Reviewer's Report on:

Status Review for Anadromous Atlantic Salmon (*Salmo salar*) in the United States

Prepared by

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Executive summary:

1. This report provides a review of the *Status Review for Anadromous Atlantic Salmon (Salmo salar) in the United States (*the "Status Review"), which was prepared in January 2006 by a Biological Review Team assembled by National Marine Fisheries Service and the U.S. Fish and Wildlife Service.

2. The Status Review provides a re-evaluation of the Gulf of Maine Distinct Population Segment (GOM DPS) of Atlantic salmon under the Endangered Species Act (ESA). Overall the Review presents a comprehensive body of relevant scientific information that provides a sound basis for this assessment. However, the structure of the document is somewhat disjointed, and some restructuring and editing would provide greater clarity.

3. The criteria for the determination of a Distinct Population Segment (DPS) require an examination of the 'discreteness' and 'significance' of the population segment in relation to the remainder of the species to which it belongs, and an assessment of its conservation status.

4. The Status Review satisfactorily demonstrates that the GOM DSP satisfies the criteria for 'discreteness', principally on the basis of genetic data, but supported also by other biological and ecological assessments. Discreteness based on international boundaries is not invoked in this review.

5. The Status Review satisfactorily demonstrates that the GOM DSP satisfies three of the four proposed criteria for 'significance', namely: that the ecological setting is unusual; that loss of the DPS would result in a significant gap in the range of a taxon; and that the DPS differs markedly from other populations of the species in its genetic characteristics.

6. The Status Review also presents a review of information on each of the five listing factors that may lead to the DSP being determined to be threatened or endangered under the ESA, and demonstrates that each could be linked to the current depleted status of the GOM DPS. While the Review makes no specific recommendation concerning the conservation status of the GOM DPS, it justifiably notes that the DPS is severely depleted and long-term projections forecast further declines in the stocks if current pressures do not change.

7. Overall, the Status Review presents extensive information relevant to the assessment of the U.S. salmon stocks, including literature from U.S. and international sources. While it is inevitably possible to suggest additional sources that could usefully have been cited, and the logical structure of the evaluation could certainly have been improved, this does not significantly detract from the overall conclusions of the Status Review.

1 Background

On November 17, 2000, the National Marine Fisheries Service and the U.S. Fish and Wildlife Service (the Services) issued a final rule to list the Gulf of Maine Distinct Population Segment of Atlantic Salmon (GOM DPS) as endangered under the Endangered Species Act (ESA). The GOM DPS was defined as all naturally reproducing wild populations of Atlantic salmon, having historical river-specific characteristics found north of and including tributaries of the lower Kennebec River to, but not including the mouth of the St. Croix River at the United States-Canada border and the Penobscot River above the site of the former Bangor Dam. Populations which met these criteria were identified as being in the following rivers: Dennys, East Machias, Machias, Pleasant, Narraguagus, Sheepscot, Ducktrap, and Cove Brook.

At this time the Services deferred a decision on the inclusion of fish that inhabit the main stem and tributaries of the Penobscot River above the site of the former Bangor Dam. This reflected the need for further information, including a detailed genetic characterization of the Penobscot population. In 2003, the Services assembled a Biological Review Team (BRT) and asked them to review and evaluate the current DPS delineations and determine the conservation status of the populations that were deferred in 2000 and their relationship to the currently listed GOM DPS.

The BRT's report, the *Status Review for Anadromous Atlantic Salmon (Salmo salar) in the United States (*the "Status Review"), was completed in January 2006 and revaluates, updates and extends the information in the 1999 Status Review, on which the 2000 listing of the GOM DPS under the ESA was based.

2 Terms of Reference

The overall objective of this report is to "review the Status Review Report to ensure that its content can be factually supported and the methodology and conclusions are scientifically valid".

The specific terms of reference for the review are to determine:

a. Is the species delineation supported by the information presented?

b. Does the Status Review include and cite the best scientific and commercial information available on the species and threats to it and to its habitat?

c. Are the scientific conclusions sound and derived logically from the results?

d. Where available, are opposing scientific studies or theories acknowledged and discussed?

In this context, 'species' is understood to have the same meaning as in the ESA, and 'species delineation' is understood to encompass the full determination and assessment of the species as required by the ESA. (These requirements are described in Section 4.2 of this report.)

3 Review activities

This review has been undertaken as a desk exercise based at Cefas's Lowestoft Fisheries Laboratory. Reference material has been obtained from personal sources, the Cefas library and the internet, including the CIE Reviewers' website.

The review includes a general assessment of the Status Review Report (Section 4), followed by a more specific examination of the evidence supporting the delineation of the GOM DPS (Sections 5-8). Conclusions relating to the four specific Terms of Reference are summarised in Section 9.

4 Overview of the Status Review

This section provides a general assessment of the layout, structure and contents of the nine sections of the Status Review.

Section 1 – Executive summary: The structure of the executive summary bears little relationship to the remainder of the document. It would have been more useful if the summary had addressed the content of each major section (possibly employing the short summary paragraphs scattered through the report) or had alternatively outlined the key elements of the ESA assessment. This might have been assisted by some restructuring of the report itself in some of the ways described below. The Summary also makes reference to a 'large river hypothesis' that receives no specific mention elsewhere in the report.

