

Establishing realistic length standards for Cutthroat Trout, Rainbow Trout, and Mountain Whitefish

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Abstract

Objective: Proportional size distribution (PSD) is a simple index used to summarize length data that is easily communicated, provides insight on fish population dynamics (e.g., growth, recruitment), and is often used to establish management objectives. However, the current length categories for Cutthroat Trout *Oncorhynchus clarkii* and Rainbow Trout *O. mykiss* were based on the all-tackle world records (an atypically large adfluvial Cutthroat Trout and a steelhead [anadromous Rainbow Trout]). Consequently, the length categories (stock [S], quality [Q], preferred [P], memorable [M], trophy [T]) are so large for these two species that the index is of limited use for most populations throughout western North America, particularly for large length-groups. In addition, length standards have not been proposed for Mountain Whitefish *Prosopium williamsoni*. As such, we sought to provide new length standards for Cutthroat Trout, Rainbow Trout, and Mountain Whitefish that allow fisheries scientists to calculate useful PSD values.

Methods: We compiled data from nearly 3 million fish across the western United States. A percentile-based approach was used to identify the individual total length that would form the basis of estimating length standards. We placed each fish into its respective 10-digit hydrological unit code, obtained the maximum length (all lengths are total length) for each 10-digit hydrological unit code by species, and then identified the 99th percentile of the maximum lengths. The species-specific 99th percentile value was then used to estimate potential length standards for each length category. For Mountain Whitefish, we used the current world-record length as the basis for generating length standards. We compared PSDs calculated using existing and revised length standards to provide insight on potential issues with the proposed values.

Results: We propose the following minimum total lengths for PSD calculations: 18 cm (7 inches; S), 28 cm (11 inches; Q), 35 cm (14 inches; P), 43 cm (17 inches; M), and 53 cm (21 inches; T) for Cutthroat Trout; 20 cm (8 inches; S), 30 cm (12 inches; Q), 40 cm (16 inches; P), 50 cm (20 inches; M), and 60 cm (24 inches; T) for Rainbow Trout; and 15 cm (6 inches; S), 25 cm (10 inches; Q), 30 cm (12 inches; P), 38 cm (15 inches; M), and 48 cm (19 inches; T) for Mountain Whitefish. Revised values provided more realistic estimates of PSD for Cutthroat Trout and Rainbow Trout than existing values. The proposed length standards for Mountain Whitefish resulted in PSD values that were realistic and useful for characterizing length structure.

Conclusions: The length standards presented here provide fisheries scientists with tools to aid in the study and management of Cutthroat Trout, Rainbow Trout, and Mountain Whitefish populations.

Keywords: Cutthroat Trout, length structure, Mountain Whitefish, proportional size distribution, Rainbow Trout

Lay summary

Cutthroat Trout, Rainbow Trout, and Mountain Whitefish are species of considerable management focus in western North America. The length standards provided here will assist in monitoring, research, and management efforts for these species.

Introduction

Characterizing the length structure of fish populations has long been foundational to fisheries science. Evaluating changes in length structure provides insight important for guiding management and conservation actions (Neumann & Allen, 2007; Neumann et al., 2012; Willis et al., 1993) because variability in length structure reflects recruitment dynamics, growth of individuals, and mortality rates (Neumann et al., 2012). A variety of techniques are used to describe length structure, varying from simple summary statistics and length-frequency histograms to length-based indices (Bonar, 2002; Miranda, 2007; Neumann et al., 2012). Length-based indices are particularly useful because they summarize large quantities of data into a format that is easily communicated among fisheries professionals and to the public (Neumann et al., 2012; Willis et al., 1993). Perhaps the most common length-based index is proportional size distribution (PSD). Proportional size distribution (formerly proportional stock density) was first proposed by Anderson (1976) and is calculated as the percentage of stock (S)-length fish that are greater than or equal to quality (Q) length. The original index only considered S- and Q-length fish, but Gabelhouse (1984) used angler preference information from Weithman (1978) to define preferred (P), memorable (M), and trophy (T) lengths. Since the initial introduction of PSD, use of the index has proliferated, particularly among fisheries managers (Neumann et al., 2012; Willis et al., 1993).

The benefits and limitations of PSD have received considerable attention from fisheries scientists. Willis et al. (1993) provided a comprehensive overview of the history, interpretation, and application of PSD. In their review, they noted two schools of thought on the use of PSD. The first school is convinced that PSD and its variations (e.g., PSD-P) is an all-encompassing index that reflects both the form and function of fish populations. This view is rooted in the large body of evidence highlighting close relationships between PSD and measurements of growth (Miranda, 1983; Willis & Scalet, 1989; Willis et al., 1991), recruitment (Novinger & Legler, 1978), and mortality (Miranda, 1983; Reynolds & Babb, 1978), as well as other factors like body condition (Johnson et al., 1992; Wege & Anderson, 1978). At the other end of the spectrum are scientists who argue that PSD has little to no value. The degree to which PSD provides an index of population dynamics certainly varies among systems and species, but at a minimum, PSD provides a simple quantification and summarization of length-frequency distributions. For good reason, early critics highlighted the narrow focus on warmwater and coolwater sport fishes (Willis et al., 1993). Gabelhouse (1984) obtained the all-tackle world-record length (as of 1982) for 65 species, three hybrids, and one family from the International Game Fish Association (IGFA). He then applied percentages of the world-record length to estimate minimum and maximum potential lengths for each category (i.e., $S = 20\text{--}26\%$, $Q = 36\text{--}41\%$, $P = 45\text{--}55\%$,

$M = 59\text{--}64\%$, $T = 74\text{--}80\%$). Despite providing a range of potential lengths, he only proposed length standards for 22 species and one hybrid, all of which were warmwater or coolwater sport fishes. More recently, length standards have been proposed for a variety of nongame fishes (e.g., Bister et al., 2000; Miller et al., 2024; Voss & Quist, 2026) and coldwater species (e.g., Hyatt & Hubert, 2001; Kruse & Hubert, 1997). Although length standards are available for many salmonids, some concerns remain regarding the use of current standards for many coldwater fishes.

