Numeric targets are the specific goals for the TMDL that will protect the beneficial uses of the water and aquatic resources. Targets of mercury in fish were calculated to protect humans and wildlife that eat fish and other aquatic organisms from the American River watershed.

**Key Points and Opportunities for Discussion**

- Target options were developed using four rates of consumption of local fish: one meal/every two weeks; one meal/week; 2 meals/week; and 4.5 meals/week.
- People eat a variety of species, which is represented in calculations as a 50/50 mix of piscivorous and nonpiscivorous fish.
- Fishing in mid-altitude reservoirs, Folsom Lake, and downstream is popular and occurs year-round. Human dependence on fishery is much less at high altitude reservoirs (e.g., Hell Hole and Loon Lake). Catch-and-release culture and/or regulations may mean large trout in these reservoirs do not pose a risk to people.
- TMDL targets must ensure that bald eagle, osprey, and other wildlife species are protected. A safe level of 0.16 mg/kg for bald eagle should protect other species and is comparable for targets to protect people.

1.1 Type of Target

The beneficial use that is currently unmet is its use as a safe fishery for humans and wildlife. A target of methylmercury in fish tissue is the appropriate form of target because it provides the most direct assessment of fish conditions and improvement. Fish in the American River watershed have been sampled for mercury between 1978 and 2009. Existing data provide a baseline against which future improvements can be measured.

California Toxics Rule (CTR) criteria apply to the American River and its reservoirs. The CTR criterion of 50 ng/l total recoverable mercury in water is intended to protect the health of humans consuming contaminated organisms and drinking water. Although the CTR criterion is less protective than the fish tissue targets, this TMDL will comply with the CTR mercury criterion.¹

1.2 Fish Tissue Target Equation

Key variables that are incorporated into the calculation of fish tissue targets are:

- Acceptable daily dose of methylmercury;

¹ The CTR mercury criterion is calculated using a ratio of concentrations of mercury in fish and total mercury in water of 7342.6 (USEPA, 2000b). For the lower American River, similar ratios (bioaccumulation factors; BAF) for large trophic 4 fish average $3 \times 10^5$. The BAFs indicate that piscivorous fish species in the lower American River accumulate higher concentrations of mercury assumed for the CTR criterion. Aqueous mercury levels need to be lower in order to meet safe American River fish tissue targets; thus the fish tissue targets are more protective.
- Body weight (bwt) of the consumer;
- Trophic level or size of fish consumed; and
- Rate of fish consumption.

These components are related in the basic equation:

\[
\frac{\text{Safe daily intake} \times \text{Consumer's body weight}}{\text{Consumption rate}} = \text{Acceptable level of mercury in fish tissue}
\]

At or below the safe intake of methylmercury, consumers are expected to be protected from adverse effects. An acceptable intake level, or reference dose (RfD), is expressed as an average daily rate (micrograms methylmercury mercury per kilogram body weight per day).

For Folsom Lake, Lake Natoma, and the lower American River, staff proposes two methylmercury targets, one each for large trophic level 3 and large trophic level 4 fish.\(^2\) Large TL3 and TL4 fish are consumed by humans and by wildlife species such as bald eagle, osprey, and river otter. In the watershed upstream of Folsom Lake, the fish assemblage eaten by humans and large wildlife species is dominated by various species of trout. Because of fish feeding patterns (i.e., brown trout are semi-piscivorous) and variation in stocking patterns and fish growth rates in different water bodies, fish in the upper watershed do not clearly separate into categories of TL3 and TL4. **For the American River watershed upstream of Folsom Lake, staff proposes a single target for large fish.** Target options are described below.

### 1.3 Wildlife Health Targets

Birds and mammals most likely at risk for mercury toxicity are primarily or exclusively piscivorous. Wildlife evaluated are: American mink, river otter, bald eagle, kingfisher, osprey, western grebe, common merganser, peregrine falcon, double crested cormorant, and Forster’s tern. Bald eagles have been removed from the federal endangered species list but remain on the State of California’s list. Mercury safe levels in prey calculated to protect the species that are highly dependent on local fish are expected to protect other species that eat some aquatic organisms, such as herons and raccoons.

