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Spawning Potential Ratio: A Key Metric for Managing Florida's Fisheries[1]

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Introduction

From red drum to red snapper, Florida manages many of its fisheries with specific consideration given to a quantity called the spawning potential ratio (SPR). This acronym appears frequently because it is an important metric to fisheries biologists and managers. It often helps determine whether a fishery should allow more or fewer fish to be harvested, and it therefore drives regulations for both commercial and recreational fishing. However, SPR is not especially intuitive to those not directly involved in fisheries management. This publication intends to describe what SPR is and explain how and why it is used in managing fish stocks. We think this publication will help people—including the interested public as well as Extension agents and management agency personnel—better understand fisheries management decisions, the publications describing them, and the science behind them. One specific way we expect this publication will be useful is helping management, outreach, and Extension personnel easily explain SPR to the public that they interact with. This publication does not contain new information unavailable in existing fisheries text books; rather it seeks to explain this information in a simple manner.

This publication focuses on specifically understanding what SPR is and why and how it is used in fisheries management. For additional detail about the importance of spawning, reproduction, and ultimately recruitment in fish populations, please see previous Ask IFAS publications FA222 and FA234. What is most important for readers to understand is that the principles of fish recruitment, which these previous publications describe, are more or less why the minimum SPR targets used in management tend to range between 20 and 40% (Camp et al. 2020; Camp et al. 2021).

Spawning Potential Ratio

$$SPR = \frac{\text{eggs produced (per individual) when population is } \textbf{fished}}{\text{eggs produced (per individual) when population is } \textbf{not fished}}$$

Figure 1. The spawning potential ratio equation.
Credits: UF/IFAS

Spawning potential ratio (SPR) describes the expected lifetime reproductive potential of an "average" individual fish when the population is fished, compared to (divided by) what would be expected for that same individual when no fishing is allowed. This means that SPR roughly compares the eggs produced by a fished population to the eggs produced by an unfished one. That's the "spawning potential" part of SPR. The "ratio" part refers to the fact that SPR is a ratio (a fraction of one thing compared to another). Because it's essentially impossible to have more eggs in the fished conditions than in the unfished ones, this ratio is almost always expressed as a percentage. That means SPR will always be between 0–100%. Knowing SPR allows fisheries managers to understand the effect fishing is having on overall egg production of the fish population. The greater the SPR value, the less impact fishing is having

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on the reproductive ability of the population. In other words, a greater SPR (e.g., >60%) indicates only slight effects of fishing, whereas a lesser SPR (e.g., 25%) indicates fishing is reducing the egg production quite a lot (Camp et al. 2021). So that is SPR in a nutshell. But it's worth looking a little deeper at the "reproductive potential" part, because it's these details that explain why the SPR is so important.

> **Box 1:** Sometimes fish biologists will use the weight of a mature fish as a proxy for eggs. The weight of a typical fish of that species at maturity is usually roughly proportional to the weight of the total eggs an individual fish of that species can produce over its lifetime.

Reproductive potential is usually presented as the number of eggs a fish can produce, which generally increases with the size of fish. Another way of describing SPR is as the ratio of the total number of eggs an average fish will contribute to the population over its lifetime if the population were fished (numerator) compared to the number of eggs an average fish would contribute if there was no fishing allowed (denominator).

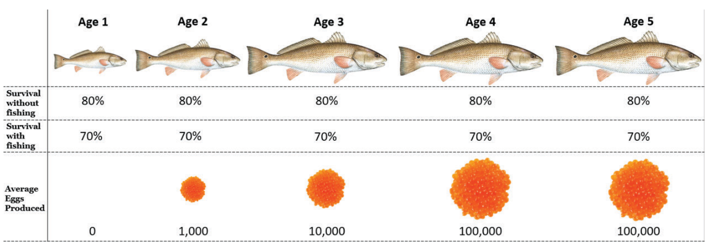

Figure 2. An example of life history values using SPR calculations. Note that these example quantities are for illustrative purposes and do not represent the actual life history schedule for red drum.
Credits: Depiction of red drum courtesy of © Diane Rome Peebles

The concept of an "average fish" is clearer with an example. Say a fish population starts off with 1,000 1-year-old fish. First, imagine this population without fishing but still with natural mortality (from predators or sickness, for instance). Of the 1,000 year-old fish we began with, say 80% of them survive each successive year. This would make 800 fish alive at age 2, 640 at age 3, 512 at age 4, and 409 at age 5 (we'll stop at age 5 for this example). Now say that in this population fish become sexually mature at age 2, and a two-year-old fish can produce 1,000 eggs that year. Because egg production increases with size, for this example, say a three-year-old fish can produce 10,000 eggs, and four- and five-year-old fish can produce 100,000 eggs. The data needed are now available to determine the denominator value necessary to calculate the SPR for this population. Simply multiply the number of fish alive at each age by the number of eggs produced at each age, sum those quantities up, and then divide by the initial 1,000 fish. This would yield 99,360 eggs contributed per lifetime of an average fish in an **unfished** population.

Now it is necessary to calculate what the eggs contributed over the lifetime of a fish would be if a population were **fished**. For simplicity, let's suppose that when a certain level of fishing is introduced the chance for survival of each age decreases from 0.8 to 0.7 (70% survive). To find the numerator for the example SPR, the exact same calculations as before are run, but this time to calculate egg production values when fishing is occurring. This yields 63,910 eggs contributed over the lifetime of an average fish when there is fishing. The SPR in this case would then be 63,910/99,360, or an SPR of 64%. Fishing in this simple case reduces the number of eggs an average fish will contribute to the population over the course of its lifetime by 36%, so the fish only contributes 64% of the eggs it could contribute without fishing.

Why is this metric important?