The use of PSD is limited for many coldwater species due to the interaction of salmonid life history variation and the methodology used to establish length standards. Many salmonids have diverse life history strategies with both anadromous and nonanadromous forms, and even within nonanadromous populations, resident, fluvial, and adfluvial life histories are common (Behnke, 2002; Birnie-Gauvin et al., 2021). The world-record length for a species is generally used to establish length standards, but the largest salmonids are typically those that are anadromous or adfluvial. Consequently, length categories are often so large that they are not useful for the vast majority of populations managed by natural resource agencies. Length categories for Cutthroat Trout *Oncorhynchus clarkii* (note that Cutthroat Trout has been separated into four species [Page et al., 2023] but the taxonomy is questioned and not recognized by many agencies and taxonomists; see Discussion section) and Rainbow Trout *O. mykiss* are of particular concern. Both species are a primary focus of natural resource agencies in western North America given their importance as sport fishes and(or) their conservation status (Behnke, 2002; Gresswell, 1988; Muhlfeld et al., 2015; P. Trotter et al., 2018). Cutthroat Trout and Rainbow Trout have diverse life histories that result in large differences in length structure.

Using the length ranges provided in Gabelhouse (1984), Kruse and Hubert (1997) proposed length standards for Cutthroat Trout. The world-record length used by Gabelhouse (1984) and Kruse and Hubert (1997) was 990 mm (39 inches; all lengths are total length unless otherwise specified), but the source of the length is not entirely clear. Although there is a record of the weight from the world-record Cutthroat Trout, an 18.6-kg (41-lb) Lahontan Cutthroat Trout *Oncorhynchus clarkii henshawi* caught in 1925 from Pyramid Lake, Nevada, there is no record of its length (L. Exton, IGFA, personal communication). The next heaviest Cutthroat Trout on record with the IGFA is a 10.9-kg (24-lb), 876-mm (34.5-inch) Lahontan Cutthroat Trout that was caught in Pyramid Lake in 2017. The longest Cutthroat Trout on record with the IGFA are several 889-mm (35-inch) fish—all from Pyramid Lake. Discussion with IGFA personnel suggests that the world-record fish was preserved in formalin and later turned into a taxidermy mount for display at the Nevada State Museum. Therefore, it seems safe to assume that the fish used by Gabelhouse (1984) was the fish caught in 1925 from Pyramid Lake and that the length was either estimated from the weight

(e.g., using a length–weight relationship) or measured from the preserved world-record fish. Nevertheless, the resulting length standards proposed by [Kruse and Hubert \(1997\)](#) for Cutthroat Trout are exceptionally large: S = 200 mm (8 inches), Q = 350 mm (14 inches), P = 450 mm (18 inches), M = 600 mm (24 inches), T = 750 mm (30 inches). Likewise, [Simpkins and Hubert \(1996\)](#) proposed length standards for Rainbow Trout using the range of values provided by [Gabelhouse \(1984\)](#). The world-record fish used by [Gabelhouse \(1984\)](#) was a 19.1-kg (42-lb 2-oz), 1,092-mm (43-inch) steelhead (anadromous Rainbow Trout) caught in 1970 at Bell Island, Alaska. The current world record is a 21.8-kg (48-lb), 1,066-mm (42-inch) Rainbow Trout caught in 2009 from Lake Diefenbaker, Saskatchewan, Canada (Exton, personal communication). As with Cutthroat Trout, the length standards proposed for Rainbow Trout ([Simpkins & Hubert, 1996](#)) are extraordinarily large: S = 250 mm (10 inches), Q = 400 mm (16 inches), P = 500 mm (20 inches), M = 650 mm (26 inches), T = 800 mm (31 inches). Most inland Cutthroat Trout and Rainbow Trout populations, particularly in lotic systems, contain few or no fish greater than the minimum preferred length and none greater than memorable length. The “unrealistically” large length standards have resulted in most managers foregoing the use of PSD for these species because the index is noninformative, particularly for large length categories. As such, the purpose of this study was to evaluate alternative length categories for Cutthroat Trout and Rainbow Trout with the goal of providing managers with information that can be used to estimate meaningful length-based indices. We also provide length standards for Mountain Whitefish *Prosopium williamsoni*, which are currently unavailable. Mountain Whitefish is a popular recreational species in western North America that is often sympatric with Cutthroat Trout and Rainbow Trout and is increasingly the focus of management and conservation activities in the Intermountain West ([Boyer et al., 2017](#); [Meyer & Vincent, 2025](#); [Meyer et al., 2009](#)).