Safe levels of mercury in fish to protect wildlife species can be calculated using maximum safe daily intake levels of methylmercury, body weights, and food consumption rates and the basic equation above (*Calculations will be provided in TMDL report appendix and may be obtained from Central Valley Water Board staff*).

Methylmercury concentrations vary as a function of size and feeding habit (represented by trophic level) of prey. In the American River watershed, large piscivorous and semi-piscivorous

\(^2\) Trophic level 1: Plants and detritus.
Trophic level 2: Herbivores and detritivores (e.g., zooplankton, clams, some invertebrates, and carp).
Trophic level 3: Predators of TL2 organisms (e.g., small fish, crayfish, some invertebrates, bluegill, rainbow trout)
Trophic level 4: Predators of TL3 organisms (e.g., largemouth bass, catfish, pikeminnow)
fish are the majority of large fish sampled. Mercury concentrations in fish, particularly brown trout, varied widely between water bodies upstream of Folsom. This variability made it difficult to classify them as either TL3 or 4 fish based on presumed feeding pattern at a given size. Factors other than size, including stocking as fingerlings or catchable size, fish growth rates, and reservoir productivity, influence mercury concentration, possibly significantly. Presumably these large fish are readily available as prey to bald eagles and osprey. Staff calculated a single mercury safe level for osprey and bald eagle. The safe levels are applied to the average concentration in all fish of appropriate size range.

Table 1.1: Safe Concentrations of Methylmercury in Fish (mg/kg) by Trophic Level to Protect Wildlife

<table>
<thead>
<tr>
<th>Species</th>
<th>TL 2-3, 50-150 mm</th>
<th>TL 3, 150-350 mm</th>
<th>TL 4, 150-350 mm</th>
<th>TL 3, &gt;150 mm</th>
<th>TL 4, &gt;150 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mink</td>
<td>0.08</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>River otter (a)</td>
<td></td>
<td>0.11</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forster’s tern</td>
<td>0.05</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Belted kingfisher</td>
<td>0.05</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Double-crested cormorant</td>
<td>0.09</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Common merganser</td>
<td>0.09</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Western grebe</td>
<td>0.08</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Osprey (a)</td>
<td></td>
<td></td>
<td></td>
<td>0.11</td>
<td></td>
</tr>
<tr>
<td>Bald eagle (a, b)</td>
<td></td>
<td></td>
<td></td>
<td>0.16</td>
<td></td>
</tr>
<tr>
<td>Peregrine falcon (c)</td>
<td></td>
<td></td>
<td>(0.17)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(a) Bold text shows the safe fish tissue concentration for all fish in the prey size range, not separated into trophic levels. Split into trophic levels based on proportion of TL3 and TL4 fish typically reported in the diet, osprey safe levels are 0.09 and 0.28 mg/kg in TL3 and TL4 fish 150-350 mm, respectively. Bald eagle safe levels are 0.10 and 0.32 mg/kg in TL3 and TL4 fish >150 mm, respectively. River otter safe levels are 0.06 mg/kg in fish <150 mm and 0.27 mg/kg in fish >150 mm.

(b) Because bald eagles are scavengers, there is no upper size limit on fish eaten by eagles.

(c) Parentheses denote the TL3 fish level corresponding to the piscivorous bird safe concentration for peregrines. In piscivorous birds eaten by peregrine falcons, the average concentrations should not exceed 2.2 mg/kg.

