NMFS NATIONAL GRAVEL EXTRACTION POLICY
NATIONAL MARINE FISHERIES SERVICE

I. INTRODUCTION

The National Marine Fisheries Service (NMFS) is responsible for protecting, managing and conserving marine, estuarine, and anadromous fish resources and their habitats. A national policy on gravel extraction is necessary because extraction in and near anadromous fish streams causes many adverse impacts to fishes and their habitats. These impacts include: loss or degradation of spawning beds and juvenile rearing habitat; migration blockages; channel widening, shallowing, and ponding; loss of hydrologic and channel stability; loss of pool/riffle structure; increased turbidity and sediment transport; increased bank erosion and/or stream bed downcutting; and loss or degradation of riparian habitat.

The objective of the NMFS Gravel Policy is to ensure that gravel extraction operations are conducted in a manner that eliminates or minimizes to the greatest extent possible any adverse impacts to anadromous fishes and their habitats. Gravel extraction operations should not interfere with anadromous fish migration, spawning, or rearing, nor should they be allowed within, upstream, or downstream of anadromous fish spawning grounds. The intent is to conserve and protect existing viable anadromous fish habitat and historic habitat that is restorable. Individual gravel extraction operations must be judged in the context of their spatial and temporal cumulative impacts; i.e., potential impacts to habitat should be viewed from a watershed management perspective.

The U.S. Army Corps of Engineers may require a permit for dredge and fill operations and other activities associated with gravel extraction projects under Sections 401 and 404 of the Clean Water Act, and/or Section 10 of the Rivers and Harbors Act of 1899. Under the Fish and Wildlife Coordination Act, NMFS reviews Section 10 or Section 404 permit applications for environmental impacts to anadromous, estuarine, and marine fisheries and their habitats. Gravel extraction projects not subject to Section 404 or Section 10 permits may still be reviewed by NMFS pursuant to the applicable County/State public hearing processes. The Magnuson Fishery Conservation and Management Act also addresses the effects which changes to habitat may have upon a fishery. None of the recommendations presented in this document are intended to supersede these regulations or any other laws, such as the Endangered Species Act. Rather, the policy's recommendations are intended as guidance for NMFS personnel who are involved in the review of gravel extraction projects. (See Appendix 1 for summaries of the relevant statutes.)

This Gravel Policy is subject to comprehensive biennial review and revision that will be initiated and coordinated by the Office of Habitat Conservation. Requests for specific changes or revisions requiring immediate attention should be brought to the attention of Stephen M. Waste, NMFS's Office of Habitat Conservation in Silver Spring, Maryland.

II. SCOPE OF GRAVEL POLICY

The types of gravel extraction activities referred to in this Gravel Policy generally entail commercial gravel mining; i.e., removing or obtaining a supply of gravel for industrial uses, such as road construction material, concrete aggregate, fill, and landscaping. Gravel can also be removed for maintenance dredging and flood control. Gravel extraction often occurs at multiple times and at multiple sites along a given stream, resulting in impacts that are likely to be both chronic and cumulative. When the rate of gravel extraction exceeds the rate of natural deposition over an extended time period, a net "mining" occurs due to the cumulative loss of gravel (Oregon Water Resources Research Institute [OWRRI] 1995).

The range of anadromous fish habitats specifically addressed by this Gravel Policy includes tidal rivers, freshwater rivers and streams, and their associated wetlands and riparian zones. Gravel extraction is a major and longstanding activity in rivers and streams, particularly in salmonid habitats on the west coast of the United States, including Alaska. Gravel extraction, as well as sand mining and dredging, also occurs on the northeast coast of the United States, but primarily in marine habitats such as the lower reaches of large tidal rivers, estuaries and offshore. Gravel and sand mining or dredging in the northeast generally raises different concerns than for the west coast. For example, few of the anadromous species found in the northeastern United States are bottom spawners or rely on specific habitat for their reproductive activities. Although many elements of the Gravel Policy are germane to all areas where gravel extraction occurs, the primary focus of this Policy is on west coast gravel extraction issues.

Northeast coast bottom disturbance activities will be addressed in greater detail in a future policy. This Gravel Policy addresses three types of instream gravel mining, which Kondolf (1993; 1994a) describes as follows: dry-pit and wet-pit mining in the active channel, and bar skimming or "scalping." Dry-pit refers to pits excavated on dry ephemeral stream beds and exposed bars with conventional bulldozers, scrapers, and loaders. Wet-pit mining involves the use of a dragline or hydraulic excavator to remove gravel from below the water table or in a perennial stream channel. Bar skimming or scalping requires scraping off the top layer from a gravel bar without excavating below the summer water level.