Methods

Length data were requested from state natural resource agencies throughout the Intermountain West and Pacific Northwest (Colorado, Idaho, Montana, Nevada, Oregon, Utah, Washington, Wyoming). Although data requests focused on agencies in the western USA, the resulting data set likely captured the diversity of habitats, life history strategies, and lengths characteristic across the distribution of each species. Agencies were asked to provide information on species, length, and Global Positioning System coordinates. We asked agencies to exclude adult fish that were clearly anadromous (i.e., steelhead, sea-run Cutthroat Trout). Records that were in fork length (FL) were converted to total length (TL) using standard FL to TL equations ([Carlander, 1969](#); [Froese & Pauly, 2010](#); hereafter, all lengths are TL). Less than 3% of the Cutthroat Trout records and less than 1% of the Rainbow Trout and Mountain Whitefish records were provided as FL. Next, we removed length records that were likely erroneous. Given the number of individual records (i.e., ~3 million fish) and lack of access to raw data (e.g., data sheets from the field), we could not verify length measurements. In an effort to be as objective as possible, we first excluded records that exceeded the

species-specific world-record length. Next, we excluded records within each state that exceeded that state’s record length for a particular species ([Supplementary Table 1](#)). Approximately 0.018% of the Rainbow Trout, 0.011% of the Cutthroat Trout, and 0.17% of the Mountain Whitefish records were removed as a result of this process.

We then sought to identify the most appropriate spatial scale for the analysis. Individual water bodies were often difficult to discern from the data provided (e.g., river–reservoir transitions); even then, the process of how to best coalesce samples from the same system (e.g., appropriate distance between sites sampled in a river system) was unclear. Instead of focusing on sampling locations or individual water bodies, we assigned each sample to its respective hydrologic unit code (HUC). Individual 12-digit HUCs (HUC12s) are often quite small (<40 km²) and include only portions of a water body (i.e., streams can span multiple HUC12s). As such, HUC12s were considered too small for the purposes of this analysis. In contrast, 8-digit HUCs were exceptionally large (e.g., Upper Salmon [17060201] = 6,280 km²) and also deemed an inappropriate scale. We considered 10-digit HUCs (HUC10s) as the most appropriate scale that balanced an adequate number of samples with a spatial scale useful to fisheries managers. In addition, HUC10s are the most appropriate scale for capturing movement dynamics of migratory individuals (e.g., fluvial fish; [Hilderbrand & Kershner, 2000](#); [Schmetterling, 2001](#)). We excluded HUC10s that contained less than 125 individual length records for each species based on guidance in [Gustafson \(1988\)](#), [Vokoun et al. \(2001\)](#), and [Miranda \(2007\)](#) suggesting that a sample size of 125 individuals was adequate to evaluate length structure in most instances (also see [Quist et al., 2009](#)).

The length that formed the basis of establishing revised length standards was determined using a percentile-based approach. First, we identified the maximum length of fish in each HUC10 by species. From the distribution of maximum lengths for each species, we then obtained the 99th percentile length. Alternative percentiles were considered, but we sought to maintain the logic associated with the original derivation of length categories while reducing the influence of anomalously large individuals in the data set. Minimum and maximum potential values for each length category were estimated by multiplying the 99th percentile length by the percentages provided in [Gabelhouse \(1984\)](#) for each category.

Mountain Whitefish presented a different situation than Cutthroat Trout and Rainbow Trout. Specifically, length standards have not been formally proposed except that [Gabelhouse \(1984\)](#) calculated a range of potential values for each length category using the world-record length (i.e., 483 mm). We calculated potential length standards for Mountain Whitefish using the methods described above for Cutthroat Trout and Rainbow Trout, as well as the current world-record, a 610-mm (24-inch) Mountain Whitefish caught in 2021 from the Deschutes River, Oregon. Comparisons were made by calculating PSD, PSD-P, PSD-M, and PSD-T by HUC10 using existing and revised standard lengths for Cutthroat Trout and Rainbow Trout. For Mountain Whitefish, comparisons were made using length standards selected from within the range provided by [Gabelhouse \(1984\)](#) and those estimated using the current world-record length.

Results

In total, we received records for ~3.0 million individual fish (791,897 Cutthroat Trout, 1,725,007 Rainbow Trout, 409,635

Mountain Whitefish) from 37,050 individual sampling events that occurred from 1933 to 2025 (Figure 1). Exclusion of records that exceeded the world-record and state-specific state-record lengths resulted in the removal of 92 Cutthroat

Table 1 Existing and revised standard lengths for estimating proportional size distribution of Cutthroat Trout, Rainbow Trout, and Mountain Whitefish. Values are provided in metric (cm) and English (inches; in parentheses) units.

Source	Length category				
	Stock	Quality	Preferred	Memorable	Trophy
Cutthroat Trout					
Existing ^a	20 (8)	35 (14)	45 (18)	60 (21)	75 (30)
Revised	18 (7)	28 (11)	35 (14)	43 (17)	53 (21)
Rainbow Trout					
Existing ^b	25 (10)	40 (16)	50 (20)	65 (26)	80 (31)
Revised	20 (8)	30 (12)	40 (16)	50 (20)	60 (24)
Mountain Whitefish					
“Existing” ^c	10 (4)	18 (7)	25 (10)	30 (12)	38 (15)
Revised	15 (6)	25 (10)	30 (12)	38 (15)	48 (19)

^aKruse and Hubert (1997).

^bSimkins and Hubert (1996).

^cValues have not been formally established. Values presented here are the approximate midpoint of potential values provided in Gabelhouse (1984).