Section 2 – Introduction and Background: This section provides general background material on the ESA and the history of the previous unsuccessful and successful attempts to list Maine salmon river stocks as endangered or threatened. It would have helped if the section had more clearly spelled out the various elements in the ESA listing process, as defined in the Policy Regarding the Recognition of Distinct Vertebrate Population Segments Under the Endangered Species Act (the "DPS Policy") (Anon, 1996). These are subsequently explained in Section 6.

Section 3 – Biological information: The section provides a comprehensive description of the biology of Atlantic salmon and specific features of U.S. rivers and their salmon stocks, and cites a good selection of references from both the European and North American literature on Atlantic salmon. However, it would have helped if more emphasis had been placed on the differences between salmon in Maine and those in other parts of the species range, since these may be particularly relevant to determining whether the Maine stocks deserve specific protection. Such differences may include both biological characteristics (e.g. mean river-age; mean sea-age) and the ecological setting (e.g. range of predators; importance of nutrient recycling). The section might also have considered evidence for the relative roles of genetic and environmental factors in determining the expressed characteristics of salmon stocks, as this would have provided useful background to later sections. There is some confusion in the use of the terms 'stock' and 'population' in the review, which is not assisted by the terminology used in the ESA procedures. Recent reports (e.g. ICES, 1996) have distinguished between management units ('stocks') and reproductive units ('populations') of salmon,

and such a distinction would have been helpful if it had been used consistently through the Status Review.

Section 4 – Historical distribution and Abundance: The section addresses the historic distribution and abundance of salmon but, surprisingly, provides no graphs of long-term changes in abundance estimates. It is not clear why this section has been separated from Section 7, which addresses the current distribution and abundance of salmon stocks in the GOM DPS (see below). It would have been helpful if the map (Fig 4.1) had included all streams referred to subsequently in the report (e.g. the Dennis Creek and the tributaries of the Penobscot and Kennebec Rivers). It would also have been appropriate to describe the status of U.S. stocks in the context of other salmon stocks around the North Atlantic, many of which are also severely depleted. It is not clear from the report whether examination of common trends among river stocks might provide greater insight into the causes and/or sources (e.g. freshwater or marine) of stock decline.

Section 5 – Artificial propagation: This section attempts to summarise the large number of Atlantic salmon propagation and stocking programmes that have been undertaken on U.S. rivers over the past 150 years. This is not an unusual story, as artificial propagation has been widely used in attempts to restore other salmon stocks, and similar accounts could be provided for a number of other rivers around the north Atlantic. An important element of the evaluation process in the Status Review is the assessment of whether the stocks remaining in Maine rivers are 'native' or are simply the product of repeated stocking. In this context, it would have helped if this Section had provided a brief summary of the stocking history in each river, including broodstock sources; this information is in the report but is quite difficult to extract for specific rivers. Stocking practices have varied markedly on U.S. rivers over time, and it would also have been useful to have had some explanation of the changes (if it exists), and/or an evaluation of them in the context of current best practice (e.g. as provided by NACSO).

Section 6 – Consideration as a 'species' under the ESA: This section begins by providing both biological and policy background to the determination of a 'species' under the ESA (Section 6.1). This sub-section might usefully have been included in the introduction (Section 2) as it sets the scene for the whole Status Review. The subsequent sub-sections are a little confusing. Section 6.2 begins with an evaluation of the ecological classification of the east coast region inhabited by Atlantic salmon. Even though the ecological classifications are far from unambiguous, the section proposes a determination of the DPS boundaries, although this depends upon referring forward to the biological information presented in Sections 6.2.1 to 6.2.3. Since stocks within the LIS and CEN areas appear to have been extirpated in the past, it is not clear why efforts are made to define these as DPSs. If this has a practical management function, it would have been useful to have had this explained.

Section 6.3 – Assessment of Gulf of Maine DPS: Since the assessment of the GOM DPS is central to the purpose of the report, it may have deserved a Section on its own. This section addresses the two key elements for defining the DPS, its discreteness and significance; the content is discussed in more detail below. There is a specific sub-section on the Penobscot population (Section 6.3.3) although it is not clear why this is addressed outside the discussions of 'discreteness' and 'significant', nor why the

Kennebec River, which was also only partly covered by the 2000 ESA listing, has not been given similar treatment; there appear to be many parallels between these two systems. The report might also have drawn on a wider range of examples demonstrating the survival of residual stock levels in rivers that have been impacted by pollution or obstructions, although it must be acknowledged that such reports are not always easy to obtain (e.g. Milner *et al*, 2004).

Section 7 – Current Distribution and Abundance: This section provides a simple summary of available data on recent measures of abundance of salmon in rivers within the GOM DPS. This section might logically have been linked with Section 4. It is not clear why the description of conservation spawning escapement (CSE) goals, which are more commonly referred to as Conservation Limits (CLs) in recent literature on Atlantic salmon, is included at the end of Section 7.1. This clearly deserves a sub-section on its own, possibly at the beginning of this section, thus providing the basis for the subsequent evaluation of stock status. There is also a need for more explanation of the key component of the CSE calculation, which is the target egg deposition of 2.4 eggs.m^{-2} needed to fully seed a river. This is based on studies by Elson (1975) in Canada, and may or may not be entirely appropriate to U.S. rivers. NASCO has also proposed that managers may wish to develop interim targets where stocks are well below CLs, and this may have deserved mention.

