Most critical to Services position on 10 mi. (Read first if time is an issue)		
Citations showing distance downstream where mussels were harmed (highlights for our position, or lowlights for the affected fauna)	**Key message**	**Uncertainties, confounds, etc.**
Anderson et al., 1991; Layzer and Anderson, 1992; Warren et al., 1999; Warren and Haag, 2005.	Mussel populations were decimated and endangered spp. extirpated as coal mining progressed along headwater tributaries. The mining started in the mid 1980s, after SMCRA had been in place for several years.	To estimate distance downstream from mining where spp. were lost (≈ 12 mi.) from assemblages, we combined spatial info from these four papers and then measured on a topographic map. Natural gas and oil were also likely contributing factors to faunal decline. *Response: Warren and Hagg (2005) note impacts were added **after** the coal mining and associated species declines were observed.*
Houp, 1993. Newell et al., 2007; Vannote and Minshall, 1982.	In Houp (1993), sedimentation and concomitant species loss occurred, and assemblage composition changed after the onset of coal mining approx. 12 mi. upstream. This too, was after SMCRA. The other two papers, although not mentioning downstream distances, show the mechanisms (shell erosion, or rendering substrate unsuitable) by which changing sedimentation regimes, just like that observed in Houp (1993), harm mussels.	Again, the distance from the mining to the mussels was not specified, but from the crude maps provided in the paper, topo maps were used to measure distance. Dredging of a small tributary also contributed to sedimentation. *Response: However, the contribution from the single dredging activity was likely miniscule and of shorter duration in comparison to the coal mining. The affected fauna was more than 10 mi. downstream.*

Critical to Service's position on mining impacts (published after protective measures were developed)		
Citations showing distance downstream where mussels were harmed (highlights for our position, or lowlights for the affected fauna)	**Key message**	**Uncertainties, confounds, etc.**
Pond et al., 2008	Pond (2008) shows that mountaintop mining consistently increases conductivity and total dissolved solids downstream from valley fills while degrading health of macroinvertebrate assemblages. Often, an entire phylogenetic order of insects, mayflies (Ephemeroptera), was lost from the aquatic insect assemblage.	On average this study looked only 0.8 km downstream of valley fills, so the effect over distance cannot be discerned. *Response: You don't have to be an ecologist to realize loss of an entire order of native insects, with its constituent families, genera, and species, as well as the ecosystem services they provide, bodes poorly for the aquatic ecosystem they inhabit. Study also indicates coal specific degradation of water quality more strongly correlated with effects to insects than physical habitat degradation, which has multiple sources. This is an EPA scientists' study published in a modern peer reviewed journal that relied on a robust data set of 37 streams in WV coalfields. While many surface mine sites in VA aren't technically called mountaintop mines they have the same type of valley fills as those in Pond (2008).*

Important to Service's position on protective measures		
Citations showing effects of coal on mussels in general (continued)	**Key message**	**Uncertainties, confounds, etc.**
USEPA, 2002	From the document: "Mine effluents and spills appear to have the greatest overall effect on mussels and fish, as compared to other human-activity sources in the [Clinch Powell, VA] watershed." Document also brings to bear compelling references showing increased sedimentation of, and coal inputs to, VA streams.	Because the study relied on historical data gathered from disparate sources, the precision of mussel data varied. Therefore, the authors deemed it necessary to do "A pilot study…that [used] the fish Index of Biotic Integrity (IBI)…[as] a useful surrogate for mussel species richness" The weakness in using fish as a surrogate is that there are many locations were fish communities are exceptional but mussels have been lost. *Response: Nevertheless, this publication is significant because it contains specific EPA statements indicating deleterious impacts of mining that are based on its own scientific research.*
Jenkinson, 2005	Specific gravity of coal is less than that of many mussel spp. occurring in VA. Therefore when the streambed becomes covered in coal particles, as it is presently in many stream reaches, particularly in the Powell R., mussels must work harder than usual to maintain their position in the substrate.	Premise regarding mussel positioning not field or lab tested yet. *Response: SVFO has contracted to test in lab raceways. Furthermore this concept may explain how mussels can decline strictly due to coal induced habitat alteration, in the absence of coal-related contaminants.*
McCann and Neves, 1992	In the Powell River, VA, mussel survival in sediments downstream of coal preparation plant was lower (statistically significant, $p = 0.0002$) than upstream.	Distance from coal facilities to tested mussels was < 0.5 mi. Downstream 14 mi., survival was not reduced. So from data available, there's no way to determine how far downstream effects occurred. *Response: State has acknowledged prep plants as stressor and, for prep plants only, accepts 10 mile trigger.*

