for Maine River Program (SFMRP; See 'Gravid Adults' below). Annual releases of ~15K Machias strain age 0+ parr are expected throughout the duration of the SFMRP. The first release of accelerated age 0+ parr occurred in fall 2020.

CBNFH ambient age 0+ parr: Future production of ambient parr at CBNFH has been discontinued as it has been found to negatively impact unfed fry production due to infrastructure limitations.

GLNFH ambient age 0+ parr: This strategy is under investigation for production and release in the Sheepscot River (Merrymeeting Bay SHRU) beginning in 2021. Future production capability will need to be increased to achieve habitat-based production targets for the DESHRU recommended in this plan.

Following production in 2021, an evaluation will be made to determine the feasibility of expanding ambient parr production for the DESHRU. Depending on rearing space, anticipated

feed needs and effluent discharge, additional ambient parr production may result in reduced age-1 smolt production.

PGH ambient age 0+ parr: The East Machias River LCMS has documented significant increases in large parr abundance, smolt abundance, and smolt production rates since monitoring began in 2013 (DSF 2020; USASAC 2020). At the watershed scale, stocking PGH ambient age 0+ parr appears to greatly enhance juvenile production with an apparent doubling of age 1+ and age 2+ parr density compared to unfed fry (roughly 4.9/unit compared to 10.5/unit). Increases in juvenile density were apparent in a range of stream sizes ranging from small (class A, less than six meters), medium (class B, between six and 12 meters; and class C, between 12 and 18 meters) and large (class D, over 18 meters). Within the highest quality class B water in the East Machias, PGH age 0+ parr stocking outperformed all other stock enhancement strategies (fed fry, unfed fry, and gravid adults) since 1997 (Figure 1). PGH 0+ origin smolt production during this period averaged 914 smolts; more than 3.5 times greater than observed from unfed fry stocking.

The Coordinating Committee supports DSF efforts to include rearing additional river-specific strains (in addition to East Machias) at the PGH (See 'Appendix A'). DSF is currently in the permitting process with the USFWS to receive additional strains. MDMR will request allocation of Narraguagus strain eggs for transfer to the PGH in 2021. The PGH will be relied upon heavily to provide 0+ parr for class B, C, and D waters in coming years. Operation of the PGH is reliant on private and federal funding.

CBNFH Large Parr

Objective: Intermittent releases of large parr (age 1, 1+ or 2), resulting from either genetic monitoring results or necessary biomass reduction from CBNFH, is not a priority objective for stock enhancement.

Release method: Attempts are made to release large parr in lower river reaches and/or to coincide with smolt emigration.

Historical use: Ongoing genetic monitoring of captive broodstock may identify individuals that are genetically redundant and not needed for reproduction; individuals identified as Landlocked Salmon are also released. Limitations on effluent discharge at CBNFH may also necessitate the release of individuals to reduce biomass, and associated effluent, at the facility.

Relative merits and use in future enhancement: Releases of large parr are an infrequent by-product of broodstock management at CBNFH and are not considered part of a stock enhancement strategy.

Age-1 Smolts

Objective: To increase the abundance of sea-run spawners and produce naturally reared offspring.

Release method: Stocking occurs in late April to the second week of May dependent upon temperature and river conditions (ice/flows). Stocking locations are chosen to ensure returning adults are imprinted to river reaches near appropriate spawning habitat in targeted reaches.

Historical use: In recent years, age-1 hatchery smolts have been released at various locations in the Machias (2013), Narraguagus (2008-2012 and 2016-2019) and Pleasant (2011-2013) rivers. Hatchery-origin adult returns to the Narraguagus River from smolt stocking (by cohort) averaged 55 adults (range 16 – 127). Adult returns originating from hatchery-origin smolts averaged 82% of the total Narraguagus River adult run. Two years following smolt stocking events, spawner surveys in the Narraguagus River identified an average 99 redds (range 16 – 263).

Relative merits and use in future enhancement: When implemented, age-1 smolt releases are the effective tool to increase the abundance of sea-run spawners in the DESHRU. However, at this time smolt production at GLNFH and NNFH is reserved primarily for the Penobscot and Merrymeeting Bay SHRUs. Significant changes in resource allocation and concurrence with partners, including the Penobscot Indian Nation, are required to shift production to DESHRU populations.

Gravid Adults

Gravid adults originate from the captive [freshwater] reared (CRF) broodstock at CBNFH and, beginning in 2022-2023, from proposed captive [marine] reared (CRM) project initiated by MDMR. Implementing a successful gravid adult stocking strategy is complex and will be based on a management approach that incorporates directed rearing of fish for size and sexual maturity, carefully chosen stocking density above minimum CSE, location and timing, and a monitoring plan. The number of gravid adults to stock is derived by considering the amount of spawning habitat available, sex ratio, sexual maturation rate, fecundity, expected reproductive success, and the presence of wild spawners.

Objective: To populate a targeted drainage or reach with gravid adults to promote natural reproduction and mate selection, components that are missing from our current restoration program. Resultant juvenile salmon will experience a completely wild life history.

Release method: Prior to 2012 program guidelines were to stock gravid adults into lower portions of rivers in lower quality habitat. More recently, experimental gravid adult stocking in high quality tributary habitat has been conducted with limited success (Mackey and Bean 2004; Bruchs 2012; Bruchs and Atkinson 2013; Stark et al. 2014). New stocking strategies for gravid adults are currently being developed by evaluating past attempts in Maine and elsewhere (Berejikian et al. 2004; Carr et al. 2004).

Historical use: Although gravid CRF broodstock from CBNFH may occasionally be released the stocking of gravid adults has not been extensively used as a stock enhancement strategy due to a variety of concerns, including insufficient quantity of adults available for release, redd superimposition (and potential destruction of redds or decreased survival of wild progeny), over-representation of hatchery broodstock genes in the population, and competition of any resulting offspring with those resulting from wild reproduction.