Section 8 – Listing Factor Analysis: This section considers the factors that may determine whether the DSP should be classed as endangered or threatened. This is a comprehensive section addressing a wide range of potential threats. The section is, quite reasonably, structured according to the 'status' criteria that may be used to determine whether a DPS is threatened or endangered, but this results in the section being somewhat repetitive (e.g. there are sections on 'Dams' in Sections 8.1.1.1, 8.1.2.2.1 and 8.3.1.2). In trying to embrace all possible impacts, the report might be seen as over-stating the potential problems. However, similar lists of threats might have been prepared for a number of salmon stocks in the North Atlantic (NASCO, 2003). There is little doubt about the potential for some of the factors cited (e.g. obstructions) to have significant impacts on stocks. Where factors are more difficult to pin down precisely, as in the case of diseases or diffuse pollution, the report provides a balanced account of potential threats based on a good selection of references, from the often very large body of literature available. There is an inevitable danger when presenting such lists of factors that they are seen as alternative explanations for the decline of stocks. In practice, it is likely that a large number of these factors are contributing to the current poor status of stocks, so the threats are not over-stated.

Section 9 – Conclusions: Although this section purportedly provides a 'conclusion' to the report, it actually only presents a very brief summary of the latter sections. It might have been simpler and clearer to include this within the Executive Summary.

5 The Endangered Species Act (ESA)

5.1 Purpose of the Act

The Endangered Species Act (1973 and as amended) (ESA) was one of a number of environmental laws passed in the United States in the 1970s in an attempt to halt or reverse the degradation of natural ecosystems. The act is designed to protect critically

imperilled species from extinction due to "the consequences of economic growth and development untempered by adequate concern and conservation." The stated purpose of the Act is not only to protect species, but also "… to provide a means whereby the ecosystems upon which endangered and threatened species depend may be conserved."

At the species level, the Act protects all plants and animals. It forbids federal agencies from authorizing, funding or carrying out actions that may jeopardize endangered species, and forbids anyone form harming or killing endangered animals without a permit. At the ecosystem level, the Act requires that endangered species be granted "critical habitats" which encompass all areas necessary for their recovery, and federal agencies are forbidden from allowing any action which "destroys or adversely modifies" a critical habitat area.

5.2 Criteria for listing a species under the ESA

The definition of 'species' within the ESA was amended in 1978 to read: '…any subspecies of fish, wildlife or plants, and any distinct population segment of any species of vertebrate fish or wildlife which interbreed when mature." Thus the term is not restricted to species as recognised in formal taxonomic terms but may include sub-species and, for vertebrate taxa, includes 'distinct population segments' (DPSs). This term is not routinely used in scientific literature. Its meaning within the ESA, has therefore been addressed and clarified by the Dept of Interior - FWS, & Department of Commerce – NOAA in the Policy Regarding the Recognition of Distinct Vertebrate Population Segments Under the Endangered Species Act (the "DPS Policy") (Anon, 1996). This document also clarifies the process for determining whether listing of a DPS may be warranted.

Three elements are considered in a decision regarding the status of a possible DPS as endangered or threatened under the Act:

a. The discreteness of the population segment in relation to the remainder of the species to which it belongs;

b. The significance of the population segment to the species to which it belongs; and

c. The population segment' conservation status in relation to the Act's standards for listing of being endangered or threatened.

In the context of this review, the 'species delineation' is understood to incorporate all three of these elements, and therefore include the definition of its limits as well as the determination of its qualities. These elements are applied in the same way whether a DPS is being considered for addition to the lists of endangered and threatened wildlife and plants, for reclassification, or for removal from the lists. They are spelled out in more detail below:

Discreteness: A population segment of a vertebrate species may be considered discrete if it satisfies either one of the following conditions:

a. It is markedly separated from other populations of the same taxon as a consequence of physical, physiological, ecological, or behavioural factors. Quantitative measures of genetic or morphological discontinuity may provide evidence of this separation.

b. It is delimited by international governmental boundaries within which differences in control of exploitation, management of habitat, conservation status, or regulatory mechanisms exist that are significant in light of section 4(a)(1)(D) of the Act.

Significance: If a population segment is considered discrete under one or both of the above conditions, its biological and ecological significance will then be considered. In carrying out this examination, the Services will consider available scientific evidence of the discrete population segment's importance to the taxon to which it belongs. This consideration may include, but is not limited to, the following:

a. Persistence of the discrete population segment in an ecological setting unusual or unique for the taxon;

b. Evidence that loss of the discrete population segment would result in a significant gap in the range of a taxon;

c. Evidence that the discrete population segment represents the only surviving natural occurrence of a taxon that may be more abundant elsewhere as an introduced population outside its historic range; or

d. Evidence that the discrete population segment differs markedly from other populations of the species in its genetic characteristics.

Status: If a population segment is discrete and significant (i.e. it satisfies the definition of a DPS), it may be determined to be threatened or endangered for any of the following reasons:

a. the present or threatened destruction, modification, or curtailment of its habitat or range;

b. over-utilization for commercial, recreational, scientific, or educational purposes;

c. disease or predation;

d. the inadequacy of existing regulatory mechanisms; and

e. other natural or manmade factors affecting its continued existence.

These criteria will therefore be examined in turn is considering the case presented in the Status Review.

6 Discreteness of East Coast DPSs for Atlantic salmon

The discreteness of putative DPSs for salmon is considered in Section 6 of the Status Review and is supported by evidence on the biological nature of salmon stocks in U.S. East Coast rivers in Section 3. The BRT has reviewed and updated the information relating to the three DPSs described in the 1999 Status Review, which were broadly defined as:

- Long Island Sound (LIS) - Houstinac, and Connecticut to Pawcatuck rivers
- Central New England (CEN) - Merrimack to Royal rivers
- Gulf of Maine (GOM) – Androscoggin to Dennys rivers.

