PANAMA CITY CRAYFISH MANAGEMENT PLAN

Procambarus econfinae

- Draft -

February 2016

Florida Fish and Wildlife Conservation Commission
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The 2015-2016 management plan team included David Cook, Justin Davis, Amy Raker, Melissa Tucker, Laura Barrett, Steve Shea, Tom Ostertag, and Angela Williams. Brie Ochoa provided editing expertise. Claire Sunquist Blunden served as stakeholder coordinator. Dr. Mark Barrett developed the PCC habitat model. Brian Beneke prepared the maps. Mike Hunter prepared the ditch illustration.

The 2006-2010 management plan team, which developed the 2007 draft plan and laid the groundwork for this plan, included David Cook, Dr. John Himes, Capt. Kenneth Parramore, Lt. Col. Louie Roberson, and Gary Warren. The team sponsors were Tim Breault and Gil McRae, with Dr. Elsa Haubold as the sponsor representative. Dr. Terry Doonan was the stakeholder meeting facilitator. The expert panel included Richard Franz, University of Florida; Dr. Ed Keppner and Lisa Keppner, Keppner Biological, Panama City; Deron Lawrence, Biological Research Associates, Tallahassee; and Paul Moler, FWC Fish and Wildlife Research Institute.

In addition to the team members, other FWC staff contributed to this process; note that several components in the 2007 draft plan were not maintained in the 2015 draft. Elsa Haubold provided a final review of the 2007 draft plan. Terry Doonan moderated meetings among planning team members, and between the planning team and stakeholders, and provided valuable input to the plan, including drafting the Ecological Impacts section. Dan Sullivan provided guidance on the revised listing process and details on plan format and content. Judy Gillan drafted the Education, Outreach, and Training section. Officer Gary Tolbert contributed as a team member in Captain Parramore's absence. Paul Moler provided biological expertise on the PCC. Brian Beneke drafted the subbasin "locations" and extent of occurrence figures. Kristen Slagle drafted the process map. Bill Hunter drafted the no-cost permit. Mary Ann Poole, Mary Scott Gilbert, and Sharon Lobello provided input on stakeholder outreach issues. Michael Yaun provided counsel on legal issues. Stan Kirkland addressed media and public issues. Shea Armstrong, Marvin Friel, and Wendy Bear recorded notes at stakeholder meetings.

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EXECUTIVE SUMMARY

The Panama City crayfish (*Procambarus econfinae*) (PCC) is a small freshwater crustacean found only in a small portion of Bay County in northwest Florida. The historical habitat of the PCC is wet pine flatwoods, but the majority of current populations exist in human-altered settings such as planted pine plantations, roadside ditches, and utility rights-of-way. Major threats to the species include habitat loss, degradation, and fragmentation; subpopulation isolation; and direct mortality due to human activities. Recent and ongoing conservation efforts include rangewide surveys and habitat restoration on conservation easements.

State listed as a Species of Special Concern (SSC) since 1987, the PCC underwent a Biological Status Review (BSR) in 2006. A panel was appointed by the Florida Fish and Wildlife Conservation Commission (FWC) to conduct the review, and included FWC staff and independent scientists. In the BSR, the panel recommended that the PCC be reclassified as state Threatened, due to its limited geographic distribution and apparent continuing decline.

A management plan was drafted and nearing finalization in December 2007, when FWC Commissioners directed staff to revise the state's listing process and suspend listing action for the PCC until a new listing process was completed. The revised listing process, approved in November 2010, phases out the SSC status and considers all state-listed species as Threatened if they meet listing criteria. Based on the 2006 BSR, the PCC meets the revised criteria for listing as state Threatened and is still recommended to be listed as Threatened on Florida's Endangered and Threatened Species List. This management plan encompasses the work done in 2006 and 2007, and includes new information and updated conservation approaches consistent with FWC's current imperiled species management system. Furthermore, it fulfills the requirement in Rule 68A-27.0012, Florida Administrative Code, that each species listed on Florida's Endangered and Threatened Species List shall have an approved management plan.

This management plan was developed by FWC staff with the assistance of PCC experts and a stakeholder advisory group representing private landowners, public utilities, municipal governments, environmental consultants, environmental organizations, and state and federal agencies. The plan is intended to serve as a blueprint for recovery for the PCC.

The conservation goal for the PCC is to ensure the long-term conservation of the PCC throughout its range so that it no longer warrants listing by the state of Florida. Two conservation objectives are proposed to achieve the goal.

1. Increase the total area of occupied PCC habitat to 2,000 acres: 1,500 acres in the eastern portion of its range consisting of parcels that are each 25 acres or greater and at least 5 parcels in the western portion of its range that are each 5 acres or greater. These management areas will be secure in long-term easements and managed in perpetuity. Transmitter Road serves as the dividing line between the eastern and western portions of the PCC range.
2. Develop and evaluate methods to accurately determine PCC densities and assess population status (age structure and sex ratios) to determine a minimum viable population size and to develop translocation guidelines.

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Sixteen conservation actions are proposed to help achieve these objectives. These include establishing partnerships among stakeholders, especially those based on agreements that set aside PCC conservation lands sufficient in size and number to ensure the species' long-term survival. Another critical action is the development of a PCC Conservation Tool that provides clear guidance on alternatives available to avoid, minimize, or mitigate potential impacts to PCC or PCC habitat while providing maximum long-term benefit to the species. The tool will better quantify PCC impacts from projects and provide mitigation options for permit applicants when impacts cannot be avoided. Mitigation options may include conservation banking, establishment of conservation easements, and/or contribution to a PCC Conservation Fund dependent on the amount of impacts. The PCC Conservation Fund would be used to support continuing management actions.

Another conservation action encourages stakeholders to follow voluntary conservation management practices (CMPs) in low-impact activities such as maintaining roadside swales, constructing residences, and conducting silviculture. The CMPs specific for PCC conservation were drafted and revised with the assistance of the stakeholder advisory group, and are presented in an appendix, and will be in the separate Panama City Crayfish Species Conservation Measures and Permitting Guidelines that are being developed.

This management plan is the product of a proactive, collaborative effort between FWC staff and stakeholders. This effort, bolstered by partnerships and outreach, will continue through the plan's implementation to ensure that we meet the conservation goal and ultimately secure this unique species within its range.

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TABLE OF CONTENTS

ACKNOWLEDGEMENTS ii
EXECUTIVE SUMMARY iii
LIST OF TABLES vii
LIST OF FIGURES viii
LIST OF ACRONYMS ix
GLOSSARY x
INTRODUCTION 1
Overview 1
Taxonomy and Morphology 1
Life History and Habitat 2
Distribution and Population Status 3
Conservation History 7
Threats and Recommended Listing Status 8
CONSERVATION GOAL AND OBJECTIVES 13
CONSERVATION ACTIONS 15
Habitat Conservation and Management 15
Population Management 16
Monitoring and Research 16
Rule Changes 18
Permitting Framework 18
Law Enforcement 20
Incentives and Influencing 21
Education and Outreach 21
Coordination with Other Entities 22
IMPLEMENTATION STRATEGY 24
Priority Actions 24
Proposed Implementation Schedule 25
Required Resources and Other Costs Associated with Plan Implementation 26
Management Plan Review and Revision 27
ANTICIPATED ECONOMIC, SOCIAL, AND ECOLOGICAL IMPACTS 30
Economic Impacts 30
Social Impacts 31
Ecological Impacts 31
LITERATURE CITED 33
APPENDICES 35
Appendix 1. Crayfish species found in Bay County, Florida. 35
Appendix 2. Comparison of Panama City crayfish with other species found in its range. 36
Appendix 3. Methods for development of Panama City Crayfish (PCC) Habitat Model 38
Appendix 4. Draft Guidelines for Translocation of the Panama City Crayfish (*Procambarus econfinae*) 40
Appendix 5. Authorizations not requiring a permit 44
Appendix 6. Conservation Management Practices (CMPs) 46
Ditch/Road Maintenance 46
Utility and Transmission Line Rights-of-Way Construction and Maintenance: 47

DRAFT

Appendix 7. Landowner Assistance Programs 48
Appendix 8. Stakeholders for 2007 Draft Panama City Crayfish Management Plan 49

DRAFT

LIST OF TABLES

Table 1. Distribution of Panama City crayfish habitat. 7
Table 2. Conservation Actions.*[to be inserted]* 28

DRAFT

LIST OF FIGURES

Figure 1. Panama City crayfish (*Procambarus econfinae)*..... 2
Figure 2. Panama City crayfish, male and female. 4
Figure 3. Panama City crayfish occurrences and absences..... 5
Figure 4. Panama City crayfish habitat range.. 6
Figure 5. Comparison of the cross-section of ditche slopes with differing configurations. 8

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LIST OF ACRONYMS

AHRES: Aquatic Habitat Restoration and Enhancement Section

AUC: Area under the curve

BMPs: Best Management Practices

BRG: Biological Review Group

BSR: Biological Status Report

CCAA: Candidate Conservation Agreement with Assurances (of USFWS)

CLC: Cooperative Land Cover

CMPs: Conservation Management Practices

CPS: Conservation Planning Services Section (of FWC)

DEP: Florida Department of Environmental Protection

DOT: Florida Department of Transportation

ERP: Environmental Resource Permit

F.A.C.: Florida Administrative Code

FNAI: Florida Natural Areas Inventory

F.S.: Florida Statutes

FWC: Florida Fish and Wildlife Conservation Commission

FWRI: Fish and Wildlife Research Institute (of FWC)

HSC: Habitat and Species Conservation Division (of FWC)

ITP: Incidental Take Permit

LE: Law Enforcement (of FWC)

NRCS: Natural Resources Conservation Service (of USDA)

NWFWMD: Northwest Florida Water Management District

OCP: Office of Conservation Planning (of FWC)

OPS: Other Personnel Services

PCC: Panama City crayfish *(Procambarus econfinae)*

SCP: Species Conservation Planning Section (of FWC)

SSC: Species of Special Concern

USACE: U.S. Army Corps of Engineers

USDA: U.S. Department of Agriculture

USFWS: U.S. Fish and Wildlife Service

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GLOSSARY

Area of Occupancy
Area within the Extent of Occurrence that is actually occupied by a species.

Box-cut ditch
A ditch with vertical or near-vertical sides and a flat bottom or a ditch with a horizontal to vertical ratio slope steeper than 3:1. (e.g., 2:1 or 1.5:1). Box-cut ditches are designed to quickly move rainwater runoff downstream. They do not support PCC and are not considered to be PCC habitat. See also Figure 5 and **ditch** and **swale**, below.

Candidate Conservation Agreement with Assurances
Formal agreement between the USFWS and others to address the conservation needs of species proposed for federal listing. Participants voluntarily commit to implement actions to reduce threats to the target species, thereby making their federal listing less likely. A CCAA provides assurances that additional regulations will not be required if the species become federally listed.

Conservation Management Practices (CMPs)
Recommended, voluntary actions that help provide suitable habitat conditions for PCC while conducting activities such as maintaining roadside swales, constructing residences, or silvicultural practices. Depending on the proposed activity, following CMPs may eliminate permitting requirements. See Appendix 6.

Detritivore
Consumer of detritus, the particulate remains of plant and animal material.

Ditch
A distinction is made in this document between roadside ditches that have a horizontal to vertical slope ratio of 3:1 or shallower (e.g., 4:1 or 5:1) and provide habitat for PCC, versus those ditches with slopes steeper than 3:1, including box-cut ditches, that are not considered to provide habitat for the PCC. See also Figure 5, and **box-cut ditch**, above, and **swale,** below.

Extent of Occurrence
Range of a species defined as the shortest continuous boundary that encompasses all known occurrence points.

Lidar
A remote sensing technology that measures distance by illuminating a target with a laser and analyzing the reflected light.

PCC Conservation Fund
Fund set up to receive contributions from PCC mitigation, which can then be used to support continuing PCC management actions, research, and other activities described in this management plan.

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PCC Management Area
Area set aside, through agreement, easement, purchase, mitigation, or other arrangement for the conservation of the Panama City crayfish.

Pleopods
Forked swimming limbs of a crustacean, five pairs of which are typically attached to the abdomen. Also called swimmerets. In male crayfish, the first pair of pleopods are used in reproduction and are species-diagnostic.

Secondary Burrowers
Crayfish species, including the PCC, that excavate a burrow, but are not restricted to it and move freely when their habitat is flooded.

Swale
As per 403.803(14), F.S., "swale" means a "man-made trench that: (a) has a top width-to-depth ratio of the cross-section equal to or greater than 6:1, or side slopes equal to or greater than three feet horizontal to one foot vertical; (b) contains contiguous areas of standing or flowing water only following a rainfall event; (c) is planted with or has stabilized vegetation suitable for soil stabilization, stormwater treatment, and nutrient uptake; and (d) is designed to take into account the soil erodibility, soil percolation, slope, slope length, and drainage area so as to prevent erosion and reduce pollutant concentration of any discharge." Grassy, gently-sloped swales often provide habitat for the PCC. See also Figure 5, and **box-cut ditch** and **ditch**, above.

Wetland
As per 373.019(25), F.S., and Chapter 62-340, Florida Administrative Code (F.A.C.), wetlands are "those areas that are inundated or saturated by surface water or groundwater at a frequency and a duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soils. Soils present in wetlands generally are classified as hydric or alluvial, or possess characteristics that are associated with reducing soil conditions. The prevalent vegetation in wetlands generally consists of facultative [occasional] or obligate [always] hydrophytic [water-loving] macrophytes that are typically adapted to areas having soil conditions described above. These species, due to morphological, physiological, or reproductive adaptations, have the ability to grow, reproduce, or persist in aquatic environments or anaerobic soil conditions. Florida wetlands generally include swamps, marshes, bayheads, bogs, cypress domes and strands, sloughs, wet prairies, riverine swamps and marshes, hydric seepage slopes, tidal marshes, mangrove swamps, and other similar areas. Florida wetlands generally do not include longleaf or slash pine flatwoods with an understory dominated by saw palmetto."