In managing fish populations, biologists are particularly concerned about replenishment. That is, we want to make sure enough spawning fish survive to produce the next generation of fish so that we can ensure fishing remains a sustainable enterprise. As you may have guessed, a key metric that fisheries managers consider in evaluating this is SPR. That's one reason we care about the ratio of eggs produced under fished conditions to eggs produced under unfished conditions. Another reason is related to recruitment (see Camp et al. 2020)—that is, the number of fish that survive from the egg to the juvenile life stage. Consequently, SPR is important because the number of recruits produced depends on the number of eggs. This isn't necessarily a proportional relationship because as you increase the number of eggs, the survival of each individual egg decreases due to competition for food and habitat. This is known as density-dependent survival, because the survival rate is dependent on the density of eggs or small fish. When there are a lot of eggs (say SPR>50%) recruitment is largely the same, because of density-dependent mortality. However, when SPR gets lower, in the 20–35% range, there starts to be so few eggs that recruitment declines. The key to choosing an SPR level for management decisions is to pick one that will ensure that the number of recruits (young fish) produced by the spawning stock does not decrease greatly compared to when the population is unfished. This is why scientists often identify specific targets or "reference points" below which the SPR must not fall.

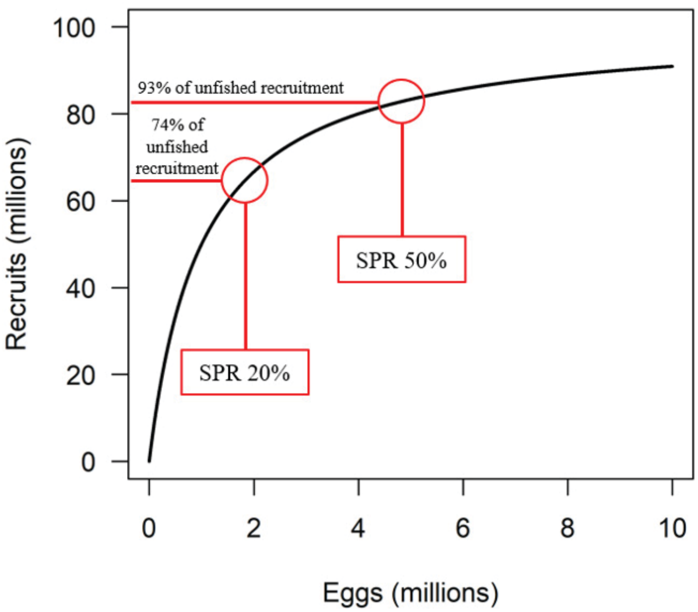

Figure 3. Example of the number of recruits (young fish) produced at two different SPR levels.
Credits: UF/IFAS

How SPR is used to manage fisheries, reference points

SPR defines the expected lifetime spawning output per fish compared to that in an unfished population for a given level of fishing mortality. Fisheries managers set what is known as a limit reference point that defines the fishing mortality not to be exceeded in a fishery. They set this limit based on a fishing mortality that would produce an SPR of *X*%. This limit reference point is known as $F_{x\%}$. Note, fishing mortality is usually estimated within stock assessments (Fisch et al. 2021). For example, an $F_{40\%}$ describes a fishing mortality level that would produce an SPR of 40%. In a stock assessment, fisheries managers can evaluate whether the current fishing mortality in the fishery exceeds this $F_{x\%}$ level (Fisch et al.2021). If it does, the fish stock would be considered "undergoing overfishing." At this point, fisheries managers may consider implementing more strict fishing regulations to decrease fishing mortality below the reference level.

The way in which fisheries managers examine the effect of fishing regulations on SPR is first by evaluating how specific regulations might change the fishing mortality at each age. They then can run the SPR calculations using predictions from stock assessments (Fisch et al. 2021) to explore the effect these different regulations have on the SPR. For example, managers may explore implementing a slot limit restricting harvest to fish ages 1–3 (all of the other ages would be protected from harvest because they would be too large). In our simple example above, this would bring survival of fish from age-4 to age-5 fish back up to 0.8 (because they would no longer be subject to additional mortality from fishing) and the total number of eggs contributed in an average individual's lifetime (the numerator) would be increased to 67,340, increasing SPR to ~68%. It is exercises such as these that fisheries managers explore when considering different regulatory changes for fishing (albeit greatly simplified in this example).

Florida's Fisheries: How much SPR is enough?

What SPRlevel is enough? Many scientific publications have explored this question, and most suggest that a level of at least 20–50% is appropriate (Caddy and Mahon 1995; Clark 1991; Goodyear, 1993). The appropriate level will vary based on the life history characteristics of the specific spe-cies being fished and the nature of how the fishery operates. Many of Florida's fisheries—red drum and spotted seatrout, for example (Chagaris et al. 2015; Addis et al. 2018)—are managed based on limit reference point of $F_{35\%}$. However, this rule isn't ubiquitous. Common snook, for instance, are managed based on an SPR of 40% (Muller et al. 2015) and red snapper had been managed based on an SPR of 26% (or an $F_{26\%}$; SEDAR 2018). Remember, the greater the percentage, the more conservative the management strategy. There are instances where SPR is not considered, typically for those fisheries that do not undergo formal stock assessments (Florida examples include black crappie and largemouth bass), and thus these fisheries are not necessarily managed with consideration from SPR. SPR is most commonly utilized by fisheries managers considering large populations of fish in expansive open waters (like the Gulf of Mexico), where it is more challenging to estimate population size or get precise measurements of harvest rate. However, even if SPR isn't often reported for some freshwater species, it still matters—it's just harder to estimate well, so other methods are used. In closing, SPR is just one of several important metrics for fisheries managers, who use it to guide regula-tions and ensure fish populations are able to maintain a reproductive capacity that sustains target population levels.

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