When employed, the most successful releases have occurred by stocking age-5 repeat broodstock in tributaries with abundant, high quality spawning and rearing habitat.

Relative merits and use in future enhancement: The release of CRF gravid adults into Northern Stream, the most productive tributary habitat in the East Machias drainage, produced statistically significant greater large parr densities over a three-year period than unfed fry stocking over the previous decade ($p < 0.05$; Tukey's HSD) (Figure 1). This indicates that in the presence of productive habitat and environmental conditions, the release of gravid CRF adults could outperform unfed fry stocking. This strategy also offers some promise of enhancing fitness by allowing for natural mate selection and the development of juveniles in sync with the targeted river.

Beginning in 2020 a new endeavor for the release of CRM gravid adults, the Salmon for Maine Rivers (SFMR) program, was initiated by MDMR in collaboration with Cooke Aquaculture and the USFWS (See '5 Year Stocking Plan'; See 'Appendix B'). Specific to the Machias River, 20,000 eyed eggs from CBNFH were transferred to GLNFH to be reared to age-1 smolts. The marine phase of the program is scheduled to begin in spring 2021 with the transfer of approximately 900 age-1 smolts to nearshore conservation net pens. Smolts will be reared to maturity and released as gravid adults in the Machias River in fall 2022 and 2023.

Post-spawn Adults

Objective: Equalizing the genetic contribution of individual broodstock and reducing biomass at CBNFH; CRF broodstock kelts that have spawned at least once during captivity are stocked to their natal river following spawning. This action is not a priority objective for stock enhancement.

Release method: Stocking occurs in lower reaches or estuarine areas of each river in November and December.

Historical use: Post-spawn CRF broodstock are released annually.

Relative merits and use in future enhancement: Post-spawn adults rarely survive to repeat spawn naturally and are therefore not considered part of a stock enhancement strategy. Re-conditioning CRF kelts for use as broodstock for additional egg take and/or gravid stocking has not been implemented beyond the retention of small numbers of spent age three brood used for insurance against incidental loss at the hatchery.

Table 2. Observed smolt production rate per supplemented habitat unit (1 unit = 100m^2) in Maine rivers (2009-2019). [Data available in USASAC report series]

Observed Smolt Production Rate Summary			
	Mean Smolt Production Rate (per habitat unit)		
Lifestage/Enhancement Strategy	East Machias	Narraguagus	Sheepscot
Eyed Egg	-	-	0.36
Unfed Fry	0.22	0.22	0.61
CBNFH Ambient 0+ Parr	-	1.21	1.54
GLNFH Accelerated 0+ Parr	-	1.46	-
PGH 0+ Parr	0.60	-	-

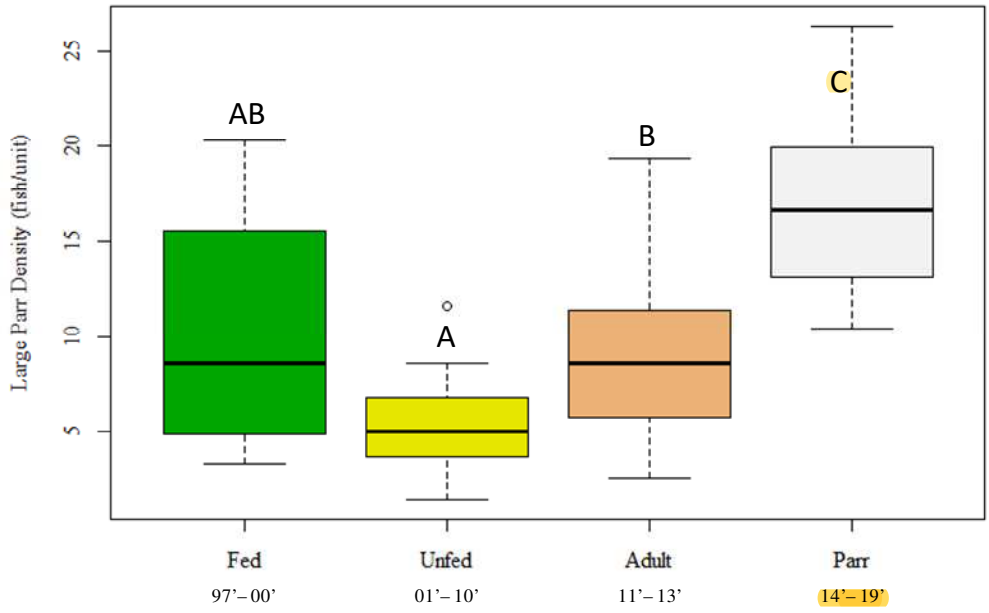

Figure 1. Box plots (max, +1 s.d., median, -1 s.d., and min) of large parr density (fish/100m^2) observed during electrofishing sampling by lifestage stocked and period (years), Northern Stream, East Machias River drainage, Maine (1997-2019). Like letters indicated no significant difference ($p > 0.05$; Tukey's HSD).

Habitat-based Production Targets

The Coordinating Committee recommends stocking the most productive lifestage by stream width-class (Table 3) based on empirical data (see 'Lifestage'). Stream width classes were defined by MDMR to stratify stream reaches for comparison of population abundance within more equally sized and characteristic width classes (Atkinson 2020). Production targets have been calculated for unfed fry and 0+ parr as those are the primary lifestages available for rivers in the DESHRU (Tables 3 and 4). The production targets below represent those necessary to fully supplement all rearing habitat in the DESHRU in the absence of natural spawning. The Coordinating committee recommends Federal and NGO facilities shift production to achieve the targets presented below as soon as possible and no later than 2025 (See '5-year Stocking Plan').