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INTRODUCTION

Overview

The Panama City crayfish (*Procambarus econfinae*) (PCC) is an inhabitant of wet pine flatwoods and is only known from a small portion of Bay County in the vicinity of Panama City (Hobbs 1942, Mansell 1994, Keppner and Keppner 2001).

This management plan is intended to facilitate the long-term conservation of the PCC throughout its range so that it no longer warrants listing by the state of Florida. The plan includes the following information: (1) a summary of available biological information; (2) an assessment of threats faced by the species; (3) a statement of the conservation goal and measurable biological objectives; (4) a list of recommended conservation actions needed to achieve the goal and objectives; (5) an implementation strategy for those conservation actions; and (6) a discussion of anticipated economic, social, and ecological impacts of the implementation.

Taxonomy and Morphology

The PCC is classified within the phylum Arthropoda, class Malacostraca, order Decapoda, and family Cambaridae. Horton Hobbs, Jr., surveyed for and collected crayfishes in northwestern Florida in 1938. Four years later (1942), Hobbs published the results of this survey, which included the first formal scientific description of the PCC as *Procambarus econfinae*. The PCC is not known to hybridize with other species of crayfishes.

The PCC is a small crayfish, growing to about two inches (body length minus claws). A detailed morphological description of the PCC is provided by Hobbs (1942) and Keppner and Keppner (2001). The color pattern consists of a medium-dark brown background color, lighter brown mid-dorsal stripe, and darker brown dorsolateral stripes (Figure 1). The lower lateral surfaces are lighter brown with reddish-brown spots. The PCC is distinguished from related species of *Procambarus* (*P. kilbyi*, *P. apalachicolae*, *P. hubbelli*) that occur outside its range by the shape and arrangement of the first pair of pleopods of the reproductive males (Hobbs 1942, Keppner and Keppner 2001).

Eleven crayfish species are known from Bay County (see Appendix 1), and eight, including the PCC, are found in the PCC range. Two of these (*P. versutus* and *P. spiculifer*) are strictly stream species, one (*P. paeninsulanus*) is more typically associated with swamps and overgrown ponds (not typical PCC habitat; see Life History and Habitat), and two (*P. pycnogonopodus* and *P. rogersi*) are found in the same habitat as the PCC and may co-occur with it. However, the PCC's size, shape, and color pattern distinguish it from most of the other species of crayfish that occur within its range (P. Moler, personal communication) (see Appendix 2). The exceptions are two species (*P. kilbyi* and *P. hubbelli*) that closely resemble the PCC and have been recently discovered in a small part of its range.

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Figure 1. Panama City crayfish (*Procambarus econfinae)*. Photo by Lisa Keppner.

Life History and Habitat

Historically, the PCC inhabited natural and often temporary bodies of shallow fresh water within open pine flatwoods (Hobbs 1942). However, most of the natural pine flatwoods have been cleared for residential or commercial development or replaced with slash pine plantations. Thus, the PCC currently is known to inhabit the waters of grassy, gently-sloped ditches and swales (see Glossary and Figure 5), slash pine plantations, and utility rights-of-way (Keppner and Keppner 2001). In a newly developed PCC habitat model (see Distribution and Population Status), the top land-cover classes occupied by PCC include tree plantations (wet), wet flatwoods, prairies and bogs, transportation corridors, and rural. Other model variables include range of elevation (10-15 m), distance to wetlands (0 m), and soils with poor drainage (Mark Barrett, Florida Fish and Wildlife Conservation Commission [FWC], unpublished data).

The highest densities of PCC have been recorded in areas with little to no shrub or tree cover. Suitable habitat is normally dominated by herbaceous vegetation such as redroot (*Lachnanthes caroliniana*), beakrushes (*Rhynchospora* spp.), pitcher plants (*Sarracenia* spp.), sundews (*Drosera* spp.), butterworts (*Pinguicula* spp.), and lilies (*Hymenocallis* spp.) (Keppner and Keppner 2004, Keppner and Keppner 2005). Lowest population densities have occurred in small, open sites where shrubs or trees were present, or in the furrows between the bedding rows in some pine plantations (Keppner and Keppner 2005). Such sites may be considered secondary or

suboptimal habitat for PCC. On sites where mixed habitat features are present (e.g., partially wooded sites or sites with permanent, deep-water ponds), PCC appear to select favorable areas dominated by herbaceous vegetation, with shallow or fluctuating water levels (Keppner and Keppner 2005). The overall value of mixed-habitat sites for conservation of PCC depends on the extent and quality of suitable wetland habitats restored or maintained on a given site. The removal and control of nonnative plants is an important part of ongoing and future PCC habitat restoration efforts.

Surface water is commonly absent in PCC habitat for part of the year. During these dry periods the PCC excavates and lives in unbranched burrows up to three feet long that extend down to the water table, thereby enabling the PCC to remain adequately hydrated and survive. However, during severe droughts, the water table may drop below the bottom of the crayfish burrow, possibly causing large-scale mortality (E. Keppner, personal communication). When surface water is absent, the entrance to PCC burrows can usually be detected through identification of small, distinct balls of mud that are deposited on the surface during burrow excavation, forming a chimney. Whenever surface water is available, the PCC leave their burrows and move into areas of open water (Hobbs 1942). It should be noted that other crayfish within the range of the PCC also build chimneys, so a given chimney cannot be assigned to a particular crayfish species unless the burrow is excavated and its occupant identified.

Sex is determined by examining the first pair of abdominal limbs (pleopods). In males these structures are used to transfer sperm into the female, are located between the last pair of walking legs, and are normally folded up along the midline (Figure 2). In sexually reproductive males, the tips of these pleopods are yellow in color whereas they are white in sexually non-reproductive males. Instead of modified pleopods, females have an annulus ventralis on the midline between the last two pairs of walking legs. Female PCC have been found with eggs and/or young from March through September. Juveniles are most frequently found in the summer, but have still been found in December, so the PCC appears to produce young from March through December, and possibly later. Juveniles can be carried overland by sheet flow during rainy periods, which aids in dispersal (Keppner and Keppner 2002). Very few data on other aspects of the life history of the PCC are available.

Distribution and Population Status

In 1999, Dr. Edwin and Lisa Keppner surveyed the historic sites from which Hobbs (1942) originally collected PCC. The Keppners continued to conduct PCC surveys in the years that followed: in Panama City through funding from the U.S. Fish and Wildlife Service (USFWS) in 2000 (Keppner and Keppner 2002), on Gulf Power rights-of-way between Star Avenue and Transmitter Road in 2002, and on St. Joe Lands east of Panama City in 2003 and 2004. As a result of these surveys, the eastern/southeastern range of the PCC was defined (Keppner and Keppner 2004). In 2003, the City of Panama City hired Dr. Frasier Bingham to conduct a PCC survey (Bingham 2003). Later in 2003, the Keppners surveyed this same general area (Keppner and Keppner 2004) and conducted resurveys at a few points in 2006.

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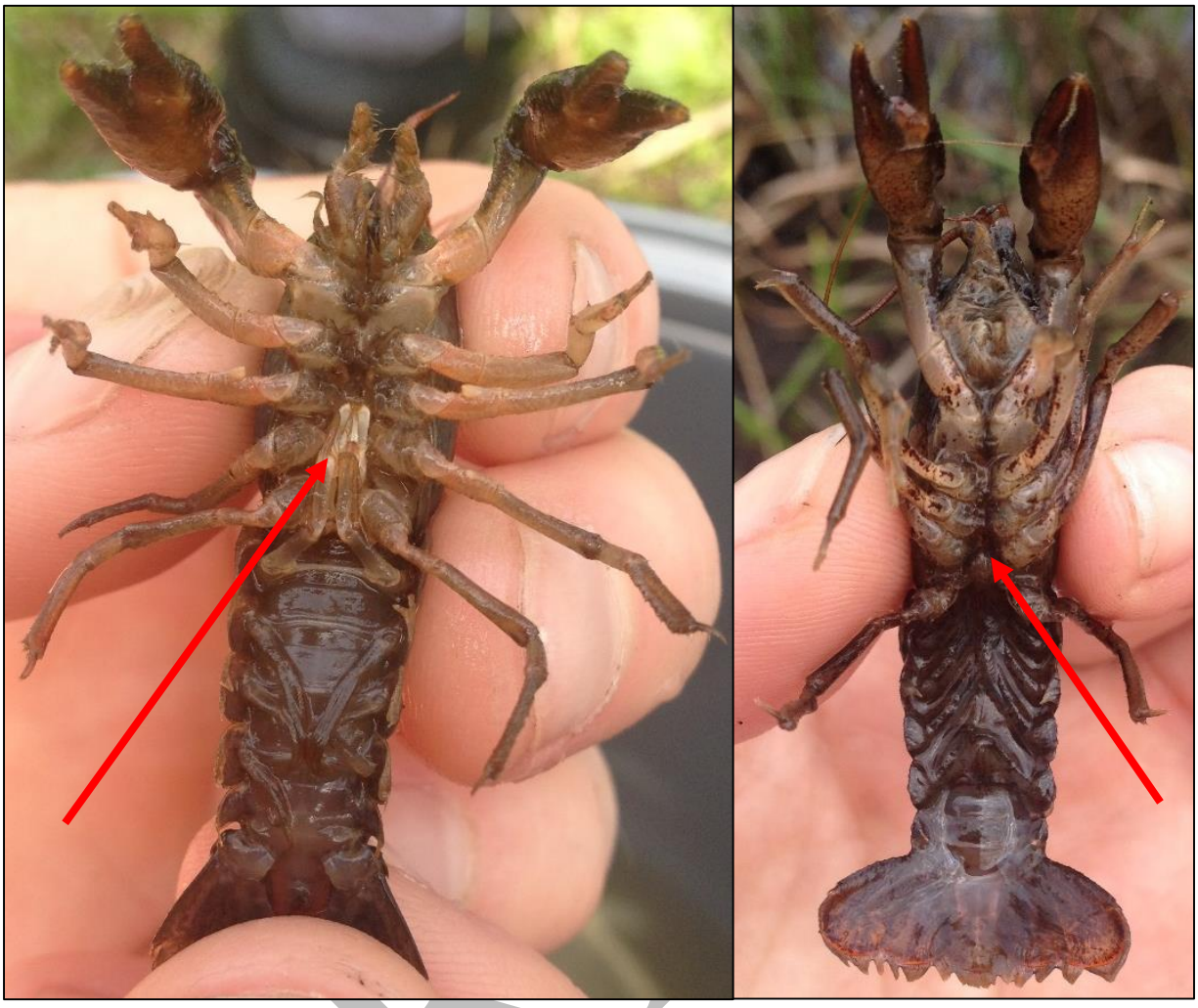

Figure 2. Panama City crayfish, male and female. Male (left), as evidenced by the modified pleopods, and female (right) as evidenced by the annulus ventralis. Photos by Amy Raker, FWC.

In 2012-2013, FWC led a survey effort in which FWC staff and partners resurveyed previously documented points on rights-of-way and public road edges and at undocumented points throughout the species' range. In 2013, some 10 years after the original surveys by the Keppners, the St. Joe Company provided access for these surveys. Although these surveys documented new occurrences that further defined the PCC range, surveyors failed to confirm PCC at several previously documented occurrence points. Data collected from opportunistic surveys, environmental consultants, and annual surveys on PCC management areas are continually added to the PCC database. Occurrence data from these surveys formed the basis for determining the species' range (Figure 3).

The PCC is found only in a small area of south-central Bay County, Florida, on the peninsula that includes Panama City, Lynn Haven, and Callaway. Its range is bounded by Callaway Bayou to the southeast, Callaway Creek to the east, Bayou George Creek and the headwaters of Callaway Creek to the northeast, North Bay to the north, and West Bay to the west and St. Andrew Bay and East Bay to the south (Keppner and Keppner 2004). To date, PCC have been

documented at over 1,000 occurrence points (FWC unpublished data) (Figure 3); however, this number does not reflect the points at which PCC were unconfirmed during resurveys.

