
BIBLIOGRAPHY OF FISHERY INVESTIGATIONS ON LARGE SALMONID RIVER SYSTEMS



with special emphasis on the Bois Brule River,
Douglas County, Wisconsin

Technical Bulletin No. 166
Department of Natural Resources
Madison, Wisconsin

1989

COVER: *Electroshocking on the Bois Brule River.*

ABSTRACT

This report provides 966 literature citations pertinent to management of salmonids in lotic systems. Of these citations, 229 (24%) include brief annotations to highlight their salient aspects to management of the Bois Brule River and other northern Wisconsin trout rivers. The subject index lists citations under 41 topic headings in 5 categories: Biology (10 headings), Ecology (9), Management (13), Sport Fishery Assessment (4), and Physical Environment (5). A salmonid species index is also provided.

KEY WORDS: Brook trout, brown trout, rainbow trout/steelhead, coho salmon, chinook salmon, salmonids, lotic systems, management, research, biology, ecology, sport fishery assessment, physical environment, annotations.

**Bibliography of Fishery Investigations on Large Salmonid River Systems
With Special Emphasis on the Bois Brule River, Douglas County, Wisconsin**

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Technical Bulletin No. 166
Wisconsin Department of Natural Resources
P.O. Box 7921, Madison, WI 53707
1989

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INTRODUCTION

The Bois Brule River, popularly known as the Brule River, is a spring-fed tributary to western Lake Superior. The river provides a popular and complex sport fishery for 5 naturally reproducing species of salmonids that collectively have both anadromous and stream-resident components. The sport fishery is directed towards substantial runs of spring and fall steelhead (*Oncorhynchus mykiss*, formerly *Salmo gairdneri*), a late summer/fall lake run of brown trout (*Salmo trutta*), and self-sustaining upper river populations of stream-resident brown and brook trout (*Salvelinus fontinalis*). Fall fisheries for coho (*Oncorhynchus kisutch*) and chinook salmon (*O. tshawytscha*) are developing as well. Pink salmon (*O. gorbuscha*) have reproduced in the Brule River system since the late 1970s but have not contributed significantly to the sport catch.

Sport fishing quality for the primary trout species appears to be on the decline, causing growing concern among anglers and Wisconsin Department of Natural Resources (DNR) fisheries management personnel responsible for the stewardship of this unique resource. In 1983 the DNR Bureau of Research initiated a broadly directed, 2-year pilot study of the Brule River fishery to identify and prioritize problems in need of research. Part of this pilot study involved an extensive literature review to locate published information (collectively referred to as papers in this introduction) on a variety of topics pertaining to the ecology and management of large-river, mixed-stock salmonid fisheries. Selected results from that literature review are brought together in this report to provide a collection of references for regional fish managers and trout stream researchers to use as a starting point for deeper investigations.

In assembling this bibliography, I placed special emphasis on reviewing literature having direct bearing on (1) the pilot study and potential long-range research on the Brule River and (2) fishery management areas of concern specific to the Brule River, including competition among juvenile salmonids, disease problems (particularly furunculosis), effects of sea lamprey control and predation, impact of high turbidity on salmonids and invertebrates, and development of more effective fish sampling gears and creel census systems. The information presented does not, therefore, cover all aspects of riverine salmonid ecology and management in equal proportion. However, for most topic areas, I believe that a useful cross-section of papers is presented.

The selection process for obtaining material for review was unavoidably subjective, and due to the breadth of the subject area, a large number of potential reference materials were not included. The period of coverage is 1929 through 1987, although some 1988 material is included. I carefully screened very early work for present-day applicability. In general, only papers published in English were reviewed. In some cases, I included material involving salmonid species that are not found in the Brule River, but that have similar life history strategies, if the potential applicability of such material to the management of the Brule River fishery was readily apparent. Almost every paper cited in this bibliography appeared in a scientific journal, miscellaneous publication, technical report, or M.S. or Ph.D. thesis. Term papers, manuscript reports, and other preliminary information were not included, except in rare circumstances when such material was significant and no other sources were available.

To further enhance the usefulness of this bibliography, papers of potential relevance to management of the Brule River and other northern Wisconsin trout rivers were annotated. These papers had clear regional applicability of findings or immediate relevance to research and management investigations in progress. No standardized annotation format was used, because the relevant aspects of many papers were unique.

Citations for 966 papers are presented, of which 229 (24% of total) are annotated. Citations are arranged alphabetically by senior author and are numbered sequentially. Annotations immediately follow the associated citations.

Two indexes are presented. The first is a subject index where 41 specific topic headings are arranged alphabetically under 5 general subjects. Cited literature is referenced by number in one of two tiers under each topic heading: the top tier (marked with a solid triangle symbol, ►) presents annotated citations, and the second tier presents unannotated citations (▷). The solid triangle symbol also appears at the beginning of each annotation in the body of the report. Most papers are listed under more than one topic heading. A paper was listed under a topic heading if the topic was substantially addressed in the paper. A salmonid species index follows the subject index.

SUBJECT INDEX

BIOLOGY

Age, Growth

▶10 31 33 140 192 299 309 363 451 471 487
488 494 578 601 648 649 662 754 757 772 791
807 837 838 840 847 853 858 900

▷35 70 79 112 135 145 147 167 176 216 236
237 252 259 289 305 326 329 334 353 360 369
405 406 424 439 470 490 492 497 500 568 577
592 617 629 640 641 708 729 737 746 763 765
784 836 842 902 910 933 941

Genetics

▶55 166 272 482 483 505 517 600 672
▷128 133 134 137 165 242 289 312 364 484
513 605 611 664 729 747 780 864 869

Health, Parasites

▶231 254 272 297 382 551 573 648 649 772
791 824
▷16 63 117 173 174 222 317 392 520 777

Miscellaneous Biology

(Anatomy, Behavior, Physiology, Swimming)

▶36 103 272 314 521 648 649 754 758 919
▷52 66 102 104 207 216 236 237 285 295 298
357 367 373 389 394 396 399 418 432 490 529
532 539 583 584 617 620 632 651 652 653 664
674 678 709 738 747 777 790 818 848 854 861
915 917 918 922 935 957

Mortality, Survival

▶10 31 33 260 299 363 413 488 559 648 649
662 772 781 782 783 791 838 853 880 919 952
▷2 63 76 79 80 105 112 145 147 191 196 217
236 237 244 305 308 326 332 347 360 393 404
405 406 409 424 433 439 450 470 474 490 497
500 508 509 519 543 552 568 585 618 640 666
671 684 726 729 737 763 769 802 803 832 842
856 882 884 892 895 901 908 910 948 950 959

Production, Standing Stock

▶1 4 10 31 33 37 140 202 238 260 286 323
363 380 416 451 471 488 489 558 570 648 649
662 772 781 783 791 807 838 840 841 853 858
907 914
▷3 14 27 74 75 76 80 94 114 115 121 125 127
133 143 159 160 177 199 217 218 219 236 237
241 252 259 263 264 268 269 271 300 305 322
325 326 336 356 360 384 395 412 439 463 469
472 490 500 501 510 515 536 560 568 571 603
619 634 643 647 651 656 659 665 688 708 737

752 766 792 811 812 827 846 855 862 872 887
903 909 932 933 934

Recruitment

▶28 37 363 783 791 853
▷115 143 154 155 177 218 219 300 320 336
385 603 687 688 737 827 855 898