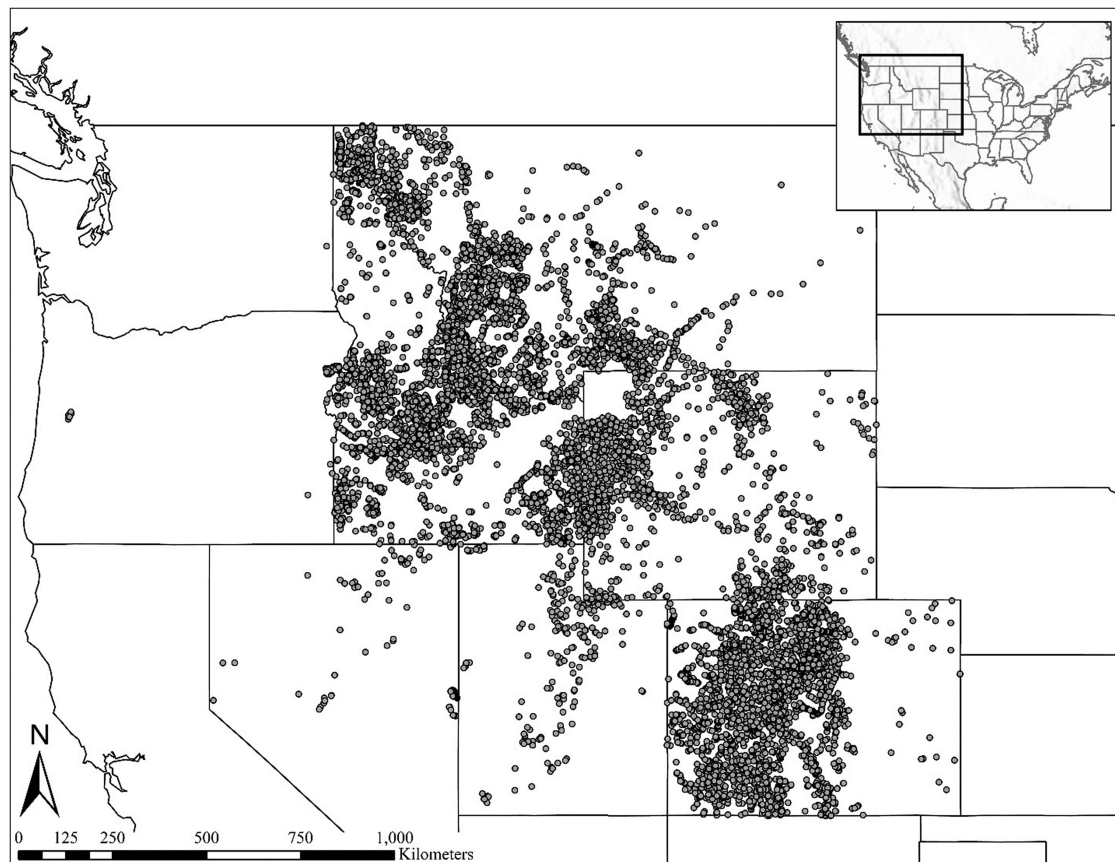


Figure 1 Sampling locations of fishes used to estimate length standards for Cutthroat Trout, Rainbow Trout, and Mountain Whitefish.

Trout, 316 Rainbow Trout, and 673 Mountain Whitefish. Removing HUC10s with less than 125 individual length records resulted in the exclusion of 441 HUC10s for Cutthroat Trout, 469 for Rainbow Trout, and 280 for Mountain Whitefish. The final data set contained 774,654 Cutthroat Trout (505 HUC10s), 1,706,229 Rainbow Trout (559 HUC10s), and 401,801 Mountain Whitefish (179 HUC10s).

Maximum length across HUC10s varied among species (Figure 2). The distribution of maximum lengths varied from 200 to 964 mm for Cutthroat Trout and was similar for

Rainbow Trout (195–915 mm). Mountain Whitefish had a narrow range of maximum lengths varying from 271 to 580 mm (mean $\pm$ SE; 468.5 ± 3.9 mm).

The 99th percentile of maximum lengths across HUC10s was 697 mm for Cutthroat Trout, 785 mm for Rainbow Trout, and 577 mm for Mountain Whitefish. Revised standard lengths were approximately 10–20% lower across length categories than existing values for Cutthroat Trout and 20–25% lower for Rainbow Trout (Table 1). For Mountain Whitefish, we evaluated the use of the 99th percentile as the basis for