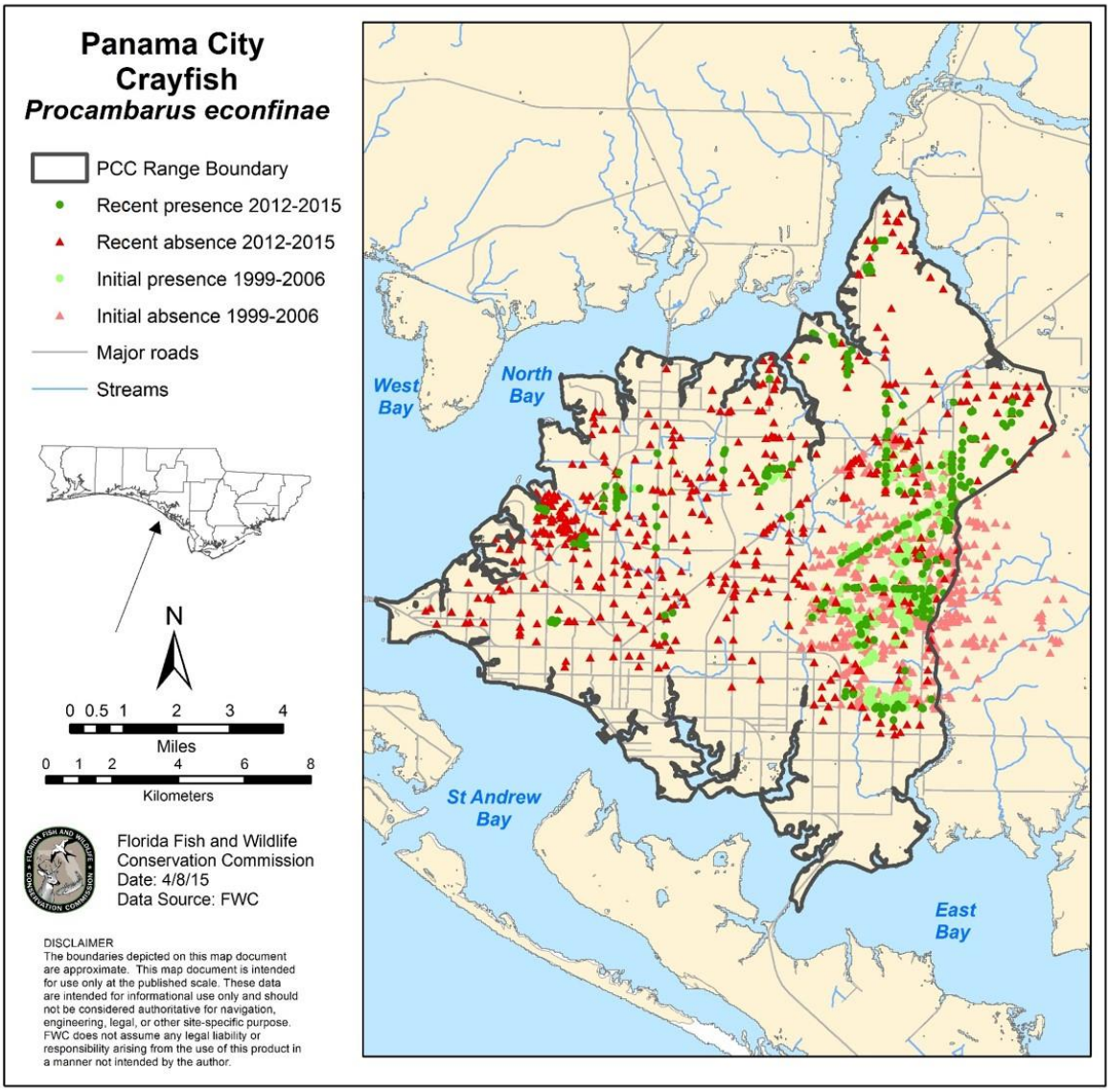

Figure 3. Panama City crayfish occurrences and absences from initial surveys (1999-2006) and from recent surveys (2012-2015). The thick gray line is the boundary of the PCC range.

Panama City has experienced rapid human population growth and subsequent widespread alteration of natural habitats that were historically occupied by PCC. Abundance of the species is unknown, but the number of known occupied locations has likely decreased as human populations increased (see Threats and Recommended Listing Status). Using the occurrence data, we used best available science to develop a PCC habitat map (Figure 4). A detailed description of how this map was developed is presented in Appendix 3.

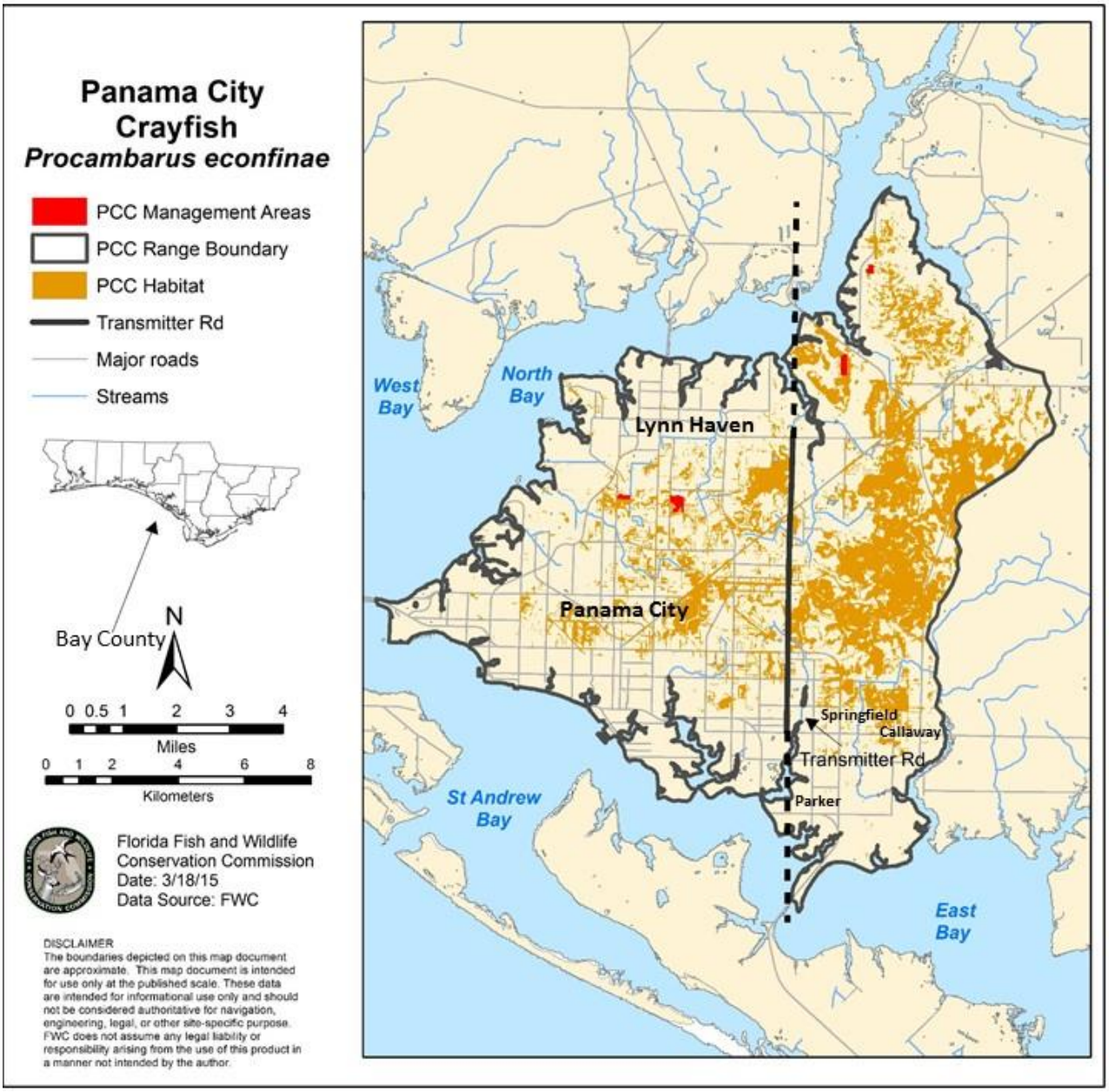

Figure 4. Panama City crayfish habitat range. See Appendix 3 for a description of how the map was developed. PCC management areas are habitat restoration sites. Transmitter Road is the dividing line for the eastern and western range.

The estimated 10,041 acres of PCC habitat is not equally distributed across the range, but predominates in the eastern portion, east of Transmitter Road (Figure 4; Table 1). Although altered by silviculture, this area is primarily undeveloped, whereas the remainder of the species' distribution has been largely modified through residential and commercial development (Keppner and Keppner 2004). Almost 90% of this acreage (8,923 acres) is located on private land, emphasizing the importance of partnering with private landowners for long-term conservation of the species (Table 1).

Table 1. Distribution of Panama City crayfish habitat. Transmitter Road separates the western portion from the eastern portion of the PCC range.

	Western	**Eastern**	**Total**
PCC habitat on private land	2,134 acres	6,789 acres	8,923 acres (89%)
PCC habitat on public land	734 acres	384 acres	1,118 acres (11%)
Total PCC habitat	2,868 acres (29%)	7,173 acres (71%)	10,041 acres

The population status of the PCC is unknown and estimates of abundance for the PCC are lacking. Although some of the surveys included a coarse assessment of dipnetted crayfish (e.g., <10, 10-20, >20 individuals captured), methods to accurately determine PCC densities and assess population status (including age structure and sex ratios) are not yet available. This information is necessary to determine a minimum viable population size and develop translocation guidelines. Thus, development of revised population survey methodology is a priority action.

Conservation History

Conservation Status

Conservation efforts were essentially lacking from the time the PCC was first described (Hobbs 1942) to when it was rediscovered in 1986 (Mansell 1994). In 1987, FWC placed the PCC on its list as a Species of Special Concern (SSC) (Rule 68A-27.005, F.A.C.). This status makes it illegal to take, possess, transport, or sell PCC except as authorized by permit from FWC. Permits for SSC are issued upon reasonable conclusion that the permitted activity will not be detrimental to the survival potential of the species.

The PCC is identified as a Species of Greatest Conservation Need in FWC's State Wildlife Action Plan (FWC 2011). The International Union for Conservation of Nature Red List (Crandall 2010) assessed the PCC as Endangered and mentioned groundwater drainage and urban development for residential housing as major threats. Another assessment was provided by the American Fisheries Society (Taylor et al. 2007), which gave the PCC a status of Endangered based (1) on existing or potential destruction, modification, or reduction of the species' habitat or range and (2) on restricted range. The state natural heritage program assesses this species as G1G2, critically imperiled (NatureServe 2013). The USFWS has been petitioned to list the PCC under the federal Endangered Species Act, along with several hundred other aquatic species from the southeastern United States (Center for Biological Diversity 2010). The efficacy of this management plan in conserving the PCC will be one of the factors considered by the USFWS in making a federal listing determination.

Restoration Efforts

Efforts began in 2011 to establish PCC management areas on conservation easements in the Panama City area through restoration of wet flatwoods. Much of this habitat had been fire excluded and overgrown with unnaturally dense stands of woody vegetation. The general prescription used to restore degraded wet flatwoods habitat begins with removal of woody vegetation (mechanically or by hand), followed by applying herbicide to cut stumps to minimize resprouting. Ideally, a prescribed burn follows vegetation removal and herbicide treatment to

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prevent regeneration of the woody vegetation, maintain an open canopy, and foster native herbaceous groundcover. Weather conditions often delay or limit ideal prescribed fire conditions; therefore, herbicide retreatment or mowing is often necessary to maintain a low understory. Logistical difficulties of burning within urban and suburban locations further limits this preferred management tool. Public outreach and partnerships will be important to build support for prescribed burning activities.

To date, restoration efforts in the eastern portion of the PCC range (east of Transmitter Road) have included work on an 11-acre and a 25-acre parcel. Restoration efforts in the western portion of the PCC range (west of Transmitter Road) have included work on a 10-acre and a 32-acre parcel. The locations of these restoration sites, or PCC management areas, are shown in Figure 4. The experience gained through these efforts will be important in future PCC habitat restoration projects.

Threats and Recommended Listing Status

Threats

Due to alteration of its natural habitats, the PCC is presently found primarily in man-made habitats. These include roadside ditches, rights-of-way, clearings in silvicultural land, and residential property. Long-term survival of the PCC in these locations is threatened by a number of factors, most of which are related to human activities. Some threats can have immediate and catastrophic effects on the population; others are subtle and may slowly affect the population over the long term by reducing productivity and recruitment of individuals into the population. Potential threats to the PCC include habitat loss and degradation, habitat fragmentation and subpopulation isolation, direct mortality related to construction activities, inappropriate application of pesticides and other toxic substances and chemical spills, off-road vehicle use, illegal harvest, and direct competition with indigenous and/or nonindigenous species.

1. Habitat Loss and Degradation

The PCC's natural habitat (wet pine flatwoods) has been lost or degraded through residential, commercial, and industrial development, and through conversion to intensive pine silviculture (Mansell 1994; Keppner 2001; Keppner and Keppner 2001, 2005; FWC 2006). It is likely that no unaltered natural pine flatwoods remain within the PCC's current range (Keppner and Keppner 2001, 2005).

Most known PCC occurrence points are in human-altered habitats and are vulnerable to loss or further alteration. Although artificial habitats such as roadside ditches and rights-of-way have allowed the PCC to persist in areas from which they would otherwise likely have been extirpated, human activities can alter the hydrology and configuration of these sites making them unsuitable for long term PCC conservation. The horizontal to vertical configuration of ditch slopes, i.e., the width of the ditch slope relative to the ditch's height, helps determine whether the ditch can support PCC. Swales and ditches with herbaceous vegetation and a 3:1 or shallower slope are more likely to support PCC, as illustrated in Figure 5. Roadside ditch maintenance and construction activities have resulted in the destruction of several crayfish sites (Keppner and Keppner 2001, 2005). Infrastructure