Table 3. Watershed summary of surveyed physical rearing habitat units (1 unit = 100m^2) by stream width class, Downeast Coastal Salmon Habitat Rearing Unit (DESHRU), Maine.

	DESHRU Watershed Summary		Width Class Units (100m^2)			
	DPS River-Specific Population	Surveyed Rearing Habitat Units (100m^2)	A (<6m)	B (6-12m)	C (12-18m)	D (> 18m)
1	Machias	7,046	1,048	1,271	1,453	3,274
2	Narraguagus	6,197	710	1,009	1,619	2,859
3	East Machias	2,281	476	780	495	530
4	Dennys	2,185	76	335	495	1,279
5	Pleasant	1,291	119	457	176	539
	DPS Non River-Specific Population					
6	Union	1,808	193	145	446	1,024
	Total Units	20,808	2,622	3,997	4,684	9,505

Table 4. Recommended enhancement targets based on surveyed physical rearing habitat units (1 unit = 100m^2) by drainage, lifestage, and stream width-class, and estimated annual production of eyed eggs at CBNFH for the DESHRU, Maine. [Recommended stocking densities: unfed fry - 100/unit; 0+ parr – 50/unit.]

	DESHRU Stock Enhancement Summary	Width Class				
		A (< 6m)	B (6-12m)	C (12-18m)	D (> 18m)	
	DPS River-Specific Population	Unfed Fry	0+ Parr	0+ Parr	0+ Parr	Drainage Total
1	Machias	104,800	63,550	72,650	163,700	404,700
2	Narraguagus	71,000	50,450	80,950	142,950	345,350
3	East Machias	47,600	39,000	24,750	26,500	137,850
4	Dennys	7,600	16,750	24,750	63,950	113,050
5	Pleasant	11,900	22,850	8,800	26,950	70,500
	DPS Non River-Specific Population					
6	Union	19,300	7,250	22,300	51,200	100,050
	Total Unfed Fry	262,200	-	-	-	**262,200**
	Total 0+ Parr	-	199,850	234,200	475,250	**909,300**
	Total Juveniles					**1,171,500**

5-Year Stocking Plan (2021-2025)

Based on available information, it is likely that shifting hatchery production and stocking to pair lifestages with appropriate width-class habitat may improve freshwater production of smolts and adult returns in the DESHRU. Over the previous two decades, various stock enhancement strategies have been used to supplement vacant habitat. During this time, evaluations indicate that unfed fry perform best in smaller A width-class habitat (<6m), and more advanced 0+ parr perform best in B and C width-classes (6-12m and 12-18m) (Bruchs 2020; DSF 2020; MDMR, unpublished). Relying solely on unfed fry will continue to provide a means to prevent extinction near term *but will not produce robust smolt populations necessary to move toward recovery goals*. To maximize smolt production and adult returns, greater emphasis will need be placed on the use of 0+ parr in larger width-class habitat to populate more habitat within the DESHRU. Existing federal and NGO facilities have the egg resources, and may have the rearing capacity, to shift production to rear sufficient quantities of 0+ parr to supplement all available ≥B width-class habitat

Placing emphasis on stocking 0+ parr in larger width-class habitat has additional advantages beyond those previously discussed. Following the protocols discussed in 'Buffering Natural Reproduction' managers do not stock unfed fry in habitat adjacent to redds. While this approach

reduces competition between hatchery origin and wild offspring, naturally produced age 0+ parr biomass may be minimal or non-existent by late summer if they cannot survive climate-related stressors (thermal and/or drought). Managers have the ability to assess early fall biomass via electrofishing and will be able to supplement habitat with hatchery origin 0+ parr if year-class failure occurs. This management approach ensures maximum age 0+ biomass annually in absence or failure of natural spawning.

The width-class based strategy has the potential to produce approximately 2.7 times more smolts on average than status quo (12,359 vs. 4,578) based on observed mean smolt production rates (Table 5). Subsequently, the strategy may yield nearly 3 times more adult returns on average than status quo (236 vs. 82) based on observed mean smolt-to-adult return rates (SAR). These projections are considered conservative. The stock enhancement plan continues to balance rearing goals for genetic conservation and fitness, while providing managers an immediate means of increasing smolt and adult abundance throughout the DESHRU.

Unfed fry will continue to be a significant component of the enhancement strategy as it has proven successful in maintaining the genetic diversity and fitness of DESHRU populations by producing juveniles with more freshwater selection. The majority of class A width-class habitat does not receive natural spawning, therefore unfed fry stocking will remain relatively static. Utilizing unfed fry representative of all available genetic families in this smaller/colder habitat will maximize survival and may increase family group retention within captive brood lines (Bartron et al. 2006).

Egg planting, a previously employed strategy to encourage early in-river experience/selection and ease logistical constraints for planting unfed fry, will only be used if egg availability is sufficient to supplement all vacant physical rearing habitat in a drainage with unfed fry and 0+ parr, when the highest quality rearing habitat does not receive natural spawning, and/or where spawning has occurred below CSE to maximize use of the spawning habitat.

CRM adults will be stocked in the Machias River in 2022 and 2023 (See 'Appendix B'). It is expected CRM adults will spawn in larger ≥B width-class habitat. Changing spatial distribution of 0+ parr stocking will be necessary based on spawning distribution and success.

The Coordinating Committee acknowledges the timeline for implementing the shift to width-class based hatchery production and stock enhancement is variable given logistical differences at individual rearing facilities. The Coordinating Committee recommends shifting production as soon as possible with additional drainages receiving 0+ parr as early as 2021 and full implementation no later than 2025 (Table 6).