Important to Service's position		
Citations showing effects of coal on mussels in general (continued)	**Key message**	**Uncertainties, confounds, etc.**
Wolcott, 1990	Mussel populations in the Powell River declined from 1975 – 1990. Contamination from coal washing facilities and abandoned mined lands were suspected as a contributor to declines.	Found evidence that mining was related to increased siltation and coal fine introduction but, unlike McCann and Neves (1992), Wolcott did not detect a difference in mussel survival among coal and non-coal bearing substrates. *Response: Although a causal link between coal particles and harm to mussels was not detected, habitat that is now federally designated critical habitat was modified by coal-related siltation. Most of the mines associated with the siltation, which are in areas still being mined today, were and are greater than 8 mi. upstream from CH. Thus it appears mine-related siltation, typically a chronic stressor, can extend beyond 5 miles and at least as far as 8 miles downstream.*
Ellis, 1936	Read pp. 39 – 40: Mussels were held in raceways for 14 months. Those exposed to ¼ to 1 inch of silt on top of sand/gravel experienced high mortality - 90% mortality when silt covered all the sand/gravel. Mortality was "low" for control mussels not exposed to silt. *Note*: This citation inadvertently omitted from SSPM version and references list submitted to RO.	"Low" mortality was not quantified. It is not clear if all mussels were held 14 months or if dead control and/or experimental mussels were replaced. *Response: This probably was state of the art experiment for the 1930s. Over 70 years ago there existed empirical evidence regarding the adverse effects to mussels from siltation, which is a documented common problem with surface mining, or any similar large-scale landscape disturbance.*

Important to Service's position		
Citations showing effects of coal on mussels in general (continued)	**Key message**	**Uncertainties, confounds, etc.**
Kitchel et al. 1981	Abundance of mussels and coal fines on streambed inversely correlated. Effect of water column coal particulates was evaluated in a lab experiment: mussels in the presence of suspended coal fines rarely siphoned and moved down into the substrate. In aquaria without suspended coal fines, mussels stayed near the surface and siphoned consistently.	Observational study without much statistical rigor. Shows the Powell river mussel fauna already significantly affected by coal ca. 1980. *Response Mussel assemblages have only gotten worse in the Powell since 1980, in spite of "improved" regulation. Physical habitat has not changed, and coal fines continue to be a predominant part of the streambed. It's likely many of the coal particles present today are newly deposited, since coal is relatively light and presumably, older coal would have washed into TN.*
Ahlstedt and Tuberville, 1997	References sediment toxicity that was found Clinch R., VA and corresponded to their finding of a lack of recruitment of young mussels to VA populations. Points to active and abandoned coal mining as possible source of toxicity. Powell River, VA and TN was seriously degraded and water column samples had copper levels exceeding effects concentrations, probably due to the Powell's long history of coal mining. In the Powell, mussel fauna closest to mining had almost completely disappeared.	While sediments in Clinch were contaminated with copper, zinc, and manganese, which are common constituents of coal and overburden, there was no attempt to track sources of the contaminants. Also, the study finding toxicity was conducted by a power company and was not published. There was no discrimination between historical vs. ongoing mining impacts. *Response: Although correlative in nature, loss of entire mussel assemblages closest to mining activities strongly suggests mining as a contributing factor. Sites in both rivers where toxicants were found, much farther (~ 20 mi.) downstream than 10 mi.*

Important to Service's position		
Citations showing effects of coal on mussels in general (continued)	**Key message**	**Uncertainties, confounds, etc.**
Ellis, 1944	Page 12 references research at "Columbia laboratory" that shows "even coal washings" injure gills of fish and mussels.	Old study. If "Columbia" results referred to by Ellis (1944) published, whereabouts are unknown. *Response: Supports earlier results published by Ellis and future published research on fish gills and suspended sediment (e.g., Sutherland & Meyer 2007)*

Important to Service's position		
Citations showing adverse effects of coal mining on water quality and biota other than mussels.	**Key message**	**Uncertainties, confounds, etc.**
Virginia's 2002 303-d list of impaired water bodies. (not forwarded to RO)	64.98 miles of stream listed as impaired due to coal mining in Clinch-Powell, VA watershed.	Does not discriminate between abandoned mined lands and active coal mining. *Response: All of these stream reaches are adjacent to and downstream of active mining. In addition, the list provides a means to assess cumulative impact of mining, which altogether spans a distance far greater than 10 miles. It is interesting to note that while the more recent 303-d list omits the cause of impairment for these streams, previous lists noted coal mining as a cause.*