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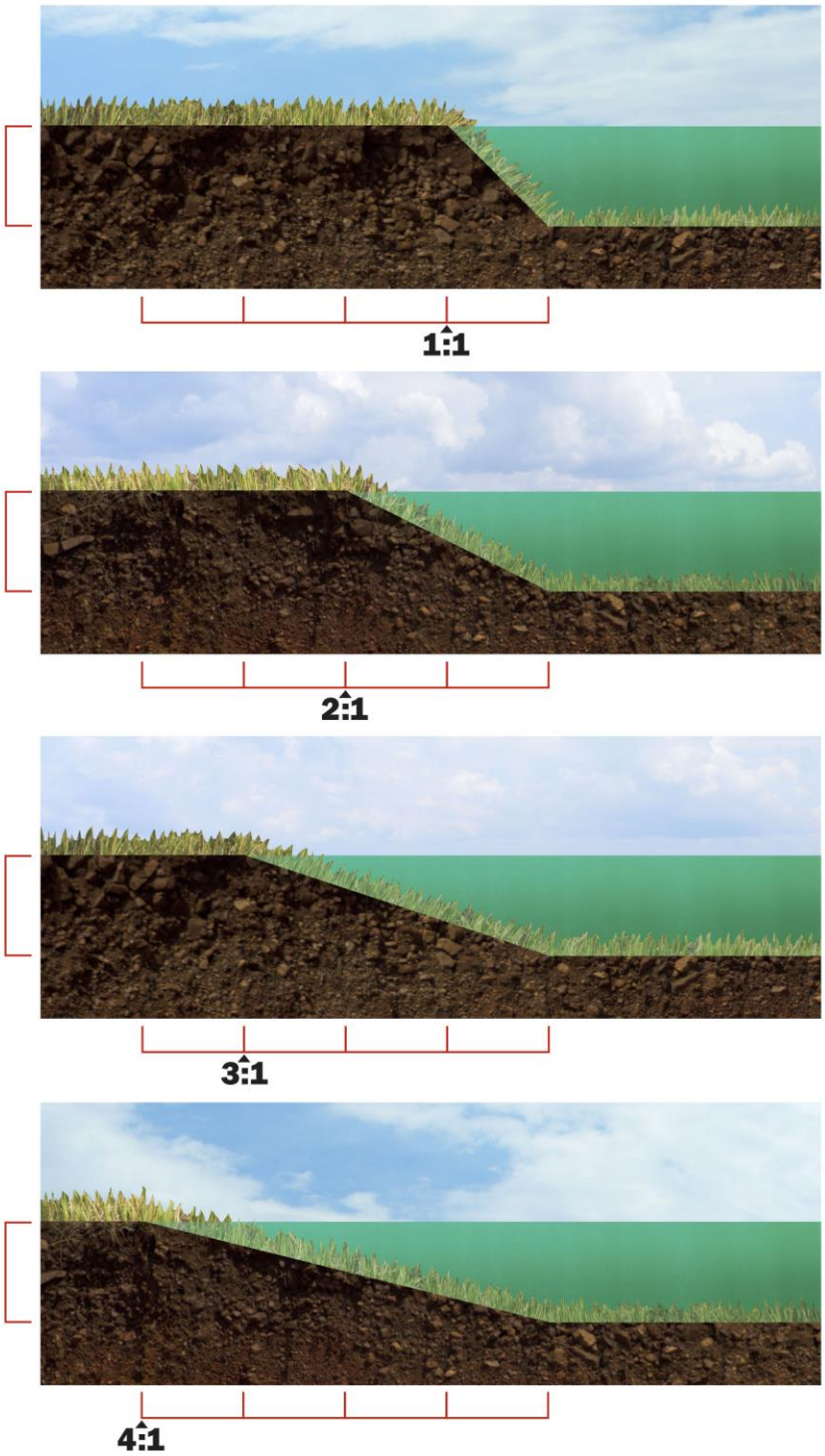

Figure 5. Comparison of the cross-section of ditch slopes with differing configurations, showing horizontal (width of slope) to vertical (slope height) ratio. The 1:1 and 2:1 ditch slopes have steep sides and do not support PCC, whereas ditches with 3:1 or shallower slopes and swales are more likely to support PCC.

development has impacted, or is anticipated to impact, several other sites (Keppner and Keppner 2001, 2005). Proposed road construction or expansion projects may impact PCC habitat in the future.

Areas in silviculture adjacent to human-altered habitats may serve as refuges for PCC, and those who follow silvicultural BMPs minimize impacts to PCC (see Appendix 5). However, silvicultural practices such as ditching and bedding, roller chopping, installing fire breaks, and constructing roads can alter the hydrology of PCC sites, create physical barriers to PCC movement, and destroy underground burrows (Hobbs 2001; Keppner and Keppner 2001, 2005; FWC 2006). Fire suppression and high tree-density on silvicultural sites can reduce herbaceous groundcover necessary for suitable crayfish habitat (Keppner and Keppner 2001, 2005; FWC 2006).

Declines in water quality are known to present a significant threat to other species of crayfish (and presumably to PCC). These declines can range from oxygen-deficient conditions resulting from algal blooms or sewage spills to pollution originating from roadway runoff or chemical spills (Acosta and Perry 2001).

2. Habitat Fragmentation and Subpopulation Isolation

The majority of known PCC occurrence points in the western part of the range are in roadside ditches and swales that are isolated from other PCC populations by roads and development. Fragmentation and isolation can increase vulnerability to local extinction due to adverse genetic, demographic, and environmental events. Further, when PCC have gone extinct from an area, the lack of habitat connections among sites can prevent PCC from recolonizing the newly vacant sites (Keppner 2001; Keppner and Keppner 2001, 2005; FWC 2006).

3. Direct Mortality Related to Construction Activities

Many of the activities contributing to habitat loss and degradation can also directly harm or kill PCC. Continuous loss of individuals can eventually lead to extinction of isolated populations (Gilpin and Soulé 1986). In particular, if done without appropriate safeguards, roadside maintenance, dredging and infrastructure development in roadside ditches supporting PCC have the potential to kill, harm, or displace PCC as soil is removed from sites with heavy machinery. In addition, fill placed on sites in preparation for construction activities can entomb crayfish in their burrows.

4. Pesticide Application, Toxic Substances, and Chemical Spills

All mosquitocides registered for use in Florida, when applied properly and in recommended concentrations, pose no known threats to water quality. The Bay County Mosquito Control District uses state-registered insecticides to treat both larval and adult mosquitoes. Only larvicides are applied directly to waters that may be inhabited by the PCC. The Bay County Mosquito Control District utilizes two larvicides, S-methoprene and *Bacillus thuringiensis israelensis* (Bay County Mosquito Control Division, personal communication, 2007).

Many substances commonly used around the home or business can be toxic to PCC and other wildlife if used or disposed of improperly. Since PCC often inhabit ditches and swales close or adjacent to private properties, landowners need to ensure that fertilizers, insecticides, and

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herbicides are applied and disposed of per label directions. Potentially toxic substances such as petroleum products and paint should be properly disposed of at hazardous waste disposal facilities. Batteries of all types should be disposed of at hazardous waste disposal facilities. Outreach efforts to remind landowners near PCC occupied sites how to safeguard downstream wildlife will be important to PCC conservation.

Accidental spills of large volumes of toxic substances such as petroleum products and acids occasionally occur in urban areas. If spills overflow into ditches, swales, or other areas inhabited by PCC, substantial localized impacts to the population are possible. Therefore, accidental spills of toxic substances should be contained and neutralized as soon as possible to minimize damage to the PCC and other wildlife populations.

5. Vehicle Use

Off-road vehicles can adversely impact PCC. Indirect effects include altering local hydrology by rutting and breaking the hardpan, decreasing water quality, and reducing vegetation. Ditch maintenance activities may have temporary impacts, but provide long-term habitat improvements that support PCC presence when conducted using conservation management practices (CMPs) (see Appendix 6).

6. Illegal Harvest

Harvesting PCC for fish bait or other uses may have long-term effects on populations if large numbers of adults are taken from single or adjacent locations. Several occurrence points in the range of the PCC are locally known as good sites to acquire crayfish for fish bait. Harvesting crayfish at those sites has been documented, but the magnitude of the impacts of recreational harvest on the PCC is unknown (Keppner and Keppner 2001, 2005).

7. Direct Competition with Other Species

Although not a major threat, range expansion by two other crayfish species inhabiting the eastern and northern boundaries of the PCC range (*P. kilbyi* and *P. apalachicolae*, respectively) could cause local displacement of the PCC along these boundaries and thereby reduce the number of PCC. These two species are superficially identical to PCC, but can be distinguished by close examination of the male reproductive structures. Some *P. kilbyi* and *P. hubbelli* have been recently found in small areas of the PCC range.

The introduction of nonindigenous crayfish for bait purposes has contributed to declines of native crayfish populations in other areas (Holdich 1987, Hobbs et al. 1989). Introduced crayfish species, such as those of the genus *Cherax* (now present in Alabama), may outcompete native crayfish and thereby reduce the number of PCC (Keppner and Keppner 2001, 2005; F. Bingham, personal communication).

Recommended Listing Status

In 2001, a petition was submitted to FWC to reclassify the PCC from SSC to state Threatened (Keppner 2001), and in 2003 FWC received a petition to delist the PCC (Bingham 2003). Both petitions were put on hold while FWC reviewed its listing process. Following the guidance of the agency's listing process (Rule 68A-27.0012, F.A.C.), a five-member biological review group (BRG) for the PCC was approved in June 2005 by the Commission.

DRAFT

After soliciting and receiving comments from external and internal crayfish experts, and reviewing the available data, the BRG concluded that the species met Criterion B for classification as a state-Threatened species. Specifically, this conclusion was based on

1. an estimated extent of occurrence (range) of 51 square miles;
2. an estimated area of occupancy of 18 square miles;
3. evidence of a severely fragmented population; and
4. a continuing decline in the species' area of occupancy; area, extent, and/or quality of habitat; and number of locations or subpopulations (FWC 2006).

In June 2006, FWC Commissioners determined that, based on the Biological Status Report (FWC 2006), the PCC should be listed as state Threatened and directed staff to develop a species management plan. Accordingly, the PCC would be reclassified to state-Threatened status once the management plan and rule changes were approved.

Following months of review, meetings, and input involving experts, stakeholders, and other members of the public, the November 2007 version of the PCC Draft Management Plan was nearing finalization when FWC Commissioners, in December 2007, directed FWC staff to revise the listing process and to suspend listing action on the PCC until that process was completed. The revised listing process, approved in November 2010, phases out the SSC status and considers all listed species as state Threatened if they meet listing criteria. The PCC meets the revised criteria for listing as state Threatened, and this document represents the management plan for the species required in Rule 68A-27.0012, F.A.C. It encompasses the work done in 2006 and 2007, and includes new information and updated conservation approaches consistent with FWC's current imperiled species management system.

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CONSERVATION GOAL AND OBJECTIVES

The PCC meets the criteria for listing as state Threatened on Florida's Endangered and Threatened Species List. The conservation goal and objectives for the PCC are as follows.

Goal

To ensure the long-term conservation of the Panama City crayfish throughout its range so that it no longer warrants listing by the state of Florida.

Rationale

The objectives supporting this goal are designed to help identify, establish, and maintain a sufficient number of areas with robust PCC populations to ensure its long-term survival across its range. Based on the listing criteria met by PCC, reversing the decline in the species' area of occupancy; area, extent, and/or quality of habitat; and number of locations or subpopulations would establish that it no longer meets the criteria for listing. The relatively limited range of the PCC will ensure that it always meets the geographic criteria for listing. However, because part of the listing involves a continuing decline in several attributes, the PCC can be delisted when those declines are no longer occurring. Progress toward achieving this goal will be the determination that declines are no longer continuing in the species' area of occupancy; area, extent, and/or quality of habitat; and number of locations or subpopulations.

Objective 1

Increase the total area of occupied PCC habitat to 2,000 acres: 1,500 acres in the eastern portion of its range consisting of parcels that are each 25 acres or greater and at least five parcels in the western portion of its range that are each 5 acres or greater. These management areas will be secure in long-term easements and managed in perpetuity. Transmitter Road serves as the dividing line between the eastern and western portions of the PCC range (Figure 4).

Rationale

Long-term survival of the PCC will require contiguous tracts of land with quality PCC habitat managed on a landscape scale and protected in perpetuity. Most remaining parcels with habitat suitable for PCC are in the eastern portion of its range; therefore, it is critical to maintain the majority of acreage in this area. However, it is also important to continue efforts to conserve the PCC in the western portion of its range even though urbanization has created smaller, more isolated parcels. Acquiring available parcels adjacent to existing PCC management areas is one way to combat fragmentation and grow existing populations to more secure numbers. Establishment of a sufficient number of secure populations on large enough parcels that will be appropriately managed in perpetuity should reverse the species' decline, stabilize its long-term conservation, and help achieve the conservation goal. Supporting conservation actions would include establishing partnerships with large landowners, restoring degraded habitat, translocating PCC as needed, acquiring properties when feasible, managing existing conservation easements, encouraging the use of CMPs, and providing conservation options that avoid, minimize, and/or mitigate the potential impacts to PCC as a result of development.

DRAFT

Objective 2
Develop and evaluate methods to accurately determine PCC densities and assess population status (age structure and sex ratios) to determine a minimum viable population size and to develop translocation guidelines.

Rationale
The achievement of Objective 1 requires that the status of PCC populations be reliably assessed and monitored to determine their likelihood for long-term persistence. Mere presence of PCC at a site does not provide information about the health or robustness of the population. Refined methods for assessing populations and habitat are needed to compare populations at different areas over time to measure achievement of the conservation goal. Supporting conservation actions include developing a tool to evaluate habitat quality, establishing standardized sampling techniques, and determining the PCC sex and age ratios that indicate a healthy or robust population.

Completing this objective will help achieve Objective 1, which should halt the species' continuing decline, thereby supporting long-term conservation and delisting.

DRAFT

CONSERVATION ACTIONS

The following sections describe the conservation actions that will make the greatest contribution toward achieving the conservation objectives. These actions emphasize protecting and managing occupied PCC habitat, restoring and conserving additional suitable habitat, developing and implementing conservation tools that provide clear guidance for PCC conservation and mitigation, and fostering partnerships among public and private entities to ensure the long-term survival of the species within its range.

Habitat Conservation and Management

Conservation of the PCC primarily depends on providing suitable habitat that is seasonally inundated, has little to no slope, and has herbaceous vegetation with little canopy cover. As described above, wet pine flatwoods is believed to be the historical habitat for PCC, but since natural expanses within the historical range of the species have all but disappeared, the PCC is now most often found in open, grassy, maintained areas, including rights-of-way and grassy roadside ditches and swales (see Glossary for adopted definitions). The importance of these man-made habitats to the survival of the PCC is not clear, but in a fragmented landscape, they may represent a source of dispersal and movement, in addition to being the sites where PCC are currently most often found. Maintaining the well-being of a listed species in small roadside ditches is fraught with difficulties; therefore, as indicated in the objectives, the desired future condition includes multiple large unfragmented areas of secure PCC habitat that can be effectively managed in perpetuity.

Action 1. Continue efforts to identify, restore, and manage areas for PCC conservation.