The Coordinating Committee supports a recent proposal to allocate Narraguagus eggs to the PGH to be reared to 0+ parr in 2021 (See 'Appendix A'). Further, the Coordinating Committee supports efforts to convert the WSRC to 0+ parr production as soon as possible. Remaining 0+ parr production targets for the Dennys, Machias, and a portion of the Narraguagus rivers will need to be met by GLFNH. A feasibility review for rearing 0+ parr at GLNFH is currently underway and should be expanded to include habitat-based production targets recommended within this plan (See 'Habitat Based Production Targets').

Table 5. Projected smolt production and 2SW returns by watershed, quantified physical rearing habitat units (1 unit = $100m^2$) and lifestage/stocking strategy, Downeast Coastal SHRU, Maine. Status quo and proposed strategy production rates based on mean Narraguagus and East Machias smolt production and smolt-to-adult return rates, respectively.

DESHRU Smolt Production/2SW Return Summary			Lifestage/Stocking Strategy			
			Unfed Fry Status Quo		Unfed Fry/0+ parr Proposed	
	DPS River-Specific Population	Mapped Rearing Habitat Units ($100m^2$)	Smolts (0.22/unit)	2SW Returns	Smolts (0.60/unit)	2SW Returns
1	Machias	7,046	1,550	28	4,228	81
2	Narraguagus	6,197	1,363	25	3,718	71
3	East Machias	2,281	502	9	1,369	26
4	Dennys	2,185	481	9	1,311	25
5	Pleasant	1,291	284	5	775	15
	DPS Non River-Specific Population					
6	Union	1,808	398	7	958	18
	Total Units	20,808	4,578	83	12,359	236

Table 6. Recommended stock enhancement strategy timeline by drainage, lifestage, and stream width-class for the DESHRU, Maine (2021-2025). [Consult Table 4 for maximum unfed fry and 0+ parr quantities]

DESHRU Stock Enhancement Strategy Timeline

	DPS River-Specific Population	2021 Width Class A	2021 Width Class B	2021 Width Class C	2021 Width Class D	2022 Width Class A	2022 Width Class B	2022 Width Class C	2022 Width Class D	2023 Width Class A	2023 Width Class B	2023 Width Class C	2023 Width Class D
1	Machias	Unfed Fry	Unfed Fry	Unfed Fry GLNFH Acc 0+ Parr	Vacant	Unfed Fry	0+ Parr CRM Adults	0+ Parr CRM Adults	0+ Parr CRM Adults	Unfed Fry	0+ Parr CRM Adults	0+ Parr CRM Adults	0+ Parr CRM Adults
2	Narraguagus	Unfed Fry	PGH 0+ Parr	PGH 0+ Parr	PGH 0+ Parr	Unfed Fry	PGH 0+ Parr	PGH 0+ Parr	PGH 0+ Parr	Unfed Fry	PGH 0+ Parr	PGH 0+ Parr	PGH 0+ Parr
3	East Machias	Unfed Fry PGH 0+ Parr	PGH 0+ Parr	PGH 0+ Parr	PGH 0+ Parr	Unfed Fry PGH 0+ Parr	PGH 0+ Parr	PGH 0+ Parr	PGH 0+ Parr	Unfed Fry PGH 0+ Parr	PGH 0+ Parr	PGH 0+ Parr	PGH 0+ Parr
4	Dennys	Unfed Fry	Unfed Fry	Unfed Fry	Unfed Fry	Unfed Fry	0+ Parr	0+ Parr	0+ Parr	Unfed Fry	0+ Parr	0+ Parr	0+ Parr
5	Pleasant	Unfed Fry	Eyed-Egg	Unfed Fry	Unfed Fry	Unfed Fry	Eyed-Egg	0+ Parr	0+ Parr	Unfed Fry	Eyed-Egg	0+ Parr	0+ Parr
	DPS Non River-Specific Population												
6	Union	Vacant	Vacant	Vacant	Vacant	Unfed Fry	0+ Parr	0+ Parr	0+ Parr	Unfed Fry	0+ Parr	0+ Parr	0+ Parr

Table 6. (Continued)

	DPS River-Specific Population	2024 Width Class A	2024 Width Class B	2024 Width Class C	2024 Width Class D	2025 Width Class A	2025 Width Class B	2025 Width Class C	2025 Width Class D
1	Machias	Unfed Fry	0+ Parr	0+ Parr	0+ Parr	Unfed Fry	0+ Parr	0+ Parr	0+ Parr
2	Narraguagus	Unfed Fry	PGH 0+ Parr	PGH 0+ Parr	PGH 0+ Parr	Unfed Fry	PGH 0+ Parr	PGH 0+ Parr	PGH 0+ Parr
3	East Machias	Unfed Fry PGH 0+ Parr	PGH 0+ Parr	PGH 0+ Parr	PGH 0+ Parr	Unfed Fry PGH 0+ Parr	PGH 0+ Parr	PGH 0+ Parr	PGH 0+ Parr
4	Dennys	Unfed Fry	0+ Parr	0+ Parr	0+ Parr	Unfed Fry	0+ Parr	0+ Parr	0+ Parr
5	Pleasant	Unfed Fry	Eyed-Egg	0+ Parr	0+ Parr	Unfed Fry	Eyed-Egg	0+ Parr	0+ Parr
	DPS Non River-Specific Population								
6	Union	Unfed Fry	0+ Parr	0+ Parr	0+ Parr	Unfed Fry	0+ Parr	0+ Parr	0+ Parr

Stocking Recommendations for 2021

Stocking recommendations balance production capacity of USFWS and DSF rearing facilities (Table 1), the quantity of eggs available to rear to specific lifestages, annual sea-run spawning (redd) distribution, and habitat-based production targets (Tables 3 and 4). Egg availability from CBNFH is estimated post-spawn, typically available in December. MDMR evaluates the spawning distribution after concluding spawner surveys (redd counts) documenting Wild Production Areas (WPAs) in late December. MDMR then allocates eggs to rear various lifestages for stocking based on stream width-class and quantity of vacant physical rearing habitat for each individual river (Table 7; 'See Appendix C').