Reducing mercury concentrations in large fish should fully protect bald eagle and osprey. Large fish species in the watershed exhibit positive relationships between mercury concentration and fish length. Rainbow trout, which are the exception to this rule, tend to be uniformly low in mercury. Since bald eagles have a higher upper limit to their prey size range than osprey, meeting the safe level in bald eagle should ensure that ospreys are fully protected. Also because mercury concentrations increase with fish size and trophic level, wildlife species that eat some large fish, like river otter, and wildlife species that rely on small fish are expected to be fully protected if bald eagle safe levels are attained.
1.4 Human Health Targets

1.4.1 Human mercury exposure parameters

Numeric targets can be developed to protect humans in a manner analogous to targets for wildlife. A reference dose, average body weight, and consumption rates are used along to calculate safe fish tissue levels. Staff uses the USEPA’s standard adult bodyweight of 70 kg. Although the target calculations use bodyweights and portions sizes for adult humans, the resulting safe levels protect children as well. An adult meal size is assumed to be eight ounces uncooked (equivalent to about six ounces cooked). Children’s portions should be smaller than those for adults, in proportion to their smaller body weight. OEHHA recommends that children eat half as much fish, in either quantity or frequency, as adults (OEHHA, 2008).

The RfD for humans is 0.1 μg methylmercury/kg bwt/day (USEPA, 2001). The human RfD is based upon results of tests of memory, fine motor control, and sensory perception in children exposed to methylmercury in fish in their normal diet. The RfD incorporates an uncertainty factor of 10 to take into account differences in metabolism and the potential for harmful effects appearing later in life. This means that the human RfD is 10 times lower than the lowest methylmercury exposure level that caused adverse effects. The State’s risk assessment agency, Office of Environmental Health Hazard Assessment (OEHHA), applies the RfD to sensitive populations of women who are pregnant, nursing, or may become pregnant and children under age 17. OEHHA uses a 3-times higher safe methylmercury intake to protect women who are not having children and men (OEHHA, 2008).

Humans are exposed to methylmercury from commercial fish (usually marine species) as well as locally caught fish. In the Sacramento area and North Delta, most people who eat local fish also consume commercial fish (Shilling, 2008; Silver 2007). To account for mercury from non-local sources, the target calculations include a relative source contribution (RSC). The RSC represents that portion of methylmercury exposure that will not be controlled by cleanup actions directed to a particular water body. Staff used an RSC of 0.027 μg methylmercury/kg bwt/day, based on a national survey of consumption of tuna and other fish and shellfish and the amount of mercury in these products (USEPA, 2001). Intake of methylmercury from all other sources (air, drinking water, soil, and foods other than fish and shellfish) is considered negligible (USEPA, 1997).

1.4.2 Consumption Rates and Consumption Patterns

Human intake of methylmercury depends on the amount and type of fish consumed. Staff reviewed consumption rates and developed options for targets to protect human health. The USEPA provides default consumption rates for the general population and some subpopulations (USEPA, 2000). The USEPA recommends a consumption rate for locally caught fish of

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3 The difference in reference doses (0.1 micrograms/kg bwt-day for child-bearing women and children and 0.3 micrograms/kg bwt-day for women not bearing children and men) is the basis for OEHHA’s safe eating guidelines for fish consumption (advisories), which the agency now issues in two tiers for sensitive and less sensitive populations. See OEHHA’s brochure for Safe Eating Guidelines for Fish from Folsom Lake and Lake Natoma, available at: [http://www.oehha.ca.gov/fish/so_cal/pdf_zip/FolsomNatomaTrifoldOct08.pdf](http://www.oehha.ca.gov/fish/so_cal/pdf_zip/FolsomNatomaTrifoldOct08.pdf)
17.5 g/day (one meal every two weeks) to protect the general population and a rate of 142.4 g/day (4.5 meals per week) for anglers who use locally caught fish as a main source of protein. These consumption rates are the 90th and 99th percentile fish consumption rates, respectively from a nationwide dietary survey.

Site-specific consumption surveys have not been conducted for American River anglers. Surveys of anglers in the Delta and Sacramento area found average and 95th percentile consumption rates of locally-caught fish were 29 and 127 g/day, respectively (Shilling et al., 2010). Of various ethnic sub-groups surveyed, Lao reported the highest consumption rates (local fish consumption rate average of 58 g/day and 95th percentile of 310 g/day). For the basis of its fish tissue objective, the San Francisco Bay mercury TMDL used 32 g/day (one meal per week), which is the reported consumption rate for the 95th percentile of anglers who eat San Francisco Bay fish on a regular basis (SFEI, 2000).