The PCC naturally inhabits shallow, ephemeral, freshwater wetlands that are associated with wet pine flatwoods in the Panama City area. These locations historically supported a native herbaceous plant community dominated by native wetland grasses and sedges with an accompanying overstory of low-density pine flatwoods, and were naturally maintained by periodic wildfire. Nearly all remaining PCC habitat has been temporarily or permanently altered due to silvicultural practices, ditching, draining, exotic plant invasion, fragmentation, and/or fire exclusion/suppression leading to unnaturally dense thickets of aggressive hardwood shrubs (e.g., black titi [*Cliftonia monophylla*], wax myrtle [*Myrica cerifera*], yaupon [*Ilex vomitoria*]). In addition to protecting and managing this species on properties already protected under conservation easements, efforts should also focus on securing large parcels on which preferred and cost-effective habitat management activities such as prescribed fire can be employed.

Since 2011, efforts have been made to restore parcels of degraded habitat to make them suitable for PCC (see Conservation History). Florida Fish and Wildlife Conservation Commission staff has worked closely with USFWS staff to identify conservation easements with PCC habitat, establish agreements with landowners, conduct habitat and faunal surveys, implement habitat management, and monitor the progress of such sites in supporting viable PCC populations.

Action 2. Encourage stakeholders to follow CMPs that have been developed for the PCC.

Conservation management practices are recommended, voluntary actions that help provide suitable habitat conditions for PCC while conducting activities such as maintaining roadside

DRAFT

swales, and constructing and maintaining utility rights-of-way. Depending on the proposed activity, following CMPs may eliminate permitting requirements. Also, activities involving land management, silviculture, and agriculture may cause take but have authorizations not requiring a permit (see Appendix 5 and Permitting Framework). Current CMPs were developed with stakeholder input and are provided in Appendix 6. They are subject to change in accordance with best available science and upon evaluation of their effectiveness (Action 7). As part of the permitting framework, any proposed changes will be approved by FWC Commissioners prior to implementation.

Population Management

The ability to manage PCC populations will depend in part on determining how to characterize and recognize healthy, robust populations (Action 4). This concept is central to Objective 2. At known occurrence points, PCC populations can likely be managed indirectly through habitat restoration, enhancement, and management. As noted above, PCC populations are subject to severe fragmentation, such that the species may be unlikely or unable to colonize newly restored habitat without human assistance. At present, no specific actions have been identified for PCC population management.

However, direct population management on some sites may occur using translocation, after research has been done to assess the efficacy of translocation protocols. Draft guidelines for PCC translocation have been developed to help direct translocation efforts (Appendix 4). The guidelines provided for translocation involve conserving the source site when possible and adding additional sites to the total number of known PCC occurrence points. A specific translocation plan will be helpful in achieving a successful translocation of PCC from source site to destination site. These guidelines will continue to be evaluated and refined (Action 5).

Monitoring and Research

Periodic monitoring of known PCC populations is critical to assessing progress toward achieving the conservation goal and to evaluating the effectiveness of conservation efforts. Past surveys recorded presence or absence of PCC and included qualitative notes on site or habitat description, coarse abundance (<10, 10-20, >20 individuals captured), and sex of specimens captured. Recent survey efforts also include quantitative site characteristics such as percent canopy cover, percent herbaceous cover, and water depth, as well as the number of individuals in each size class (e.g., hatchling, juvenile, and adult). Further refining the sampling protocol and specific data collected as they pertain to population and habitat assessment is necessary to fully achieve plan objectives. Several aspects of PCC life history and ecology are poorly understood and research projects will be critical to documenting species' requirements and determining science-based population estimates. Results from this research will help guide and refine conservation strategies, CMPs, and future conservation actions.

Action 3. Develop and implement a monitoring plan and a more comprehensive and accessible database to track distribution and status of occupied PCC habitat.

A monitoring plan will support progress assessment towards the objectives and conservation goal. Implementation of the monitoring plan will be contingent upon available resources. Monitors should be trained in PCC identification, habitat evaluation, survey techniques, database

DRAFT

management, and permit requirements. Staff from FWC would be the stewards of all monitoring data (see Implementation Strategy).

An important component of implementing the monitoring plan is development of a comprehensive and accessible database to track the species' population status and document changes in habitat quality as restoration occurs. The current database includes data from all PCC surveys conducted since 1999 and contains the date, surveyors, geographical coordinates, site location, presence/absence of PCC, number of PCC captured (<10, 10-20, >20 individuals), survey time/size of area surveyed, habitat characteristics, and notes on other species captured. As sampling techniques are standardized (Action 4), the PCC database would be updated to include habitat and species characteristics that better reflect the health of the site and the population. Additional information in the database may include the site owner/manager, land management history including the use of CMPs, and potential threats. Ideally, the PCC database would become an abridged version of the Florida Shorebird Database, an online repository with a data entry interface for shorebird and seabird surveys across Florida. This type of tool would allow researchers and consultants to submit PCC survey data that would then be available to researchers, managers, conservationists, and permit reviewers. Scientific collection permits issued to environmental consultants and researchers would specify entry of survey data into the PCC database as a permit requirement.

Action 4. Develop standardized sampling techniques to assess PCC population densities and demographic structure.

Standardized methods for assessing PCC population density have not been developed but are critical to assessing PCC populations. The protocol for PCC monitoring typically depends on dip-net sampling when sufficient surface water is present and nondestructive evaluation of crayfish burrows. However, these protocols are largely qualitative, can miss specimens in vegetation, and do not sample individuals living below ground in burrows. Other survey techniques suitable for surveying PCC should be investigated. Inverted cone minnow (funnel) traps have been used to survey other crayfish species (Hobbs 1942, Hobbs 2001) and their effectiveness in surveying PCC should be assessed.

Improved sampling strategies will ensure a more complete evaluation of the demographic structure of PCC populations. Little is known about the rate of growth or the specific age and/or size at which breeding begins, making age classes (e.g., juvenile or adult) fairly qualitative and ambiguous. Researching these data gaps will help to better assess the health of PCC populations and develop translocation guidelines for conservation areas (Action 5).

Action 5. Develop and test PCC translocation techniques.

Reestablishment of PCC populations in disturbed areas and creation of new populations in conservation areas are important steps toward achieving the conservation goal for this species. Translocation guidelines have been drafted (Appendix 4), but successful techniques for rearing, transporting, and dispersing PCC need to be tested to ensure the effectiveness of this tool.

Action 6. Describe and quantify habitat requirements for the PCC.

DRAFT

Keppner and Keppner (2001) described general habitat characteristics and specific soil types associated with PCC. Additional studies are needed to define optimal habitat conditions and facilitate the development of conservation easements, mitigation areas, and CMPs specific to PCC survival requirements. Biological constraints (habitat, demographic, and biophysical) to PCC should be fully understood to ensure the most effective conservation efforts. A habitat model for the PCC has been developed (Appendix 3) and is being used to guide rangewide conservation efforts. Additional refinement of this model in conjunction with ground-truthing efforts is important to guiding restoration actions and assessing parcels for potential importance to PCC conservation. A quantifiable assessment of PCC habitat is key to any future conservation banking that may be pursued (Action 8).

Action 7. Determine the effectiveness of CMPs to PCC conservation.

Little is known about the specific management actions, or lack thereof, that have allowed PCC to persist in highly human-altered areas. The effectiveness of following CMPs at particular sites should be closely evaluated in formal studies. The information derived from such studies can be used to modify CMPs so that they more effectively protect PCC.

Rule Changes

The PCC was previously state listed as a Species of Special Concern (SSC), a category that is being phased out following the revision to the state listing process, approved in 2010. Since this species was determined to meet criteria for listing as Threatened (FWC 2006), rule changes to accommodate this change in listing is required. The rule changes move the PCC from a Species of Special Concern in 68A-27.005 F.A.C. to a Threatened species in 68A-27.003 F.A.C.

Permitting Framework

A permitting framework is under development and will be provided in the Panama City Crayfish Species Conservation Measures and Permitting Guidelines. The PCC status will change to state Threatened upon approval of a final management plan by the Commission. As a state-Threatened species, permitting standards are outlined for both intentional and incidental take in Rule 68A-27.007, F.A.C. The definition of *take* in Rule 68A-27.001(4), F.A.C., is "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in such conduct. The term 'harm' in the definition of take means an act which actually kills or injures fish or wildlife. Such act may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. The term 'harass' in the definition of take means an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering."

Intentional take is limited to activities conducted for scientific or conservation purposes that will benefit the survival potential of the species. As described in 68A-27.007(2)(a), F.A.C., a scientific or conservation purpose means activities that further the conservation or survival of the species, including collection of scientific data needed for conservation or management of the species. A scientific collecting permit will be issued for research purposes where the proposed

DRAFT

activity will further management plan goals and objectives, and addresses the six factors described in rule.

In general, an incidental take permit (ITP) is required for any otherwise legal activity that is expected to result in take of PCC on private or public property; taking of PCC in these cases is incidental to, and not the intent of, the activities. An ITP is issued for state-Threatened species upon the conclusion that the permitted activity will provide a scientific or conservation benefit and only upon the applicant showing that the permitted activity will not have a negative impact on the survival potential of the species (68A-27.007(2)(b), F.A.C.), and address the seven factors also identified in the rule. Incidental take permits typically include a combination of avoidance, minimization, and mitigation to achieve a conservation benefit and assurance that the survival potential of the species will not be negatively impacted.

However, a permit is not required if the incidental take of PCC occurs during some activities that are authorized in rule, including land management that is not inconsistent with management plans. This activity is covered under "authorizations not requiring a permit" because the long-term benefits outweigh the potential negative impacts. Land management practices are described in Appendix 5. Management plans may also authorize activities that may cause take, when such authorizations are in the best interest of the public or conservation of the species. Other authorizations of take granted in this management plan include agriculture (specifically cow/calf operations) and silviculture enrolled in the Florida Department of Agriculture and Consumer Services (FDACS) water quality best management practices, emergency actions for human safety and health, culvert replacement following Florida Department of Environmental Protection regulations, and replacement of a destroyed structure if it occurs on the same footprint. More details on all of these authorizations not requiring a permit are provided in Appendix 5.

This management plan is also authorizing take without a permit for activities that follow Conservation Management Practices (CMPs), since the CMPs minimize impact to PCC, while also maintaining habitat characteristics suitable for the species. See Appendix 6 for more details.

For other activities during which incidental take cannot be avoided, permitting options may include: (1) the standard, existing permitting process option that may be found at FWC incidental take permits, wherein applicants describe the project, impacts, and propose avoidance, minimization, and mitigation options; (2) a programmatic permitting option, which would allow an entity to receive a single permit for a suite of actions, avoiding project-by-project permitting; and (3) a streamlined tool option that would allow applicants a standardized method to assess take and determine appropriate mitigation. Such a streamlined tool option is under development; see Action 8 below.

Action 8. Develop, implement, and evaluate a PCC Conservation Tool that provides clear guidance on alternatives available to avoid, minimize, or mitigate potential impacts to PCC or PCC habitat while providing maximum long-term benefit to the species.

The proposed PCC Conservation Tool will present a clear path to landowners and developers for determining what role they can play to further PCC conservation while conducting their normal

DRAFT

activities. The tool will cover a wide variety of activities that could impact PCC or their habitat. It would accommodate small or large projects and clarify what actions or permits may be needed to reduce and/or mitigate impacts to the PCC.

The first step toward developing the PCC Conservation Tool is the PCC Impact Assessment and Mitigation Tool, which is intended to help guide the decision-making of those who want to conduct an activity that may impact PCC. A working draft of this tool will be presented in the PCC Species Conservation Measures and Permitting Guidelines that are under development. The FWC staff will continue working with stakeholders to evaluate and fine-tune the tool and to develop other components of the PCC Conservation Tool, including a PCC habitat valuation protocol.

The Conservation Tool will better quantify impacts projects have on PCC and provide mitigation options for permit applicants. The tool will incorporate the avoidance and minimization that occur on-site through site design and use of CMPs. Depending on the activity, a permit might not be needed for activities that follow all applicable CMPs. The FWC staff has identified mitigation options to include on-site management and habitat conservation and establishment of conservation easements on- and off-site, or contribution to the PCC Conservation Fund. The PCC Conservation Fund has been set up to receive contributions from mitigation and will be used to support continuing PCC management actions, research, and other activities described in this management plan. Additional mitigation options may be developed in the future, including a conservation banking mechanism.

Law Enforcement

Conservation actions involving law enforcement include education of officers and the public about the presence of PCC; its imperiled status; and the rules, CMPs, and other actions that are intended to safeguard it.

Action 9. Conduct PCC training for law enforcement officers to equip them to properly advise the public and protect the species from take.

Training for officers would include history of the PCC, range maps, species identification, currently identified threats, and an explanation of the need for protection. Officers will receive training on the interpretation and application of CMPs.

Officers can utilize routine contacts during regular patrols, public speaking engagements, coordination with the Community Relations Office, and presence at bait and tackle shops as opportunities to educate the public about the threats PCC face and reasons for their protection. Collection of PCC for recreational use (bait) is an identified threat, and officers can provide an important link in educating anglers on the use of crayfish as bait and the potential impacts to the PCC. Action 11 (Education and Outreach) is supplementary and supportive of this action.

Officers should conduct regular patrols of PCC range for the illegal take of PCC, and coordinate with biologists to identify hot spots for this activity. Officers will respond to complaints about illegal harvest and off-road vehicle use to determine if violations have occurred. The primary focus of officer interactions will be to educate the public; however, if educational measures are

DRAFT

not sufficient citations may be issued if appropriate. Violations should be documented through the Division of Law Enforcement's computer-aided dispatch system (1-888-404-FWCC). Authority for the enforcement of Rule 68A-27.003, F.A.C., is provided in section 372.07, Florida Statutes (F.S.), Police Powers of Commission and Its Agents.