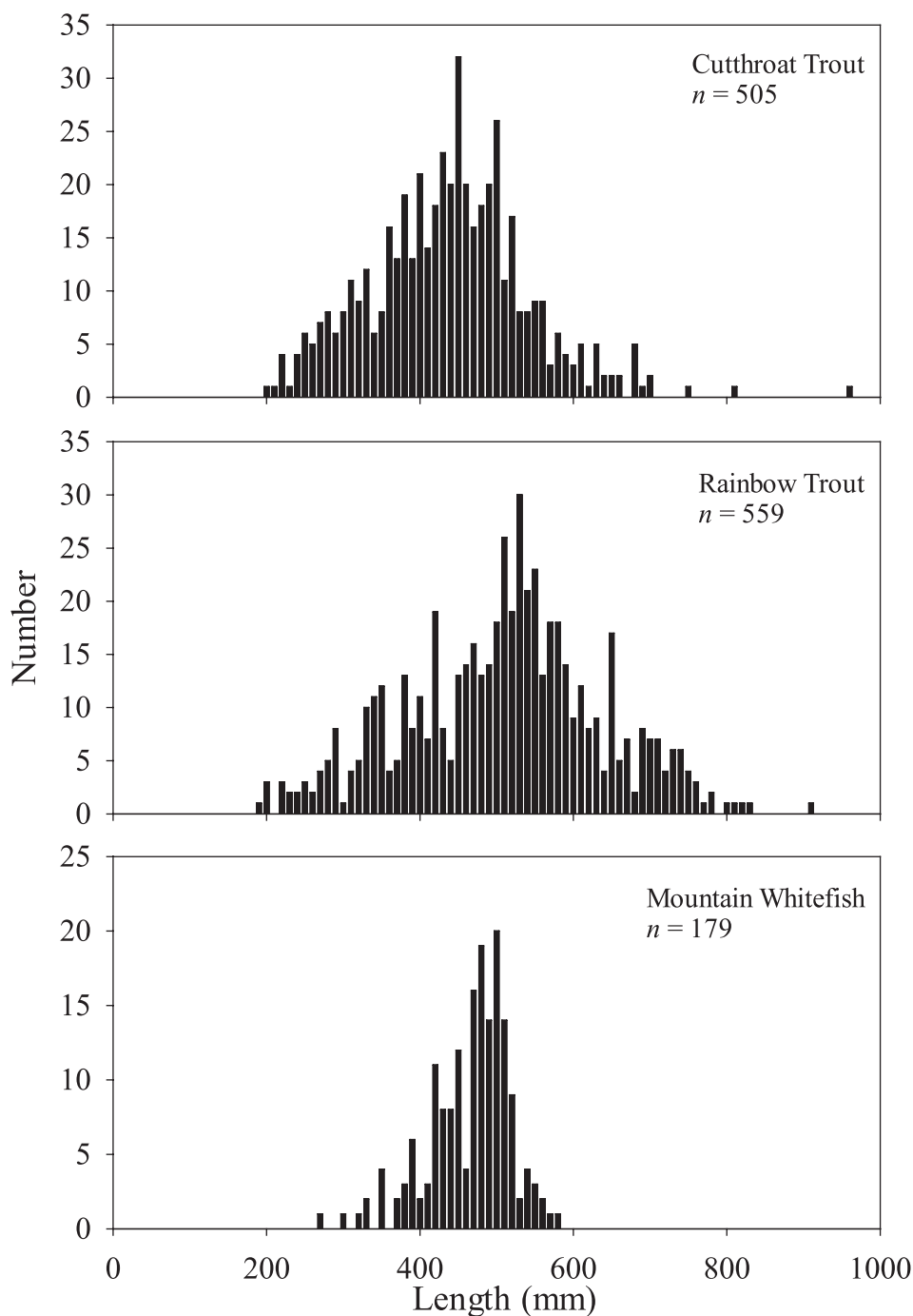


Figure 2 Frequency distribution of the maximum length of Cutthroat Trout, Rainbow Trout, and Mountain Whitefish in 10-digit hydrologic unit codes (n = number of 10-digit hydrologic unit codes).