The first criterion of the DPS Policy for the assessment of 'discreteness' calls for consideration of physical, physiological, ecological, or behavioural factors, and suggests the use of quantitative measures of genetic or morphological discontinuity.

6.1 Ecological classification

The Status Review has considered both freshwater and marine ecological information, to investigate and define DPS boundaries within the area inhabited by anadromous Atlantic salmon in east coast U.S. rivers, although the marine data have not been presented in any detail. The two principal ecosystem classification schemes employed by the previous BRT (Bailey 1995 and Maxwell *et al*, 1995) provide complementary approaches. The geographical approach (Bailey 1995) which is also called 'regionalisation' is a top-down method whereby the classifier begins with a large land area and splits it into smaller units with similar vegetation, landform, or other attributes (Dahms *et al*, 1997). This approach is complemented by the Hierarchical Framework of Aquatic Ecological Units (Maxwell *et al*., 1995), which provides a framework for classifying and mapping aquatic systems at various scales using ecologically significant physical and biological criteria.

However, as salmon stocks and populations are structured at the catchment and sub-catchment level, the BRT's decision to also consider Ecological Drainage Units (EDUs) (Olivero, 2003) is appropriate. EDUs delineate areas within a zoogeographic sub-region that correspond roughly with large watersheds and are likely to have a distinct set of freshwater assemblages and habitats associated with them. In conjunction with these approaches, the Status Review states that BRT examined a range of other ecological data, including aquifer structure, groundwater temperature, near-shore marine community structure; however these features are not discussed in any detail.

Not surprisingly, these approaches do not provide a single unambiguous classification of east coast rivers that is directly appropriate to Atlantic salmon. This is somewhat ambiguously presented in the Status Review (Section 6.2), because the conclusion that delineation of three DPSs, as proposed in the 1999 Status Review, remains largely appropriate depended upon the examination of biological data in subsequent sections of the report (see below).

6.2 Biological characteristics

The Status Review cites information from a range of sources on the historical distribution and abundance of Atlantic salmon in U.S. rivers (Sections 4 and 6.2). These all confirm that native stocks of salmon in the LIS and CEN DPSs became extinct in the 19th or early 20th Centuries, and the existing stocks are the result of restoration programmes rather than natural re-colonisation. These assessments do not appear to be in question, and the BRT has appropriately concluded that these DPSs should not be considered further for listing under the ESA (Section 6.2)

Further behavioural and genetic data on the river stocks have been examined to assess the discreteness of the GOM DPS. The Status Review correctly notes that one would not expect complete reproductive isolation of salmon river stocks, and indeed that the residual levels of straying between river and tributary populations help maintain genetic fitness and can significantly assist stock recovery.

The Status Review presents information on differences in life history characteristics to throw light on the stock structuring within the GOM DPS (Section 6.3.1). However, Atlantic salmon exhibits considerable life-cycle plasticity, particularly in characteristics such as river-age, sea-age and run-timing, and populations within a single catchment may vary quite markedly. The expression of such characteristics will be the result of both differences in the genetic make-up of the populations and their response to differing environmental conditions. This is particularly evident in hatchery stocks, which have a general tendency to produce younger smolts and younger returning adults than their progenerative wild stock. It is therefore difficult to draw conclusions from the biological characteristics alone, and the Status Review has referred also to genetic data in coming to their conclusions. The biological differences are nevertheless consistent with the Maine rivers comprising a DPS and being adapted to the particular freshwater and marine conditions that they must experience in this region.

6.3 Genetic differences

Rapid developments in genetic techniques in the past decade, in particular using microsatellite markers (e.g. King et al., 2001), have enabled far more detailed analysis of salmon population structures than was previously possible. Thus for example, European and North American salmon can now be distinguished with 100% accuracy using microsatellite markers. The BRT has examined the results of a number of new studies on U.S. and Canadian salmon stocks published since the 1999 Status Review. These studies have been at the forefront of genetic research on Atlantic salmon and certainly provide the best available assessment of the GOM DSP.

The genetic studies have included samples from anadromous salmon populations from U.S. and Canadian rivers, ranging from the Connecticut river in the south to the Sandhill River, Labrador in the north, collected between 1992 and 1998. Samples have also been analysed from landlocked salmon populations in Maine and from east coast aquaculture facilities.

Multidimensional scaling of genetic distance showed tight clustering for 11 of the Maine samples (Spidle ***et al.,*** 2003). This includes samples from four rivers/tributaries

that were not in the previous DPS delineation, namely: the main stem of the Penobscot River; one of its tributaries, the Kenduskeag Stream; and two tributaries of the Kennebec River, the Bond Brook and Togus Stream.

Salmon from another Penobscot tributary, Cove Brook, which was previously included with the GOM DPS, did not clearly fall within the 'two primary Maine clusters' described by Spidle *et al* (2003). Spidle *et al* also noted that these salmon clustered nearer to those from Newfoundland and Labrador than any other populations. However, the conclusions of Spidle *et al* are slightly ambiguous on the questions of whether Cove Brook is distinct from the Maine clusters, because they say both that, 'Outside these two primary clusters is the Penobscot tributary Cove Brook' but also that, 'Of the sites in the second cluster, Cove Brook has never been stocked'.