Reproduction

▶10 17 28 32 67 98 139 144 192 202 238 239
363 487 517 648 649 662 730 754 772 791 839
853 900 942 949
▷73 104 116 122 149 163 165 191 203 236 237
262 263 308 315 332 358 365 370 393 457 458
490 491 493 500 534 536 572 598 602 620 637
647 668 669 683 690 694 702 704 709 710 727
731 744 745 749 777 805 806 808 814 821 832
856 857 859 882 890 920 922 948 954

Smoltification

▶37 354 363 368 488 489 754 782 785 791 837
919
▷77 80 92 170 172 193 225 236 237 250 263
278 295 298 300 302 390 433 439 500 508 545
549 566 591 607 753 775 812 826 835 868 870
881 885 896 910 921 950 960 961 962

Taxonomy, Systematics

▶272
▷53 402 556 565 777

ECOLOGY

Aquatic Invertebrate Ecology, Sampling

▶8 10 229 388 411 456 706 791 817 845
▷6 258 435 436 503 644 912 913 936

Competitive Interactions

▶29 212 288 299 314 372 451 453 456 494 506
570 751 758 838 840 858 899 914
▷9 136 158 213 235 251 276 287 305 357 365
373 445 452 465 466 470 523 531 592 617 645
650 746 789 811 854 933

Distribution, Life History

▶10 67 238 272 275 363 487 537 648 649 662
751 754 758 772 791 942
▷9 27 39 52 53 63 84 100 113 151 157 198
206 236 237 367 395 402 432 460 490 500 518
529 533 544 567 568 588 606 615 617 632 647
676 679 709 734 743 750 759 764 767 776 777
787 796 819 820 868 889 903 904 905 935 947

Food Habits

▶ 10 36 272 351 411 434 437 453 456 489 494
604 662 754 791 847 899 937 938
▷ 2 6 7 74 122 135 160 162 164 235 252 258
264 270 407 418 438 440 452 454 461 539 584
586 587 591 593 622 650 684 726 739 789 806
811 854 905

Habitat Requirements, Evaluation, Use

▶ 30 129 130 212 286 380 480 730 880 919 923
925
▷ 24 41 42 48 71 72 74 93 94 101 109 110 127
151 152 163 169 211 214 215 241 276 278 308
373 383 386 455 461 501 522 524 530 531 626
635 676 680 698 700 701 716 718 719 725 731
752 766 795 805 806 816 846 850 863 924 934
953

Homing, Imprinting, Straying

▶ 44 363 773 853 942
▷ 78 96 97 362 396 449 653 683 713 813 834
835

Migration, Movements

▶ 1 10 31 44 67 118 120 140 238 281 299 331
363 488 489 601 618 648 649 662 754 772 791
828 837 853 919 942
▷ 20 35 62 74 84 119 153 158 170 172 205 217
236 237 257 261 282 318 330 353 360 362 366
389 410 439 467 477 500 516 519 529 549 576
602 614 654 655 656 670 684 712 713 721 738
744 750 753 787 794 797 810 825 826 836 867
870 885 898 910 915 950 960 961 962

Riparian and Instream Vegetation

▶ 18 30 283 313 426 480 817 865 866 880
▷ 89 161 377 423 435 557 587 609 610 627 644
663 701 703 863 924

Stream Ecosystem

▶ 888
▷ 89 161 209 210 375 435 609 610 627 634 699

MANAGEMENT

Culture, Stocking, Strains

▶ 272 430 512 537 578 600 623 751 754 772
782 893 919
▷ 34 87 92 95 131 134 147 165 175 187 189
195 205 208 222 242 243 250 312 346 353 379
400 405 406 424 433 470 476 484 513 518 527
562 575 582 599 605 625 666 683 685 705 707
729 786 857 894 895 896 898 901 910 957

Decision-making, Economics

▶ 355 686 829 853
▷ 19 40 107 108 150 185 200 207 301 321 338
348 401 431 540 561 569 596 630 681 682 711
733 788 830 906

Fish Sampling Gears, Methods, Data Analysis

▶ 10 37 202 286 303 306 309 354 363 368 378
488 489 550 624 751 782 785 923 925 965
▷ 20 23 41 49 59 77 80 172 193 217 221 225
279 291 300 301 307 319 334 336 349 350 383
384 385 399 439 442 462 464 466 485 496 514
525 526 534 545 549 566 577 594 603 607 639
698 701 702 704 737 744 755 763 765 768 778
792 844 881 885 921 941 964

Fishways, Traps, Weirs

▶ 231 281 378 648 649 662 772 785 791
▷ 20 25 49 58 59 74 186 279 439 485 500 753
881 904 921

General Strategies

▶ 46 55 85 88 272 275 391 505 600 686 751
791 817 853
▷ 75 82 100 106 113 126 187 197 198 204 228
267 293 337 339 348 364 486 504 507 528 533
541 567 588 606 613 618 621 630 631 685 689
697 703 735 742 756 790 855 883 890 897 906
911 916 951

Habitat Enhancement, Preservation, Restoration

▶ 129 130 144 146 296 313 343 398 415 420
426 427 623 673 817 907 927 930 931
▷ 47 83 90 93 95 109 132 194 215 232 240 253
269 278 280 304 315 324 335 344 345 361 377
397 422 423 431 468 479 510 530 535 538 587
598 625 627 644 657 658 680 703 717 725 748
761 779 793 843 849 851 862 878 891 924 928
929 953 955

Marking, Tagging

▶ 26 266 274 498 624 648 649 720 772
▷ 25 57 61 111 112 145 246 248 249 265 277
292 333 349 371 585 597 616 646 667 677 695
696 744 780 794 836 842 956 958 959

Radio Telemetry

▶ 118 120 331 521 563 589 828 886 942
▷ 65 119 168 467 477 564 870 943 944

Regulations

▶ 4 33 180 181 184 414 419 425 429 447 511
537 559 570 692 693 728 853 952
▷ 11 12 13 40 45 56 124 178 179 182 183 201
244 246 284 290 325 328 369 401 404 408 417
421 428 459 474 475 502 543 552 605 638 685
705 714 715 732 756 769 798 799 800 801 802
803 804 872 884 908 917 939 957

Research Inputs

▶ 156 414 420 774 823 946
▷ 15 217 224 294 401 495 574 703 793

Sea Lamprey Control

▶ 68 69 171 220 229 231 316 444 481 542 590
633 771
▷ 22 63 247 580 595 879

Stock Identification

- ▶ 482 483 578
- ▷ 203 216 486 541 641 710 780 786 864

Water Quality Assessment

- ▶ 387 642 845
- ▷ 255 310 403 503 628 675 940

PHYSICAL ENVIRONMENT

Chemistry, Temperature

- ▶ 38 233 380 648 649 662 760 772 817 873 874 875 876 877 926
- ▷ 74 101 223 262 308 393 524 627 636 691 808 843 863 882 896 918 940 963

Discharge, Flow

- ▶ 233 311 380 648 649 662 760 772 781 817 873 874 875 876 877 926 927
- ▷ 24 74 127 163 264 524 636 666 670 700 718 719 731 752 814 882 890 915

Geology, Topography

- ▶ 18 51 234 273 648 649 772 817
- ▷ 555 699 871

Pollution, Toxics, Acid Deposition

- ▶ 38 256 272 579
- ▷ 91 114 149 282 342 492 608 745 920 953 963

Turbidity, Sedimentation

- ▶ 18 21 60 230 234 327 722 807
- ▷ 352 381 386 463 723 724 762

SPORT FISHERY ASSESSMENT

Angler Attitudes, Preferences

- ▶ 81 355 374
- ▷ 50 86 107 138 148 201 226 245 348 473 478 569 581 612 732 735 788 815