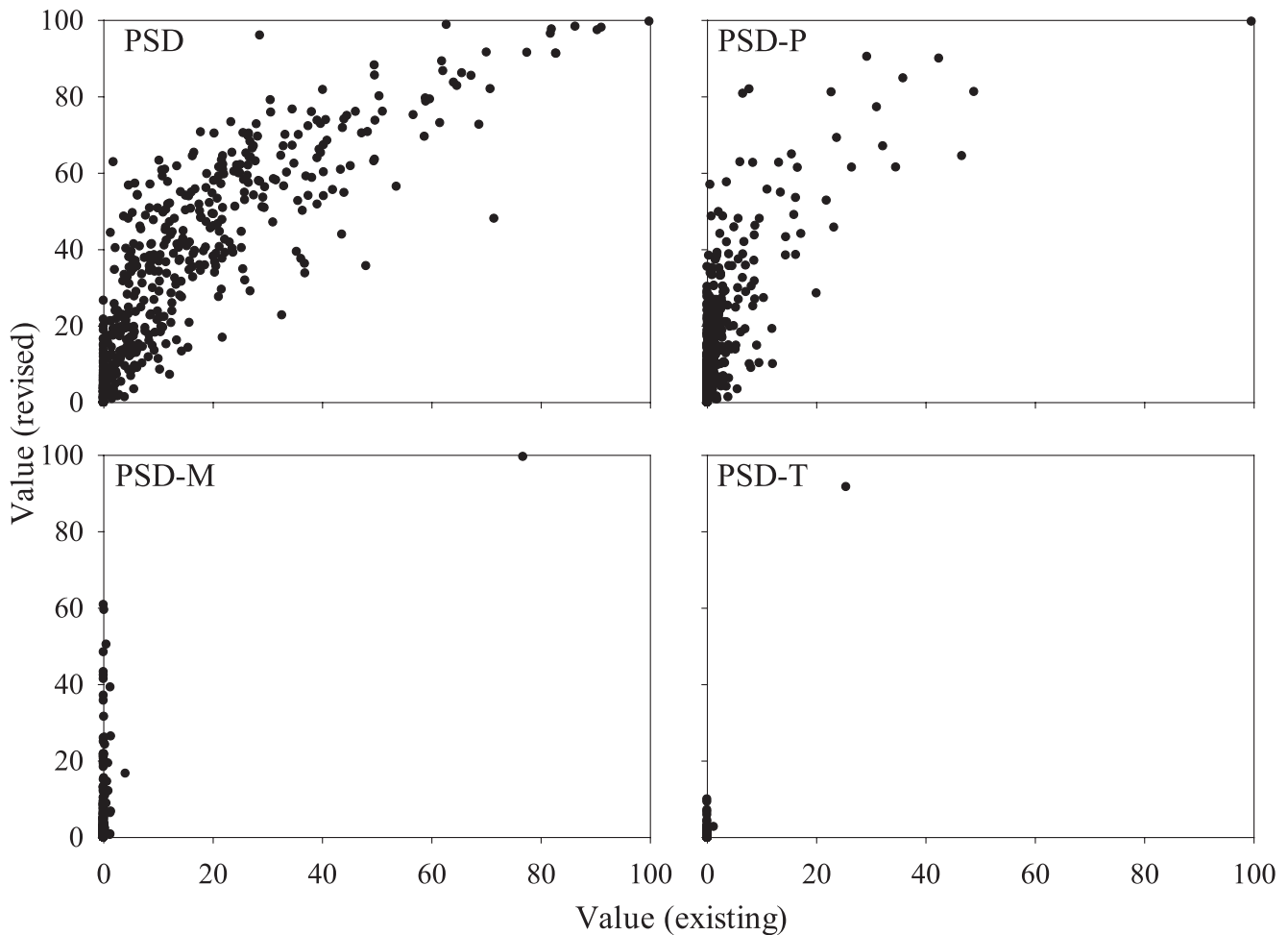


Figure 3 Proportional size distribution (PSD) values for Cutthroat Trout using existing and revised standard values for stock, quality, preferred (P), memorable (M), and trophy (T) lengths. Each point represents an individual 10-digit hydrologic unit code.

establishing length standards, as well as the current world-record length (610 mm), but the results were nearly identical. For instance, the range of potential values for stock length using the 99th percentile value was 115–150 mm, compared with 122–158 mm using the world-record length. As such, we used values estimated from the world-record length to compare with values selected from Gabelhouse (1984). In contrast to Cutthroat Trout and Rainbow Trout, the revised values for Mountain Whitefish were slightly higher than values extracted from Gabelhouse (1984) (Table 1).

Patterns in estimated PSD values from across the Intermountain West and Pacific Northwest highlighted issues with existing standards and the benefits of revised standards for Cutthroat Trout (Figure 3) and Rainbow Trout (Figure 4), particularly for large length categories. For instance, only a single HUC10 for Cutthroat Trout had a PSD-M value greater than five, and a single HUC10 had a PSD-T greater than two using existing standards (Figure 3). With revised length standards, 80 HUC10s had a PSD-M greater than five and 16 had PSD-T values greater than two. Similar patterns were observed for Rainbow Trout, where five HUC10s had PSD-M values greater than five with existing standards compared with 50 with a PSD-M greater than five with revised lengths (Figure 4).

No HUC10s had PSD-T values greater than one using existing values, whereas 22 had PSD-T values over one and nine had values over five using revised length standards. The proposed length standards for Mountain Whitefish resulted in PSD values that were realistic and useful for characterizing length structure (Figure 5).

Discussion

Proportional size distribution is a simple index that facilitates communication, provides insight on fish population dynamics, and is regularly incorporated into management plans (e.g., target PSD values) for species or specific water bodies (Neumann et al., 2012; Willis et al., 1993). Although resource managers have a desire to use PSD for Cutthroat Trout and Rainbow Trout, the index has limited value when the great majority of fish have little chance of reaching all but the smallest length categories. The existing length standards for Cutthroat Trout and Rainbow Trout were developed using standard methods (Gabelhouse, 1984; Kruse & Hubert, 1997; Simpkins & Hubert, 1996), and the implications of such extraordinarily long world-record fish on the use of PSDs were likely not anticipated when the standards were proposed. Nevertheless, the length