The Cove Brook fish were also unusual in exhibiting among the lowest genetic diversity (along with fish from the Kennebec River) but having a relatively high proportion of unique alleles (Spidle *et al.*, 2003). The Status Review cites a thesis by Lage (2005), which estimates that the measures of divergence for Cove Brook are consistent with a potential bottleneck event of 6 individuals, and simulated diversity measures are consistence with a bottleneck event of 9 individuals. These values are also consistent with both the estimate of Spidle ***et al*** (2003), that the annual number of effective breeders in Cove Brook was about 11 salmon, and the very low numbers of fish seen in the river in recent years (e.g. Anon, 2005). However, the sighting of only one salmon redd in Cove Brook since 1998, inevitably raises concern that the stock has been, or is on the verge of being, extirpated.

The St. Croix river has not been included within the GOM DPS because its wild salmon population is considered to have been extirpated and the river has been extensively stocked with fish from the Penobscot (Baum 1997). The genetic analysis included a sample collected in 1995 from Dennis Creek and showed the remnant stock to be more closely associated with a cluster of Canadian stocks than with the Maine stocks. Furthermore the population is now understood to be functionally extinct. It is therefore appropriate that this creek should be excluded from the GOM DPS, as previously, and the Dennys River should form its northern limit.

The genetic analysis therefore provides good evidence that the GOM DSP should be extended to include the main stem of the Penobscot River, above the site of the former Bangor Dam, and the upper tributaries of the Penobscot and Kennebec Rivers. However, it is also necessary to consider whether the discreteness of the GOM DPS reflects the survival of remnants of the original wild stocks or simply the results of the varied stocking that has been undertaken in these rivers. As this has been a contentious issue in the past, it probably deserves more attention within the Status Review and more consideration of the opposing views. The question has been addressed primarily in relation to the Penobscot River (Section 6.3.3), because there is more uncertainty about whether the native stock was completely extirpated as a result of the building of obstructions. The Status Review notes that it is not possible to firmly refute either of two hypotheses: that the Penobscot population was never completey lost; or the Penobscot population became functionally extinct and has been rebuilt through stocking from neighbouring systems. However, the Review provides three sound reasons why, in either case, this stock is biologically significant to the survival of the GOM DPS. It

is notable that there are other examples of salmon stocks apparently having been lost from large river systems, which have subsequently been demonstrated to have maintained a tenuous foothold for extended periods (e.g. Milner, 2004). Other genetics studies have also demonstrated that the introgression of new genetic material into stocked salmonid populations may be far less than might be expected from the scale of the stocking programmes.

Overall, the Status Review is justified in concluding from the genetic studies that despite extensive stocking with non-native hatchery fish, there is strong evidence that wild salmon in Maine are genetically distinct from Canadian salmon, as well as from European salmon. Furthermore, the extent and pattern of genetic variation within Maine rivers is similar to that seen in other wild salmon populations and suggests that these stocks do not simply reflect long periods of hatchery stocking.

6.4 International governmental boundaries

Under the second criterion of the DPS Policy, the discreteness of a DPS may be determined on the basis of international governmental boundaries, if they demark significant differences in control of exploitation, management of habitat, conservation status, or regulatory mechanisms. The northern limit of the proposed Golf of Maine DPS falls close to the US/Canadian border, and demarcation might be supportable on the basis of different management approaches, but this it is not considered necessary in this determination of 'discreteness' and is not pursued in the Status Review.

7 Significance of the GOM DPS

The four criteria relating to the significance of the GOM DPS are dealt with in Section 6.3.2 of the Status Review.

7.1 Persistence of the DPS in an ecological setting unusual or unique for the taxon

The first possible measure of 'significance' is that the DPS 'persists in an ecological setting unusual or unique for the taxon'. The Status Review suggests (Section 6.3.2.1) that the habitat occupied by the GOM DPS is unique because these waters are close to the southern limit of the current range of anadromous Atlantic salmon in North America. This is justified since these stocks are certainly likely to experience extreme environmental conditions within freshwater at these southern latitudes, and emigrating smolts and returning adult salmon will have to undertake longer migrations through less favourable marine environmental conditions than more northerly stocks.

The Status Review also notes that much of the freshwater habitat of the GOM DPS lies within a unique ecological setting of the Penobscot-Kennebec-Androscoggin Ecological Drainage Unit (Section 6.2.3), and the report provides evidence of the marked differences in habitat from more northerly areas, which is confirmed by the ecological classification studies. This habitat also differs markedly to that of more distant salmon stocks in Iceland and Europe (NASCO 2002).

Whether the ecological setting within which the GOM DPS persists can therefore be classified as truly 'unique' as stated in the Status Review is perhaps open to debate, but it nevertheless seems clear it is 'unusual', and it is probable that this has consequences for the genetic characteristics of salmon populations in this region. It is to be expected that stocks native to these streams will have become adapted to these conditions, and the genetic studies indicate that it is reasonable to believe that they have retained many of these characteristics despite heavy stocking programmes.

7.2 Evidence that the DPS would result in a significant gap in the range of a taxon

The Status Review concludes that the loss of the GOM DPS would result in a significant gap in the range of a taxon, because it represents the southernmost Atlantic salmon populations in the western Atlantic. The distribution of Atlantic salmon spans much of the North Atlantic from the U.S. rivers in the west, through Canada, Iceland, Scandinavia and the British Isles, to Spanish rivers in the east. Loss of the GOM DPS would represent a contraction of this range by several hundred kilometres, which would certainly constitute a significant change in the geographic distribution of the species around the North Atlantic.