Creel Surveys

- ▶ 31 33 81 99 123 188 272 340 341 648 649 661 772 831 852 853
- ▷ 3 5 64 107 141 142 190 227 284 359 376 439 441 443 499 546 547 548 632 740 741 809 833 966

Effort, Exploitation, Harvest, Yield

- ▶ 4 31 33 123 188 340 341 363 488 512 648 649 661 772 852 853
- ▷ 54 76 142 217 227 268 284 289 326 353 359 412 424 439 441 446 496 510 543 554 632 687 705 710 714 715 736 737 742 744 747 756 796 809 860 869 884 906

Historical Perspective

- ▶ 85 184 448 512 537 553 648 649 660 772 823
- ▷ 43 50 580 627 770 779 822

SALMONID SPECIES INDEX

***Oncorhynchus clarki* (Cutthroat Trout)**

55 96 127 130 151 153 205 266 286 318 334
 345 372 397 398 400 439 501 524 551 552 556
 626 631 673 707 730 749 750 751 766 768 769
 775 777 814 862 867 872 909 911 923 935 952
 965

***Oncorhynchus gorbusha* (Pink Salmon)**

39 44 52 62 88 92 96 151 202 266 312 318 369
 490 491 504 527 551 565 576 582 647 686 687
 718 730 749 750 775 776 777 792 814 818 867
 900 902 934 951

***Oncorhynchus keta* (Chum Salmon)**

44 52 62 70 92 151 202 225 266 318 369 504
 527 551 562 565 576 582 667 687 730 749 750
 775 777 780 792 814 818 859 867 885 934 950
 951

***Oncorhynchus kisutch* (Coho Salmon)**

9 25 28 52 53 57 60 68 85 88 92 96 97 104
 108 118 129 130 138 139 140 151 153 158 159
 175 177 187 193 202 204 206 225 227 235 240
 241 266 278 288 293 296 298 305 314 318 322
 323 330 339 345 349 357 369 372 377 394 397
 398 430 449 451 453 454 456 457 463 467 479
 494 504 512 524 527 530 531 545 551 558 560
 562 565 575 576 582 596 597 607 622 623 624
 625 626 673 678 683 684 689 694 695 696 723
 724 730 747 749 750 751 752 772 773 775 777
 791 792 794 795 807 809 810 814 815 818 830
 838 839 840 850 857 858 861 867 880 885 899
 907 910 917 918 919 922 950 951 952 961

***Oncorhynchus mykiss* (Rainbow Trout/Steelhead)**

1 9 22 27 28 34 44 45 46 50 52 53 55 63 66
 67 73 74 75 76 77 83 84 85 88 91 92 95 96 99
 104 105 108 116 119 122 124 127 129 135 137
 140 151 153 156 157 165 166 168 170 175 189
 190 191 193 204 205 212 213 216 223 227 231
 236 237 238 239 246 249 250 251 258 266 274
 275 276 278 280 281 282 286 291 292 293 294
 295 296 297 305 308 309 314 318 322 323 326
 330 332 340 341 346 353 357 358 359 360 363
 364 365 372 373 377 380 384 391 397 398 400
 402 405 406 407 411 438 439 445 450 451 452
 453 454 455 456 457 463 471 472 479 482 487
 488 489 494 500 501 506 507 512 516 517 518
 519 521 524 527 528 530 536 537 538 544 545
 551 553 556 559 565 567 575 576 577 578 588
 589 591 593 596 597 600 601 602 615 616 620
 621 623 625 626 629 630 631 632 637 641 643
 646 649 654 655 660 661 662 668 672 673 676
 678 679 680 685 690 691 692 693 694 705 707
 721 723 724 727 728 729 730 734 743 744 745
 746 747 749 750 751 754 757 758 766 772 773
 774 775 777 781 782 783 785 786 787 789 790

791 795 796 807 808 809 811 812 813 814 815
 816 817 819 820 821 822 830 831 832 836 837
 838 840 841 842 846 850 852 853 857 858 859
 862 867 881 882 883 884 889 893 894 895 896
 897 898 899 901 903 904 907 911 914 917 918
 919 920 923 933 935 939 942 945 946 947 948
 950 952 957 961

***Oncorhynchus nerka* (Sockeye Salmon)**

15 44 52 62 70 92 96 102 103 151 202 207 266
 300 318 369 504 527 551 565 576 582 597 607
 678 686 730 749 750 775 777 792 814 818 862
 867 885 951

***Oncorhynchus tshawytscha* (Chinook Salmon)**

25 28 44 52 53 62 73 74 76 85 88 92 96 108
 120 138 139 157 163 167 175 187 188 192 193
 202 225 227 230 248 249 250 251 266 274 276
 293 296 318 330 331 349 368 369 370 372 386
 451 453 457 463 467 479 493 504 512 524 527
 531 545 551 561 565 575 576 596 597 639 640
 641 673 686 704 721 730 749 750 751 772 775
 777 792 808 809 814 815 818 830 850 867 887
 897 919 922 950 951 952 961 962

***Salmo salar* (Atlantic Salmon)**

44 53 61 62 79 85 92 115 154 155 175 202 203
 223 252 263 266 301 306 314 315 318 354 372
 373 376 433 458 465 466 470 498 508 514 551
 563 564 576 606 614 650 670 674 691 707 708
 710 730 738 749 750 753 755 756 763 764 767
 775 777 826 827 828 834 848 854 855 867 870
 908 919 937 952 960

***Salmo trutta* (Brown Trout)**

2 3 4 10 17 29 31 32 33 36 40 44 45 48 53
 85 88 92 94 99 112 113 114 127 136 156 164
 175 176 178 181 182 183 184 196 205 208 214
 215 223 231 232 252 254 257 258 259 260 261
 262 266 268 269 270 271 281 286 287 288 289
 291 297 304 306 309 318 322 323 325 326 332
 335 351 361 365 366 367 372 376 380 384 391
 400 402 404 411 422 423 425 426 427 445 452
 458 460 461 465 469 470 483 501 502 510 511
 512 515 525 529 532 533 535 539 551 553 554
 556 567 572 576 590 593 599 606 615 617 618
 619 621 636 645 648 650 658 660 661 662 665
 669 670 685 707 719 730 731 739 749 750 757
 758 766 772 777 789 797 806 816 817 825 826
 828 840 847 848 852 857 858 867 883 891 899
 911 914 919 923 925 927 935 939 942 945 949
 952

***Salvelinus alpinus* (Arctic Char)**

62 223 266 318 551 652 653 664 730 749 750
 777

***Salvelinus fontinalis* (Brook Trout)**

2 3 4 6 7 31 40 53 74 76 94 98 99 100 127
134 143 144 145 146 147 156 169 175 176 182
183 184 196 199 205 211 212 213 214 215 223
247 254 264 266 269 272 281 286 287 288 297
299 308 314 318 326 327 329 332 334 343 372
380 393 399 400 402 408 410 411 412 413 414
415 416 420 421 422 423 424 426 428 429 439
446 452 466 484 492 501 502 506 509 510 511
512 514 539 551 553 554 556 567 568 571 583
584 585 593 604 614 615 617 621 631 636 645
652 658 659 660 661 662 666 685 691 707 709
716 730 731 746 749 750 755 757 758 766 777
781 789 797 799 801 816 817 840 846 847 852
891 905 914 923 927 932 933 935 937 939 945
949 952 954