The Central Valley Water Board has heard from anglers that some depend on fish from Delta-area waterways, including the lower American River. Lake Natoma and Folsom Lake are also popular for fishing year-round and are easily accessed. Fishing pressure is assumed to be much less at upper watershed reservoirs, such as Oxbow, Hell Hole, and Loon Lake. DFG permits fishing in reservoirs year-round, but weather and driving distance may limit use of the high-altitude reservoirs. Steep canyons and lack of roads also reduce access to some reaches of the North and Middle Forks American River. Upstream of Folsom, the American River and tributaries is closed to trout fishing between 16 November and the end of April.

Species and size of fish also affect methylmercury intake. Piscivorous or TL4 fish in the lower American River, Lake Natoma, and Folsom Lake (e.g., fully-grown bass, catfish, and pikeminnow) have mercury concentrations that average three times higher than TL3 species (e.g., American shad, salmon, rainbow trout/steelhead, sunfish, and splittail bluegill) that mainly have a non-piscivorous diet. Because of their feeding patterns, a statistically significant difference in mercury levels between TL4 and TL3 fish is expected to persist even as mercury concentrations are reduced. To clarify species to which targets apply, staff determined separate safe levels for TL3 and TL4 fish in Folsom Lake and downstream, assuming a 3-fold difference in mercury concentrations between the trophic levels.

The target calculations assume an even split between consumption of TL3 and TL4 fish. In the lower American River, CDFG creel surveys show that anglers take home a mixture of TL3 and TL4. Shilling and colleagues interviewed anglers and fish consumers in the North Delta and Sacramento. They found that while angling varies by ethnic group and season, target fish species were catfish, bass, shad, salmon, and “any fish species” (Shilling, 2008). Many anglers in the Sacramento area fish in the Delta and American River (CDHS, 2006, Shilling, 2008).

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4 Ratio between existing mercury concentrations in large TL4 fish (150-350 mm length; 0.54 mg/kg Hg) and large TL3 fish (150-350 mm length; 0.17 mg/kg Hg). Averages of Lower American River, Lake Natoma, and Folsom Lake non-anadromous fish.

5 The USEPA’s recommended methylmercury criterion is based on a breakdown that includes TL2 fish. A national dietary survey showed people ate 22%, 46%, and 32% TL2, TL3, and TL4 fish or other aquatic organisms, respectively. Other than clams, which are very low in mercury, staff is not aware of TL2 organisms in the American River watershed that are eaten by people. Crayfish are eaten by people but are classified as TL3 organisms.
People fishing in waterways upstream of Folsom Lake are presumed to take home a variety of fish species, as well. In 1990-91 surveys on the Rubicon River, anglers reported keeping brown and rainbow trout (CDFG, 1993). In a recent survey in the nearby Bear and Yuba watershed reservoirs, The Sierra Fund found that most popular fish were trout and bass, followed by kokanee, catfish, and crappie (Sierra Fund, 2010).

Staff calculated human health target options using four fish consumption rates: the USEPA’s default consumption rate for the general population (17.5 g/day), San Francisco Bay and Delta TMDLs’ consumption rate (32 g/day), an intermediate rate of 64 g/day, and the USEPA’s recommended consumption rate for sustenance fishers (142 g/day). Recognizing that consumers eat a variety of species, the targets assume for the lower watershed a 50-50 split between TL3 and TL4 fish and for the upper watershed any large fish.

1.4.3 Calculation of Human Health Targets

For each of the consumption rate options, staff calculated a single safe mercury level for all large fish (>150 mm) in a water body as well as safe levels for TL3 and TL4 fish assuming the consumer eats equally from the two trophic groups (Table 1.2). Other Central Valley mercury TMDLs have targets for TL3 and TL4 fish. Because semi-piscivorous trout dominate the fish assemblage in the upper watershed, staff felt a single, large fish target would be more appropriate. For a given consumption rate, the single safe level and TL3 + TL4 pair of safe levels are equivalent in terms of protection of consumer. Staff presumed no upper limit on size of large fish eaten by people. Thus, the target options below are directly comparable to wildlife targets in large fish to protect bald eagle.