While the plasticity of Atlantic salmon has enabled populations to successfully colonise rivers over a wide latitudinal range of the North Atlantic, this adaptability depends in part on maintaining genetic diversity. In this context, populations with, for example, adaptations to more southerly conditions may retain distinct genetic characteristics. With increasing impacts of climate change, it is conceivable that the introgression of such genetic characteristics into more northerly stocks through the low levels of staying between populations may become important to their continued survival. [In this context it is reasonable to ignore the restored stocks in the LIS and CEN DPSs, which will not possess the adapted characteristics of the original southern stocks.]

7.3 Evidence that the DPS represents the only surviving natural occurrence of a taxon within its historic range

The Status Review presents no information in relation to the third significance criterion, which would require evidence that the GOM DPS represents the only surviving natural occurrence of a taxon that may be more abundant elsewhere as an introduced population outside its historic range. This is clearly not the case.

7.4 Evidence that the discrete population segment differs markedly from other populations of the species in its genetic characteristics

The BRT has utilised the latest genetic data available on a substantial proportion of the U.S. stocks (e.g. Spidle et al 2003). The genetic analysis, which has been discussed above, has confirmed that the GOM DPS differs markedly from European salmon and other populations of North American Atlantic salmon in its genetic characteristics. Furthermore the pattern and extent of genetic variation is consistent with the stocks retaining substantial proportions of the original Maine characteristics and do not appear to be simply the result of creating new populations through stocking.

8 Status of the GOM DPS

Having established that the GOM DPS is both 'discrete' and 'significant', the Status Review considers its status in the context of the five status criteria. This is discussed in Section 8 of the Status Review and is supported by information elsewhere in the document (Sections 3 – 5).

8.1 Destruction, modification, or curtailment of habitat

The Status Review presents extensive information demonstrating 'present or threatened destruction, modification, or curtailment' of the GOM DPS's habitat or range. The factors they cite include dams and obstructions, water quality, water abstraction, sedimentation, land use, and habitat complexity and connectivity. Such factors have caused the decline or loss of salmon in many parts of the North Atlantic (NASCO, 2002), and there is a large body of literature confirming their potentially damaging effects. Two of the greatest problems for the GOM DPS are likely to have been obstructions and water quality.

Obstructions to the free upstream and downstream movement of salmon are likely to have been a particular problem, and fish passes are often less than 100% effective, particularly for obstructions sited in tidal waters. The Status Review correctly notes: the wide array of obstructions, from simple road culverts to hydropower dams, which may adversely affect salmon stocks in the GOM DPS; the additional mortalities arising from passage of both juveniles and adults through hydro-power turbines, including subsequent losses due to predation; and the cumulative effects of large numbers of obstructions in a system.

Recent studies, cited in the Status Review, have demonstrated that contaminants may also have a range of effects on salmon. While initial concerns are for direct lethal impacts, there is growing evidence of the range of ways in which salmon may be affected by low levels of diffuse contaminants.

The impacts of many of these factors can be critical and the Status Review is justified in concluding that their combined effects can certainly present a serious threat to the survival of the stocks.

8.2 Over-utilization for commercial, recreational, scientific, or educational purposes;

The Status Review describes the range of ways in which direct exploitation of U.S. salmon is being minimised. Currently no recreational or commercial fisheries for anadromous Atlantic salmon are permitted in the U.S. other than by the Penobscot Indian Nations (PIN) for sustenance purposes. Furthermore, the PIN has developed its own system for regulating the sustenance fishery and, recognising the depleted condition of the stock, has allowed no fish to be killed since 1988.

Salmon from U.S. rivers have been taken in several fisheries outside the U.S. EEZ, including fisheries on the West coast of Greenland, around the Islands of St.Pierre et Miquelon, and on the Labrador coast, which are all still operating. These fisheries all

exploit a mixture of river stocks from more than one country, and while the exploitation rate of U.S. salmon is expected to be low, they make the management of individual river stocks more difficult and pose particular risks to the weakest stocks (ICES, 2005). These fisheries are discussed by NASCO, and the NASCO Convention provides a mechanism 'to propose regulatory measures for salmon fisheries under the jurisdiction of one member which harvests amounts of salmon significant to another Party in whose rivers that salmon originates.' (NASCO, 2000)

The requirement to base management, such as under the ESA, upon best available scientific information presents a potential conflict while stocks are in a severely depleted condition. There is clearly a desire to minimise mortalities within these stocks, but it is never possible to guarantee that fish will not be killed by experimental procedures, and some studies may require the sacrifice of individuals for examination (e.g. for parasites). The Status Review indicates that some mortalities do occur during assessment studies and other research, but that these are kept to a minimum and some of the losses may be compensatory. It is difficult to be certain about the extent of compensatory mechanisms, however, it is to be expected that they will have maximum effects in stocks that are a severely depleted as those in question here. Clearly it is important that all experimental studies are kept under close review and procedures terminated or modified if unacceptable mortalities are observed.

The Status Review describes a number of education programmes, but notes that these only use eggs or fish from restoration programmes after the numbers required for the recovery programmes have been accounted for. The Status Review is thus justified in concluding that any mortalities would not therefore be considered to be a problem. Educational programmes such as these have been shown to increase the awareness of children to environmental issues and to improve their attitude to the conservation of natural resources. They may therefore play an important role in the recovery of stocks within the DPS, and so the benefits are likely to outweigh any minor threats.