Habitat quality is considered on a reach level when making stocking allocations. Where available, objective data from habitat surveys and past population assessments are used to prioritize reaches for stocking. Generally, the most productive habitat reaches are stocked when water conditions are most favorable for the survival of each lifestage. Stocking logistics, including access, fry development and weather conditions are secondary considerations after habitat quality and existing natural production.

The 2021 egg allocation (Table 7) includes eyed-eggs and unfed fry for the Dennys and Pleasant rivers. The upper reaches of these rivers contain high quality spawning and rearing habitat that did not receive natural spawning in 2020. Eyed-eggs will be used to supplement these reaches at or above CSE (2.4 eggs/m2). Unfed fry will be stocked in all remaining vacant habitat in lower river reaches. This stock enhancement strategy has been used in the Dennys and Pleasant rivers since 2014. The 2021 Pleasant River allocation continues transfer of a portion of eggs to rear

unfed fry at the WSRC. The allocation retains ~20k eggs to rear unfed fry at CBNFH, providing back-up genetic redundancy of all families.

The Machias allocation includes eyed-eggs for vacant high-quality spawning and rearing habitat in Crooked River and Old Stream. Eyed-eggs will be used to supplement these reaches at or above CSE (2.4 eggs/m2). Unfed fry will be used to supplement remaining vacant habitat in tributaries. The allocation also includes transfer of eggs to GLNFH to rear age-1 smolts and age 0+ parr for the MDMR SFMR program. Smolts will be transferred to near-shore conservation net pens for grow-out to mature adults. Accelerated parr will be released in mainstem habitat in fall.

The East Machias allocation transfers the majority of eggs to the PGH to rear age 0+ parr. This stock enhancement strategy has been employed since 2013. The 2021 allocation retains ~20k eggs to rear unfed fry at CBNFH to providing back-up genetic redundancy of all families and provides a component of the resulting juvenile population with more in-river exposure for recapture for broodstock.

The Narraguagus allocation provides unfed fry for vacant high-quality tributaries and mainstem habitat in the upper Narraguagus River above Beddington Lake as well as the West Branch sub-watershed. The allocation transfers ~27% of available eggs to the PGH to rear age 0+ parr (dependent on permitting). Stocking will occur in larger mainstem habitat above Beddington Lake and one vacant mainstem reach below Beddington Lake. The majority of habitat below Beddington Lake downstream to Schoodic Brook received spawning escapement at or above CSE (147 redds). This WPA will not receive hatchery augmentation.

Table 7. Egg allocation, Downeast SHRU, 2021.

Strain	**Estimated Green Eggs**	**Estimated Eyed Eggs (Captive & Domestic @70%)**	Potential Eyed Egg Transfers to Rear Advanced Lifestages				
			Transfer to GLNFH (Smolts and Accelerated 0+ parr)	Transfer to PGH (0+ parr)	Transfer to WSRC (Unfed Fry)	CBNFH (Unfed Fry)	CBNFH (Egg Planting)
Dennys	322,074	225,452	0	0	0	182,452	43,000
East Machias	459,263	321,484	0	301,484	0	20,000	0
Machias	328,794	230,156	20,700	0	0	169,456	40,000
Narraguagus	539,177	377,424	0	100,000	0	277,424	0
Pleasant	286,381	200,467	0	0	80,467	20,000	100,000
Total	**1,935,689**	**1,354,983**	**20,700**	**401,484**	**80,467**	**669,332**	**183,000**

Buffering Natural Reproduction

Habitat buffers are established around redds to minimize potential adverse competition between hatchery fry and naturally produced fry during the first few weeks following their emergence from redds. This is done in three steps: 1) locate and spatially document redd locations in Maine salmon rivers, 2) determine the number of hatchery salmon to request to fill vacant habitat, and 3) determine where to apply buffers around redds.

Habitat buffers estimate the amount of habitat that could be occupied by emerging salmon fry. These buffers are derived using the following assumptions:

- the number of eggs needed to fully seed a unit rearing habitat equals 240 (Baum, 1995; Gibson & Claytor, 2012);
- an average multi-sea winter (MSW) female Atlantic Salmon produces approximately 7,500 eggs and constructs 1-3 redds (Baum and Meister 1971);
- a single redd averages 2,400-7,500 eggs that could saturate the adjacent 10-30 rearing habitat units. Therefore, a single redd will seed 30 units of habitat between 33% and 100% of the management target.

Using these estimates of occupancy, the balance of fish needed to fully seed the remaining rearing habitat can be calculated.

Because river characteristics in the vicinity of each redd or redd cluster are highly variable, in terms of river width and juxtaposition of habitat types, applying a fixed buffer based on the number of units seeded around each redd is not practical. Because individual redds or redd clusters in the DPS rivers are relatively few, it is possible to compute the distance needed to buffer around each known redd or redd cluster. But a better way is to use empirical dispersal distances to create a standard upstream buffer around a given redd.

Atlantic Salmon fry emergence and dispersal from artificial redds has been well studied and dispersal distances as much as 1,600 meters have been documented (Beall et.al., 1994; Crisp and Hurley, 1991; Phillips and Koski, 2011; Brunsdon et al., 2017). Experiments at MDMR in the Dennys River and Northern Stream support these studies showing dispersals in the first few weeks after stocking of unfed fry up to 1,700 meters (E. Atkinson, personal communication). In other work upstream dispersals were observed as much as 750 meters. As a result, MDMR has used a buffer of 500 meters upstream of a redd and 1,500 meters below. This works well where clusters of redds occur since the upstream buffer is based on the upstream most redd and likewise the downstream buffer based on the lowest redd in the cluster.