Staff calculated safe levels of mercury for TL3 and TL4 fish as follows:

\[
\text{Avg. mercury concentration in all fish eaten} = (\% \text{ diet } TL_3 \times TL_3\text{conc}) + (\% \text{ diet } TL_4 \times TL_4\text{conc})
\]

Where:

- \( % \text{ diet} \) = percent of trophic level 3 (or 4) fish in diet
- \( TL_3(\text{or }4)\text{conc} \) = concentration of methylmercury in TL3 (or TL4) fish
Table 1.2 Target Options to Protect Humans

<table>
<thead>
<tr>
<th>Target Option</th>
<th>Acceptable Daily Intake of mercury from local fish (ug/kg bwt-day) (a)</th>
<th>Total Consumption Rate of local fish (g/day) (b)</th>
<th>Target in All Large Fish (mg/kg Hg in fish, wet wt) (c)</th>
<th>Targets in Large Fish by Trophic Level (mg/kg Hg in fish, wet wt) (d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.073</td>
<td>17.5</td>
<td>0.30</td>
<td>0.14 0.44</td>
</tr>
<tr>
<td>B (e)</td>
<td>0.073</td>
<td>32</td>
<td>0.16</td>
<td>0.08 0.24</td>
</tr>
<tr>
<td>C</td>
<td>0.073</td>
<td>64</td>
<td>0.08</td>
<td>0.04 0.12</td>
</tr>
<tr>
<td>D</td>
<td>0.1</td>
<td>142.4</td>
<td>0.05</td>
<td>0.02 0.07</td>
</tr>
</tbody>
</table>

(a) For people eating fish from commercial markets and the American River, the safe intake level of methylmercury from American River fish is the USEPA reference dose minus the methylmercury from commercial fish (Options 1-3). Option 4 assumes people are depending heavily on locally-caught fish and are not purchasing commercial fish.

(b) 17.5 g/day = one 8oz, uncooked, fish meal every two weeks; 32 g/day = 1 fish meal/week; 64 g/day = 2 meals/week; 142 g/day = 4.4 fish meals/week.

(c) Staff recommends a single target for all large fish be selected for the upper portion of the American River watershed, defined as reservoirs and river reaches, including tributaries, upstream of Folsom Lake.

(d) Staff recommends that targets for TL3 and TL4 fish be selected for the lower portion of the watershed, specifically Folsom Lake, Lake Natoma, and American River downstream of Nimbus Dam.

(e) Equal to bald eagle safe level.

1.4.4 Considerations for Evaluation of Numeric Safe Fish Tissue Targets

Staff is seeking stakeholder comment before drafting a recommendation for fish mercury targets for the American River watershed. Following are items to consider in evaluation of the target options and their application.

- Options B, C, and D are at or below the mercury safe levels for piscivorous wildlife species. Option A target values exceed the safe level to protect bald eagle and osprey.
- Option B is consistent with the water quality objectives that have been adopted for the Sacramento-San Joaquin Delta and San Francisco Bay.
- Target values are calculated to protect the most sensitive subpopulations, women of childbearing age and children. Using OEHHA’s guidelines, less sensitive populations (women who are not having children and men) may eat three times as much local fish.
- All of the options assume people eat a mixture of large fish species. Humans can reduce their mercury exposure, even from an impaired water body, by eating fish species that are low in mercury.
• Targets apply most logically to the fish species that pose the greatest risk to human and wildlife consumers. In the upper watershed, this idea could mean that targets do not apply to fish that are treated as caught-and-release.