8.3 Disease or predation

The Status Review describes a wide array of diseases and parasites that could potentially affect the GOM DPS (Section 8.3.2). There remains considerable uncertainty about whether many of these cause significant mortalities other than in the unnaturally crowded and stressed conditions of aquaculture facilities, although there are on-going debates about the extent to which wild fish may be infected with diseases or parasites from fish in aquaculture facilities or *vice-versa*. Nevertheless, there are well documented accounts of stocks being severely depleted by diseases such as Ulcerative Dermal Necrosis (UDN) (Roberts et al 1970), and the parasite *Gyrodactilus salaris* currently presents one of the greatest threats to stocks in parts of the North East Atlantic (NASCO, 2002).

Clearly, the use of stocking programmes presents an additional potential threat to wild stocks, and the Status Review notes the measures taken to screen hatchery stocks for a wide array of pathogens.

Salmon are preyed upon by a variety of other species throughout their life cycles, and the impact of these predators has long been a contentious issue in salmon management

(NASCO, 1996). Predator-prey relationships are frequently very complex and will certainly be influenced by a range of factors. The Status Review presents evidence to suggest that Maine salmon may be eaten by a wide range of predators, including a number of introduced species, and that predation levels may have been exacerbated by other factors, such as the presence of hydro-power dams.

8.4 Inadequacy of existing regulatory mechanisms

Section 8.4 provides details of a large number of international, national and state treaties and agreements affecting Atlantic salmon originating in the GOM DPS. These are comprehensive and provide wide-ranging powers to protect this resource. However Section 8.4.4 summarises many of the inadequacies in the application or implementation of these measures and the consequent effects on stocks. Many of these issues relate back to options for controlling the factors affecting fish passage, the quantity and quality of the water flowing in the rivers, and the control of fishing and aquaculture.

8.5 Other natural or manmade factors affecting the continued existence of the DPS.

Section 8.5 of the Status Review examines others factors affecting the continued existence of the GOM DPS and notes in particular the potential impacts of artificial propagation, aquaculture, changes in the marine environment, and factors affecting ecosystem function. While there may be uncertainly about the potential mechanisms or processes (e.g. causing reduced marine survival), the potential effects of these factors on Atlantic salmon have been well documented and it is likely that they pose significant problems to U.S. stocks.

9 Conclusions

The Terms of Reference for this review pose four questions that are addressed individually below.

9.1 Is the species delineation supported by the information presented?

The Status Review presents a substantial body of information which satisfactorily supports the view that: (a) the wild salmon populations in the Dennys, East Machias, Machias, Pleasant, Narraguagus, Penobscot, Sheepscot, Ducktrap, and Kennebec Rivers (including the tributaries of the Penobscot and Kennebec Rivers) constitute a population segment of salmon that may be considered ‘discrete’; (b) this DSP is both biologically and ecologically ‘significant’; and (c) the current status of the DPS is severely depleted and declining, and this may be accounted for by a range of natural and man-made factors.

The Status Review makes no specific recommendation to the Services regarding the listing of the DPS under the ESA, which is also not called for in this review.

9.2 Does the Status Review include and cite the best scientific and commercial information available on the species and threats to it and to its habitat?

The Status Review cites a wide range of scientific literature that illustrates many of the points discussed. Potential and actual threats to the freshwater habitat of salmon are described in detail and are supported by a range of suitable references. While there is a bias towards North American literature in the report, this is not inappropriate since the context of the factors affecting U.S. salmon are strongly dictated by the nature of the local ecosystems and environment, and the local regulatory framework and controls. It is almost inevitable that other references can be identified that might shed further light on the issues discussed (see above), but overall these omissions do not detract significantly from the conclusions of the Status Review. Little commercial information is cited, but such information would not generally be relevant to this review.

9.3 Are the scientific conclusions sound and derived logically from the results?

The conclusions to the Status Review, as presented in Section 9, are extremely brief and relate simply to the classification of the GOM DPS as a 'species' under the ESA and a description of the threats it faces. These conclusions are sound and reasonable, although it must be noted that some elements of the evaluation of the genetic data cannot (and probably will never) provide incontrovertible proof.

Parts of the report could have been presented in a clearer and more logical fashion, and areas where particular improvements could have been made are discussed above.

9.4 Where available, are opposing scientific studies or theories acknowledged and discussed?

The most uncertain element of the delineation, and the part that has been particularly important in previous decisions on listing of the GOM DPS under the ESA, relates to the analysis of genetic data on U.S. salmon. The extent of the previous debate on this issue was not immediately apparent from the Status Review, and this deserved greater attention. There is a clear uncertainty about the relative role of different factors impinging on the GOM DPS, but the Status Review does not attempt to draw unreasonable conclusions on the precise causes of current stock declines.

APPENDIX 1. BIBLIOGRAPHY

Materials provided by the Center of Independent Experts

The CIE provided, by internet access, a copy of the report to be reviewed:

Fay, C., M.Bartron, S.Craig, A Hecht, J Pruden, R.Saunders, T.Sheehan, and J. Trial (2006) Status Review for Anadromous Atlantic Salmon (***Salmo salar***) in the United States. Report to the National Marine Fisheries Service and US Fish and Wildlife Service. 283pp.

The CIE also provided access to pdf's of a substantial proportion of the documents cited in the above review, as well as:

Annual Reports of the U.S. Atlantic Salmon Assessment Committee Reports 11, 12, 14, 15, 16 and 17, relating to activities in the years 1997 through 2004 respectively.