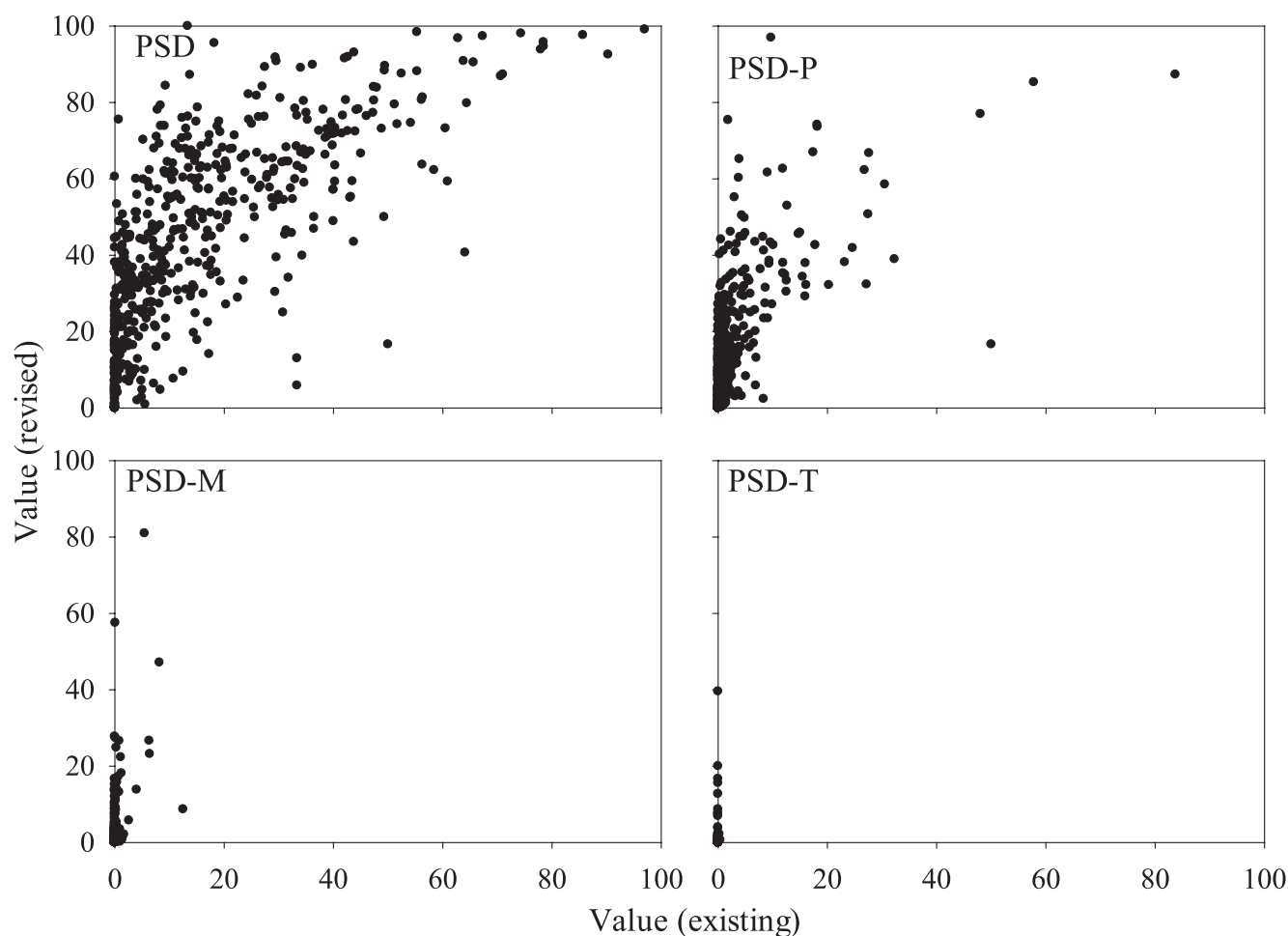


Figure 4 Proportional size distribution (PSD) values for Rainbow Trout using existing and revised standard values for stock, quality, preferred (P), memorable (M), and trophy (T) lengths. Each point represents an individual 10-digit hydrologic unit code.

standards have clearly hindered application of PSD for Cutthroat Trout and Rainbow Trout across their distributions. In fact, we have collectively experienced firsthand or listened to complaints from fisheries managers for decades about the limitations of PSDs for these species.

Although using the world-record length as the basis for estimating length standards is the most common approach, other techniques have been employed. For example, [Bister et al. \(2000\)](#) provided length standards for 10 nongame and riverine fish species. The authors compiled a large data set to develop standard weight equations and compared the maximum length of fish in their data set with the world-record length of the target species. The longer of the two lengths was then used as the basis for calculating length standards. [Black et al. \(2021\)](#) compiled data across the distribution of Utah Chub *Gila atraria* to develop a standard weight equation and evaluate length standards. Their data set included information on ~30,000 individual Utah Chubs from 24 populations. They used the largest fish in their data set after excluding fish from Jackson Lake, Wyoming, to calculate length standards. The largest individual fish (612 mm) from Jackson Lake was over 115 mm larger than the next largest individual in any other population. Furthermore, the next 11 largest fish in their data set were also from Jackson Lake. The authors

argued that using the fish from Jackson Lake would have resulted in length standards that were too large for most Utah Chub populations. For those species where the world record is not atypically large or overly small (e.g., species that are not a major focus of angling efforts), the use of world-record fish is appropriate. In other situations, using the largest fish in a large data set or adopting a percentile-based approach may be most appropriate. Regardless, applying new length standards by estimating PSDs for a diversity of populations (e.g., [Voss & Quist, 2026](#)) would help avoid the problems observed for Cutthroat Trout and Rainbow Trout.

As stated in the *Introduction*, the taxonomy of Cutthroat Trout has recently been a source of contention. Cutthroat Trout has long been treated as a single species with multiple subspecies (e.g., [Behnke, 2002](#)). The text, *Common and Scientific Names of Fishes from the United States, Canada, and Mexico* ([Page et al., 2023](#)), is typically treated as authoritative with regard to the taxonomy of North American fishes. The most recent (eighth) edition separated Cutthroat Trout into four species: Coastal Cutthroat Trout *Oncorhynchus clarkii*, Lahontan Cutthroat Trout *O. henshawi*, Westslope Cutthroat Trout *O. lewisi*, and Rocky Mountain Cutthroat Trout *O. virginialis*. However, the new species designations have not been met with widespread acceptance by natural resource agencies