***Salvelinus malma* (Dolly Varden)**

74 76 223 225 240 266 318 377 551 626 631
652 673 730 749 750 777 814 850 911 935

***Salvelinus namaycush* (Lake Trout)**

45 53 88 175 223 266 318 402 512 524 551 567
615 652 691 707 730 749 750 777 822 823 935
952

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▶ Annual production of juvenile rainbow trout in this Lake Huron tributary was estimated at 13.2 g/m². Most smolts (91%) emigrated at age 1.
- 2** Alexander, G. R. 1977. Consumption of small trout by large predatory brown trout in the North Branch of the Au Sable River, Michigan. Mich. Dep. Nat. Resour. Fish. Res. Rep. No. 1855. 26 pp.
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- 4** Alexander, G. R. and J. R. Ryckman. 1976. Trout production and catch under normal and special angling regulations in the North Branch of the Au Sable River, Michigan. Mich. Dep. Nat. Resour. Fish. Res. Rep. No. 1840. 14 pp.
▶ Annual production and angler harvest of wild brook and brown trout were both substantially higher on water under normal regulations (7.0-inch minimum size limit, 10 trout creel limit, any lure permitted) than on special-regulation water (9.0-inch minimum size limit, 5 trout creel limit, artificial flies only).
- 5** Alexander, G. R. and D. S. Shetter. 1967. Fishing and boating on portions of the Au Sable River in Michigan, 1960-1963. Trans. Am. Fish. Soc. 96(3):257-67.
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- 7** Allan, J. D. 1981. Determinants of diet of brook trout (*Salvelinus fontinalis*) in a mountain stream. Can. J. Fish. and Aquat. Sci. 38:184-92.
- 8** Allan, J. D. and E. Russek. 1985. The quantification of stream drift. Can. J. Fish. and Aquat. Sci. 42:210-15.
▶ Drift sampling (6 or 7 replicates) just after dark, when drift is normally greatest, required fewer replicates than benthic sampling for comparable precision.
- 9** Allee, B. A. 1982. The role of interspecific competition in the distribution of salmonids in streams. pp. 111-22 in E. L. Brannon and E. O. Salo, eds. Proceedings of the salmon and trout migratory behavior symposium. Univ. Wash., Seattle. 309 pp.
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▶ This report on a world-famous investigation of a New Zealand trout population describes the physical, chemical, and biological (trout population, bottom fauna, nongame fishes, etc.) aspects of the trout's environment from an ecosystemic perspective. Thorough examinations of trout population dynamics, feeding, and angling history were conducted.
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- 15** Allen, K. R. 1973. The application of research to the management of British Columbia sockeye salmon. *Trans. Am. Fish. Soc.* 102(1):172-77.
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- 17** Anderson, D. W. 1983. Factors affecting brown trout reproduction in southeastern Minnesota streams. *Minn. Dep. Nat. Resour. Invest. Rep. No. 376.* 36 pp.
 ► Late winter and spring flooding was the major cause of reproductive failure of brown trout in 6 southeastern Minnesota streams. None of the other factors examined (redd superimposition, substrate composition, siltation, water velocity, hydraulic gradient, intra-redd dissolved oxygen, and stream morphometry) were limiting to brown trout recruitment.
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 ► This study describes the structure and dynamics (spring and fall densities and biomass, age, and growth) of wild brook and brown trout populations in 2 northern Wisconsin streams; characterizes the associated sport fisheries; and discusses the management significance of

- angler harvest of these populations. The seasonal movement of larger brown trout was of much greater magnitude and management importance than was such movement in recently studied central Wisconsin streams. The report states that no major or immediate revisions of harvest regulations are required to protect these wild brown trout populations, but more intensive studies of brook trout populations and their sport fisheries in northern Wisconsin are recommended.
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 ▶ Spring and fall population inventories were conducted on wild brown trout populations in 4 central Wisconsin streams for 3 years. Average spring density and biomass were 2,016 trout/mile and 96 lb/acre, respectively, while average fall density and biomass were significantly higher. Regulation changes to a minimum length limit of 7 inches and a season-long bag limit of 5 brown trout/day are recommended for the southern half of Wisconsin.
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 ▶ A method is described for relating population estimates for juveniles occupying different habitat areas to estimates of smolt production. Riffles and rapids were the most productive habitats, providing 86% of the production from 28% of the water area.
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► Changing a fishing regulation from a 12-inch minimum to a slotted limit allowing harvest of trout between 8 and 12 inches and over 16 inches resulted in decreased abundance of brown trout of all sizes but did not affect growth rates. Total harvest of brown trout increased nearly 5 times but consisted of smaller fish. The greatest effect of the slotted limit regulation was in reshaping angler use of the trout population. Biological effects were relatively unimportant.
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► Mathematical modelling was used to predict brook and brown trout population responses to various minimum size limits and a no-kill regulation. Maximum harvest (both numbers and weight) was obtained at the lowest size limit tested (152 mm) for both species. Total yield (weight of trout caught and harvested plus weight of trout caught and released) increased as size limit increased and was maximum with a no-kill regulation.
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 ► This report is subdivided according to techniques that have been used to estimate spawning salmon populations in the Pacific Northwest. Topics include discussions of methodology, locations of use, outlines of effective use and related problems, and summaries of available data on accuracy and precision.
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 ► This study documents the impact of red clay turbidity on the aquatic community of the Nemadji River system (tributary to western Lake Superior). Major differences in community structure were identified between clear and turbid waters; however, in most cases it was

- not proven that turbidity alone caused the differences. Many commonly held postulates concerning red clay turbidity (e.g., replacement of desirable fish species by less desirable ones, discouragement of spawning runs, decreased oxygen levels, increased nutrient levels) were shown not to be true. However, salmonid reproduction was adversely impacted by relatively low levels of red clay sedimentation.
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 ► Convincing evidence is presented to support the hypothesis that the electric lamprey control weir operated on the Brule River, Douglas County, caused a high incidence of spinal deformities to out-migrating juvenile anadromous fish.
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- 233** Dickas, A. B., ed. 1973. Wisconsin's Lake Superior basin water quality study. Univ. Wis.-Superior, Cent. Lake Superior Environ. Stud. Publ. No. 21. 116 pp.
 ► This report, along with its supplement (Whisnant 1974), presents 2 years of selected water quality data collected from the Brule River and 7 other river drainages along the Wisconsin shore of Lake Superior.
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 ► The preceding 2 reports describe a successful methodology for estimating a sport catch of steelhead using voluntarily returned punch cards. The total catch is estimated by multiplying the returned cards by a projection factor (to account for cards not returned) that has been corrected for nonresponse bias.