In addition to instream gravel mining, this Policy also addresses another method, which Kondolf (1993; 1994a) describes as the excavation of pits on the adjacent floodplain or river terraces. Dry pits are located above the water table. Wet pits are below, depending on the elevation of the floodplain or terrace relative to the base flow water elevation of the channel. Their isolation from an adjacent active channel may be only short term. During a sudden change in channel course during a flood, or as part of gradual migration, small levees may be breached and the channel will shift into the gravel pits. Because floodplain pits can become integrated into the active channel, Kondolf (1993; 1994a) suggests that they should be regarded as existing instream if considered on a time scale of decades.

III. ENVIRONMENTAL EFFECTS OF GRAVEL EXTRACTION

Extraction of alluvial material from within or near a stream bed has a direct impact on the stream's physical habitat parameters such as channel geometry, bed elevation, substrate composition and stability, instream roughness elements (large woody debris, boulders, etc.) depth, velocity, turbidity, sediment transport, stream discharge and temperature (Rundquist 1980; Pauley et al. 1989; Kondolf 1994a, b; OWRRI 1995). OWRRI, (1995) states that:

Channel hydraulics, sediment transport, and morphology are directly affected by human activities such as gravel mining and bank erosion control. The immediate and direct effects are to reshape the boundary, either by removing or adding materials. The subsequent effects are to alter the flow hydraulics when water levels rise and inundate the altered features. This can lead to shifts in flow patterns and patterns of sediment transport. Local effects also lead to upstream and downstream effects.

Altering these habitat parameters has deleterious impacts on instream biota and the associated riparian habitat (Sandecki, 1989). For example, impacts to anadromous fish populations due to gravel extraction include: reduced fish populations in the disturbed area, replacement of one species by another, replacement of one age group by another, or a shift in the species and age distributions (Moulton, 1980). In general terms, Rivier and Seguier (1985) suggest that the detrimental effects to biota resulting from bed material mining are caused by two main processes: (1) alteration of the flow patterns resulting from modification of the river bed, and (2) an excess of suspended sediment. OWRRI (1995) adds:

Disturbance activities can disrupt the ecological continuum in many ways. Local channel changes can propagate upstream or downstream and can trigger lateral changes as well. Alterations of the riparian zone can allow changes in-channel [sic] conditions that can impact aquatic ecosystems as much as some in-channel [sic] activities.

One consequence of the interconnectedness of channels and riparian systems is that potential disruptions of the riparian zone must be evaluated when channel activities are being evaluated. For example, aggregate mining involves the channel and boundary but requires land access and material storage that could adversely affect riparian zones; bank protection works are likely to influence riparian systems beyond the immediate work area.

The potential effects of gravel extraction activities on stream morphology, riparian habitat, and anadromous fishes and their habitats are summarized as follows:

1. Extraction of bed material in excess of natural replenishment by upstream transport causes bed degradation. This is partly because gravel “armors" the bed, stabilizing banks and bars, whereas removing this gravel causes excessive scour and sediment movement (Lagasse et al. 1980; OWRRI, 1995). Degradation can extend upstream and downstream of an individual extraction operation, often at great distances, and can result from bed mining either in or above the low-water channel (Collins and Dunne 1990; Kondolf 1994a, b; OWRRI, 1995).

Headcutting, erosion, increased velocities and concentrated flows can occur upstream of the extraction site due to a steepened river gradient (OWRRI, 1995). Degradation can deplete the entire depth of gravel on a channel bed, exposing other substrates that may underlie the gravel, which would reduce the amount of usable anadromous spawning habitat (Collins and Dunne, 1990; Kondolf, 1994a; OWRRI, 1995). For example, gravel removal from bars may cause downstream bar erosion if they subsequently receive less bed material from upstream than is being carried away by fluvial transport (Collins and Dunne, 1990). Thus, gravel removal not only impacts the extraction site, but may reduce gravel delivery to downstream spawning areas (Pauley et al., 1989).

2. Gravel extraction increases suspended sediment, sediment transport, water turbidity and gravel siltation (OWRRI, 1995). The most significant change in the sediment size distribution resulting from gravel removal is a decrease in sediment size caused by fine material deposition into the site (Rundquist, 1980). Fine sediments in particular are detrimental to incubating fish eggs as blockage of interstitial spaces by silt prevents oxygenated water from reaching the eggs and removal of waste metabolites (Chapman, 1988; Reiser and White, 1988). High silt loads may also inhibit larval, juvenile and adult behavior, migration, or spawning (Snyder, 1959; Cordone and Kelly, 1961; Bisson and Bilby 1982; Bjornn and Reiser, 1991; OWRRI, 1995). Siltation, substrate disturbances and increased turbidity also affect the invertebrate food sources of anadromous fishes (OWRRI, 1995).