Because mercury is present naturally at low, detectable levels in soil in the American River watershed, concentrations in fish are not expected to be zero, even in pristine environments. A study of fish mercury concentrations throughout the Western United States found that mercury concentrations were at or below the Option D target levels in almost none of the 626 streams and rivers examined (Peterson et al., 2007). Waterways studied were located in watersheds with and without historic mining activity. The safe mercury concentrations in Option D are likely below the regional background for mercury in fish, meaning that Option D may not be attainable even with a rigorous control program. Comparing with Option C, 6% of the waterways evaluated by Peterson and colleagues would meet the TL4 value (0.12 mg/kg) and around 30% would support the TL3 level (0.04 mg/kg). Forty to 50% of the western US waterways support fish populations with the Option B mercury concentrations.

All of the sites in the Peterson study are expected to have received some mercury that deposits from the global atmospheric pool. Thus the mercury in fish from pristine areas does not derive only from sediment background concentrations. Because there have been many changes in fish species, flow, and other parameters, it would be very difficult to estimate the mercury concentrations in fish prior to 1850. Staff cannot be sure that even if national and international efforts reduce mercury from outside the region, that Option D targets could be attained.

Table 1.3. Percent Reduction (%) in Existing Fish Mercury Concentrations Needed to Meet Target Options

<table>
<thead>
<tr>
<th>Target Option(a)</th>
<th>LAR</th>
<th>Natoma</th>
<th>Folsom</th>
<th>N Fork Am R d/s NF dam</th>
<th>Oxbow</th>
<th>Hell Hole</th>
<th>S Fork Am R</th>
<th>Slab Creek</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (1 meal/2 weeks)</td>
<td>24</td>
<td>17</td>
<td>32</td>
<td>27</td>
<td>none</td>
<td>27</td>
<td>32</td>
<td>none</td>
</tr>
<tr>
<td>B (1 meal/week)</td>
<td>57</td>
<td>55</td>
<td>63</td>
<td>61</td>
<td>none</td>
<td>61</td>
<td>64</td>
<td>43</td>
</tr>
<tr>
<td>C (2 meal/week) (b)</td>
<td>81</td>
<td>77</td>
<td>78</td>
<td>80</td>
<td>18</td>
<td>81</td>
<td>82</td>
<td>71</td>
</tr>
<tr>
<td>D (4.4 meal/week) (b)</td>
<td>89</td>
<td>87</td>
<td>89</td>
<td>90</td>
<td>59</td>
<td>90</td>
<td>91</td>
<td>86</td>
</tr>
</tbody>
</table>

a) Fish mercury concentrations in lower American River, Natoma, and Folsom were compared with TL3 and TL4 safe levels. For other water bodies, average concentrations in all large fish were compared with the single large fish safe level.

b) To meet Options C and D, Middle Fork American River d/s Oxbow, North Fork of Middle Fork American River, Union Valley Reservoir, and French Meadows Reservoir would also need to reduce fish mercury concentrations. Loon Lake would need reductions under all options. Of the 17 reservoirs and river reaches that have been sampled, only Ice House and Duncan Creek achieve Option D.

Note that this target evaluation treats all fish within a water body as equally likely to be captured and eaten. In some locations in the upper watershed, a culture already exists among anglers to
preserve self-sustaining populations of lake and brown trout by releasing fish that are caught (K. Thomas, DFG, personal communication, 6 Jan. 2011). When these fish are long-lived, such as those in Hell Hole Reservoir, they are relatively high in mercury. Official designation of some waters and/or fish species as catch-and-release only, coupled with the existing culture, could provide that these fish are rarely or not eaten and do not pose a risk to human consumers. Staff requested guidance from the US Fish and Wildlife Service regarding the likelihood of bald eagle and osprey eating trout from deep, high-altitude reservoirs.

Comparisons of existing mercury concentrations in fish that are eaten by humans with target concentrations would not include fish that should not be eaten. For example, this could mean that mercury concentrations in large lake and brown trout in Hell Hole are “not counted” and the percent reduction shown in Table 1.3 to meet the target would be less. The approach of assuming some fish would not be eaten should not be applied where fishing pressure is great, a wide variety of fish species is eaten, and activism to maintain fish populations through catch and release is not developed (e.g., Folsom Lake and downstream).

Citations