Incentives and Influencing

As noted in the Introduction, almost 90% of PCC habitat is on private land. Achieving the conservation goal and objectives will only be possible through establishing strong partnerships with private landowners. Their willingness to support initiatives that establish and maintain suitable habitat for robust PCC populations is essential to the species' long-term survival.

Action 10. Establish partnerships with private landowners to ensure the long-term survival of the PCC on their lands. These partnerships may be founded on agreements and other incentive programs that further the conservation of PCC.

Incentives may be provided to private and public agencies that conduct activities that reduce or remove threats to, or otherwise improve conditions for, the PCC. In 2010, the USFWS was petitioned to assess the status of the PCC for federal listing (Center for Biological Diversity 2010). One incentive program available to federal candidate species is a Candidate Conservation Agreement with Assurances (CCAA, see Glossary). The CCAA provides assurances to nonfederal property owners who voluntarily agree to manage their lands or waters to remove threats to imperiled species. These are assurances that future regulatory obligations by the USFWS, in excess of those the parties agree to at the time they enter into the CCAA, will not be required.

Conservation measures for PCC include management and retention of suitable PCC habitat, restoration or enhancement of degraded PCC habitat, retention or establishment of hydrologic connections between wetlands that contain the PCC, and assistance with addressing research needs for PCC. The FWC staff should investigate specific incentive programs that might help achieve conservation objectives for the PCC and seek opportunities to work with stakeholders to ensure that their activities have low potential to negatively impact PCC habitat (Action 2).

The FWC will continue to consider other innovative land-use incentive programs to encourage conservation of PCC on private and non-conservation lands. Potential programs include conservation banking, the Forest Stewardship Program, Environmental Quality Incentives Program, and Partners for Fish and Wildlife Program. These and other programs should be reviewed to determine which provide additional incentives for managing PCC and which can be combined with CCAAs. Brief descriptions of these landowner assistance programs are presented in Appendix 7.

Education and Outreach

Introducing the public to the unique and interesting forms of wildlife that depend on wetland areas, even in urban and suburban situations (as with PCC found in roadside ditches), will help build a constituency who recognizes the importance of protecting water quality and Florida's natural resources. Preparing and sharing information that explains to or reminds the public how

DRAFT

to ensure that their activities do not hurt habitats and wildlife downhill or downstream can be an effective conservation tool.

Action 11. Inform the public about the PCC, its conservation needs, and how stakeholders can play a role in its long-term survival. Educational techniques could include hosting public forums, installing interpretive signs at PCC management sites and other areas, and developing informational materials for distribution to the public.

The PCC has been the center of controversy in the past, and education and outreach in the form of public forums, media releases, and fact sheets may help clarify the conservation approach presented in this plan. Garnering public support for the conservation initiatives in this management plan, including using prescribed fire, improving water quality, and preventing direct harm to PCC populations and habitats, is critical to the plan's successful implementation.

Coordination with Other Entities

Effective partnerships between FWC staff and other agencies, organizations, companies, county and municipal governments, and the public are critical to achieving the conservation goal and objectives in this management plan. The effectiveness of this management plan will be partly determined by whether it helps to preclude federal listing for the PCC, since this includes consideration of other regulatory processes and existing conservation efforts. Restoring and maintaining the suitability of PCC habitat and ensuring the species' long-term survival will require communication and coordination with multiple entities on the state, local, and private levels. These entities can help regulate, ameliorate, or avoid potential threats, and their responsibilities, policies, and actions directly or indirectly impact the PCC and its habitat. In addition to these entities, it is critical to continue working with the USFWS, which has supported many of the PCC conservation initiatives over the last two decades.

Action 12. Continue to coordinate with the Florida Department of Environmental Protection (DEP), Northwest Florida Water Management District (NWFWMD), and the U.S. Army Corps of Engineers (USACE) with regard to wetland protections and PCC conservation.

Although the PCC is a wetland-dependent species, it often does not inhabit the typical wetland habitats covered by wetland permitting procedures overseen by DEP, NWFWMD, and USACE. However, some overlap may occur, with PCC inhabiting wetlands subject to wetland permitting. No wetland mitigation banks are currently within the range of the PCC, so typical wetland mitigation does not benefit this species; continued coordination can potentially increase opportunities to address mitigation through the Environmental Resource Permit (ERP) process within the PCC's range.

Action 13. Continue to coordinate with Florida Department of Transportation, Bay County, and municipal transportation departments to minimize impacts to PCC habitat due to road construction or modification.

As noted above, PCC are able to subsist in roadside ditches and swales with herbaceous vegetation, low slope sides, and slow flow. Such ditches have slopes with a horizontal to vertical ratio of 3:1 or shallower; see Glossary and Figure 5. The CMPs provide guidance for

DRAFT

maintenance of swales and roads. Improved communication with the agencies responsible for road maintenance about the benefits of following CMPs will increase the opportunities for PCC conservation.

Action 14. Continue to coordinate with utility companies to maintain suitable PCC habitat on rights-of-way.

Where utility rights-of-way cross wetland areas, the maintenance to reduce shrub cover in favor of grassy vegetation often provides suitable habitat for PCC. Ongoing maintenance activities, specifically mowing, herbicide treatment, and other brush reduction techniques, are often consistent with CMPs and should be encouraged to further PCC conservation.

Action 15. Continue to coordinate with local governments about issues that impact PCC habitat, and provide technical assistance to local government staff on PCC habitat needs and use of the PCC Conservation Tool.

The Bay County government and municipal governments within the PCC range can play an important role in enabling PCC conservation within their jurisdictions. Some local governments have established conservation easements that might be potential PCC management areas. When implemented, the PCC Conservation Tool will provide clear guidance on how local governments can minimize impacts to PCC habitat.

Action 16. Continue to coordinate with USFWS to ensure that the conservation actions and initiatives implemented through this plan match federal conservation goals for the PCC and that our combined efforts are effective in improving the species' conservation status.

The USFWS is a keenly interested and active player in PCC conservation, has funded surveys and restoration projects, and is currently considering a petition to federally list the PCC. The USFWS will continue to be a critical partner during implementation of this management plan and in advising FWC on issues pertinent to the PCC petitioned federal listing. Their northwest Florida field office is located within the PCC's range, providing further advantages for close coordination.

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IMPLEMENTATION STRATEGY

Prioritizing the 16 PCC conservation actions presented earlier will facilitate the coordination and cooperation necessary to successfully implement this management plan. Substantive progress toward accomplishing the highest priority actions is expected to be made within two years following approval of the management plan. Other high- to moderate-priority conservation actions should be implemented within five years following management plan approval.

Priority Actions

The identified conservation actions, along with their priority ranking, are summarized in Table 2. Priority conservation actions have been divided into three overarching categories: 1) Habitat and Population Management and Restoration, 2) Research and Monitoring, and 3) Coordination. These categories will direct implementation for the next 10 years.

1. Habitat and Population Management and Restoration

Maintain existing PCC management areas and establish new ones

- Continue restoration activities, using translocation if necessary (Actions 1, 5)
- Identify other conservation areas with potential for PCC conservation (Actions 1, 5)
- Establish partnerships with landowners of large parcels within the PCC range for PCC conservation (Actions 1, 11)

On-the-ground conservation is the highest priority for managing the PCC. As described in Conservation History, staff within FWC's Species Conservation Planning section in the Northwest Region has taken the lead in identifying and restoring conservation easements in the PCC range. To date, restoration efforts have been funded through FWC's Aquatic Habitat Restoration and Enhancement Section (AHRES) and USFWS. Until the PCC Conservation Fund can sustain conservation and management activities, AHRES funds will continue to be used if available.

Maintain and expand PCC outside of management areas

- Evaluate the efficacy of recommended CMPs (Actions 2, 7)
- Educate the public and law enforcement agencies about PCC status and conservation (Actions 10, 12)

2. Research and Monitoring

Continue development of management tools

- Determine survey protocols and parameters of robust PCC populations (Actions 4, 6)
- Conduct tests of draft translocation guidelines and modify them as needed (Action5)
- Establish a comprehensive and accessible PCC database and PCC monitoring plan (Action3)

All research actions will be coordinated with FWC's Fish and Wildlife Research Institute (FWRI) and funding sought through internal and external grant sources. Achieving these actions is dependent on funding availability and staff resources.

As part of the Imperiled Species Management Plan under development by FWC, a monitoring plan will be developed for all state-listed species, which will be coordinated with PCC

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monitoring efforts. Staff from FWRI and the Office of Information Technology will assist in developing a robust protocol for surveys and a tracking database. Statisticians will be consulted to assure that the monitoring plan is statistically viable.

Continue development of PCC conservation tools

- Implement the PCC Impact Assessment and Mitigation Tool (Action 8)
- Develop a PCC Habitat Valuation Tool (Action 6)

The PCC Impact Assessment and Mitigation Tool has been developed and will continue to be refined through stakeholder and partner involvement. This will be available when the status of the PCC is changed and revised as needed. As part of the PCC Species Guidelines that are under development, revisions to the tool will be approved through the Commission, and implementation will occur through the Protected Species Permitting program. Distributing the tool (and PCC Conservation Tool once complete) to DEP, NWFWMD, and FWC's Office of Conservation Planning will benefit the PCC and developers by determining PCC impacts and associated mitigation options early in the planning stage of projects.

3. Coordination

- Coordinate with other agencies on PCC conservation (Actions 12, 13, 14, 15, 16)

The concept of coordination runs throughout the implementation of this plan. Actions 12, 13, 14, 15, and 16 all address coordination with specific entities in the Bay County area.

Several of FWC's existing programs can assist in achieving these actions, as well as the priority actions listed above.

The Landowner Assistance Program provides logistical and technical support in working with private landowners on conservation actions for a variety of species, and often coordinate on the use of BMPs. The Office of Conservation Planning (OCP) provides technical assistance to developers and consultants and comments on wetland ERPs. During the commenting process, OCP can encourage the use of PCC CMPs that may prevent the need for a permit and/or provide the PCC Conservation Tool to clarify mitigation options for landowners and developers. An additional FWC resource is the Species Conservation Planning Section (SCP) Incentives Program, which has worked collaboratively with private entities and the USFWS to develop CCAAs for other species, including the Black Creek crayfish (*P. pictus*).

Proposed Implementation Schedule

Prioritizing actions will facilitate the extensive coordination and cooperation necessary to successfully implement the plan. The following implementation schedule includes the priority actions for achieving the conservation goal and objectives over a five-year period. These actions should be continued/initiated as soon as possible and should be the first consideration of those undertaking PCC conservation.

Actions that FWC and partners (including local governments, other state agencies, federal agencies, universities, and nongovernmental organizations) should continue

- Maintain legal protections for the PCC

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- Continue ongoing habitat restoration activities on current PCC management areas
- Continue ongoing efforts to establish additional PCC management areas
- Survey for occurrence points for PCC at known sites and new sites
- Identify funding sources to support restoration activities, surveys, and development of the PCC Conservation Tool
- Consult regularly with USFWS to coordinate PCC conservation progress
- Meet with landowners with large acreage of PCC habitat to discuss PCC long-term conservation

Actions that FWC and partners should undertake within the next 12 months

- Meet with agencies, utilities, and local governments to discuss following PCC CMPs and using the PCC Impact Assessment and Mitigation Tool (and PCC Conservation Tool once developed)
- Establish a comprehensive and accessible database for monitoring PCC populations and occurrence points throughout the range and for tracking acreage-based achievement of conservation objectives
- Develop and implement education and outreach messages and materials to further public and law enforcement support for PCC conservation

Actions that FWC and partners should undertake within the next five years

- Evaluate the draft PCC translocation guidelines and modify as needed
- Draft and finalize agreements and incentive programs for PCC conservation
    - Investigate potential establishment of CCAAs
    - Explore feasibility of a conservation banking program
- Begin research on standardized sampling techniques and demographics of robust PCC populations
- Investigate how to assess conservation value of PCC populations in roadside ditches

Required Resources and Other Costs Associated with Plan Implementation

Several FWC staff members will assist with the implementation of the plan. The projected annual costs of their salaries and other expenditures, including a proposed OPS biologist position, are presented below. These positions will be responsible for coordinating and tracking implementation of the plan and for providing an annual report on progress towards plan activities to be included in the FWC's annual legislative report on threatened and endangered species.

$ 26,880	100% time proposed FWRI OPS Biologist ($14/hour)
$ 13,352	30% time SCP Regional Species Conservation Biologist
$ 12,000	100% time PCC Project Coordinator (contracted services)
$ 6,585	20% time SCP Assistant Regional Species Conservation Biologist
$ 5,103	10% time HSC Invertebrate Conservation Coordinator
$ 4,450	10% time OCP staff
$ 2,284	5% time HSC permitting staff
$ 1,893	5% time Florida Wildlife Legacy Initiative Biologist
$ 458	1% time Public Outreach Staff
$ 1,000	field/office equipment and supplies

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$ 2,225	transportation costs (estimated 5,000 miles/year @ $0.445/mile)
$ 1,600	per diem costs (estimated 20 days @ $80/day)
$ 500	vehicle maintenance
$ 78,330	**Total Annual Cost**

Funds from grants and other sources will be needed to support development of the PCC Habitat Valuation Tool.

Management Plan Review and Revision

Panama City crayfish populations rangewide should be periodically assessed to ensure progress toward the conservation goal and objectives. Revision of the plan may be warranted if monitoring reveals a declining trend despite management efforts or successful establishment of translocated populations. Revision may also be warranted if new research indicates that the plan objectives need to be revisited. For example, future research on sampling techniques, translocation techniques, the effectiveness of CMPs, and genetic relationships could necessitate a revision of the plan. At a minimum, the management plan should be evaluated for potential revision within five years following its approval.

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Table 2. Conservation Actions.

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ANTICIPATED ECONOMIC, SOCIAL, AND ECOLOGICAL IMPACTS

Economic Impacts

This assessment of economic impacts is based on the conservation actions proposed in this plan, and PCC-related costs that have been incurred in the past.