Evaluation of Stocking Recovery Actions

Evaluation of stocking recovery actions in the DESHRU will provide objective data for management of future stock enhancement. MDMR directs Atlantic Salmon population monitoring activities throughout the DESHRU. As a component of the MDMR-NOAA Cooperative Agreement, MDMR operates a Life Cycle Monitoring Station (LCMS) on the Narraguagus River to evaluate trends in juvenile abundance, smolt production, adult returns, spawning escapement and distribution, and smolt-to-adult return rates (SARs). Continued

operation of the Narraguagus LCMS serves as an index of relative success of recovery actions in similarly managed watersheds across the DESHRU. Additionally, the DSF partners with MDMR and NOAA to operate a LCMS on the East Machias River.

Additional opportunities exist within the DESHRU to further knowledge of the effectiveness of width-class based stock enhancement and the effectiveness of stocking specific lifestages (See 'Lifestage Descriptions, Release Methods, Historical Use, and Relative Merits'). Further research is suggested to determine production metrics from eyed-egg planting, a head-to-head comparison of age 0+ parr stocking with different rearing histories, and the SFMR Program.

Suggested future evaluation opportunities:

- The Upper Pleasant River provides a segregated sub-drainage area to monitor the effectiveness of eyed-egg planting. This habitat area has been supplemented solely with eyed-eggs since 2014. A time-series of large parr population assessments is available for comparison and smolt monitoring would be possible if a partner (NGO and/or University) desired to staff and operate a LCMS. Within the DESHRU, observations of large parr and smolt abundance, age, and survival are lacking for this lifestage. Partnerships should be pursued to perform this evaluation.

- MDMR assessments of age 0+ parr origin smolt populations reared at different facilities indicate notable differences in survival rates and life history observations between hatchery products (Bruchs et al. 2014, 2015, 2016, 2018a, 2018b; Christman et al. 2008). To explore these differences, a head-to-head comparison wherein Narraguagus and/or East Machias strain 0+ parr from both rearing facilities are released simultaneously in the same rearing habitat will remove watershed-specific environmental variables, allowing for direct comparison of large parr and smolt abundance, age, and survival (Bruchs et al. 2019). Existing rearing infrastructure, sampling plans, and staffing provide an opportunity to increase program knowledge of age 0+ parr rearing and stocking practices using minimal additional resources. Knowledge obtained in this study may be critical to management of rearing and stocking practices necessary to produce more natural-like life history and improve post-release survival of hatchery age-0+ parr.

- The MDMR SFMR Program presents an opportunity to evaluate the effectiveness of stocking gravid CRM adults in the Machias River. Evaluation of this program (within current resources) will be limited to electrofishing and spawner surveys. Additional evaluation of spawning success at emergence (redd trapping) and smolt production are key to understanding relative success of the program. While a full LCMS is desirable, logistical constraints exist at the smolt lifestage where mark-recapture is not feasible if naturally-reared smolts are captured and used as the source population for marine rearing. If the program remains reliant on hatchery-origin smolts as a source population, mark-recapture smolt monitoring will be feasible. Partnerships should be pursued to perform these evaluations.

Experimental Population Concept

Operation of hatcheries may produce fish in excess of management recommendations within this plan. This scenario presents both a problem and an opportunity. The problem arises when surplus fish conflict with management recommendations and may result in a net loss in recovery efforts and/or our ability to segregate and assess stock enhancement recovery actions. However, the scenario also provides an opportunity to use the fish in a manner that will improve our knowledge of current management effectiveness. Such uses will typically require either vacant, isolated habitat within a drainage, or outside of the natal drainage to avoid confounding results of other management. Such locations are scarce to nonexistent within the five primary river-specific managed drainages of the DE SHRU. However, neighboring drainages within or outside the geographic range of the DPS may provide opportunities for experimental stocking approaches as described below.

Genetic Refuge Area/ Single Stock:
One approach would be to use the West Branch Union River as a Genetic Refuge Area (GRA) for a single river-specific stock to both increase the distribution and abundance of a selected stock and as a way to spatially separate lifestages within the stock. The DESHRU would benefit from additional smolt production and resulting adult returns in a largely vacant but critical river for recovery efforts. This approach would not require additional hatchery resources and may provide genetic resiliency more severely imperiled stocks.

Genetic Refuge Area/ Mixed Stock:
A second approach would be to use the West Branch Union River as a Genetic Refuge Area (GRA) for combining all DESHRU river-specific stocks into a mixed-stock to maximize effective population size. The Union River is within critical habitat and currently unmanaged. The GRA stock could receive a small quantity of egg production representative of all genetic families within the current river-specific program to produce an initial donor stock. Creation of the GRA captive broodstock line could be completed, following initial capture of large parr, if broodstock rearing space could be identified. The GRA could receive any lifestage deemed in excess of management needs from river-specific stocks within the DESHRU in the future. The DESHRU would benefit from additional smolt production and resulting adult returns in a largely vacant but critical river for recovery efforts. Although this approach may require additional resources (rearing space for more adults), long-term benefits may outweigh near-term costs as the GRA stock will provide additional genetic resiliency to the conservation program.