3. Bed degradation changes the morphology of the channel (Moulton, 1980; Rundquist, 1980; Collins and Dunne, 1990; Kondolf, 1994a,b; OWRRI, 1995). Gravel extraction causes a diversion or a high potential for diversion of flow through the gravel removal site (Rundquist, 1980). Mined areas that show decreased depth or surface flow could result in migration blockages during low flows (Moulton, 1980). This may compound problems in many areas where flows may already have been altered by hydropower operations and irrigation. Even if the gravel extraction activity is conducted away from the active river channel during low water periods, substrate stability and channel morphology outside the excavated area's perimeter could be affected during subsequent high water events. As active channels naturally meander, the channel may migrate into the excavated area. Also, ponded water isolated from the main channel may strand or entrap fish carried there during high water events (Moulton, 1980; Palmisano, 1993). Fish in these ponded areas could experience higher temperatures, lower dissolved oxygen, and increased predation compared to fish in the main channel, desiccation if the area dries out, and freezing (Moulton, 1980).

4. Gravel bar skimming significantly impacts aquatic habitat. First, bar skimming creates a wide flat cross section, then eliminates confinement of the low flow channel, and results in a thin sheet of water at baseflow (Kondolf, 1994a.) Bar skimming can also remove the gravel "pavement," leaving the finer subsurface particles vulnerable to entrainment (erosion) at lower flows (Kondolf, 1994a; OWRRI, 1995). A related effect is that bar skimming lowers the overall elevation of the bar surface and may reduce the threshold water discharge at which sediment transport occurs (OWRRI, 1995). Salmon redds (nests) downstream are thus susceptible to deposition of displaced, surplus alluvial material, resulting in egg suffocation or suppressed salmon fry emergence, while redds upstream of scalped bars are vulnerable to regressive erosion (Pauley et al., 1989). Gravel bar skimming also appears to reduce the amount of side channel areas, which can result in the reduction and/or displacement of juvenile salmonid fishes that use this habitat (Pauley et al., 1989).

5. Operation of heavy equipment in the channel bed can directly destroy spawning habitat, and produce increased turbidity and suspended sediment downstream (Forshage and Carter, 1973; Kondolf, 1994a). Additional disturbances to redd may occur from increased foot and vehicle access to spawning sites, due to access created initially for gravel extraction purposes (OWRRI, 1995).

6. Stockpiles and overburden left in the floodplain can alter channel hydraulics during high flows. During high water, the presence of stock piles and overburden can cause fish blockage or entrapment, and fine material and organic debris may be introduced into the water, resulting in downstream sedimentation (Follman, 1980).

7. Removal or disturbance of instream roughness elements during gravel extraction activities negatively affects both quality and quantity of anadromous fish habitat. Instream roughness elements, particularly large woody debris, play a major role in providing structural integrity to the stream ecosystem and providing critical habitat for salmonids (Koski, 1992; Naiman et al., 1992; Franklin et al., 1995; Murphy, 1995; OWRRI, 1995). These elements are important in controlling channel morphology and stream hydraulics, in regulating the storage of sediments, gravel and particulate organic matter, and in creating and maintaining habitat diversity and complexity (Franklin, 1992; Koski, 1992; Murphy, 1995; OWRRI, 1995). Large woody debris in streams creates pools and backwaters that salmonids use as foraging sites, critical over wintering areas, refuges from predation, and spawning and rearing habitat (Koski, 1992; OWRRI, 1995). Large wood jams at the head of gravel bars can anchor the bar and increase gravel recruitment behind the jam (OWRRI, 1995). Loss of large woody debris from gravel bars can also negatively impact aquatic habitat (Weigand, 1991; OWRRI, 1995). The importance of large woody debris has been well documented, and its removal results in an immediate decline in salmonid abundance (e.g., see citations in Koski, 1992; Franklin et al., 1995; Murphy, 1995; OWRRI, 1995).