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- 353** Hansen, M. J. and T. M. Stauffer. 1971. Comparative recovery to the creel, movement and growth of rainbow trout stocked in the Great Lakes. *Trans. Am. Fish. Soc.* 100(2):336-49.
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- 412** Hunt, R. L. 1966. Production and angler harvest of wild brook trout in Lawrence Creek, Wisconsin. *Wis. Conserv. Dep. Tech. Bull. No. 35.* 52 pp.
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 ► Survival of brook trout through their first winter of life ranged from 35% to 73% during 11 successive winters and averaged 54%. Survival generally was independent of fingerling density. Factors positively affecting overwinter survival were mean length of fingerlings and winter water temperatures.
- 414** Hunt, R. L. 1970. A compendium of research on angling regulations for brook trout conducted at Lawrence Creek, Wisconsin. *Wis. Dep. Nat. Resour. Res. Rep. No. 54.* 36 pp.
 ► This report provides conclusions and management implications based on 13 years of testing and evaluating a variety of angling regulations. The size limit was found to be the best single regulation for preventing excessive angler harvest of brook trout populations. A "rule of thumb" procedure for setting size limits is offered. Anglers were attracted by "fly fishing only" regulations and enjoyed high quality fishing, but no detectable responses by the trout population to such a restriction were observed.
- 415** Hunt, R. L. 1971. Responses of a brook trout population to habitat development in Lawrence Creek. *Wis. Dep. Nat. Resour. Tech. Bull. No. 48.* 35 pp.
 ► Habitat development in this central Wisconsin trout stream was followed by significant increases in standing crops of wild brook trout, angler use, and yield. Annual cost of development did not compare favorably with the annual cost of stocking legal-sized domestic trout, but pragmatic and philosophical reasons for rejecting the latter option are discussed.
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- 418** Hunt, R. L. 1975. Food relations and behavior of salmonid fishes. pp. 137-51 *in* A. D. Hasler, ed. *Coupling of land and water systems.* Springer-Verlag, New York. 336 pp.
- 419** Hunt, R. L. 1975. Angling regulations in relation to wild trout management. pp. 66-74 *in* W. King, ed. *Wild trout management. Proc. of a Symp. held at Yellowstone Natl. Park.* 103 pp.
 ► This report reviews the 1974 agency fishing regulations for all 43 states and 11 provinces that provide trout fishing. A useful summary of the results of numerous angling regulation studies is provided.
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costly way to conduct some long-term studies of aquatic systems.

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- This report provides a follow-up assessment of 10-11 years of research on 2 central Wisconsin trout streams to evaluate woody stream bank vegetation removal as a trout habitat development technique. Anticipated physical improvements to the stream channels occurred in both situations, but abundance of legal-sized and quality-sized trout increased significantly in only one stream.
- 427** Hunt, R. L. 1986. An evaluation of brush bundles and half-logs to enhance carrying capacity of two brown trout streams. pp. 31-62 in J. G. Miller, J. A. Arway, and R. F. Carline, eds. Fifth trout stream habitat improvement workshop. Proc. of a Conf. Lock Haven Univ., Pa. 283 pp.
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- 429** Hunt, R. L., O. M. Brynildson, and J. T. McFadden. 1962. Effects of angling regulations on a wild brook trout fishery. Wis. Conserv. Dep. Tech. Bull. No. 26. 58 pp.
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- 439** Irving, J. S., F. S. Elle, and T. C. Bjornn. 1977. The fish populations and fishery in the Teton River prior to impoundment by Teton Dam. *Univ. Ida., For., Wildl., and Range Exp. Stn. Contrib. No. 68.* 97 pp.
- 440** Ivlev, V. S. 1961. *Experimental ecology of the feeding of fishes.* Yale Univ. Press, New Haven, Conn. 302 pp.
- 441** Jacobson, J. O., R. D. Cook, and R. Sopuck. 1983. An evaluation of alternative methods of collecting sportfishing statistics for the Northwest Territories. *Can. Tech. Rep. Fish. and Aquat. Sci. No. 1180.* 18 pp.
- 442** James, P. W., S. C. Leon, A. V. Zale, and O. E. Maughan. 1987. Diver-operated electrofishing device. *North Am. J. Fish. Manage.* 7:597-98.
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- 446** Jensen, A. L. 1971. Response of brook trout (*Salvelinus fontinalis*) populations to a fishery. *J. Fish. Res. Board Can.* 28:458-60.
- 447** Jensen, A. L. 1981. Optimum size limits for trout fisheries. *Can. J. Fish. and Aquat. Sci.* 38:657-61.
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locations of angler-caught tagged trout, trout spawning areas and conditions, creel survey results, and significance of Pacific salmon in the Brule River.

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- 791** Shapovalov, L. and A. C. Taft. 1954. The life histories of the steelhead rainbow trout (*Salmo gairdneri gairdneri*) and silver salmon (*Oncorhynchus kisutch*) with special reference to Waddell Creek, California, and recommendations regarding their management. Calif. Dep. Fish and Game. Fish Bull. No. 98. 375 pp.
 ► Results are presented from an exhaustive investigation into all fresh-water aspects of the life history and population dynamics of steelhead rainbow trout and silver salmon in a small California river. This classic study provided much of the scientific knowledge for subsequent management plans for these species in their native range.
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- 802** Shetter, D. S. and L. N. Allison. 1955. Comparison of mortality between fly-hooked and worm-hooked trout in Michigan streams. Mich. Dep. Conserv., Inst. Fish. Res. Misc. Publ. No. 9. 44 pp.
- 803** Shetter, D. S. and L. N. Allison. 1958. Mortality of trout caused by hooking with artificial lures in Michigan waters 1956-57. Mich. Dep. Conserv., Inst. Fish. Res. Misc. Publ. No. 12.
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- 806** Shirvell, C. S. and R. G. Dungey. 1983. Microhabitats chosen by brown trout for feeding and spawning in rivers. Trans. Am. Fish. Soc. 112:355-67.
- 807** Sigler, J. W., T. C. Bjornn, and F. H. Everest. 1984. Effects of chronic turbidity on density and growth of steelheads and coho salmon. Trans. Am. Fish. Soc. 113:142-50.
 ► Chronic turbidity in streams during emergence and rearing of young anadromous salmonids was shown to adversely affect the number and quality of fish produced. Fish subjected to continuous clay turbidities grew less well than those living in clear water, and more of them emigrated from the experimental stream channels.
- 808** Silver, S. T., C. E. Warren, and P. Doudoroff. 1963. Dissolved oxygen requirements of developing steelhead trout and chinook salmon embryos at different water velocities. Trans. Am. Fish. Soc. 92(4):327-43.
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- 812** Slaney, P. A., C. J. Perrin, and B. R. Ward. 1986. Nutrient concentration as a limitation to steelhead smolt production in the Keogh River. Proc. of the 66th Annu. Conf. West. Assoc. of Fish and Wildl. Agencies 66:146-58.
- 813** Slatick, E., L. G. Gilbreath, and J. R. Harmon. 1982. Imprinting steelhead for homing. pp. 247-64 in E. L. Brannon and E. O. Salo, eds. Proceedings of the salmon and trout migratory behavior symposium. Univ. Wash., Seattle. 309 pp.
- 814** Smith, A. K. 1973. Development and application of spawning velocity and depth criteria for Oregon salmonids. Trans. Am. Fish. Soc. 102(2):312-16.
- 815** Smith, C. L. 1980. Attitudes about the value of steelhead and salmon angling. Trans. Am. Fish. Soc. 109(3):272-81.
- 816** Smith, G. E. and M. E. Aceituno. 1987. Habitat preference criteria for brown, brook, and rainbow trout in eastern Sierra Nevada streams. Calif. Dep. Fish and Game. Stream Eval. Rep. No. 87-2. 103 pp.
- 817** Smith, L. L. and J. B. Moyle. 1944. A biological survey and fishery management plan for the streams of the Lake Superior north shore watershed. Minn. Dep. Conserv., Div. Game and Fish. Tech. Bull. No. 1. 228 pp.
 ► A thorough biological survey was conducted on 30 major streams of the Lake Superior north shore watershed that included assessment of fish species, chemical quality, plant and animal plankton, bottom algae, aquatic macrophytes, and bottom fauna. Minnesota's subsequent management plan for the north shore watershed was based on the results of this survey.
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- 819** Smith, S. 1974. Early life history of the steelhead in a North Shore stream. Univ. Minn., St. Paul. M.S. Thesis. 78 pp.
- 820** Smith, S. B. 1960. A note on two stocks of steelhead trout (*Salmo gairdneri*) in Capilano River, British Columbia. J. Fish. Res. Board Can. 17(5):739-42.
- 821** Smith, S. B. 1969. Reproductive isolation in summer and winter races of steelhead trout. pp. 21-38 in T. G. Northcote, ed. Symposium on salmon and trout in streams. H. R. MacMillan Lect. in Fish., Univ. B.C., Vancouver. 388 pp.
- 822** Smith, S. H. 1972. The future of salmonid communities in the Laurentian Great Lakes. J. Fish. Res. Board Can. 29(6):951-57.
- 823** Smith, S. H. 1973. Application of theory and research in fishery management of the Laurentian Great Lakes. Trans. Am. Fish. Soc. 102(1):156-63.
 ► This review of the history of the Great Lakes indicates that extensive research and intensive management have failed to prevent deterioration of the fisheries either because research was not timely, did not provide necessary information, or was not interpreted to indicate a need for corrective action. Smith concludes that successful application of theory and research to fishery management has been impeded by lack of close coordination among some state, provincial, and federal government units that have various degrees of influence on fishery programs of the Great Lakes.
- 824** Snieszko, S. F. 1973. Furunculosis of Salmonidae. pp. 157-62 in W. A. Dill, ed. Symposium on the major communicable fish diseases in Europe and their control. Eur. Inland Fish. Advis. Comm. Tech. Pap. No. 17, Suppl. 2.
 ► Furunculosis is caused by the gram-negative, nonmotile pigment-producing bacterium *Aeromonas salmonicida*. It is transmitted by water, physical contact, contaminated ova, and equipment. Prevention can be achieved by sanitary measures, disinfection of ova and facilities, selective breeding, environmental control, and immunization.
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- 827** Solomon, D. J. 1985. Salmon stock and recruitment, and stock enhancement. J. Fish Biol. 27 Suppl. A:45-57.
- 828** Solomon, D. J. and T. J. Storeton-West. 1983. Radio tracking of migratory salmonids in rivers: development of an effective system. Minist. Agric., Fish., and Food, Lowestoft, England. Fish. Res. Tech. Rep. No. 75. 11 pp.
 ► This paper documents the development of a strategy for monitoring upstream movements of adult salmonids (Atlantic salmon and brown trout) in rivers using both internally and externally placed radio transmitters. Migratory be-