Estimated cost to FWC of implementing proposed conservation actions

Many of the plan's conservation actions involve coordination with stakeholders, and may be accomplished with existing FWC staff. The major expenses expected to be incurred are those associated with on-the-ground restoration activities on PCC management areas. To date, restoration activities have cost ~$150,000, with funds being provided internally through the Aquatic Habitat Conservation and Restoration Section of FWC and USFWS. It is difficult to estimate the proposed restoration costs moving forward because efforts are dependent on the number and acreage of properties acquired for conservation, current state of those properties (i.e., amount and intensity of restoration needed), type of restoration activities required (i.e., prescribed burning vs. mechanical shrub reduction vs. herbicide), whether those areas are currently being managed in perpetuity by existing mitigation funds, and weather. A rough estimate based on past efforts would be $50,000 to $80,000 per year. It is expected that most PCC habitat-restoration activities will be supported by the PCC Conservation Fund, a component of the PCC Conservation Tool, once it is developed.

Conservation actions proposed in this plan need to be prioritized along with other agency programs, species' needs, and available resources. Additional funding and perhaps additional personnel may be necessary to accomplish all proposed actions.

Estimated cost to potentially affected parties of implementing the proposed conservation actions

The PCC Conservation Tool will provide the public with a clear process for assessing impacts to the PCC and its habitat, and how to avoid, minimize, or mitigate for those impacts. The type of impact and the amount of land involved will determine whether on-site or off-site mitigation or payment into the PCC Conservation Fund may apply.

Some developments will be subject to wetland-regulation-related costs, so additional costs specific to PCC management should be minimal under normal circumstances. Participation in a Candidate Conservation Program could be financially beneficial to private landowners who, by participating in the program, might increase their eligibility to receive funds through state and federal land-management incentive programs. If the market supports conservation banking for PCC, those landowners with protected and managed high-quality PCC habitat may benefit by selling credits to persons needing to mitigate for loss of habitat. For some activities, including silviculture, utility or transmission line maintenance, and ditch or swale maintenance, following CMPs will preclude additional permitting costs.

The roadside ditches and swales that support PCC are considered suboptimal habitat since they are subject to periodic disturbance from ditch maintenance and other human activities. Following CMPs can help limit impacts to the PCC inhabiting these sites, but it is recognized that required roadway improvement or expansion may necessitate permanent impacts and loss of this

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suboptimal habitat. In particular, existing roadways may have limited rights-of-way available to support improvement projects for sidewalks and other safety features. In such areas it might not be possible to accommodate existing PCC populations, resulting in expenses associated with mitigation of loss of habitat. Note that this does not apply to roadways with box-cut ditches or similar steep-sided ditches (see Glossary and Figure 5) that function to move rainwater runoff swiftly downstream; these ditches do not support PCC, are not considered PCC habitat, and require no further action relating to PCC.

Social Impacts

Potentially positive social effects include increased public awareness of PCC and wet flatwoods habitats in Florida, public recognition and support of FWC for taking a comprehensive approach to PCC management, and development of integrated working relationships among various public agencies and private landowners involved with the species' management. In addition, restoration within an urban setting reduces the risk of wildfire through removal of thick woody underbrush and provides Florida residents an opportunity to observe FWC conservation efforts at a local level. Conversely, if the plan is not implemented, there could be negative social impacts. Continued declines in the PCC and its habitat could erode public confidence in FWC's ability to manage and conserve the wildlife resources of the state. Moreover, with any further PCC population reductions, Bay County will face the possibility of losing a unique species found nowhere else.

Ecological Impacts

Positive ecological impacts should accrue through enhancement of the overall quality of preserved and managed wet flatwoods habitats.

Historically, periodic, naturally occurring fires were important for maintaining early successional wet prairie-marsh communities that were likely some of the most suitable habitats for PCC. Fire exclusion and reduction in many areas of that wet prairie-marsh and pine flatwoods community led to increased cover by shrub vegetation and the tree canopy, rendering those habitats unsuitable for PCC. To reverse this effect and restore PCC habitats, prescribed fire should be applied in appropriate regimes to conservation lands. Where prescribed fire is not a management option, mechanical treatment plans should be developed to maintain early successional herbaceous groundcover across the irregularly inundated wetland habitats that PCC prefer. Restoration of degraded PCC habitat will result in increased cover and diversity of native herbaceous and woody vegetation typical of high-quality wet flatwoods.

Restoration of PCC habitat and subsequent reestablishment of PCC will create more suitable habitat for a multitude of rare plant and animal species (Florida Natural Areas Inventory [FNAI] 2001). Habitats potentially occupied by PCC, such as wet prairies and wet flatwoods support a number of rare and listed species of plants, including pitcher plants, wiregrass gentian (*Gentiania pennelliana*), orchids (*Cleistes* spp. and *Pogonia* spp.), and sundews that are adapted to the particular parameters of those habitats. Management activities that enhance these areas will also restore the rare plant communities associated with them. Panama City crayfish act as detritivores, herbivores, and prey within their biological communities. The burrowing activities of PCC can increase nutrient and mineral availability as material is brought to the surface from deeper soil layers (E. Keppner, personal communication). Through burrowing, they also help to aerate the

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soil (P. Moler, personal communication). Therefore, reestablishing PCC populations can benefit numerous other animal species in wetland areas.

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APPENDICES

Appendix 1. Crayfish species found in Bay County, Florida.

Species	Found in PCC range*	Uses same habitat as PCC	Comments
Procambarus apalachicolae	No	-	Coastal flatwoods crayfish; closely related and similar to PCC
Procambarus econfinae	**Yes**	**Yes**	**Panama City crayfish (PCC); see Appendix 2**
Procambarus hubbelli	Yes	-	Jackknife crayfish; closely related and similar to PCC; see Appendix 2
Procambarus kilbyi	Yes	-	Hatchet crayfish; closely related and similar to PCC; see Appendix 2
Procambarus latipleurum	No	-	Wingtail crayfish
Procambarus paeninsulanus	Yes	Possibly	Peninsula crayfish; more commonly found in swamps and ponds; see Appendix 2
Procambarus pycnogonopodus	Yes	Yes	Stud crayfish; see Appendix 2
Procambarus rogersi	Yes	Yes	Seepage crayfish; see Appendix 2
Procambarus spiculifer	Yes	No	White-tubercled crayfish; stream-dweller; see Appendix 2
Procambarus versutus	Yes	No	Sly crayfish; stream-dweller; see Appendix 2
Cambarus diogenes	No	-	Devil crayfish

*Of the eight species that are currently known from the range of the PCC, most can be distinguished from each other by size, shape, and color pattern (see Appendix 2).

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Appendix 2. Comparison of Panama City crayfish with other species found in its range.

A. Panama City crayfish (*Procambarus econfinae*). Photo © Lisa Keppner.
B. Panama City crayfish (*P. econfinae*). Photo © Barry Mansell.

C. Stud crayfish (*P. pycnogonopodus*). Photo © Jonathan Mays, FWC.
D. Peninsula crayfish (*P. paeninsulanus*). Photo © Jonathan Mays, FWC.

E. Seepage crayfish (*P. rogersi*). Photo © Jonathan Mays, FWC.
F. Sly crayfish (*P. versutus*). Photo © Barry Mansell.

G. White-tubercled crayfish (*P. spiculifer*). Photo © Jonathan Mays, FWC.
H. Hatchet crayfish (*P. kilbyi*). Photo © Jonathan Mays, FWC.

I. Jackknife crayfish (*P. hubbelli*). Photo © Jonathan Mays, FWC.

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Appendix 3. Methods for development of Panama City Crayfish (PCC) Habitat Model

A potential habitat model was developed using Maxent (Phillips et al. 2004), a machine-learning technique that uses a maximum entropy algorithm to produce likelihoods of habitat suitability for a species based on presence-only data and environmental variables. The model included occurrence data for PCC (*n*=1,056) collected from 1999 to 2014 and the following environmental variables (*n*=6):

- Cooperative Land Cover (CLC) (2014), a cooperative land cover layer by FWC and FNAI;
- Distance to wetlands (2014), developed using a distance function from a mosaic of relevant wetlands from CLC, National Hydrography Dataset, and National Wetlands Inventory;
- Digital Elevation Model (2012), Lidar data from NWFWMD;
- Topographical Position Index (2008), a landform variable from FWC;
- Canopy % cover (2011), from U.S. Forest Service; and
- Surficial geology (2014), soil drainage class within the Soil Survey Geographic database layer.

Maxent searches for the approximation that satisfies a set of constraints on an unknown distribution and, subject to those constraints, maximizes the entropy of the resulting distribution (Phillips et al. 2006). The distribution is a cumulative representation where the assigned value to a pixel is the sum of the probabilities of that pixel and all other pixels with equal or lower probability, multiplied by 100 to give a percentage. Predicted areas do not necessarily indicate the probability of a species being present, but the likelihood that the area contains suitable habitat based on underlying variables used in the model.

The habitat model area was restricted to the historical boundary. Default parameters in Maxent were used with 10,000 random background samples. The 10-fold cross-validation procedure was used to test model performance on training data, and on test data by withholding 10% of data points from each training model run; the test data were run to make sure the model was not over fit and to develop prediction thresholds. Singular species models were validated using the Receiver Operating Characteristic curve (Hanley and McNeil 1982), which represents the relationship between the percentage of presences correctly predicted (sensitivity) and 1 minus the percentage of the absences correctly predicted (specificity). The area under the curve (AUC) was employed that measures the ability of the model to classify correctly a species as present or absent, where AUC scores above 0.9 are considered to be “excellent” (Araujo and Guisan 2006).

A potential habitat map was created using the mean value of the 10-fold cross validation Maxent output, and a binary threshold (i.e., suitable and unsuitable habitat) was applied. The optimal threshold has not been determined when applying Maxent (Phillips et al. 2006), but larger thresholds will usually decrease commission errors but increase omission errors (Hernández et al. 2006). Therefore, a conservative threshold, 10 percentile, was used where values above the predicted value at the lowest 10% of presence locations were considered potential habitat.

The resulting potential habitat model had an acceptable AUC value of 0.892 with distance to wetlands being the strongest influential variable. Canopy cover and soil drainage were the least

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influential variables. The 10 percentile threshold included 4,067 ha of potential habitat; however, 33 ha of nonhabitat (e.g., high intensity urban, tidal flats/salt marsh) were manually removed due to the artifact of the distance to wetlands variable including slivers of these land-cover types on the fringe of the model area.

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Appendix 4. Draft Guidelines for Translocation of the Panama City Crayfish (*Procambarus econfinae*)

1. Introduction

The Panama City Crayfish (PCC) Management Plan guides us to develop and implement a translocation program to increase the number of occupied locations. This document provides specific and comprehensive "how to" guidelines for translocating the PCC. During implementation of a translocation program, these guidelines should be followed, continuously evaluated, and adjusted as new information becomes available to ensure optimum conservation results for this species.

2. Selecting a Source Site

The source site can be selected from any known population of PCC located in the defined PCC habitat (Figure 4 in text). Selecting a source site from defined PCC habitat will help ensure recovery of the source population after removal of the individuals to be translocated. In some cases, local entities such as Bay County, municipalities, or developers, may be required to translocate PCC populations as a result of proposed activities. The source site will be the location of the PCC population adversely impacted by the proposed activity.

Gore (2000) stated that translocated animals should be of the same subspecies or isolated geographical population as those found or formerly found on the recipient site. The PCC's small range allows one to assume that all PCC within its range are from the same geographic metapopulation with a similar genetic background. Therefore, it is not necessary to use multiple source sites to improve genetic variability.

Two species of ecologically similar crayfish (*P. kilbyi* and *P. hubbelli*) that occupy soil types and habitat similar to PCC are known to occur within the range of the PCC. Interspecific competition for habitat and resources between the three species is unknown. However, it is prudent to minimize the chance of including individuals of *P. kilbyi* and/or *P. hubbelli* in those to be translocated to a new location. Therefore, when possible, source sites should not be chosen from the northeastern part of the PCC range east of Star Avenue and south of John Pitts Road, nor from the southeasternmost portion of the PCC range west of Star Avenue, since these other species have been captured in those vicinities.

If a source site needs to be one of these areas, specimens selected for translocation will be confirmed as PCC by an individual qualified to make the proper identification. *Procambarus pycnogonopodus* is known to occur with PCC at a number of locations within the PCC range. It and all other macro-organisms should also be excluded from translocation to reduce potential predation and to reduce the risk of unknowingly introducing potentially invasive species into the destination site.

3. Selecting a Destination Site

The destination site must be approved by FWC and USFWS. An inventory of destination sites with currently suitable habitat for translocated PCC shall be maintained by FWC and/or USFWS. Each destination site shall have a long-term management plan to assure the maintenance and protection of the habitat and of PCC established as a result of translocation. Prior to

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translocation, PCC will need to be evaluated to determine the number of crayfish that can survive and reestablish within the site. The destination site should not receive more translocated PCC than it can support.

The destination site should be a natural, suitable site that has been restored, enhanced, or created; is free from mulch materials (e.g., pine straw, woodchips); and supports appropriate herbaceous wetland vegetation at the time of the translocation. Habitat at the destination site must be suitable for survival and reproduction of translocated individuals (Gore 2000). Decisions regarding suitability should be supported by quantitative data or by opinions of FWC and/or USFWS biologists knowledgeable of the species' habitat needs. Table 4.1 provides some ecological factors to be considered in determining the suitability of a destination site for translocated PCC.

Summary of ecological requirements for PCC translocation destination sites.