8. Destruction of the riparian zone during gravel extraction operations can have multiple deleterious effects on anadromous fish habitat. The importance of riparian habitat to anadromous fishes should not be underestimated. For example, a Koski (1992) state that a stream's carrying capacity to produce salmonids is controlled by the structure and function of the riparian zone. The riparian zone includes stream banks, riparian vegetation and vegetative cover. Damaging any one of these elements can cause stream bank destabilization, resulting in increased erosion, sediment and nutrient inputs, and reduced shading and bank cover leading to increased stream temperatures. Destruction of riparian trees also means a decrease in the supply of large woody debris. This results in a loss of instream habitat diversity caused by removing the source of materials responsible for creating pools and riffles, which are critical for anadromous fish growth and survival, as outlined in Number 7, above (Koski, 1992; Murphy, 1995; OWRRI, 1995).

Gravel extraction activities can damage the riparian zone in several ways:

a. If the floodplain aquifer discharges into the stream, groundwater levels can be lowered because of channel degradation. Lowering the water table can destroy riparian vegetation (Collins and Dunne, 1990).
b. Long-term loss of riparian vegetation can occur when gravel is removed to depths that result in permanent flooding or ponded water. Also, loss of vegetation occurs when gravel removal results in a significant shift of the river channel that subsequently causes annual or frequent flooding into the disturbed site (Joyce, 1980).
c. Heavy equipment, processing plants and gravel stockpiles at or near the extraction site can destroy riparian vegetation (Joyce, 1980; Kondolf, 1994a; OWRRI, 1995). Heavy equipment also causes soil compaction, thereby increasing erosion by reducing soil infiltration and causing overland flow. In addition, roads, road building, road dirt and dust, and temporary bridges can also impact the riparian zone.
d. Removal of large woody debris from the riparian zone during gravel extraction activities negatively affects the plant community (Weigand, 1991; OWRRI, 1995). Large woody debris is important in protecting and enhancing recovering vegetation in streamside areas (Franklin et al., 1995; OWRRI, 1995).
e. Rapid bed degradation may induce bank collapse and erosion by increasing the heights of banks (Collins and Dunne, 1990; Kondolf, 1994a).
f. Portions of incised or undercut banks may be removed during gravel extraction, resulting in reduced vegetative bank cover, causing reduced shading and increased water temperatures (Moulton, 1980).
g. Banks may be scraped to remove "overburden" to reach the gravel below. This may result in destabilized banks and increased sediment inputs (Moulton, 1980).
h. The reduction in size or height of bars can cause adjacent banks to erode more rapidly or to stabilize, depending on how much gravel is removed, the distribution of removal, and on the geometry of the particular bed (Collins and Dunne, 1990).

IV. RECOMMENDATIONS

The following recommendations should not be regarded as static or inflexible. The recommendations are meant to be revised as the science upon which they are based improves and areas of uncertainty are resolved. Furthermore, the recommendations are meant to be adapted for regional or local use (e.g., Alaska often has opportunities to comment through their State coastal management programs), so a degree of flexibility in their interpretation and application is necessary.

1. Abandoned stream channels on terraces and inactive floodplain should be used preferentially to active channels, their deltas and floodplain. Gravel extraction sites should be situated outside the active floodplain and the gravel should not be excavated from below the water table. In other words, dry-pit mining on terraces or floodplain is preferable to any of the alternatives, in particular, wet-pit mining instream, but also bar skimming and wet-pit mining in the floodplain. In addition, operators should not divert streams to create an inactive channel for gravel extraction purposes, and formation of isolated ponded areas that cause fish entrapment should be avoided. Also, all gravel extraction activities for a single project should be located on the same side of the floodplain. This will eliminate the need for crossing active channels with heavy equipment.

2. Larger rivers and streams should be used preferentially to small rivers and streams. Larger systems are preferable because they have more gravel and a wider floodplain, and the proportionally smaller disturbance in large systems will reduce the overall impact of gravel extraction (Follman, 1980). On a smaller river or stream, the location of the extraction site is more critical because of the limited availability of exposed gravel deposits and the relatively narrower floodplain (Follman, 1980).

3. Braided river systems should be used preferentially to other river systems. The other systems, listed in the order of increasing sensitivity to physical changes caused by gravel extraction activities, are: split, meandering, sinuous, and straight (Rundquist, 1980). Because braided river systems are dynamic and channel shifting is a frequent occurrence, theoretically, channel shifting resulting from gravel extraction might have less of an overall impact because it is analogous to a naturally occurring process (Follman 1980). In addition, floodplain width progressively decreases in the aforementioned series of river systems. If gravel extraction is to occur in the adjacent floodplain, it is likely that the other four river system types will experience greater environmental impacts than the braided river system (Follman, 1980).