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Glossary of Life History Terms

Green Egg	Life stage from spawning until faint eyes appear.
Eyed Egg	Life stage from the appearance of faint eyes until hatching.
Fed Fry	Fry that have been fed an artificial or natural diet. Often used interchangeably with the term “feeding fry” and most often associated with stocking activities.
Unfed Fry	Fry that have not been fed an artificial diet or natural diet. Most often associated with stocking activities.
Parr	Life stage immediately following the fry stage until the commencement of migration to the sea as smolts.
Age 0+ Parr	Life stage occurring during the period from July 1 to December 31 of the year of hatching.
Age 1+ Parr	Life stage occurring during the period from July 1 to December 31 one year after hatching.
Age 2+ Parr	Life stage occurring during the period from July 1 to December 31 two years after hatching.
Parr 8 (p8)	A parr stocked at age 0+ that migrates as 1 Smolt (8 months spent in freshwater).
Parr 20 (p20)	A parr stocked at age 0+ that migrates as 2 Smolt (20 months spent in freshwater).
Parr 32 (p32)	A parr stocked at age 0+ that migrates as 3 Smolt (32 months spent in freshwater).

Smolt	An actively migrating young salmon that has undergone the physiological changes to survive the transition from freshwater to saltwater.
Wild Smolt	A wild smolt is an Atlantic salmon which is the product of natural spawning, emerged from a redd and was reared in the river prior to emigrating to the ocean.
Hatchery Smolt	A hatchery smolt is a product of hatchery spawning which has spent nine months (or more) of its life within a hatchery prior to stocking. These include fall parr origin (i.e. fingerlings, parr 8, parr 20, or parr 32), Age-1 and Age-2 smolts.
Naturally Reared Smolt	A naturally reared smolt is the product of wild spawning, egg planting, or fry stocking.
1 Smolt	Life stage occurring during the period from January 1 to June 30 of the year of migration. The migration year is one year after hatch.
2 Smolt	Life stage occurring during the period from January 1 to June 30 of the year of migration. The migration year is two years after hatch.
3 Smolt	Life stage occurring during the period from January 1 to June 30 of the year of migration. The migration year is three years after hatch.
Post Smolt	Life stage occurring during the period from July 1 to December 31 of the year the salmon became a smolt. Typically encountered in the ocean.
Grilse	A one-sea-winter (SW) salmon that returns to the river to spawn. These fish usually weigh less than five pounds.
Multi-Sea-Winter (MSW) Salmon	All adult salmon, excluding grilse that return to the river to spawn. Includes terms such as two-sea-winter salmon, three-sea-winter salmon, and repeat spawners. May also be referred to as large salmon.

2SW Salmon	A salmon that survives past December 31 twice since becoming a smolt.
3SW Salmon	A salmon that survives past December 31 three times since becoming a smolt.
4SW Salmon	A salmon that survives past December 31four times since becoming a smolt.
Kelt	Life stage after a salmon spawns. For domestic salmon, this stage lasts until death. For wild fish, this stage lasts until it returns to home waters to spawn again.
Reconditioned Kelt	A kelt that has been restored to a feeding condition in captivity.
Repeat Spawner	A salmon that returns numerous times to the river for the purpose of reproducing. Previous spawner.

Appendix A.

Memo: Notice of a proposed action in the Downeast SHRU

Date: 5-21-2020

To: CMS Implementation Team

From: Downeast SHRU Coordinating Committee

Regarding: Draft Downeast Salmon Federation (DSF) project to rear an additional strain of Atlantic Salmon at the Peter Gray Hatchery

The Downeast SHRU Coordinating Committee (Committee) has received a draft project from DSF outlining their wish to raise additional strains of salmon to the age 0+ parr stage at the Peter Gray Hatchery in East Machias. DSF recently built an addition to their facility which allows for segregated rearing, provides additional rearing space and improved biosecurity. Initially, DSF proposed to raise two populations, the Machias and Narraguagus, in addition to the East Machias salmon they currently rear. DSF previously discussed biosecurity issues of rearing two populations in a single rearing room with fish health experts at the U.S. Fish and Wildlife Service's (Service) Lamar Fish Health Center and it was deemed feasible. The attached draft project provides details including bio-security measures and numbers of eggs from each population requested for transfer from the Service's Craig Brook National Fish Hatchery (CBNFH). This document serves to provide notification of our intention to support this proposal and memorializes the bases for our recommendation. No action is requested of the Implementation Team at this time.

The Committee is supportive of the draft project, however based on input by committee members and their respective agencies the following comments are offered:

- **U.S. Fish and Wildlife Service (Service)**
  - Egg availability is a function of annual budgets, numbers of captive broodstock, fecundity and eye-up survival.
  - The Service will transfer eggs from two populations [East Machias and one other], totaling up to 400,000; adding a third is not supported by the Service at this time.
  - The Service and DSF have a preexisting Memorandum of Understanding (MOU) that caps the transfer of eyed eggs to the Peter Gray Hatchery at 400,000.
  - The Service requires DSF to either modify, amend their existing Endangered Species Act (ESA) Section 10 Permit or apply for a new permit [if applicable] to allow for flexibility in the populations they wish to rear.
  - If DSF receives new Federal Funding for the Peter Gray Hatchery, this action would require Section 7 Consultation by the lead Federal Action Agency with the Service.
  - The Service requires DSF to either modify, amend their existing MOU with the Service or develop a new version, in order secure their relationship with the Service and allow flexibility in the populations used to supply eggs.
  - The Service will retain up to 15,000 eyed East Machias eggs to be reared to the unfed fry stage and released into the East Machias River in support of the captive broodstock program.
  - The Service, DMR and DSF will coordinate stocking locations during annual stocking allocation.

- **Maine Department of Marine Resources (DMR)**
  - DMR recommends the rearing of the Narraguagus population with the Machias as a second option.
  - The Narraguagus population is recommended by DMR because there is extensive existing infrastructure to perform assessments of fall parr raised at the Peter Gray hatchery. Smolt trapping and adult trapping allow for data that describes return rates and origins.
  - DMR requests parr be marked with an adipose fin clip prior to release to assist in determining origin at both smolt and adult traps.
  - DMR and DSF will conduct electrofishing surveys to provide information of spatial distribution and mid-season growth.
  - DMR recommends Narraguagus parr be released into reaches below Beddington Lake to minimize interactions with ongoing Project SHARE habitat restoration work and resulting salmon production in the upper Narraguagus River.
  - DMR staff will support assessment and logistics with stocking of parr into the Narraguagus.