Legualt, C.M. (2005) Population Viability Analysis of Atlantic salmon in Maine, USA. Transactions of the American Fisheries Society 134: 549-562

Additional material used in the review:

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NASCO (2005) Strategic Approach for NASCO's 'Next Steps' CNL(05)49. 9 pp.

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Oliviero, A.P. (2003) Planning meyhods fopr ecoregional targets: freshwater aquatic ecosystems and networks. The Nature Conservancy, Conservation Science Support, Northeast and Carribean Divuision. Boston, MA. 55 pp.

Roberts, R.J., W. M. Shearer, A. L. S. Munro and K. G. R. Elson (1970) Studies on ulcerative dermal necrosis of salmonids II. The sequential pathology of the lesions Journal of Fish Biology 2(4) p.373

APPENDIX 2. STATEMENT OF WORK

Consulting agreement between the University of Miami and Ted Potter

April 24, 2006

Atlantic salmon status review

Background

The purpose of this technical review is to ensure that the scientific information presented and analyzed in the Status Review for Atlantic salmon in the United States is the best available scientific data.

On November 17, 2000, the National Marine Fisheries Service and the U.S. Fish and Wildlife Service (the Services) issued a final rule to list the Gulf of Maine Distinct Population Segment of Atlantic Salmon (GOM DPS) as endangered under the Endangered Species Act (ESA). The GOM DPS was defined as all naturally reproducing wild populations of Atlantic salmon, having historical river-specific characteristics found north of and including tributaries of the lower Kennebec River to, but not including the mouth of the St. Croix River at the United States-Canada border and the Penobscot River above the site of the former Bangor Dam. Populations which met these criteria were identified as being in the following rivers: Dennys, East Machias, Machias, Pleasant, Narraguagus, Sheepscot, Ducktrap, and Cove Brook.

In the final rule listing the GOM DPS, the Services deferred the determination of inclusion of fish that inhabit the main stem and tributaries of the Penobscot River above the site of the former Bangor Dam. The deferred decision reflected the need for further analysis of scientific information, including a detailed genetic characterization of the Penobscot population. In addition, the Services were committed to reviewing data regarding the appropriateness of including the upper Kennebec and other rivers as part of the DPS. In late 2003, the Services assembled a Biological Review Team (BRT) comprised of biologists from the Maine Atlantic Salmon Commission, Penobscot Indian Nation, NMFS, and USFWS. The BRT was charged with reviewing and evaluating all relevant scientific information necessary to evaluate the current DPS delineations and determining the conservation status of the populations that were deferred in 2000 and their relationship to the currently listed GOM DPS.

NOAA Fisheries is required to use the best available scientific and commercial data in making determinations and decisions under the ESA. The first question that must be addressed is what the appropriate species delineation is for consideration of conservation status. The ESA defines an endangered species as “any species which is in danger of extinction throughout all or a significant portion of its range,” and a threatened species as “any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.” A species may be determined to be threatened or endangered due to any one of the following factors:

(1) the present or threatened destruction, modification, or curtailment of its habitat or range;
(2) overutilization for commercial, recreational, scientific or educational purpose;
(3) disease or predation;
(4) the inadequacy of existing regulatory mechanisms; and
(5) other natural or manmade factors affecting its continued existence.

The scientific and commercial information contained in the Status Review will likely contain essential factual elements upon which the agency could base its ESA determination. Accordingly, it is critical that the Status Review contain the best available information on the species and the threats, that all relevant information is identified and included, and that all scientific findings be both reasonable, and supported by valid information contained in the document.

Objectives of the CIE Review

As stated above, the Status Review has been prepared by the BRT. The Center for Independent Experts (CIE) shall review the Status Review Report to ensure that its contents can be factually supported and that the methodology and conclusions are scientifically valid.

There are several primary issues related to this species that must be addressed, and, therefore, reviewers with the following expertise are required to ensure the best available information has been utilized:

1. Life history and population dynamics of Atlantic salmon;
2. Atlantic salmon genetic, physiological, behavioral, and/or morphological variation throughout the species' range;
3. Habitat requirements;
4. Predation and disease;
5. Regulatory mechanisms for managing the species;
6. Other natural or manmade impacts affecting Atlantic salmon;
7. Aquaculture; and
8. Conservation actions including restoration efforts and recovery activities (including the conservation hatchery program).

Familiarity with ESA is also highly desirable. Each reviewer will be supplied with the Status Review Report prepared by the BRT. Any of the reports and papers cited in the Status Review Report will be made available to the reviewers upon their request.

Specific terms of reference for the CIE review:

a. Is the species delineation supported by the information presented?
b. Does the Status Review include and cite the best scientific and commercial information available on the species and threats to it and to its habitat?

c. Are the scientific conclusions sound and derived logically from the results?
d. Where available, are opposing scientific studies or theories acknowledged and discussed?

Specific Activities and Responsibilities

The CIE shall provide four reviewers to conduct a letter review of the Status Review Report. Each reviewer's duties shall not exceed a maximum of five work days. Each reviewer shall analyze the Status Review Report and develop their report in response to the above terms of reference. The reviewers shall conduct their analyses and writing duties from their primary locations. Each written report is to be based on the individual reviewer's findings, and no consensus report shall be accepted. See Annex I for additional details on the report outline.

No later than May 15, 2006, each reviewer's report shall be submitted to the CIE for review[1]. The reports shall be sent to Dr. David Sampson, via email at david.sampson@oregonstate.edu, and to Mr. Manoj Shivlani, via email at mshivlani@rsmas.miami.edu.

[1] Each written report will undergo an internal CIE review before it is considered final.