4. Gravel removal quantities should be strictly limited so that gravel recruitment and accumulation rates are sufficient to avoid extended impacts on channel morphology and anadromous fish habitat. While this is conceptually simple, annual gravel recruitment to a particular site is, in fact, highly variable and not well understood. (Recruitment is the rate at which bedload is supplied from upstream to replace the extracted material.) Kondolf (1993; 1994b) dismisses the common belief that instream gravel extraction can be conducted safely so long as the rate of extraction does not exceed the rate of replenishment. Kondolf (1993; 1994b) states that this approach to managing instream gravel extraction is flawed because it fails to account for the upstream/downstream erosional effects that change the channel morphology as soon as gravel extraction begins. In addition, Kondolf (1993; 1994b) reiterates that flow and sediment transport for most rivers and streams is highly variable from year-to-year, thus an annual average rate may be meaningless. An "annual average deposition rate" could bear little relation to the sediment transport regimes in a river in any given year. Moreover, sediment transport processes are very difficult to model, so estimates of bedload transport may prove unreliable. These problems and uncertainties indicate a need for further research.

5. Gravel bar skimming should only be allowed under restricted conditions. (See Section III, Number 4, for the environmental impacts of gravel bar skimming.) Gravel should be removed only during low flows and from above the low-flow water level. Berms and buffer strips must be used to control stream flow away from the site. The final grading of the gravel bar should not significantly alter the flow characteristics of the river during periods of high flows (OWRRI, 1995). Finally, bar skimming operations need to be monitored to ensure that they are not adversely affecting gravel recruitment downstream or the stream morphology either upstream or downstream of the site. If the stream or river has a recent history of rapidly eroding bars or stream bed lowering, bar skimming should not be allowed.

6. Pit excavations located on adjacent floodplain or terraces should be separated from the active channel by a buffer designed to maintain this separation for two or more decades. As previously discussed in Section II, the active channel can shift into the floodplain pits, therefore Kondolf (1993; 1994a) recommends that the pits be considered as potentially instream when viewed on a time scale of decades. Consequently, buffers or levees that separate the pits from the active channel must be designed to withstand long-term flooding or inundation by the channel.

7. Prior to gravel removal, a thorough review should be undertaken of potentially toxic sediment contaminants in or near the stream bed where gravel removal operations are proposed or where bed sediments may be disturbed (upstream and downstream) by the operations. Also, extracted aggregates and sediments should not be washed directly in the stream or river or within the riparian zone. Turbidity levels should be monitored and maximum allowable turbidity levels for anadromous fish and their prey should be enforced.

8. Removal or disturbance of instream roughness elements during gravel extraction activities should be avoided. Those that are disturbed should be replaced or restored. As previously stated in Section III, Number 7, instream roughness elements, particularly large woody debris, are critical to stream ecosystem functioning.

9. Gravel extraction operations should be managed to avoid or minimize damage to stream/river banks and riparian habitats. Gravel extraction in vegetated riparian areas should be avoided. Gravel pits located on adjacent floodplain should not be excavated below the water table. Berms and buffer strips in the floodplain that keep active channels in their original locations or configurations should be maintained for two or more decades (as in Number 6, above). Undercut and incised vegetated banks should not be altered. Large woody debris in the riparian zone should be left undisturbed or replaced when moved. All support operations (e.g., gravel washing) should be done outside the riparian zone. Gravel stockpiles, overburden and/or vegetative debris should not be stored within the riparian zone. Operation and storage of heavy equipment within riparian habitat should be restricted. Access roads should not encroach into the riparian zones.

10. The cumulative impacts of gravel extraction operations to anadromous fishes and their habitats should be addressed by the Federal, state, and local resource management and permitting agencies and considered in the permitting process. The cumulative impacts on anadromous fish habitat caused by multiple extractions and sites along a given stream or river are compounded by other riverine impacts and land use disturbances in the watershed. These additional impacts may be caused by river diversions/impoundments, flood control projects, logging, and grazing. The technical methods for assessing, managing, and monitoring cumulative effects are a future need outside the scope of this Gravel Policy. Nevertheless, individual gravel extraction operations must be judged from a perspective that includes their potential adverse cumulative impacts. This should be a part of any gravel extraction management plan.

11. An integrated environmental assessment, management, and monitoring program should be a part of any gravel extraction operation, and encouraged at Federal, state, and local levels. Assessment is used to predict possible environmental impacts. Management is used to implement plans to prevent or minimize negative impacts. A mitigation and restoration strategy should be included in any management program. Monitoring is used to determine if the assessments were correct, to detect environmental changes, and to support management decisions.