havior of radio-tagged fish was similar to that of control fish.

- 829** Sorg, C. F., D. M. Donnelly, J. B. Loomis, and G. L. Peterson. 1984. Implications of economics as applied to wild trout fisheries management in Idaho. pp. 187-91 in F. Richardson and R. H. Hamre, eds. Wild trout III. Proc. of a Symp. held at Yellowstone Natl. Park. 192 pp.
▶ Monetary values associated with wild trout fishing are identified and explained in this report, and methods are given to derive these values.
- 830** Sorhus, C. N., W. G. Brown, and K. C. Gibbs. 1981. Estimated expenditures by salmon and steelhead sport anglers for specified fisheries in the Pacific Northwest. Oreg. State Univ., Agric. Exp. Stn. Spec. Rep. 631. 86 pp.
- 831** Southward, G. M. and J. Douglas. 1972. Evaluation of a winter steelhead fishery on a western Washington river. Trans. Am. Fish. Soc. 101:29-34.
▶ This report provides an example of the use of a punch card system to evaluate the sport fishing harvest of a steelhead fishery.
- 832** Sowden, T. K. and G. Power. 1985. Prediction of rainbow trout embryo survival in relation to groundwater seepage and particle size of spawning substrates. Trans. Am. Fish. Soc. 114:804-12.
- 833** Spiller, K. W., A. W. Green, and H. R. Osburn. 1988. Increasing the efficiency of angler surveys by canceling sampling during inclement weather. North Am. J. Fish. Manage. 8:132-38.
- 834** Stabell, O. B. 1982. Homing of Atlantic salmon in relation to olfaction and genetics. pp. 238-46 in E. L. Brannon and E. O. Salo, eds. Proceedings of the salmon and trout migratory behavior symposium. Univ. Wash., Seattle. 309 pp.
- 835** Stabell, O. B. and T. Refstie. 1985. Influence of the olfactory sense upon smolt transformation in salmonid fishes. J. Chem. Ecol. 11(10):1427-38.
- 836** Stauffer, T. M. 1955. Migration and growth of tagged, immature rainbow trout in the Black River, Mackinac County, and in Lake Michigan, 1951-1954. Mich. Dep. Conserv., Inst. Fish. Res. Rep. No. 1441. 18 pp.
- 837** Stauffer, T. M. 1972. Age, growth, and downstream migration of juvenile rainbow trout in a Lake Michigan tributary. Trans. Am. Fish. Soc. 101:18-28.
▶ Steelhead smolts in the downstream migration averaged 64% age I, 34% age II, and 2% age III. Growth averaged 76 mm/year. Most downstream migrants in Great Lakes tributaries were age II or less, while in Pacific Ocean tributaries, most were age II and III.
- 838** Stauffer, T. M. 1975. Population characteristics and summer-to-autumn survival of juvenile rainbow trout and coho salmon in two Lake Superior tributaries, 1969-1972. Mich. Dep. Nat. Resour. Fish. Res. Rep. No. 1825. 21 pp.
▶ Numbers, biomass, production, survival, and growth were estimated for age 0 coho salmon and ages 0 and I rainbow trout by monthly sampling over a 3-year period.
- 839** Stauffer, T. M. 1976. Fecundity of coho salmon (*Oncorhynchus kisutch*) from the Great Lakes and a comparison with ocean salmon. J. Fish. Res. Board Can. 33:1150-55.
▶ Fecundity (range 1,600-3,500 eggs/female) of Great Lakes coho salmon was comparable to fecundity (range 1,500-3,300 eggs/female) of Pacific coho of similar size. Average egg diameters were similar for Lake Michigan (7.1-7.4 mm) and Pacific (6.1-7.4 mm) coho, but Lake Superior eggs were smaller (5.1-5.4 mm). Lake Michigan coho averaged more eggs (2,938) than did Lake Superior coho (2,150) of the same year class and early life history.
- 840** Stauffer, T. M. 1977. Numbers of juvenile salmonids produced in five Lake Superior tributaries and the effect of juvenile coho salmon on their numbers and growth 1967-1974. Mich. Dep. Nat. Resour. Fish. Res. Rep. No. 1846. 29 pp.
▶ Newly established populations of juvenile coho salmon did not have a detectable effect on numbers or growth of rainbow trout. The data did suggest that coho salmon depressed brook and brown trout populations. Additional investigations are needed on interrelationships between coho salmon and brook and brown trout.
- 841** Stauffer, T. M. 1979. Two-year cycles of abundance of age-0 rainbow trout in Lake Superior tributaries. Trans. Am. Fish. Soc. 108:542-47.
▶ Two-year cycles of abundance of age 0 rainbow trout occurred in 2 of 5 tributaries on the south shore of central Lake Superior from 1967-74. The cause(s) of the cycles could not be determined but were not obviously related to density of juvenile salmonids, spawner abundance, weather conditions, or abiotic stream characteristics.
- 842** Stauffer, T. M. and M. J. Hansen. 1969. Mark retention, survival, and growth of jaw-tagged and fin-clipped rainbow trout. Trans. Am. Fish. Soc. 98(2):225-29.
- 843** Stern, D. H. and M. S. Stern. 1980. Effects of bank stabilization on the physical and chemical characteristics of streams and small rivers: a synthesis. U.S. Fish and Wildl. Serv. Rep. No. FWS/OBS-80/11. 43 pp.
- 844** Sternberg, R. B. 1978. Minnesota stream survey manual. Minn. Dep. Nat. Resour., Div. Fish and Wildl. Spec. Publ. No. 120. 82 pp.
- 845** Steven, J. C. and G. Z. Jacobi. 1978. Macroinvertebrates in ten streams in northern Wisconsin

sin. U.S. For. Serv., Chequamegon Natl. For. Chequamegon Watershed Rep. 74 pp.