Important to Service's position		
Citations showing adverse effects of coal mining on water quality and biota other than mussels. (Continued)	**Key message**	**Uncertainties, confounds, etc.**
Pond, 2004	Precursor to Pond et al. (2008), discussed above, that showed similar effects to macroinvertebrates in KY Coalfield streams. Clearly distinguishes between effect of residential development vs. mining, the latter of which was most severe.	Thus far there have been no published studies showing mortality to mayflies induced by high conductivity alone. *Response: Study accounts for inputs of other land use stressors including natural gas, oil, timber, and residential. Difficult to mimic mine effluents in lab setting and the specific chemical components and their ratios within the effluent may be the as yet detected toxicant.*
Burkhead and Jelks, 2001	In lab experiments, spawning success of tricolor shiner decreased with increasing sedimentation	Tricolor shiner not native to coalfields. *Response sister species in the same genus, Cyprinella, do occur in VA's coalfields. Shows how sedimentation can reduce populations chronically. At 100 mg/l, a level exceeded often in coalfields, spawning success decreased.*
Sutherland 2007	Using native whitetail shiner, showed mean suspended sediment concentration was consistently negatively correlated with spawning success (number propagated).	Specimens not collected in VA. *Response: used native coalfield species and corroborated Burkhead and Jelks (2001) using sister taxon in same genus.*
Sutherland et al., 2002; Jones III et al., 1999	Tree clearing > 1 linear km resulted in alteration in composition of fish assemblages (Jones III). Turbidity was markedly greater during storm flows in disturbed watersheds, where benthic spawners' abundance was reduced (Sutherland).	This research did not occur in the coalfields. Downstream distance of effect was not specified. *Response: Field research for both studies occurred in southern Appalachians and involved several spp. that occur in VA coalfields. Surface mines typically disturb more than 1 km of riparian.*

Important to Service's position		
Citations showing adverse effects of coal mining on water quality and biota other than mussels. (Continued)	**Key message**	**Uncertainties, confounds, etc.**
Sutherland and Meyer 2007	Assessed suspended sediment concentration effects on growth and gill tissue of spotfin chub and whitetail shiner. Found effects on growth at 100 mg/l, and gill thickness (measure of gill health) decreased with increasing sediment concentration. Suggested respiratory impairment is a mechanism by which suspended sediment adversely effects southeastern minnows.	State regulatory authority relies on their conformance SMCRA & CWA regulations for non-point and point source control of sediment as assurance that permitted actions are protective. *Response, when dischargers are routinely allowed a variance on suspended sediment limits for occurrences of rainfall as low as **0.2 inches**, fish and other aquatic wildlife can incur suspended sediment concentration downstream of mining at levels shown to be harmful.*
Sutherland et al. 2008	Stress hormone increased with increasing suspended sediment in whitetail shiner and spotfin chub.	Spotfin chub native to S. Western VA but not the coalfields. *Response: Whitetail shiner is native. Corroborates work of Burkhead and Jelks (2001) using different endpoint. Found effects to juvenile fish at 100 mg/l, level commonly observed in Coalfield streams after rainfall.*
Zamor and Grossman, 2007	Turbidity > 9 NTU, negatively affected feeding of rosyside dace.	Turbidity instead of suspended sediment concentration measured. *Response: Rosyside dace, native to the coalfields, occurs adjacent to some mine sites. Turbidity is an appropriate surrogate for suspended sediment, which can be predicted from regression equations. No one would disagree that 9 NTU often exceeded as a result of mining activities.*

Important to Service's position		
Citations showing adverse effects of coal mining on water quality and biota other than mussels. (Continued)	**Key message**	**Uncertainties, confounds, etc.**
Pautzke, 1938	Showed suspended coal washings damaged gills an increased mortality of steelhead.	Observational study using species not native to VA coalfields. *Response: Old study, but one that shows physical mechanism by which coal particles can cause harm directly.*
Newcomb & Mcdonald, 1993; Newcomb 1996; Newcomb, 2003	Show suspended sediment concentrations at which certain fish spp. are affected. Effects are a function of time and concentration.	Much of this work was conducted on salmonids, which are not native, but are stocked, in the coalfields. *Response: these references were included primarily to provide a sampling of the abundant literature quantifying how sediment can harm fishes.*
Pond & McMurray, 2002.	**Not germane to this exercise**. It is a methods paper that in part is a protocol for assessing mining impacts to aquatic insects.	No confounds. *Response: A reference included in the draft protective measures guide for how to implement protective measures, if they are ever adopted*