Factor	Suitable	Unsuitable
Physical Habitat	Shallow depressions and/or swales with open canopy in appropriate soil type with herbaceous wetland vegetation.	Depressions and swales with closed tree or shrub canopy or in inappropriate soil type.
Burrowing	PCC are secondary burrowers and require substrate free from mulch such as woodchips or dense pine straw that impede burrowing.	Substrate mulched with woodchips or pine straw, for example, impedes burrowing as surface waters decline.
Hydroperiod	Inundation during the wet seasons. Water table within about 2.75 feet of the surface during dry seasons.	Permanent inundation or inadequate period of inundation. Water table falls below 2.75 feet during dry season.
Shelter and Food	Herbaceous vegetation for food, detritus formation, and cover.	Absence of herbaceous vegetation with reduced food supply and exposure to predators or abundance of algae.
Habitat Management	Prevent overgrowth of shrubs and other woody vegetation that will close the canopy, reduce or eliminate growth of herbaceous plants, and may increase the transpiration rate and reduce the hydroperiod and depth to groundwater during drought. Use of fire during absence of surface water.	Unmanaged habitat tends to over grow with woody vegetation, particularly species of titi (*Cliftonia monophylla* and *Cyrilla racemiflora*), reducing or eliminating herbaceous vegetation and possibly increasing the transpiration rate and increasing the depth of the water table during dry periods.

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4. Collecting PCC at the Source Site

Baseline monitoring of source and destination sites shall be completed prior to implementing a translocation plan. Baseline information should include size of the area, species present, and ecological function of the area (e.g., natural herbaceous wetland depression, man-made drainage swale or ditch, wetland depression in silviculture). Soil type, pH, dissolved oxygen, water temperature, and PCC population density should be determined. This data should be measured in such a way that it can be compared to post-removal monitoring.

Translocation of PCC must be done in a manner that ensures the least amount of damage and stress to individuals and ensures maximum survival at the destination site. Collecting specimens by digging them from burrows is not recommended; it is inefficient, disturbs the source site, can cause crayfish injury or mortality, and does not guarantee sufficient numbers of specimens. Instead, PCC should be collected using dip nets when surface water is present. Water temperatures below approximately 45^0F may affect normal mobility of PCC and translocation should be rescheduled to a time when the entire process can be performed during warmer temperatures. Visibly diseased or injured individuals should be removed and preserved in 70% isopropyl alcohol or 70% ethyl alcohol (not denatured alcohol).

Little is known about demographic ratios in PCC populations. Therefore, all PCC captured during a sampling event should be recorded for size (length from end of tail to head), life stage (adult or juvenile), and sex.

A range of size classes should be selected to include a balance of males and females for translocation. The number of smaller juveniles present at a site often outnumber adult males and females, and a high proportion of smaller individuals may be taken to emulate the natural population structure. An equivalent number of male versus female adults should be selected. Do not include the following crayfish as specimens to be translocated:

- Molting or recently molted individuals,
- Females with eggs or young attached to the pleopods, and/or
- Injured or deformed individuals.

5. Transportation

It is important to avoid unnecessary stress or damage to the harvested stock during transport to the destination site (Kemp et al. 2003). Key recommendations are to (1) keep crayfish cool and out of direct sunlight, (2) provide sufficient oxygen, and (3) minimize aggression by preventing overcrowding and providing refuges.

Crayfish should be placed in five-gallon buckets with a small amount of water and ample damp, wetland vegetation to minimize contact with other specimens, but not enough to allow them to crawl out. Specimens should be transported to the destination site within four hours of collection.

6. Introducing PCC to Suitable Destination Site

To reduce predation, PCC should be released at multiple locations within the destination site. A group of crayfish in one area may become an easy target for predators such as herons, egrets, and raccoons, thereby significantly reducing the number of translocated crayfish. Global positioning system coordinates of each release site should be recorded.

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7. Monitoring

Each release site should be monitored annually for PCC. Sampling should parallel pre-translocation data in time of year, effort, location, and amount of surface water. After each survey, the PCC database managed by FWC should be updated to track progress toward achieving the goals of the plan.

Appendix 4 Literature Cited

Gore, J. 2000. Draft Policy of BWDC/DOW for translocation of terrestrial vertebrate wildlife within Florida. Florida Fish and Wildlife Conservation Commission, Tallahassee, Florida.

Kemp, E., N. Birkinshaw, S. Peay, and P.D. Hiley. 2003. Reintroducing the white-clawed crayfish *Austropotamobius pallipes*. Conserving Natura 2000 Rivers Conservation Techniques Series No. 1. English Nature, Peterborough.

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Appendix 5. Authorizations not requiring a permit

Activities that have the potential to benefit the PCC may also cause take, however the benefits outweigh the potential negative impact of the activities. The following activities are authorized under these conditions, without any additional permitting required:

Land Management

Land management activities that benefit wildlife and are not inconsistent with management plans for the species, and wildfire suppression activities necessary to ensure public safety during emergency circumstances as described in 68A-27.007(c) and (e), F.A.C. do not require any permits. Examples of land management activities that benefit wildlife, and PCC specifically, include prescribed fire and roller chopping to reduce shrubs.

PCC Management Areas. Areas that are secured for PCC habitat restoration and management, and these could include PCC mitigation areas, should have features in common with habitats where PCC populations are currently known and/or managed, including minimal canopy cover, high herbaceous groundcover, and management practices that encourage these conditions (i.e., prescribed fire).

- Ensure >50% of the site is within PCC habitat (see Figure 4).
- Restore or maintain basal area to ≤ 30 or no more than 40 trees per acre.
- Maintain a minimum of 75% herbaceous groundcover of low-growing grasses, sedges, and herbs.
- Use a maximum 3-year fire rotation to reduce shrub component and improve herbaceous groundcover (burn when possible).
- When restoring wetlands that have been bedded, reduce impact to PCC by using a phased approach and dipnetting and removing PCC to restored areas.

Silviculture

Silvicultural lands represent a significant proportion of the currently known PCC sites, with PCC occurring specifically at sites within or adjoining lands used for slash pine plantations. Continued presence of PCC at silvicultural sites indicates that these activities are not inconsistent with PCC persistence. Through significant coordination with agricultural and silvicultural stakeholders, the water-quality based Silviculture Best Management Practices (FDACS 2008) are believed to provide protection to the PCC. Silvicultural activities that follow these water quality BMPs, as indicated by signing an FDACS Notice of Intent (FDACS Silviculture BMP webpage), do not require any FWC permitting for PCC. As of 2013, over 9,600 acres of BMP parcels were enrolled within the PCC range.

Agriculture

Agricultural activities are currently fairly limited in the small range of the PCC; however some pasture and rangeland occurs in or adjacent to PCC habitat. Improperly managed cow/calf operations can adversely affect the quality of streams and wetlands through runoff, soil erosion, and major habitat disturbance (e.g., overuse). However, when these operations are conducted according to FDACS BMPs, they can be beneficial to the PCC by creating open expanses of quality habitat. Cow/calf operations enrolled in and implementing *Water Quality Best*

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Management Practices for Florida Cow/Calf Operations (FDACS 2008) as indicated by providing an FDACS Notice of Intent form do not need FWC permitting for PCC.

This management plan is authorizing the following activities which have the potential for take of the Panama City crayfish, and these activities do not require a permit:

- Emergency services required for flood control or other human health or safety concerns.
- Culvert installation, maintenance, and replacement that follow the general permit for culverts (FDEP Rule 62-341.439, F.A.C.).
- Replacement of a destroyed structure if it occurs on the same footprint as the original structure.

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Appendix 6. Conservation Management Practices (CMPs)

Conservation Management Practices (CMPs)

Conservation management practices are measures that minimize impacts to PCC and their habitat. When fully implemented across an entire project site, use of CMPs for specific activities as described below serve as authorization for the potential take of PCC during otherwise lawful activities. In cases where CMPs cannot be followed at all PCC habitat areas impacted by a project, or where parts of the CMPs are not practicable based on site conditions, following the CMPs to the extent practicable can reduce FWC take permitting or mitigation requirements. These CMPs were derived through meetings of planning team members, public comment, and the Stakeholder Advisory Group during the initial process of writing the FWC's *Panama City Crayfish Management Plan.* Some of the original CMPs have been revised for clarification and simplification; others are now included among authorizations not requiring a permit (Appendix 5).

Conservation management practices are a critical part of FWC's *Panama City Crayfish Management Plan* because adherence to them can eliminate the need for an Incidental Take Permit (ITP), thereby saving valuable time and money for landowners and the public. The effectiveness of the CMPs in reducing or eliminating impacts to PCC will be evaluated on an ongoing basis and modified accordingly. Conservation management practices will only be modified if negative impacts are documented, changes are discussed with affected parties in a public forum, and changes are approved by the Commission. Additional CMPs may be added based on information that the change would benefit PCC. These additions would also require discussion with affected parties in a public forum, and approval by the Commission.

Ditch/Road Maintenance

Panama City crayfish persist in gently-sloped grassy ditches that provide drainage in urban and suburban areas. Ensuring that these gently-sloped grassy ditches are appropriately maintained will help ensure the continued presence of PCC in this habitat. Box-cut ditches are steep-sided ditches that provide water conveyance and are not considered PCC habitat.

- Maintain ditches with side slopes equal to or greater than 3 feet horizontal to 1 foot vertical; 4 feet horizontal to 1 foot vertical preferred.
- Maintain ditches with rounded bottoms. Avoid creating box-cut ditches.
- If possible, perform ditch maintenance when no standing water is present.
- Re-vegetate side slopes as soon as possible with low-growing grasses, sedges, and herbs.
- Ditches should be mowed with little or no rutting. Boom arm mowers are preferred to reduce rutting from equipment.
- Remove no more than 12 inches of soil during ditch maintenance procedures.
- Existing box-cut ditches are not considered PCC habitat and are exempt from these maintenance CMPs.

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Utility and Transmission Line Rights-of-Way Construction and Maintenance:

In many areas of its range, available PCC habitat is the result of anthropogenic changes to the landscape, such as along utility and transmission line rights-of-way. Regular mowing and other brush reduction techniques prevents succession into hardwood thickets and provides ideal open, herbaceous conditions in wet areas along the right-of-way.

- Maintain ground floor of low-growing native vegetation by mowing or herbicide application. Minimize vehicle impacts by using low-ground-pressure equipment or wetland mats to avoid rutting hydric soils. Mowing should be done with little to no digging or rutting. Boom arm mowers are preferred.
- Ditches in PCC habitat should be no more than 36 inches in width, and the total impact, including the temporary stockpiling of spoil material, should not exceed nine feet in width. Spoil removed from different depths should be replaced in the same order as prior to removal.
- When directional boring is necessary, there should be no more than 500 linear feet between bores to minimize the possibility of frac-outs (spillage of toxic drilling mud). Ensure complete removal of any drilling mud.
- Overhead utilities should be used where appropriate to minimize wetland impacts.

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Appendix 7. Landowner Assistance Programs

Program	Description	Contact
Conservation Banking Program	Seeks to offset adverse impacts to a particular species by permanently protecting suitable habitat (i.e., the conservation bank) for the species. Landowners purchase credits in the bank in order to compensate for environmental impacts of development projects.	FWC Conservation Planning Services (CPS) biologist
Forest Stewardship Program	Seeks to help private landowners develop a plan designed to increase the economic value of their forestland while maintaining its environmental integrity for future generations. Stewardship is based on the multiple-use land strategy.	Your county forester or an FWC CPS biologist
Environmental Quality Incentives Program	Administered by USDA's Natural Resources Conservation Service. Provides both technical assistance and up to 50 percent cost-share assistance to farmers and ranchers who face threats to soil, water, air, and related natural resources.	Your local district conservationist through the nearest USDA Service Center
Partners for Fish and Wildlife Program	Administered by the USFWS. Provides technical assistance and up to 50 percent cost-share assistance to private landowners and other partners who conduct habitat restoration and improvement activities on their land. The focus of the program in Florida is on restoration of native habitats, restoration of degraded streams and wetlands, and eradication of invasive, exotic species.	FWC CPS biologist

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Appendix 8. Stakeholders for 2007 Draft Panama City Crayfish Management Plan

Agencies, businesses, and other stakeholder groups and their representatives who attended one or more stakeholder advisory group meetings held September 2006 through April 2007 or the public meetings held December 13, 2006, and May 17, 2007. Inclusion on this list does not imply that these groups or individuals are directly responsible for, should be held accountable for, or necessarily endorse all or part of the management plan.

ARETCO (Jim Anders)
Bay County (Larry Hawks, Ken Schnell, Tita Sokoloff)
Bay County Association of Realtors (Scott Bowman)
Bay County Audubon Society (Neil J. Lamb)
Bay County Chamber of Commerce (Paul Runk)
Bay County Economic Development Alliance (Ted Clem)
Bay County Home Builders Association (Brian Davidenko, Allen Guthrie, Ron Putman)
Bay Tax Foundation (Kim Minter, Huey Moore)
Bayco Development Company (Mary K. Sittman)
Bingham Environmental (Frasier Bingham)
Biological Research Associates (Jason Dickey, Deron Lawrence, Janet Strutzel)
City of Callaway (Whitey Adams, Jeff Grindle)
City of Lynn Haven (Phil Mount)
City of Panama City (Neil H. Fravel)
D & H Properties (Belton Cooper, John David, Sister Dodd)
Dream Home Group (Tom McPeak)
DRMP, Inc. (Ben Faust)
Eastbay Development Company (Diane Bateman)
Eco Consulting Group (Lisa Fowler)
Florida Department of Environmental Protection (Brad Hartshorn)
Florida Department of Transportation (Joy Giddens, J. Howard Lovett, Michael Wittkopf)
Gulf Power Company (Robin Finkel, Richard Gilbert, Earl Mirus)
J.R. Environmental (Roxanne Jones)
Keppner Biological (Ed Keppner, Lisa Keppner)
Post, Buckley, Shuh, and Jernigan (Jennifer Brown, Eric Schneider)
St. Joe Company (Jim Moyers, Steve Shea)
The Nature Conservancy (Michael McManus)
U.S. Fish and Wildlife Service (Gail Carmody, Patty Kelly, Janet Mizzi)

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