PROTEIN AND LIPID UTILIZATION IN THE EARLY LIFE STAGES OF SENEGALESE SOLE, ATLANTIC HALIBUT, AND TURBOT

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Understanding how fish larvae and post-larvae use protein and lipids as energy substrates is essential both for optimized microdiet formulations, and for building accurate models of growth, metabolism, and nutrient requirements. In flatfish as in other species, the balance between protein and lipid catabolism during early development may strongly influence growth potential, survival, and the conversion efficiency of formulated diets. In this study, we combined oxygen consumption and ammonia excretion measurements to estimate substrate utilization patterns in three flatfish species of high relevance for European aquaculture: Senegalese sole (*Solea senegalensis*), Atlantic halibut *(Hippoglossus hippoglossus*), and turbot (*Scophthalmus maximus*). The three species exhibited very high variability among individuals in the allocation of protein and lipids to energy metabolism during early growth. Senegalese sole, from first feeding up to ~5 g, relied almost exclusively on protein as the metabolic fuel, with negligible lipid catabolism, as indicated by low O:N ratios. Turbot showed a similar pattern up to ~2 g, after which lipid utilization increased modestly. In turbot between 2 and 8 g, approximately 18% of metabolized energy was derived from lipids, revealing a gradual shift away from strict protein dependency. Atlantic halibut displayed a similar pattern to larger turbot: from 1 to 7 g, halibut catabolized ~15% lipids, indicating earlier onset of lipid use compared with turbot but still maintaining protein as the dominant energy substrate. These differences across species and size ranges highlight important physiological variability in metabolic flexibility during early life stages. Such variability has direct relevance for precision feeding, dietary formulation, the design of energy-efficient, and eventually protein-sparing, microdiets targeting the first months of development. Incorporating species- and size-specific substrate utilization data into nutritional models will improve predictions of growth and feed conversion and support the development of optimized feeds that reduce reliance on protein as the metabolic fuel.

Keywords: Energy metabolism; Protein and lipid utilization; Flatfish early life stages; Senegalese sole; Atlantic halibut; Turbot

Preferred Topic: broodstock and larval nutrition

Secondary Alignment: nutritional requirements