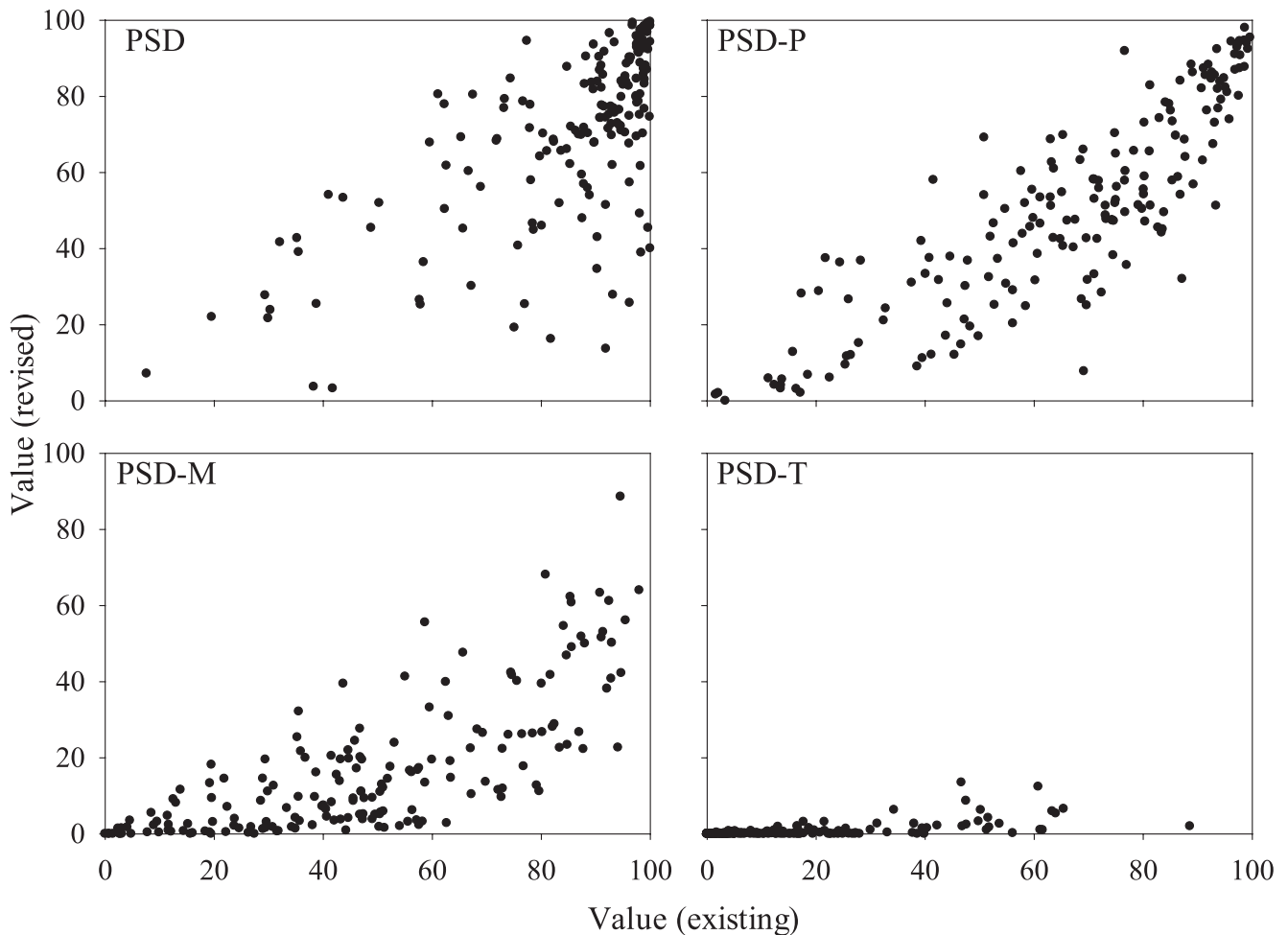


Figure 5 Proportional size distribution (PSD) values for Mountain Whitefish using existing (extracted from [Gabelhouse, 1984](#)) and revised standard values for stock, quality, preferred (P), memorable (M), and trophy (T) lengths. Each point represents an individual 10-digit hydrologic unit code.

or phylogeneticists and taxonomists. Whether Cutthroat Trout is treated as one or four species likely has little bearing on our analysis or interpretation of results. Admittedly, we lacked data on Cutthroat Trout that would be classified as Coastal Cutthroat Trout, but Coastal Cutthroat Trout, including anadromous forms, are similar in length to Cutthroat Trout in more inland systems (e.g., [Sheldon & Richardson, 2022](#); [P. C. Trotter, 1989](#)). Perhaps a more relevant concern is Lahontan Cutthroat Trout, which reach exceptionally large lengths ([Behnke, 2002](#); [Heredia & Budy, 2018](#); [Sigler et al., 1983](#)). In an effort to better understand the influence of Lahontan Cutthroat Trout on our analysis, we removed Lahontan Cutthroat Trout (as identified by agencies providing data) from our data set and repeated the analysis. The overall maximum length was reduced from 964 to 810 mm, but the 99th percentile of maximum lengths across HUC10s only declined from 697 to 688 mm. The slight reduction in the 99th percentile length would functionally have no influence on the proposed length standards across length categories. Despite the current uncertainty of Cutthroat Trout taxonomy, we treated Cutthroat Trout as a single species and argue that the values provided in our analysis are widely applicable to Cutthroat Trout regardless of taxonomy. A few

populations of Lahontan Cutthroat Trout (e.g., Pyramid Lake) will consistently have high PSD values, even for the largest categories (i.e., PSD-M, PSD-T), but such PSD values are reflective of the trophy fisheries those systems support.

Proportional size distribution requires realistic length standards to be useful in resource management. Our investigation highlighted clear issues with current values for Cutthroat Trout and Rainbow Trout and sought to provide an objective approach to establishing length standards. The values provided here will allow fisheries scientists to better summarize length data, communicate results in an efficient manner, and set realistic management targets for Cutthroat Trout, Rainbow Trout, and Mountain Whitefish populations across North America.

Supplementary material

Supplementary material is available at [North American Journal of Fisheries Management](#) online.

Data availability

Data that support the findings of this study are available for corresponding authors upon reasonable request.

Ethics statement

As this study examined existing data and no fish handling occurred, no ethical guidelines applied.

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Conflicts of interest

Kevin A. Meyer holds the position of associate editor for the *North American Journal of Fisheries Management* and has not peer reviewed or made any editorial decisions for this paper. There are no other potential conflicts of interest to declare in this article.

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