- **National Marine Fisheries Service (NMFS)**
  - Supports assessment through their cooperative agreement with DMR.

The Downeast Coordinating Committee believes that this proposed action has biological merit and should be put into action, but we wonder if the expected benefits would be better realized if more than 400,000 total eggs could be made available to DSF. The Committee supports the transfer of Narraguagus eyed eggs from CBNFH to the Peter Gray Hatchery as outlined in the attached proposal; this is in addition to the East Machias strain already allocated. In order to proceed DSF will need to meet the requirements listed from the Service. Once agreed upon, the Committee will include this project and resultant stocking into the 5-year SHRU plan. The Committee and DSF wish to initiate the project beginning with eggs from the 2020 spawn.

Appendix B.

Maine DMR Salmon for Maine's Rivers Program

The Salmon for Maine's Rivers Program (SFMR) is a proposed endeavor to achieve recovery goals by using smolt-to-adult supplementation and the release of marine reared gravid adults into the wild. This program is expected to support salmon recovery by substantially increasing the number of adults spawning in quality habitat, thereby increasing the number of smolts in freshwater, a freshwater recovery goal identified in the Recovery Plan for Atlantic Salmon released in 2019 (USFWS and NMFS 2018).

The SFMR is based on the Fundy Salmon Recovery (FSR) program (https://www.fundysalmonrecovery.com/), an established marine captive rearing program for endangered Inner Bay of Fundy Atlantic Salmon located in New Brunswick, Canada which has demonstrated successful spawning and production of offspring (parr and smolts) (Evans et al. 2015; Clarke et al. 2016).

The SFMR program is specifically designed to address Recovery Action F2.0, "Implement Stocking Programs for Vacant Habitat Targeted at Preventing Extinction of Locally Adapted Stocks and Increasing Their Abundance and Distribution." The release of net-pen reared adults into vacant habitat (Recovery Action F2.2) for spawning represents a stocking strategy that will promote increased fitness and genetic diversity (Recovery Action F2.1). This program is expected to substantially increase natural spawning in high quality habitats, which in turn is expected to increase the numbers of smolts produced. A greater number of out-migrating smolts should produce more returning adults, even as marine survival rates remain low.

Although the captive marine-reared adults will themselves not count towards the biological abundance criteria specified for downlisting or delisting, offspring that survive to spawning adults would be considered natural-origin returns, thus contributing towards recovery criteria (USFWS and NOAA, 2018). The program has been initiated by the transfer of eggs to GLNFH for smolt rearing; smolts are anticipated to be transferred to net pens in 2021 with gravid adults available for release in 2022 and 2023. Beginning in spring 2022, MDMR anticipates capturing naturally reared smolts in rotary screw traps in the Machias River to raise to maturity along with 900 hatchery origin smolts. The goal will be to reduce the number of hatchery origin fish over time and rely more on naturally reared fish as the program progresses.

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Appendix C.

Annual cycle of workflow related to stock enhancement: planning, stocking, assessment, and reporting.

Month	Activity	Lead Agency	Data Management	Data Products
January	• Eyed egg enumeration • Eyed egg transfers • Develop smolt stocking plan • Eyed egg planting	• USFWS • USFWS • MDMR/USFWS • MDMR	MaineBroodstock.mdb	Eyed egg production and estimated fry production provided to CMS
February	• Eyed egg enumeration • Eyed egg transfers • Eyed egg planting	• USFWS • USFWS • MDMR	MaineBroodstock.mdb and Fisheries Information System (FIS)	Transfer summary from FIS
March	• Fish Health Analysis • Develop fry stocking plan	• USFWS • USFWS/MDMR		Fish health certificates
April	• Release smolts • Monitor smolt emigration	• USFWS • MDMR	FIS	Smolt stocking summary from FIS
May	• Release fry • Monitor smolt emigration • Release large parr • Collect Penobscot sea-run broodstock	• USFWS/MDMR • MDMR • USFWS • USFWS	MaineBroodstock.mdb and FIS	Fry stocking summary from FIS and ISAv monitoring results
June	• Monitor smolt emigration • Release large parr • Collect Penobscot sea-run broodstock • Tag and genetic sample age 2+ parr	• MDMR • USFWS • USFWS • USFWS	MaineBroodstock.mdb	ISAv monitoring results and genetic characterization (to be received the following year)
July	• Collect Penobscot sea-run broodstock • Receive genetic information from prior year parr collections	• USFWS	MaineBroodstock.mdb	ISAv monitoring results
August	• Collect Penobscot sea-run broodstock • Develop age 1+	• USFWS • USFWS/MDMR	MaineBroodstock.mdb	ISAv monitoring results

	parr collection plan			
September	• Collect Penobscot sea-run broodstock • Collect age 1+ parr for broodstock • Estimate need/desire to release CFR gravid adults	• USFWS • USFWS/MDMR • USFWS	MaineBroodstock.mdb	ISAv monitoring results
October	• Release CFR gravid adults • Prepare for spawning sea-run and CFR broodstock	• USFWS • USFWS	MaineBroodstock.mdb and FIS	Estimated egg production provided to CMS
November	• Spawn sea-run and CFR broodstock • Release post-spawn sea-run and CFR broodstock	• USFWS • USFWS	MaineBroodstock.mdb and FIS	
December	• Release post-spawn sea-run and CFR broodstock	• USFWS	MaineBroodstock.mdb and FIS	Fry stocking summary from FIS and updated egg production provided to CMS