12. Mitigation and restoration should be an integral part of the management of gravel extraction projects. Mitigation should occur concurrently with gravel extraction activities. In terms of National Environmental Policy Act (NEPA) regulations, mitigation includes: (1) avoidance of direct or indirect impacts or losses; (2) minimization of the extent or magnitude of the action; (3) repair, rehabilitation or restoration of integrity and function; (4) reduction or elimination of impacts by preservation and maintenance; and (5) compensation by replacement or substitution of the resource or environment.

Thus, restoration is a part of mitigation, and according to the preceding definitions, the aim of restoration should be to restore the biotic integrity of a riverine ecosystem, not just to repair the damaged biotic components. (However, see also Phase III of Section V, below.) An overview of river and stream restoration can be found in Gore et al. (1995). Koski (1992) states that the concept of stream habitat restoration as applied to anadromous fishes is based on the premise

that fish production increases when those environmental factors that limit production are alleviated.
Thus, an analysis of those "limiting factors" is critical to the restoration process. Koski (1992) further states that effective stream habitat restoration must be holistic in scope, and approached through a three-step process:

First, a program of watershed management and restoration must be applied to the watershed to ensure that all major environmental impacts affecting the entire stream ecosystem are addressed (i.e., cumulative impacts). Obviously, an individual gravel extraction project is not expected to restore an entire watershed suffering from cumulative effects for which it was not responsible. Rather, needed mitigation and restoration activities in a riverine system should focus on direct and indirect project effects and must be designed within the context of overall watershed management.

Next, restore the physical structure of the channel, instream habitats and riparian zones (e.g., stabilize stream banks through replanting of riparian vegetation, conserve spawning gravel, and replace large woody debris). This would reestablish the ecological carrying capacity of the habitat, allowing fish production to increase.

Finally, the fish themselves should be managed to ensure that there are sufficient spawning populations for maximizing the restored carrying capacity of the habitat.
NMFS recommends that either a mitigation fund, with contributions paid by the operators, or royalties from gravel extraction be used to fund the mitigation and restoration programs as well as for effectiveness monitoring.

13. Habitat protection should be the primary goal in the management of gravel extraction operations. Resource management agencies acknowledge that, under the right circumstances, some gravel extraction projects, whether commercial or performed by the agencies themselves, may offer important opportunities for anadromous fish habitat “enhancement". That is, gravel removal itself can be used beneficially as a tool for habitat creation, restoration, or rehabilitation (e.g., OWRRI, 1995). However, stream restoration and enhancement projects should be regarded with caution (see caveats on restoration and reclamation in Section V, Phase III, and OWRRI, 1995). While it is tempting to promote gravel extraction as a means to enhance or restore stream habitat, the underlying objective of this Gravel Policy is to prevent adverse impacts caused by commercial gravel extraction operations. Therefore, gravel extraction for habitat enhancement purposes done in conjunction with commercial gravel operations will not take precedence over and is not a substitute for habitat protection.

V. OPTIMUM MANAGEMENT OF GRAVEL EXTRACTION OPERATIONS

This section outlines a simple management scenario for gravel extraction operations, with the goal of minimizing impacts to anadromous fishes and their habitats. It is organized around the three program elements outlined in recommendation 11. This general framework is intended only as an introductory guide for creating a more comprehensive assessment, management and monitoring program. Other examples can be found in the literature (e.g., Collins and Dunne, 1990; OWRRI, 1995).

Before implementing Phase I, the operators should submit plans to the appropriate Federal, State and local agencies outlining their proposed project, including locations, methods, timing, duration, proposed extraction volumes, etc. The operators should also check with their NMFS Regional offices for any region specific procedures and guidelines.

Phase I. Prior to extraction, conduct comprehensive surveys and research to establish and document baseline environmental data, evaluate possible environmental impacts, and prescribe ways in which adverse environmental impacts are to be prevented or minimized. Use a combination of best available technologies and methods, including field sampling and surveys, modeling, GIS technology and analyses of archival materials and historical databases; e.g., aerial photographs, maps, previous surveys, etc. Characterize and identify species distributions and abundances; identify habitats critical to fisheries management objectives and NMFS responsibilities under a variety of legislative mandates; determine the limiting environmental factors of the anadromous fish populations (see Koski 1992); calculate sediment budgets and hydraulic flow rates; predict possible changes in water quality, channel morphology, etc.