► Quantitative and qualitative benthic macroinvertebrate collections were made at 14 locations on Chequamegon National Forest streams. Biotic index values ranged from 1.80-4.64.

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847 Strogon, J. W. 1979. A comparison of the diet and growth of the trout from the upper Au Sable and upper Manistee rivers, Michigan. Mich. Dep. Nat. Resour. Fish. Res. Rep. No. 1867. 56 pp.

► *Hexagenia limbata* accounted for about 35% of the total annual food consumption by brook trout in the upper Au Sable River. Trichopterans made up about 45% of the total diet of brown trout in the upper Manistee River.

848 Stuart, T. A. 1962. The leaping behaviour of salmon and trout at falls and obstructions. Dep. Agric. and Fish. Scotland. Freshwater and Salmon Fish. Res. Rep. No. 28. 46 pp.

849 Stuber, R. J. 1986. Stream habitat improvement evaluation: an alternative approach. pp. 153-61 in J. G. Miller, J. A. Arway, and R. F. Carline, eds. Fifth trout stream habitat improvement workshop. Proc. of a Conf. Lock Haven Univ., Pa. 238 pp.

850 Swales, S., R. B. Lauzier, and C. D. Levings. 1986. Winter preferences of juvenile salmonids in two interior rivers in British Columbia. Can. J. Zool. 64:1506-14.

851 Swales, S. and K. O'Hara. 1980. Instream habitat improvement devices and their use in freshwater fisheries management. J. Environ. Manage. 10:167-79.

852 Swanson, B. L. 1974. Brule River creel census. Wis. Dep. Nat. Resour., Bayfield. 4 pp. (unpubl. rep.).

► This unpublished memo reports the results of a creel survey conducted on the Brule River during the early, late, and regular seasons. A brief comparison is provided of the characteristics of spring and fall migratory rainbow trout runs and their sport fisheries.

853 Swanson, B. L. 1985. Pikes Creek/Lake Superior steelhead population: population dynamics, fishery, and management alternatives. Wis. Dep. Nat. Resour. Fish Manage. Rep. No. 125. 29 pp.

► The population dynamics of a naturally reproducing steelhead population were determined via tagging, scale analysis, and creel survey for a 4-year period (1977-81) on a small Wisconsin tributary to Lake Superior. The mean annual spawning population was 989 fish. Annual fishing mortality rates were 23% and 20% for males and females, respectively. Changes

in the population structure were estimated for various fishing mortality rates, and a rate of 20% was recommended to maintain a quality fishery.

854 Symons, P. E. K. 1971. Behavioral adjustment of population density to available food by juvenile Atlantic salmon. J. Anim. Ecol. 40:569-87.

855 Symons, P. E. K. 1979. Estimated escapement of Atlantic salmon (*Salmo salar*) for maximum smolt production in rivers of different productivity. J. Fish. Res. Board Can. 36:132-40.

856 Tappel, P. D. and T. C. Bjornn. 1983. A new method of relating size of spawning gravel to salmonid embryo survival. North Am. J. Fish. Manage. 3(2):123-35.

857 Taube, C. M. 1974. Transfer releases of coho salmon and trout into an upper part of Platte River and observations on salmonid spawning. Mich. Dep. Nat. Resour. Fish. Res. Rep. No. 1815. 28 pp.

858 Taube, C. M. 1975. Abundance, growth, biomass, and interrelationship of trout and coho salmon in the Platte River. Mich. Dep. Nat. Resour. Fish. Res. Rep. No. 1830. 8 pp.

► Juvenile coho salmon exerted no detectable effect on growth or numbers of brown or rainbow trout in sections of a Lake Michigan tributary except for one section heavily used by spawning coho. However, a reduction in numbers of young brown trout in this section was compensated for by better survival to the older ages.

859 Tautz, A. F. and C. Groot. 1975. Spawning behavior of chum salmon (*Oncorhynchus keta*) and rainbow trout (*Salmo gairdneri*). J. Fish. Res. Board Can. 32(5):633-42.

860 Tautz, A., P. A. Larkin, and W. E. Ricker. 1969. Some effects of simulated long-term environmental fluctuations on maximum sustained yield. J. Fish. Res. Board Can. 26:2715-26.

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862 Taylor, G. D. 1978. Enhanced stream production for kokanee, rainbow and cutthroat trout in British Columbia. pp. 29-30 in K. Hashagen, ed. Wild trout management. Proc. of a Natl. Symp. Calif. Trout, Inc., San Francisco. 69 pp.

863 Theurer, F. D., I. Lines, and T. Nelson. 1985. Interaction between riparian vegetation, water temperature, and salmonid habitat in the Tucannon River. Water Resour. Bull. 21(1):53-64.