Also address potential adverse cumulative impacts (see Recommendation No. 10, above) and propose a possible mitigation and restoration strategy (see Recommendation No. 12, above, and also discussion in Phase III, below). For example, from a perspective limited to abiotic factors, Collins and Dunne (1990) recommend that appropriate rates and locations for instream gravel extraction should be determined on the basis of:

a. The rate of upstream recruitment (note Recommendation No. 4, above).
b. Whether the river bed elevation under undisturbed conditions remains the same over the course of decades, or if not, the rate at which it is aggrading or degrading.
c. Historic patterns of sediment transport, bar growth, and bank erosion in particular bends.
d. Prediction of the specific, local effects of gravel extraction on bed elevations, and the stability of banks and bars. The prediction should take into account an analysis of present or past effects of gravel extraction at various rates.
e. A determination of the desirability or acceptability of the anticipated effects.

Phase II. Monitors permitted operations and verify environmental safeguards. Extraction rates and volumes should be closely regulated. Impacts to the river bed, banks and bars upstream and downstream of the project should be documented using bench-marked channel cross-sections and aerial photographs taken at regular intervals. Species distributions and abundances should be surveyed regularly. Water quality should be monitored. Mitigation and restoration should be an ongoing process (see Recommendation No. 12, above), with continual monitoring for effectiveness.

Also, NMFS recommends that permits should have a 5 year limit and be subject to annual review and revision to protect anadromous fish and their habitats (e.g., one element of the annual review should determine whether fishery management objectives are being met).

Phase III. Establish and implement a long-term monitoring and restoration program. This should continue Phase II objectives after completion of the project. A universal, prototype long-term monitoring strategy for watershed and stream restoration can be found in Bryant (1995). However, reliance on restoration should be put into proper perspective. It is important to acknowledge that there are significant gaps in our understanding of the methodology and effectiveness of restoration of streams and anadromous fish habitat affected by gravel extraction activities. Overall, restoration as a science is relatively young and experimental, and the processes and mechanisms are poorly understood. Little is known about the functional value, stability and resiliency of many so-called "restored" habitats. To date, existing regulations or plans pertaining to the mitigation and restoration of gravel extraction sites have been simplistic or vague. As an example: gravel extraction in California is regulated under the concept of "reclamation," which is derived from open-pit surface mining, such as large coal mines. Kondolf (1993; 1994b) states the concept of reclamation, as applied to open-pit mines, assumes that the environmental impacts are confined to the site; therefore, site treatment is considered in isolation from changes in the surrounding terrain.

Because reclamation does not occur until after the cessation of extraction, Kondolf (1993; 1994b) suggests that this definition treats the site as an essentially static feature of the landscape. Kondolf (1993; 1994b) argues that, while these assumptions may work for extraction operations located in inactive stream or river terraces, active channels and floodplain are dynamic environments, where disturbances can spread rapidly upstream and downstream from the site during and after the time of operation. The stream or river will irrevocably readjust its profile during subsequent high flows, eradicating the gravel pits and giving the illusion that extraction has had no impact on the channel. Kondolf (1993; 1994b) claims that a survey of bed elevations will show a net lowering of the bed, which reflects the more even distribution of downcutting (erosion) along the length of the channel. Even if the channel profile were to recover after completion of the project due to an influx of fresh sediment from upstream, habitat may have been lost in the meantime. Thus, it may not be possible to disturb one site in isolation from the rest of the ecosystem, or confine the disturbance to a single, detached location, and then subsequently reclaim or reverse the impacts. Kondolf (1993; 1994b) concludes that reclamation can be applied to gravel pits in terrace deposits above the water table, but the reclamation concept is not workable for regulating instream gravel extraction. For all of these reasons, it is important to heed Murphy's (1995) assertion that:

The best form of restoration is habitat protection. There is no guarantee that restoration efforts will succeed, and the cost of restoration is much greater than the cost of habitat protection. The most prudent approach is to minimize the risk to habitat by ensuring adequate habitat protection.

Adopted August 29 , 1996
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APPENDIX 1

SUMMARIES OF MAJOR STATUTES

The following summaries of the major statutes mentioned in this Gravel Policy, with the exception of the River and Harbor Act of 1899, were obtained from Buck (1995)[(1)].

Anadromous Fish Conservation Act

The Anadromous Fish Conservation Act (16 U.S.C. 757a-757g) authorizes the Secretary of Commerce, along with the Secretary of Interior, or both, to enter into cooperative agreements to protect anadromous and Great Lakes fishery resources. To conserve, develop, and enhance anadromous fisheries, the fisheries which the United States has agreed to conserve through international agreements, and the fisheries of the Great Lakes and Lake Champlain, the Secretary may enter into agreements with states and other non-Federal interests. An agreement must specify:

(1) the actions to be taken; (2) the benefits expected; (3) the estimated costs; (4) the cost distribution between the involved parties; (5) the term of the agreement; (6) the terms and conditions for disposal of property acquired by the Secretary; and (7) any other pertinent terms and conditions.

Pursuant to the agreements authorized under the Act, the Secretary may: (1) conduct investigations, engineering and biological surveys, and research; (2) carry out stream clearance activities; (3) undertake actions to facilitate the fishery resources and their free migration; (4) use fish hatcheries to accomplish the purposes of this Act; (5) study and make recommendations regarding the development and management of streams and other bodies of water consistent with the intent of the Act; (6) acquire lands or interests therein; (7) accept donations to be used for acquiring or managing lands or interests therein; and (8) administer such lands or interest therein in a manner consistent with the intent of this Act. Following the collection of these data, the Secretary makes recommendations pertaining to the elimination or reduction of polluting substances detrimental to fish and wildlife in interstate or navigable waterways. Joint NMFS-FWS regulations applicable to this program are published in 50 C.F.R. Part 401.

Clean Water Act

The Clean Water Act (CWA) (33 U.S.C. 1251-1387) is a very broad statute with the goal of maintaining and restoring waters of the United States. The CWA authorizes water quality and pollution research, provides grants for sewage treatment facilities, sets pollution discharge and water quality standards, addresses oil and hazardous substances liability, and establishes permit programs for water quality, point source pollutant discharges, ocean pollution discharges, and dredging or filling of wetlands. The intent of the CWA Section 404 program and its 404(b)(1) "Guidelines" is to prevent destruction of aquatic ecosystems including wetlands, unless the action will not individually or cumulatively adversely affect the ecosystem. National Marine Fisheries Service (NMFS) provides comments to the U.S. Army

Corps of Engineers as to the impacts to living marine resources of proposed activities and recommends methods for avoiding such impacts.

Endangered Species Act

The purpose of the 1973 Endangered Species Act (ESA) (16 U.S.C. 1531-1543) is to provide a means whereby the ecosystems upon which endangered or threatened species depend may be conserved and to provide a program for the conservation of such endangered and threatened species. All Federal departments and agencies shall seek to conserve endangered and threatened species and shall utilize their authorities in furtherance of the purposes of the ESA.

Fish and Wildlife Coordination Act

The Fish and Wildlife Coordination Act (16 U.S.C. 661-666c) requires that wildlife, including fish, receive equal consideration and be coordinated with other aspects of water resource development. This is accomplished by requiring consultation with the FWS, NMFS and appropriate state agencies, whenever any body of water is proposed to be modified in any way and a Federal permit or license is required. These agencies determine the possible harm to fish and wildlife resources, the measures needed to both prevent the damage to and loss of these resources, and the measures needed to develop and improve the resources, in connection with water resource development. NMFS submits comments to Federal licensing and permitting agencies on the potential harm to living marine resources caused by the proposed water development project, and recommendations to prevent harm.

Magnuson Fishery Conservation and Management Act

The Magnuson Act requires that fishery management plans shall "include readily available information regarding the significance of habitat to the fishery and assessment as to the effects which changes to that habitat may have upon the fishery" 16 U.S.C. 1853 (a)(7).

National Environmental Policy Act

The National Environmental Policy Act (NEPA) (42 U.S.C. 4321-4347) requires Federal agencies to analyze the potential effects of a proposed Federal action which would significantly affect the human environment. It specifically requires agencies to use a systematic, interdisciplinary approach in planning and decision-making, to insure that presently unquantified environmental values may be given appropriate consideration, and to provide detailed statements on the environmental impacts of proposed actions including: (1) any adverse impacts; (2) alternatives to the proposed action; and (3) the relationship between short-term uses and long-term productivity. The agencies use the results of this analysis in decision making. Alternatives analysis allows other options to be considered. NMFS plays a significant role in the implementation of NEPA through its consultative functions relating to conservation of marine resource habitats.

Rivers and Harbors Act of 1899

The Rivers and Harbors Act of 1899, Section 10 (33 U.S.C. 403) requires that all obstructions to the navigable capacity of waters of the United States must be authorized by Congress. The Secretary of the Army must authorize any construction outside established harbor lines or where no harbor lines exist. The Secretary of the Army must also authorize any alterations within the limits of any breakwater or channel of any navigable water of the United States.

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1. Buck, E.H. 1995. Summaries of major laws implemented by the National Marine Fisheries Service. CRS Report for Congress. Congressional Research Service, Library of Congress, March 24, 1995.