864 Thompson, D. 1985. Genetic identification of trout strains. Aquaculture 46:341-51.

- 865** Thomson, J. W. 1944. A survey of the larger aquatic plants and bank flora of the Brule River. Trans. Wis. Acad. Sci., Arts and Lett. 36:57-76.
▶ This report describes the results of a thorough reconnaissance of the aquatic and riparian floral association of the Brule River during 1943. This survey was part of a larger interdisciplinary study done on the Brule River. Eleven technical papers from this study were subsequently published under one cover (see Wis. Cons. Dep. 1954).
- 866** Thomson, J. W. 1945. An analysis of the vegetative cover of the Brule River (Wisconsin) watershed. Trans. Wis. Acad. Sci., Arts and Lett. 37:305-23.
▶ An extension of Thomson's previous work on Brule River aquatic and bank flora, this descriptive report of the vegetative cover of the entire watershed was issued under the same cover (see Wis. Cons. Dep. 1954).
- 867** Thorpe, J. E. 1982. Migration in salmonids, with special reference to juvenile movements in freshwater. pp. 86-97 in E. L. Brannon and E. O. Salo, eds. Proceedings of the salmon and trout migratory behavior symposium. Univ. Wash., Seattle. 309 pp.
- 868** Thorpe, J. E. 1987. Smolting versus residency: developmental conflict in salmonids. Am. Fish. Soc. Symp. 1:244-52.
- 869** Thorpe, J. E. and J. F. Koonce (with D. Borgeson, B. Henderson, A. Lamsa, P. S. Maitland, M. A. Ross, R. C. Simon, and C. Walters). 1981. Assessing and managing man's impact on fish genetic resources. Can. J. Fish. and Aquat. Sci. 38:1899-907.
- 870** Thorpe, J. E., L. G. Ross, G. Struthers, and W. Watts. 1981. Tracking Atlantic salmon smolts *Salmo salar* through Loch Voil Scotland, United Kingdom. J. Fish Biol. 19(5):519-38.
- 871** Threinen, C. W. and R. Poff. 1964. The geography of Wisconsin's trout streams. Wis. Acad. Sci., Arts and Lett. 52:57-75.
- 872** Thurow, R. F. and T. C. Bjornn. 1978. Response of cutthroat trout populations to the cessation of fishing in St. Joe River. Ida. Coop. Fish. Res. Unit. Proj. No. F-6-R. 40 pp.
- 873** Tiegs, C. 1982. State of Wisconsin surface water quality monitoring data 1980. Wis. Dep. Nat. Resour., Madison. 93 pp.
- 874** Tiegs, C. and J. St. Amant. 1983. State of Wisconsin surface water quality monitoring data 1981. Wis. Dep. Nat. Resour., Madison. 106 pp.
- 875** Tiegs, C. and R. Wallace. 1980. State of Wisconsin surface water quality monitoring data 1973-1976. Wis. Dep. Nat. Resour., Madison. 213 pp.
- 876** Tiegs, C. and R. Wallace. 1980. State of Wisconsin surface water quality monitoring data 1977. Wis. Dep. Nat. Resour., Madison. 130 pp.
- 877** Tiegs, C. and R. Wallace. 1980. State of Wisconsin surface water quality monitoring data 1978. Wis. Dep. Nat. Resour., Madison. 133 pp.
▶ The 5 preceding reports, covering 1973-81, provide monthly print-outs of selected chemical surface water data for 44 river locations in Wisconsin, including the Brule River at the Hwy. 13 bridge area.
- 878** Toews, D. A. A. and M. J. Brownlee. 1981. A handbook for fish habitat protection on forest lands in British Columbia. Dep. Fish. and Oceans, Vancouver, B.C. 166 pp.
- 879** Torblaa, R. L. 1968. Effects of lamprey larvicides on invertebrates in streams. U.S. Fish and Wildl. Serv. Spec. Sci. Rep.-Fish. No. 572. 13 pp.
- 880** Tschaplinski, P. J. and G. F. Hartman. 1983. Winter distribution of juvenile coho salmon (*Oncorhynchus kisutch*) before and after logging in Carnation Creek, British Columbia, and some implications for overwinter survival. Can. J. Fish. and Aquat. Sci. 40:452-61.
▶ Sections of a British Columbia coastal stream containing adequate winter habitat in the form of deep pools, log jams, and undercut banks with tree roots and debris lost fewer juvenile coho salmon during freshets and maintained higher numbers of fish in winter than sections without these habitat characteristics.
- 881** Tsumura, K. and J. M. B. Hume. 1986. Two variations of a salmonid smolt trap for small rivers. North Am. J. Fish. Manage. 6:272-76.
- 882** Turner, S. E. 1972. Rainbow trout literature review. Mo. Dep. Conserv. Final Rep. Study S-9. Dingell-Johnson Proj. F-1-R-21. 9 pp.
- 883** Turner, S. E. 1984. Missouri trout: wise use of a limited resource. pp. 85-89 in F. Richardson and R. H. Hamre, eds. Wild trout III. Proc. of a Symp. held at Yellowstone Natl. Park. 192 pp.
- 884** Turner, S. E. 1986. The effects of restrictive fishing methods upon catch, harvest and survival of trout in Meramec River. Mo. Dep. Conserv. Final Rep. Study S-31. Dingell-Johnson Proj. F-1-R-35. 30 pp.
- 885** Tyler, R. W. 1979. Method of sampling seaward migration of juvenile salmon. Prog. Fish-Cult. 41(2):78-81.
- 886** Tyus, H. M., B. D. Burdick, and C. W. McAda. 1984. Use of radio-telemetry for obtaining habitat preference data on Colorado squawfish. North Am. J. Fish. Manage. 4:177-80.
▶ Habitat use observations made using radiotelemetry appeared to avoid some of the bias associated with conventional collection tech-

niques and therefore provided a better understanding of habitat requirements (depth, velocity, substrate preferences) of Colorado squawfish (*Ptychocheilus lucius*) in a turbid river.

- 887** Van Hyning, J. M. 1973. Factors affecting the abundance of fall chinook salmon in the Columbia River. Fish Comm. Oreg. Res. Rep. 4(1). 87 pp.
- 888** Vannote, R. L., G. W. Minshall, K. W. Cummins, J. R. Sedell, and C. E. Cushing. 1980. The river continuum concept. Can. J. Fish. and Aquat. Sci. 37:130-37.
- ▶ This concept has provided a valuable framework for interpreting and predicting progressive shifts in biological community structure and function over a river's length.
- 889** Van Velson, R. C. 1978. The McConaughy rainbow: life history and a management plan for the North Platte River Valley. Nebr. Game and Parks Comm. Nebr. Tech. Ser. No. 2. 83 pp.
- 890** Vaux, W. G. 1968. Intragravel flow and interchange of water in a streambed. Fish. Bull. 66(3):479-89.
- 891** Vetrano, D. M. 1988. Unit construction of trout habitat improvement structures for Wisconsin coulee streams. Wis. Dep. Nat. Resour., Bur. Fish. Manage. Adm. Rep. No. 27. 35 pp.
- 892** Vetter, E. F. 1988. Estimation of natural mortality in fish stocks: a review. Fish. Bull. 86(1):25-43.
- 893** Vincent, E. R. 1984. Effect of stocking hatchery rainbow trout on wild stream-dwelling trout. pp. 48-52 in F. Richardson and R. H. Hamre, eds. Wild trout III. Proc. of a Symp. held at Yellowstone Natl. Park. 192 pp.
- ▶ When stocking of catchable-size hatchery rainbow trout was discontinued on a section of the Madison River, Montana, the wild trout population increased in numbers and biomass by over 180%. A previously unstocked section of a nearby creek showed a 45% decrease in wild trout numbers and biomass immediately following planting of hatchery catchables. At the same time, an unplanted creek section (control) showed no significant change in its trout population.
- 894** Wagner, H. H. 1967. A summary of investigations of the use of hatchery-reared steelhead in the management of a sport fishery. Oreg. State Game Comm., Res. Div. Fish. Rep. No. 5. 62 pp.
- 895** Wagner, H. H. 1968. Effect of stocking time on survival of steelhead trout, *Salmo gairdneri*, in Oregon. Trans. Am. Fish. Soc. 97(4):374-79.
- 896** Wagner, H. H. 1974. Photoperiod and temperature regulation of smolting in steelhead trout (*Salmo gairdneri*). Can. J. Zool. 52:219-34.
- 897** Wagner, H. H. 1977. Options for managing the anadromous fisheries of lower Deschutes River. pp. 127-32 in E. Schwiebert, ed. Columbia River salmon and steelhead. Am. Fish. Soc. Spec. Publ. No. 10. 214 pp.
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ACKNOWLEDGMENTS

I extend special thanks to my supervisor, Robert Hunt, Cold Water Group Leader, for his guidance and encouragement during the compilation of this bibliography. Special thanks are also due to Rose Smith and Amy Kindschi of the Bureau of Research Technical Library for successfully responding to numerous requests for reprints and copies of reports. I am also indebted to Scott Plaster for his dedicated efforts at typing proper citations for the reports and assisting with filing duties. Scott Plaster and Mike Rackouski assisted with indexing. Helpful comments on the manuscript were received from Betty Les, Research Information and Publication Technical Editor and Jeff Kampa, Fish Manager.

This research was supported in part by funds provided by the Anadromous Fish Conservation Act, Project AFS-16.

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